xCoAx 2021

Proceedings of the 9th Conference on
Computation, Communication, Aesthetics & X

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Edited by
Miguel Carvalhais, Mario Verdicchio, Luísa Ribas, André Rangel

Published by
i2ADS
Research Institute in Art, Design and Society
School of Fine Arts, University of Porto
Avenida Rodrigues de Freitas, 265
Room 109 A and 109B
4049-021 Porto, Portugal

ISBN
978-989-9049-06-2

Organising Committee
André Rangel, David Pirrò, Hanns Holger Rutz, Jason Reizner,
Luís Nunes, Luísa Ribas, Mario Verdicchio, Miguel Carvalhais

Design
Juhan Reis

Web Design
Mariana Simões

Doctoral Symposium Chairs
Angela Ferraiolo, Marko Ciciliani

Keynote Speakers
Yuk Hui, Špela Petrič

Special thanks:
Rosemary Lee

Contents

Artworks

Performances

Doctoral Symposium

Committees

Scientific Committee

Adriana Sá
ESAD/CICANT

Alessandro Ludovico
Winchester School of Art,
University of Southampton / Neural

Alice Cannava
Technische Universität Berlin / Occulto Magazine

Alice Eldridge
University of Sussex

André Rangel
CITAR / i2ADS / Faculty of Fine Arts,
University of Porto

Andreas Broeckmann
Leuphana Arts Program, Lüneburg

Andreas Muxel
Faculty of Design at University of
Applied Sciences Augsburg

Anna-Luise Lorenz

Anna Terzaroli
Nicola Sala Conservatory of Music

Anne Balsamo
University of Texas at Dallas

Anneké Pettican
Department Lead Art & Communication,
University of Huddersfield

Astrid Drechsler
Sound Design, FH Joanneum, University
of Applied Sciences

Aura Satz
Royal College of Art

Boris Debackere
V2 / Luca School of Arts

Carlos Guedes
New York University Abu Dhabi

Chara Lewis
Manchester School of Art, Manchester
Metropolitan University

Christian Faubel
Academy of Media Arts Cologne

Cristina Sá
CITAR / Portuguese Catholic University, School of Arts

Dale MacDonald
University of Texas at Dallas

Daniele Pozzi
Institute of Electronic Music and Acoustics,
University of Music and Performing Arts, Graz

Daniel Irrgang
Weizenbaum Institute / Berlin University of the Arts

Daniel Schorno
STEIM

Daphne Dragona
Independent curator and writer

Darko Velazquez
Bauhaus Form + Function Lab,
Bauhaus-Universität Weimar

David Pirrò
Institute of Electronic Music and Acoustics,
University of Music and Performing Arts, Graz

Diemo Schwarz
IRCAM

Filipe Pais
Ensadlab, Ensad, Paris

Francisco Cardoso Lima
Independent Artist, Aveiro

Frieder Nake
University of Bremen & Hochschule für Künste Bremen

Gerhard Nierhaus
University of Music and Performing Arts Graz

Hanns Holger Rutz
Institute of Electronic Music and Acoustics, University of Music and Performing Arts, Graz

Heitor Alvelos
ID+ / Faculty of Fine Arts, University of Porto

Jason Reizner
Bauhaus-Universität Weimar

Jia-Rey Chang
archgary.com / Art & Design Department, University of Delaware

Ji Youn Kang
The Royal Conservatoire in The Hague

Joanna Zylinska
Department of Media, Communications and Cultural Studies, Goldsmiths, University of London

João Cordeiro
CITAR / University of West London

Johannes Zmölnig
University of Music and Performing Arts Graz

Jon He
Massey University

Jon McCormack
Monash University

Nathan Wolek
Stetson University

Jung In Jung
InGAME, University of Dundee

Kristin Mojsiewicz
Edinburgh College of Art, University of Edinburgh

Laura Beloff
School of Arts, Design and Architecture, Aalto University

Luc Döbereiner
Institute of Electronic Music and Acoustics, University of Music and Performing Arts, Graz

Luísa Ribas
CIEBA / Faculty of Fine Arts, University of Lisbon

Manuela Naveau
Ars Electronica

Marko Ciciliani
Institute of Electronic Music and Acoustics at the University of Music and Performing Arts Graz

Mario Verdicchio
Università degli Studi di Bergamo

Martin Rumori
sonible GmbH

Max Hampshire
Independent Researcher & Artist

Miguel Carvalhais
INESC TEC / i2ADS / Faculty of Fine Arts, University of Porto

Michael Markert
Hochschule Coburg

Mitchell Whitelaw
College of Arts and Social Sciences, Australian National University

Monty Adkins
University of Huddersfield

Nora Al-Badri

Nuno N. Correia
University of Greenwich

Patrícia João Reis
University of Applied Arts Vienna,Austria,
Department of Digital Arts

Pedro Cardoso
INESC TEC / Faculty of Fine Arts,
University of Porto

Penousal Machado
University of Coimbra

Philip Galanter
Texas A&M University

Ricardo Melo
Fraunhofer Portugal Research Center for
Assistive Information and Communication
Solutions (Fraunhofer AICOS)

Rodrigo Hernández-Ramírez
UNIDCOM / Instituto de Arte,
Design e Empresa (IADE)

Ron Kuivila
Wesleyan University

Rosemary Lee
IT-University Copenhagen

Rui Penha
ESMAE / INESC TEC

Rui Torres
Electronic Literature Organization /
Faculty of Human and Social Sciences,
University Fernando Pessoa, Porto

Samuel Van Ransbeeck
UCP-CITAR

Sissel Marie Tonn

Sophie-Carolin Wagner
Austrian National Library / RIAT

Shusha Niederberguer
House of Electronic Arts Basel

Søren Pold
School of Communication and Culture,
Aarhus University

Tim Boykett
Time's Up

Thor Magnusson
University of Sussex / ixi audio

Trent Kim
University of the West of Scotland

Valentina Nisi
University of Madeira

Valentina Vuksic
Zurich University of the Arts

Valerie Wolf Gang

Veronika Mayer
Freelance Artist and Lecturer

Victoria Bradbury
University of North Carolina, Asheville

Visda Goudarzi
School of Media Arts at
Columbia College Chicago

Winnie Soon
Department of Digital Design at
Aarhus University

Yucef Merhi
Open Doc Lab,
Massachusetts Institute of Technology

Organising Committee

André Rangel
CITAR / i2ADS / Faculty of Fine Arts,
University of Porto

David Pirrò
Institute of Electronic Music and Acoustics,
University of Music and Performing Arts, Graz

Hanns Holger Rutz
Institute of Electronic Music and Acoustics,
University of Music and Performing Arts, Graz

Jason Reizner
Bauhaus-Universität Weimar

Luís Nunes
i2ADS / Faculty of Fine Arts, University of Porto

Luísa Ribas
CIEBA / Faculty of Fine Arts, University of Lisbon

Mario Verdicchio
Università degli Studi di Bergamo

Miguel Carvalhais
INESC TEC / i2ADS / Faculty of Fine Arts,
University of Porto

Past Organisers

Alejandro Sanchez Zaragoza
MACA / ETSAM

Andrea González Garrán
MACA / ETSAM

Atxu Amann
MACA / ETSAM

Carol Pierina
MACA / ETSAM

Alison Clifford
University of the West of Scotland

Daniele Pozzi
Institute of Electronic Music and Acoustics,
University of Music and Performing Arts, Graz

Graeme Truslove
University of the West of Scotland

Pedro Tudela
i2ADS / Faculty of Fine Arts, University of Porto

Foreword

Welcome to the proceedings of the 9th Conference on Computation, Communication, Aesthetics & X, also known as xCoAx 2021, which took place online from July 12th to July 16th 2021.

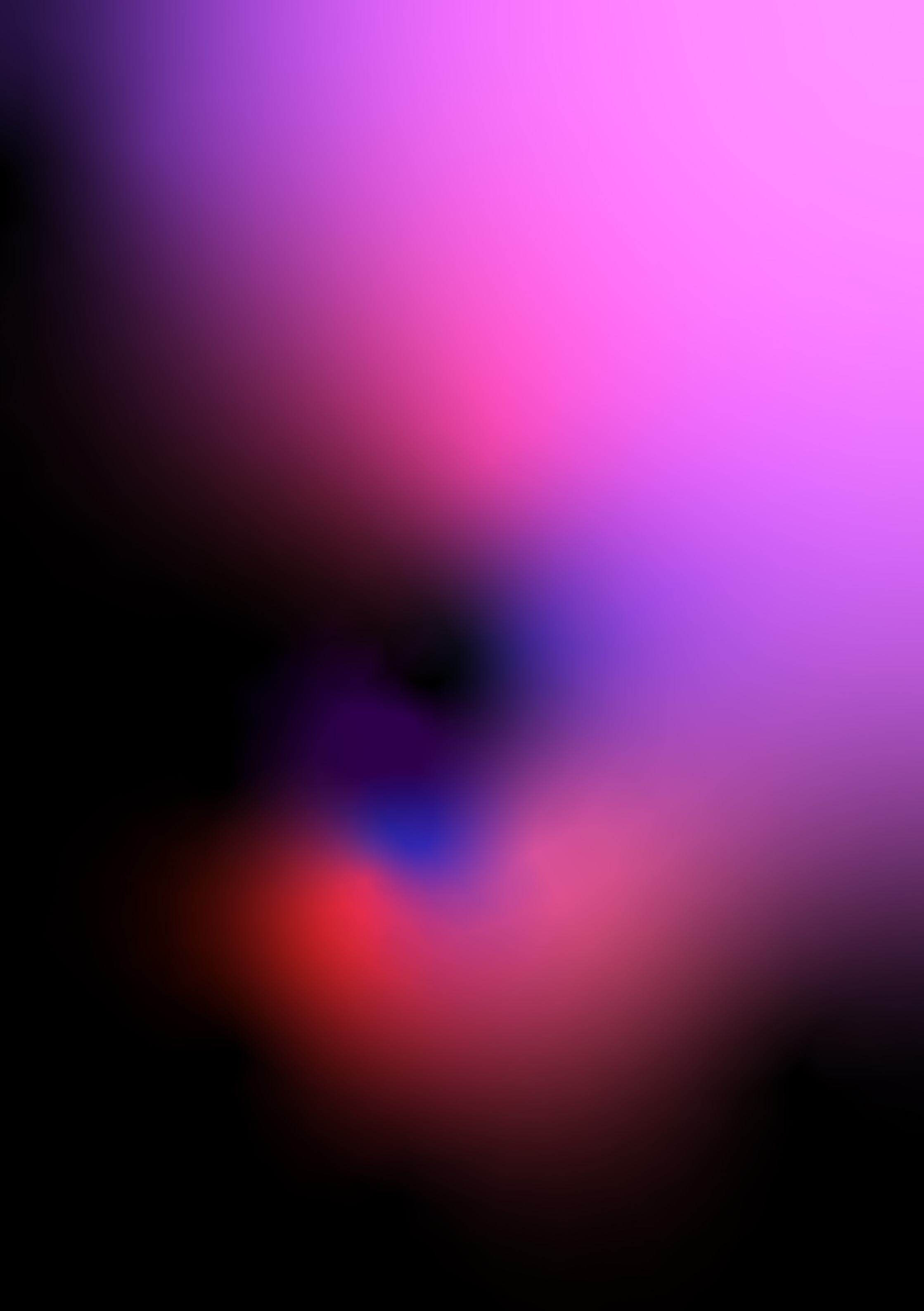
After our first experience of an online version of xCoAx in 2020, we were eager to return to a traditional physical format where we could meet artists, performers, researchers and friends in person. Despite incredibly quick strides towards a massive vaccination campaign, at least in some parts of the world, we are not there yet and we had to settle for an online edition also this year. In an evolving situation where compromise and safety are key more than ever, we opted to have participants meet and show their work in a digital space once again but, as usual, we try to learn from our past experience and the helpful feedback of our guests, and made sessions more interactive, relying on pre-recorded videos only for part of the event, and going live with performances, Q&A sessions, round tables and keynotes.

We took a risk, and we hope that the participants felt rewarded as handsomely as we did. We have no idea for how long this new kind of social life will have to go on. Anyway, we are made more and more aware that digital technology, whether it is used for creative purposes or for communication necessities, is not an additional, ethereal layer added to a consolidated stack, or a sophisticated enhancement of our traditional ways. Instead, it is the fundamental backbone of all operations of our artistic, academic, cultural and professional lives, especially in a world where physical distances need to be maintained by people for their own safety.

We are still recovering from a traumatic past and we are facing an uncertain future, while grappling with the power and the meaning of the tools at our disposal. Let this book be a support in this task, and a reminder that there will always be communities you can count on. Wherever you are, we are very happy to have you here.

Enjoy!
The 2021 xCoAx Organizing Committee

Papers



xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Classification, Slippage, Failure and Discovery

Keywords: Machine Learning, Classification, Failure, Creativity, Algorithm Auditing, Technology Governance, Critical Technical Practices

Marc Böhlen
marcbohlen@protonmail.com
University at Buffalo, Department of Art, Emerging Practices in Computational Media

This text argues for the potential of machine learning infused classification systems as vectors for a technically-engaged and constructive technology critique. The text describes this potential with several experiments in image data creation and neural network based classification. The text considers varying aspects of slippage in classification and considers the potential for discovery — as opposed to disaster — stemming from machine learning systems when they fail to perform as anticipated.

1. Introduction

New technologies bring with them the promise of new avenues for creative inquiry. Machine learning is no exception, yet it offers itself at the same time as a vehicle for testing the previous generalization. What kind of creative inquiry, if any, does machine learning in fact allow for, and which kinds of operations might this creative inquiry be applied to? Inversely, how might creative energies applied to machine learning modulate procedures and assumptions within machine learning itself?

The field of machine learning is wide and deep, and this short discussion concerns only one particular category of machine learning, namely supervised machine learning implemented with neural network architectures. Furthermore, the text investigates only machine learning supported image classification within visual culture.

2. Discovery

Broadly speaking, the primary contribution of machine learning is in algorithmic knowledge discovery: the automated detection of knowledge expressed as patterns and relationships in data. In a basic sense, supervised machine learning — detecting information patterns represented with a predefined collection of data — is a kind of search function that detects only what is already inherent in a dataset. Yet if the dataset is vast and distributed enough, seemingly trivial detection operations scale to something grander, as no human could practically perform this task.

Computer-based knowledge discovery is based on statistical methods (Piateski 1991) and can process vast amounts of data. Specifically, neural network-based machine learning was identified early on as a promising candidate for the development of knowledge discovery (Fu 1999). Over the past years, machine learning for knowledge discovery has been applied to domains ranging from materials science (Raccuglia 2016) to software design and vulnerability detection (Grieco 2016), drug and drug side effects research (Dimitri 2017) and the design of wining strategies for the game of go (Silver 2018). In all of these examples, machine learning-supported methods of discovery generated useful and sometimes unexpected results that human-produced strategies were not able to create.

In the arts, discovery traditionally carries a different meaning. In particular, the Neoplatonist interpretation (Hendrix 2007) of the significance of the idea and imagination formed the groundwork for the unique position of artistic creativity that endures in several variations to the present. Through the power of *disegno inferno* (Zuccari 1607) the 'spark of fire', the artist perceives the artwork as a vision before it materializes into paint, stone (or code).

Computational creativity has, not without self-interest, attempted to expand and differentiate this traditional insular interpretation of creativity. Ventura, for example, places creative systems on a spectrum, beginning with the state of the merely generative (producing random events) through various states of filtration, inception and culminating in the act of creation at the end of the spectrum (Ventura 2016). In this framework, machinic discovery resides on the far end of the spectrum; distinct from what human-originating and unconstrained discovery abilities produce. However, the fact that the term discovery is now used across domains is at least indication of a contested territory within this generally accepted figuration of discovery. And as computing systems continuously expand the territory of what they can discover, they simultaneously suggest a re-evaluation of the uniqueness of human discovery dynamics as well as opportunities for collaborative human-computer discovery approaches.

3. Classification

Classification is omnipresent in everyday life. It is much older than the computational systems in which it is encoded today. In fact, to classify is human (Bowker 1999). More generally, classification is a form of controlled sense-making, a process of systematically composing predefined categories according to specific criteria. As opposed to generative systems, classification systems are by default forced to acknowledge their dependency on human agency in the very construction of categories. Classification is a supervised operation that requires information designers to formally represent the domain they attempt to capture in images, texts or sensor readings. These assemblages represent the world to the classification system.

The pedestrian world of machine learning-based classification offers no equivalent to the spectacular visual results that its younger cousin Generative Adversarial Networks can produce. Generative systems attract all the attention; they can create stunningly realistic portraits of people who never existed (Karras 2019), further eroding any vestiges of the notion of veracity in digital images. However, image classifications systems impact algorithmic and visual culture in their own unique ways. From the epistemology of defining what constitutes a category, to declaring what is 'found' when a classifier makes a decision (or a mistake), machine learning classification holds underexplored potential for inquiry. The following sections outline this argument through examples and considers some possible consequences for machine learning classification.

3.1. Image Classification

Deep learning has become a potent method for learning from the world, and it has delivered state of the art results in voice recognition, sentiment analysis and image classification (LeCun 2015). Deep learning for image classification is a form of supervised deep learning in which a machine is exposed to examples (training data) of the objects it is tasked to recognize.

The most widely used network architectures for deep learning image classification are Convolutional Neural Networks (CNNs). These networks apply a series of dimension reductions to ingest the multidimensional image data, creating a fully connected neural net. During training, a CNN is sequentially exposed to images in the training set and the corresponding category in a pattern of scores. The objective function measures the distance (error) between output scores and the desired pattern of scores. The machine modifies its multitude of internal parameters (weights) to reduce this error. The learning algorithm computes a gradient vector for each weight that indicates how the error would change if the weights were increased by a small value (LeCun 2015, 436). Adjustment of the weights then occurs in the opposite direction of that gradient, resulting in a complex adaptive negative feedback loop. This adjustment operation (backpropagation) is the 'magic sauce' of the learning process. Eventually, the average value of the objective function stops decreasing, and the network has 'learned' to represent its training data. At any given time, the weights represent the current knowledge of the network.

3.2. Interventionist Image Classification

The input data selection for network training provides substantial freedom of experimentation, as almost any kind of information can be applied to a neural network classifier.

But that opportunity comes with substantial commitment. It is very time-consuming and costly to design and create good image training sets. Not only must image categories be crisp enough for classifiers to robustly identify and distinguish, but the collection must also contain copious amounts of high-quality labeled data representing each of the categories. Not surprisingly, there exists a dearth of publicly available, professionally curated, high-quality datasets suitable for supervised machine learning. Moreover, many machine learning datasets suffer from a serious lack of diversity and a demonstrated bias in one form or another (Torralba 2011). And a data-labelling industry outsourced to operations using cheap labor presents its own obstacles to the quality control of image collections, as the case of the *CelebA* dataset has shown (Chandola 2017).

The dependencies of classifiers on input data are not only constraints, but opportunities. The configuration of a dataset is defined procedurally by the tasks which a classification system intends to perform, and it is always impacted by the biases and specific intentions of the design team putting the materials together in the first place. Hence, the most direct path into probing the logics and biases of neural networks is to confront them with data they were not specifically designed for. That is the approach Adam Harvey took in the project *Cluster Munition Detector Prototype* (Harvey 2018) which uses a Single Shot Detector (Liu 2016) approach to identify multiple objects in a single image. Instead of applying this technique to run-of-the-mill analytic tasks such as tracking human faces in a crowd or vehicles on a highway, Harvey applies his adaptation to the goal of finding munitions in the field, expanding the operational scope of this technique and facilitating at least in principle the dangerous work of mine-clearing crews.

As such, data-side interventions that leave the logics of networks unaltered yet bend the system into a different direction, constitute one new and viable approach to interventionist art. While this class of intervention is noteworthy, it can not disassociate itself from the logics of the network upon which it is constructed.

4. Accidents and Dilemmas

The cultural critic Paul Virilio suggested that every invention creates its very own negativity, i.e. that the invention of the train co-invents the rail accident (Virilio 2007). Artificial intelligence systems are no exceptions to this observation. In fact, artificially intelligent systems continue to create small and large accidents, a prominent example being a fatal traffic accident in which a self-driving vehicle failed to respond to a pedestrain pushing a bicycle across a road at night, killing the pedestrian (NTSB 2019).

In the context of this text, less spectacular examples of artificial intelligent accidents are perhaps more revealing of the main argument. A pertinent case is the report of an Asian man applying for a new passport, and being denied the document as the image analysis software determined that his eyes where not open, algorithmically re-creating an ugly ethnic stereotype (Cheng 2016). Such algorithm slippage demonstrates what can happen when laboratory-designed machine learning is confronted with real world data and cultural dynamics. Despite the fact that such incidents have become embarrassingly common, and despite the fact that both industry and academia openly acknowledge dysfunction in this class of machine learning, paths to ameliorating the problem remain stubbornly illusive.

While machine learning is subject to the Collingridge dilemma (Collingridge 1989; Genus 2017) according to which technology control is difficult at early stages because not enough is understood about its consequences and costly later on, once the consequences are in fact apparent, it also occupies a particular space in the technology arena due to the dynamics of data sources upon which it relies. Supervised machine learning requires copious amounts of domain-specific and high-quality training data that is often only later, when a system is deployed in the field, found to be inadequate to the original task while the algorithm itself performs according to specifications.

5. Failure

Computer science provides an array of tools to quantify the performance of neural network classifiers, from precision, recall and confusion scores to error rates (Tian 2020). These metrics help assess how well a classifier can detect a given category and how likely it is to confuse one category with another, for example.

In addition to these category-confusion approaches, researchers have developed a variety of algorithm-auditing procedures to assess which factors influence the performance of a given learning system. Algorithm audits study the functionality and the impact of algorithms. Computer scientists generally focus on the first aspect, functionality, while legal and humanities scholars focus on the second aspect, impact. Computer science has developed, for example, approaches by which one can estimate the degree to which a prediction would change had the model been fit on different training data (Schulam 2019). Humanities scholarship on the other hand has described how even algorithms that appear to work can be dangerous, because it may not be apparent when a breakdown occurs, and it is often unclear at what point they produce harm (Sandvig 2014). The lack of failure 'in obvious ways' in content personalization systems (Mittelstadt 2016) for example can lead to inadequate representation of content; this is a loss that the user remains ignorant of precisely because they never had the opportunity to be exposed to an alternate and possibly better solution.

6. Slippage

While quantitative measures are solid indicators of engineering performance, they are not tuned to uncover slippages in interpretation. Also, algorithm auditing studies tend to simplify complex data and decision landscapes in order to clarify cases for discrimination to a wide audience (Sandvig 2014). Moreover, the very concept of the audit comes with certain preconceptions. It already presupposes what kind of deficiencies it has to look for. Auditing implies that there is in fact something amiss that requires amelioration of one form or another.

The following sections take a different approach to supervised machine learning algorithm inquiry, focusing not on finding faults but on observing algorithmic behavior at the edges of their performance regime.

6.1. False similarities and Unanticipated Relationships

A variation of the analysis failure in the passport case mentioned above is the presence of 'false similarities'. False similarities are an aggregate effect of similarities across multiple features between test cases that make two categories appear more similar than they in fact are (Böhlen 2016). The false similarities approach was deployed, for example, to demonstrate how the output of the machine learning enabled expert system *Watson* — having detected in the authors of the *Communist Manifesto* very similar character traits as in the authors of an IBM annual report — suggested that the writers behind these radically different texts are much more similar than they could possibly be.

Fig. 1. Images from the bali-26 collection (images courtesy of the author). Top row: bamboo at a construction site, dragon fruit and snake fruit at a market. Bottom row: bamboo, dragon fruit and snake fruit in the wild of Central Bali.

In addition to false similarities, one might consider more broadly 'unanticipated relationships' between classifier outputs. Unanticipated relationships in this context present themselves as classifier results that suggest commonalities across categories. An example of this type of classifier performance is described in the *Return to Bali* project[1] that aims to build a machine learning-compatible representation of ethnobotancially relevant plants from the island of Bali. Currently the collection comprises some 50.000 images of 26 distinct categories of flora collected in the wild from Central Bali. Of the half-dozen classifier architectures applied to the task, the ResNet152 network (He 2016) was able to identify the same plants in completely different contexts (see Fig. 1). Trained on images of bamboo, snake fruit and dragon fruit growing in forests, the network was able to detect bamboo on construction sites as well as snake fruit and dragon fruit at markets (Sujarwo 2020), showing that it was able to generalize across disparate contexts.

1. https://www.realtechsupport.org/new_works/return-2bali.html

Detection across disparate contexts is a side-effect of neural networks' ability to generalize and find patterns across singular items in a way human beings often fail to. At the same time, the ability of networks to generalize can be fragile and fooled by noise that human observers disregard with ease (Serre 2019). Recently, researchers demonstrated the ability of neural network image classifiers to exhibit a form of generalization akin to Gestalt perception – the ability to perceive a whole only from parts (Kim 2019). The researchers found in several network topologies the ability to detect geometric forms such as triangles when only corner elements were presented to the system, an example of the Law of Closure (Wertheimer 1923). What makes this approach to network investigation significant in this context is not only the fact that the machine finds something we associate with human visual intelligence, but also that the experiment offers a new vector into probing the human side of Gestalt perception in the first place.

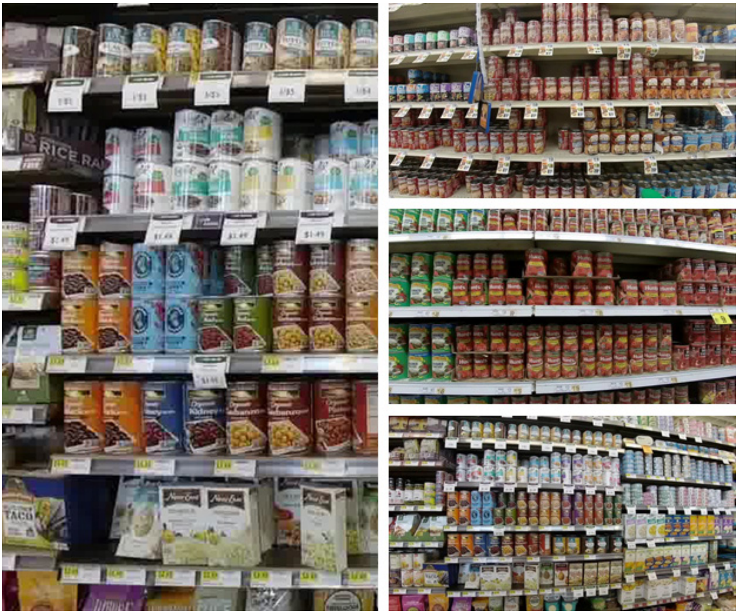


Fig. 2. Identifying shopping goods with convolutional neural networks (images courtesy of the author). Left: personal-use sized canned goods at an upper scale grocery store. Right: arrangement of canned goods in three different grocery stores. Top: large sized canned goods. Center: large and mixed sized canned goods. Bottom: small sized canned goods.

7. Classification as Discovery

At face value, discovery and classification may appear as mutually opposing operations. Discovery generally means the recognition of new relationships, and classification the assignment of pre-existing relationships. And yet it is possible that a trained classifier might 'know about' (encode) far more than the primary aim (classification categories) for which it was prepared. In other words, it has the potential for discovery because it is even 'smarter', i.e. it recognizes deeper patterns than it was trained for. This is a line of argumentation that artificial intelligence proponents might suggest. However, there is a different path along which discovery and classification meet, to wit, when classification fails.

```
/tops/cannedgoods_labeled/cans_13_16.jpg      predicted category: cannedgoods with 0.983491241932
/tops/cannedgoods_labeled/canned_21_6.jpg,    predicted category: beverages with 0.999880194664
/tops/cannedgoods_labeled/canned_10_17.jpg,   predicted category: cannedgoods with 0.965077579021
/tops/cannedgoods_labeled/goods_18_16.jpg,    predicted category: beverages with 0.988903701305
/tops/cannedgoods_labeled/goods_2_11.jpg,     predicted category: snacks with 0.616939246655
/tops/cannedgoods_labeled/canned_16_16.jpg,   predicted category: beverages with 0.547861039639
/tops/cannedgoods_labeled/Goods_14_8.jpg,     predicted category: cannedgoods with 0.977403461933
/tops/cannedgoods_labeled/goods_5_12.jpg,     predicted category: snacks with 0.429273635149
/tops/cannedgoods_labeled/canned_8_8.jpg,     predicted category: beverages with 0.873719930649
/tops/cannedgoods_labeled/goods_4_7.jpg,      predicted category: cannedgoods with 0.849367558956
```

Fig. 3. Discovery in failure. Identifying shopping goods with convolutional neural networks (data courtesy of the author). The network trained on goods from one store struggles to detect the same category (of canned goods) in another store.
Left side: ground truth (label). right side: classifier output showing failures (highlighted in red).

7.1. Discovery in Failure — Lessons From the Supermarket

As the observations on algorithm failure describe, the failure modes are not always obvious, and algorithms can fail even when they appear to succeed numerically. This last section describes the inverse phenomenon of 'failing while succeeding', namely 'succeeding while failing' and discusses the kinds of discovery that can occur in failure.

I recently collected several thousand images of grocery store items across five categories (beverages, canned goods, cereals, snacks and cleaning items) in preparation for the training of multiple neural network classifiers. These images were collected in three different grocery stores in Western New York. I then trained a generic low-dimensional convolutional neural network classifier on the images from one store and tested the trained model on images from the other two stores. Given the low-dimensionality of the network, the results were quite good, in the range of about 90% accuracy.

However, two categories faired much worse than the others, namely those of beverages and canned goods. While considering the reasons for the poor performance and checking the images themselves for clues, it became apparent what the 'failure' did indeed reveal, namely that canned goods and beverages varied considerably in product arrangement, size and shape across the three stores (see Fig. 2). In machine learning, the standard response to such a situation is to select a different classifier, one with a stronger discriminating capacity for the given task. Problem solved. In this case, an alternative response suggested itself. The apparent failure of the classifier could be scrutinized in a different way.

Canned goods in one store, catering to less-affluent members of the city were much more likely to be shelved in uniform larger sizes than in another store catering to health conscious and more affluent clientele who can afford the luxury of small packaged goods. What the failing classifier detected was an in-category difference in item packaging.

One store's canned goods are not another store's canned goods. Accounting for this observation, the system identified what the task had not asked for: merchandise difference across class boundaries: the social reality of cheap bulk produce landed outside of the features the simple classifier had assembled to identify canned goods.

Here, the system 'succeeds' in its failing mode as a mechanism that detects economic disparities behind the scenes, expressed in the differing visual dynamics of shelved goods. To be clear, this discovery requires some user support, as it were. It is co-produced by the classifier behavior and the observer who seeks to look beyond the immediate system response, namely the failure to classify 'properly' according to the pre-defined categories.

7.2. Something good can come from failing algorithms

Classifiers fail for many reasons, including poor concept and algorithm design, inadequate, incorrect, or sloppy data, and bias of every variety. More generally, however, they fail because they are tasked with an impossible challenge, to wit mapping complex realities onto simple outputs. As products of reductionist logics, classifiers are doomed to succumb to failure of one type or another.

The technical community goes to great lengths to address failure modalities, and the special status of failures in neural network classification is at least indirectly acknowledged through an explicit referral to the need for human expertise to handle 'hard cases' (Shi 2020). The discursive artificial intelligence community, on the other hand, identifies in failing algorithms proof of a fundamentally irrational project that algorithms are subscribed to, hopelessly entangled with the data-associated attributes of things and people (Amoore 2020).

Facing this binary landscape, I hope to locate an alternative, critical constructive position; a position that seeks a potential for discovery instead of the application of technological fixes, and that takes into account the fact that algorithms exist in ways that exceed their source code (Amoore 2020). So, I ask, how might one operationalize discovery in failure beyond the case I describe above? Unfortunately, the territory falls between the cracks of hard engineering work and eyes-wide-open reflexivity, suggesting that one must identify which professional class might even do this kind of work in the first place. Might the effort come from the side of regulatory and technology — savvy oversight practices such as *Public Interest Technology*[2]? Or more software-oriented algorithm auditing despite the tendency of that field to find what it — a priori - is looking

2. https://www.newamerica.org/pit/about/.

for? Or might a different approach be in order, an approach that considers such underdetermined opportunities for discovery in fact as an act of creativity (as opposed to one of accounting)? It seems that the later would be necessary as discovery invariably requires some form of creative thinking and spontaneous acting under uncertain conditions. But which type of creativity could that be?

In the *Invention of Creativity*, the sociologist Reckwitz (2017) offers a critical and harsh assessment of modern creativity, specifically of the personal gain-seeking variety. Reckwitz develops the concept of the 'creativity dispositif' as a constellation of coercive practices, modes of knowing and sensibilities circling around the production and institutionalization of relentless novel and 'exciting' innovation and 'being different'. In this arrangement, "the body, soul and practice become the self's own aesthetic object" (Reckwitz 222), largely excluding questions of shared concerns. Reckwitz offers at least one addition of interest to the endeavour I outline here, to wit *profane creativity*, a form of creativity that is not dependent on an audience and "locally situated". However, this profane creativity that "produces delights and discovery for the participants in the here and now" (Reckwitz 223) seems a bit too mild to address some of the tricky challenges machine learning systems tend to produce.

In the supermarket case described above, the dynamics between the failure of the machinery and the effort on the part of the viewer might be akin to the dynamics produced between a broken car and a driver when the dysfunctional vehicle transforms itself from annoyance into an opportunity to reflect on the vehicle in an utterly different way, as described in the *Tree of Knowledge* (Maturana 1987). A broken car with a dead battery then becomes a car with functioning open circuit, and an opportunity to reflect on open circuits in general, the invisible electronic control of complex consumer products, etc. The added value of this situated autopoetic process derives from the fact that it opens avenues for thoughts that might otherwise not occur.

In the case of the classification experiment described above, the system is not an isolated technical apparatus, and the resultant discovery carries with it considerable baggage, illuminating not only what we are not paying attention to, but also what we are reluctant to see in the first place. Because the issue (of unexpected indicators of economic inequality) only becomes apparent in the review of the algorithm's behavior and because the result speaks to an issue reflected in the source data, building a machine to 'solve the problem' seems unlikely to succeed.

Let's assume for argument's sake that the problem can be addressed (i.e. easily detected) with some very clever formalism, one that is able to make even a future artificial intelligence system accountable to communal values (Etzioni 2016). There is no guarantee that the system would also work properly on subsequent generations of yet more sophisticated machine learning systems. The algorithm-versus-critical reading encounter will repeat itself, requiring a new fix at each iteration in an infinite regress. Until superhuman artificial intelligence becomes a reality, human attention will have to intervene in the cycle in a yet to be defined artificial intelligence-meets-human intuition collaborative exchange.

In the meantime, an intermediate approach to developing 'revealing' (not merely transparent, accountable or interpretable) machine learning systems might be required. Clearly technical creative thinking is required. While there is no escaping the forces of the creativity dispositif when requiring some of its assets, it is possible to add new positions from outside of the creativity dispositive, as Reckwitz demonstrated. For example, can one include questions like "what kind of problems are we trying to solve?" (Stephensen 2020), and "can we recognize when new problems emerge from within the efforts to solve an existing one? "

And so we return to the question formulated at the onset regarding the scope and application-territory of creative inquiry in machine learning. Beyond the current infatuation with generative systems that portend to produce 'something new', the territory of discovery through failure outlined in this text deserves attention even though it does not belong to any particular formal type of inquiry. Maybe it is time to again to (or attempt to) update Agre's Critical Technical Practice (Agre 1997) for the age of ubiquitous, platform-centric, globally-distributed and data-heavy artificial intelligence to a less introspective, more collaborative approach distributed across multiple stakeholders; studying failures, developing algorithms while thinking deeply about what they enable, what kind of data they are dependent on, what they represent now and what they might come to represent in the future.

7.3. GitHub Repository

The code originally created during the grocery store experiment and used to produce the image dataset in the *Return to Bali* project has been released as *Catch & Release*; an open source software package that facilitates audio-based image annotation for convolutional neural network label generation: https://github.com/realtechsupport/c-plus-r

References

Agre, Philip.
1997. *Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI*. In: Geoffrey Bowker, Les Gasser, Leigh Star, and Bill Turner, eds, Bridging the Great Divide: Social Science, Technical Systems, and Cooperative Work, Erlbaum.

Amoore, Louise.
2020. *Cloud Ethics. Algorithms and the Attributes of Ourselves and Others*.
Duke University Press.

Böhlen, Marc.
2016. *Watson Gets Personal. Notes on Ubiquitous Psychometrics*.
xCoAx Conference Proceedings 2016, pp. 99-111.

Bowker, Geoffrey,
and Susan Leigh Star.
1999. *Sorting Things Out*.
MIT Press.

Chandola, Varun, Marc.
Böhlen, and Amol Salunkhe.
2017. *Server, server in the cloud. Who is the fairest in the crowd?* ArXiv:1711.08801v1.

Cheng, Selina.
2016. *An algorithm rejected an Asian man's passport photo for having "closed eyes"*. Quartz Magazine. December 7th. https://qz.com/857122/an-algorithm-rejected-an-asian-mans-passport-photo-for-having-closed-eyes/
Last accessed January 2021.

Collingridge, David.
1980. The Social Control of Technology. Pinter, London.

Giovanna, Dimitri,
and Lió Pietro.
2017. DrugClust: *A machine learning approach for drugs side effects prediction*. Computational Biology and Chemistry, Vol. 68, pp. 204-210.

Etzioni, Amitai,
and Oren Etzioni.
2016. *AI Assisted Ethics. Ethics and Information Technology*, Vol. 18.2, pp. 149-156.

Fu, LiMin.
1999. *Knowledge discovery based on neural networks*. Commun. ACM 42, 11, pp. 47-50.

Genus, Audley,
and Andy Stirling.
2017. Collingridge and the dilemma of control: towards responsible and accountable innovation. Research Policy, 47 (1), pp. 61-69.

Grieco, Gustavo, Guillermo Grinblat, Lucas Uzal, Sanjay Rawat, Josselin Feist, and Laurent Mounier. 2016. *Toward Large-Scale Vulnerability Discovery using Machine Learning*. CODASPY'16, New Orleans, USA.

Harvey, Adam.
2018. *Cluster Munition Detector Prototype*, https://vframe.io/research/cluster-munition-detector/ Last accessed January 2021.

He, Kaiming, Xiangyu Zhang, Shaoqing Ren, and Jian Sun.
2016. *Deep Residual Learning for Image Recognition*, 2016 IEEE Conference on Computer Vision and Pattern Recognition. Las Vegas, pp. 770-778.

Hendrix, John.
2007. *Humanism and Disegno: Neoplatonism at the Accademia di San Luca in Rome*. Bristol, Rhode Island: Roger Williams University School of Architecture, Art and Historic Preservation Faculty Publications.

Karras, Tero,
Samuli Laine, and Timo Aila.
2019. *A Style-Based Generator Architecture for Generative Adversarial Networks*, 2019 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Long Beach, CA, USA, pp. 4396-4405.

Kim, Been, Emily Reif, Martin Wattenberg, Samy Bengio, and Michael Moxer.
2019. *Do Neural Networks Show Gestalt Phenomena? An Exploration of the Law of Closure*. ArXiv:1903.01069v3.

LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton.
2015. *Deep learning*, Nature. 521(7553), pp. 436-444.

Liu, Wei, Dragomir Anquelov, Dumitru Erhan, Christian Szegedy, Scott Reed, Cheng-Yang Fu, and Alexander Berg.
2016. SSD: *Single Shot MultiBox Detector*. Lecture Notes in Computer Science: pp. 21-37.

Maturana, Humberto,
and Francisco Varela.
1987. *The Tree of Knowledge*. Shambhala.

Mittelstadt, Brent.
2016. *Automation, Algorithms, and Politics. Auditing for Transparency in Content Personalization Systems*. International Journal of Communication, v. 10, p. 12, October.

National Transportation Safety Board (NTSB). 2019. *Preliminary Report HWY18MH010*. November 2019. https://dms.ntsb.gov/pubdms/search/hitlist.cfm?docketID=62978. Last accessed January 2021.

Piateski, Gregory,
and William Frawley.
1991. *Knowledge Discovery in Databases*. MIT Press, Cambridge, MA, USA.

Raccuglia, Paul, Katherine Elbert, Philip Adler, Casey Falk, Malia Wenny, Aurelio Mollo, Matthias Zeller, Sorelle Friedler, Joshua Schrier, and Alexander Norquist.
2016. *Machine-learning-assisted materials discovery using failed experiments*. Nature 533, pp.73-76.

Reckwitz, Andreas, and Steven Black.
2017. *The Invention of Creativity: Modern Society and the Culture of the New*. Chicester: Polity Press.

Sandvig, Christian, Kevin Hamilton, Karrie Karahalios, and Cedric Langbort.
2014. *Auditing algorithms: Research methods for detecting discrimination on Internet platforms*. Paper presented at the 2014 International Communication Association Preconference on Data and Discrimination: Converting Critical Concerns into Productive Inquiry, Seattle, WA.

Schulam, Peter, and Suchi Saria.
2019. *Can You Trust This Prediction? Auditing Pointwise Reliability After Learning*. Proceedings of Machine Learning Research, in PMLR 89, pp.1022-1031.

Serre, Thomas.
2019. *Deep Learning: The Good, the Bad, and the Ugly.* Annu. Rev. Vis. Sci.5: pp. 399-426.

Shi, Zheyuan Ryan, Clair Wang, and Fei Fang.
2020. *Artificial Intelligence for Social Good: A Survey*. ArXiv abs/2001.01818.

Silver, David, Thomas Hubert, Julian Schrittwieser, Ioannis Antonoglou, Matthew Lai, Arthur Guez, Marc Lanctot, Laurent Sifre, Dharshan Kumaran, Thore Graepel, Timothy Lillicrap, Karen Simonyan, and Demis Hassabis.
2018. *A general reinforcement learning algorithm that masters chess, shogi, and Go through self-play*, Science, 07, pp. 1140-1144.

Stephensen, Jan Løhmann.
2020. *Post-creativity and AI: Reverse-engineering our Conceptual Landscapes of Creativity*. Proceedings of the Eleventh International Conference on Computational Creativity, pp. 326-332.

Sujarwo, Wawan, and Marc Böhlen.
2020. *Machine Learning in Ethnobotany*. IEEE International Conference on Systems, Man, and Cybernetics. Toronto, Canada, pp. 108-113.

Tian, Yuchi, Ziyan Zhong, Vicente Ordonez, Gail Kaiser, and Baishakhi Ray.
2020. Testing DNN image classifiers for confusion & bias errors. In Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering (ICSE '20). Association for Computing Machinery, New York, NY, USA, pp. 1122-1134.

Torralba, Antonio, and Alexei Efros.
2011. *Unbiased look at dataset bias*, CVPR 2011, Providence, RI, pp. 1521-1528.

Ventura, Dan.
2016. *Mere Generation: Essential Barometer or Dated Concept*. Proceedings of the Seventh International Conference on Computational Creativity, pp. 22-29.
Virilio, Paul. 2007. The Original Accident. Cambridge: Polity.

Wertheimer, Max.
1923. *Laws of organization in perceptual forms*. First published as: Untersuchungen zur Lehre von der Gestalt II, in Psychologische Forschung, 4, pp. 301-350. Translation published in Ellis, W. 1938. A source book of Gestalt psychology, pp. 71-88, London: Routledge & Kegan Paul.

Zuccari, Federico.
1607. *L'Idea de' Pittori, Scultori e Architetti, Torino*. in Detlef Heikamp, ed., Scritti d'Arte di Federico Zuccaro (Firenze: Leo S. Olschki Editore, 1941).

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Synthetic Images and Creative AI: A Discussion on the Nature and Production of Images in the era of Deep Learning

Keywords: Synthetic Images, Deep Learning, Artificial Intelligence, Creative AI, Image Science, Vilém Flusser

Fabrizio Augusto Poltronieri
fabrizio.poltronieri@dmu.ac.uk
De Montfort University, Leicester, United Kingdom

Alex Florian Heilmair
alex_f_h@yahoo.com
PUC-SP, São Paulo, Brazil

The emergence of new AI algorithms in recent years, especially those concerning deep learning, brings new challenges to the sphere of art, changing how artists creatively use computer systems. Although AI is not new in the universe of art, the new scenario makes it possible for algorithms to produce new types of automated images. Given this picture, this paper proposes to shed some theoretical and practical lights on the processes employed in the generation of visual art using AI. We start exploring the very nature of computer images, having as a theoretical framework the ideas of Dietmar Kamper (1936-2001), Hans Belting (1935-), Christoph Wulf (1944-), and Vilém Flusser (1920-1991). Next, building on this conceptual exploration, we describe the process of using deep learning techniques to generate self-portraits, which are synthetic images pointing to an external index.

1. Introduction

The emergence of new artificial intelligence (AI) algorithms in recent years, especially those concerning deep learning, brings new challenges to the sphere of art, changing how artists creatively use computer systems. Although AI is not new in the universe of art (Boden 1998, Cohen 1995), the new scenario makes it possible for algorithms to produce new types of automated images. Regardless of what kind of AI is used to generate images, they are all synthetic images, i.e., images that are algorithmically generated or modified by an apparatus, sharing a specific set of features and characteristics. According to Flusser (2011, 2012), apparatuses are instruments programmed to codify abstract scientific concepts into images. Apparatuses abstract scientific discourse, articulating computer programming languages and symbols through calculations to produce synthetic images composed of a series of points that appear superficially as an image. These images are, therefore, mosaic-like structures. The mosaic points are so tiny that, to be perceived as meaningful forms, apparatuses are required to compute, calculate, and group them into images. A clear understanding of synthetic images' nature is critical as they are now ubiquitous, permeating the internet, social media and the art world.

2. The Nature of Synthetic Images

We will start by exploring what the German philosopher Dietmar Kamper understands by image. In the article *Bild* (1998) he exposes the concept of image in a systematic way and presents it in a very close conception to what the German art historian Hans Belting (1990) proposes, mainly its differentiation between cult images and art images. In line with Belting, Kamper proposes a distinction between image as a magical presence and image as an artistic representation.

According to Kamper, such ambivalence will run through the entire history of image, even in the current images that seem to escape this double sense. Nevertheless, in the historical journey of image in the West, its destiny was decided in favour of representation, of mimesis, and against its magical aspect. This occurs, says Kamper, in the Greek philosophy in Plato, runs through the Judeo-Christian tradition, is taken up again by modern philosophy, and has its peak in the Enlightenment. However, the denied aspect is still present in all images and can manifest itself at any moment. There is also a third variant – that of images as technical simulations.

In line with Belting, Kamper understands the concept of image as "ambiguous from the beginning, 'image' is, among other things, the presence, representation and simulation of an absent thing" (1998, 210). However, in a complementary way to Belting, Kamper does not think of the problem through art history, but as a psychological and philosophical problem. Belting had already pointed to the birth of image in the rituals of death. In Kamper, this becomes the central problem and the reason why images provoke so much fascination – death both in its sense of physical absence and in its indisputable destiny that haunts existence from the moment of birth. According to Kamper, on the back of images – be they presence, representation or simulation –, the deepest fear of emptiness is hidden.

> Behind the horizon and the objects threaten an abyssal "horror vacui". The material to which the various images correspond is an absence, a void, an elementary scarcity, so to speak, it is the experienced loss of the mother's womb's environment, which permeates throughout life the one of premature birth. That one is born and must die offers the condition for the experience of loss which seems irrecoverable but can be replaced. Images are thus substitutes for what is lacking, for what is absent, without affecting the dignity of what they replace (Kamper 1998, 211).

Christoph Wulf (2004), Kamper's writing partner in several books on historical anthropology, has elucidated the three categories mentioned above more extensively.

2.1. Image as a Magical Presence

Wulf explains that the magical cult image has the characteristic of being a producer of presence; it does not refer to something outside of it, as is the case with the mimetic image, but points to itself, to its presence in the present. This occurs with the mortuary, cult and, in some cases, artistic images. Based mainly on Belting's studies, Wulf exposes the deepest and most archaic sense of the images: they are the answers to the fear of death. According to Belting (2014), mortuary images – painted skulls, mannequins, and masks – dating up to 7000 BC. highlight the human capacity to overcome physical absence by symbolic presence, i.e., the absence of the body by the presence of the image. As in the case of the Golden Calf, there are also other cult images reported by the Old Testament, which are producers of presence through the association of the divine with images, when images are the embodiment of the divine and, therefore, inseparable from it. This is the spatiotemporal coincidence of the divine with images. Wulf also mentions artistic images, especially particular works of modern art, whose production of presence occurs because they refer only to themselves and not to something external to them, as in the case of mimetic images and in the artworks of Mark Rothko and Barnett Newman (Wulf 2004).

2.2. The Image as an Artistic Representation

The second type of image characterized by its artistic representation and ability to mimic the world. It is not a matter of copying or resemblance to the represented, but, according to Wulf, in the production of appearance: "the mimetic act creates images of art and poetry, making visible something that otherwise could not appear" (Wulf 2004, 236). Wulf uses Plato's theory to substantiate the representation problem and shows it as being of ancient interest to philosophy. As is already common knowledge, Plato was against poetry and artistic representation, justifying his aversion by understanding that poets and painters make artificial appearances of things, not the things themselves. Still, according to Wulf's reading, the result is "the creation of an aesthetic realm separated from reality and therefore unaffected by questions of truth" (Wulf 2004, 236). Since images mimic the world and constitute a world of appearances, they are not under the same norms as things in the real world and are, therefore, dangerous. The point here is that such images can exert a powerful fascination over the people who come to mimic them. It happens not only because real things can be mimicked, but appearances, that is, images, too. In line with Wulf, the philosopher Gernot Böhme (2004) states that Plato's image theory is still the fundamental basis of the whole West-Central image theory.

The question of mimetic representation gains more relevance to the study of images in an anthropological sense when thought of in relation to the body. Wulf argues that representation belongs to one of the most elementary forms of the human condition and that one of its central themes is the body. Since the earliest times of humankind, the creation of images has the body as the main object of representation. The body is both a product and a producer of images. This overlap is evident in the first natural exogenous images. Shadow and reflection are images produced by the body exposed to light, and its theme is the body itself. The paradoxical condition of human existence, problematized by Helmuth Plessner (1975) in the formula of having a body (*Körper haben*) and being a body (*Leib sein*), is repeated in the experience with the image: we have images, and we are images.

According to Belting, "whenever people appear in the image, bodies are represented. Therefore, images of this kind have a metaphorical meaning: they show bodies, but they mean people" (2014, 117). Images have accompanied human existence since ancient times. Today there is an increase in them thanks to the new media and the imaging devices that offer every layperson the possibility of creating images. That is also why studies in anthropology and philosophy have become increasingly concerned with them.

2.3. The Image as a Technical Simulation

The images that surround us today are mostly characterized by their abstract nature and circulation in complex electronic media. Wulf points out that such images circulate on media that radically reconfigure space and time. The electronic media allow overcoming the limitations imposed by the circulation of images in more traditional media.

Another striking feature of images as technical simulations is that they are the result of a high degree of abstraction. According to Wulf, these images "miniaturize the world and make possible an experience of the 'world as image'" (2013, 33). Not only the world but also bodies and things. The process of abstraction turns bodies into body images as we have already seen above. In Kamper, the question is the imprisonment in a world made of such images and the disappearance of what is on its back. In this world "the surface triumphs over all perception! The surface [...] asserts itself worldwide as the only generator of meaning" (Kamper 1994, 63). The disappearance of everything behind the images results in a problem of reference. Not that images no longer have a reference, but that the old "healthy" relationship which existed between image and world, image and body, and all the critical categories associated with them – truth and fiction, reality and illusion, appearance and essence – is in crisis and do little to help understand self-referring media images, that is, images which refer to images.

2.4. The Synthetic Image and the Problem of Reference

Flusser advances the discussion by proposing the concept of synthetic image. The Czech-Brazilian thinker elaborated the hypothetical model of the ladder of abstraction (Figure 1) to highlight the image's autonomy in its relation with the world, in an inversion in the vector of meaning found in the new media images, mainly the digital ones. Still in the initial phase of his writings on the subject, mainly between the 1970s and 1980s, Flusser proposed a growing distance from the world as a model for understanding culture's history through communication codes.

The first type of image produced by man had, in this approach, the characteristic of being the first step backwards in relation to the world, preserving its relationship with it. This relationship crisis was explained as a crisis of representation, that is, an inability of images to point to the world in a transparent way, like a kind of window that closes and becomes opaque, pointing only to itself. Thus Flusser characterised this process as "idolatry" – a veneration of images that conceals the world they originally referred to.

Amid this crisis, says Flusser, texts were invented to recover, through explanation, the connection with the world, lost in the images. Later these texts also become opaque and meaningless, and a third hegemonic code was invented to reconnect the mankind with the world. Here the synthetic images emerge, invented to recover the meaning of texts that point to images that mean the world. With each new code, a new step back. The synthetic image is the last step and is linked to the world by a synthesis of the dialectics between concept and imagination. The world remains as the matrix of the image, and the attempt to approach it leads to the paradoxical situation of detachment.

Later, Flusser defined synthetic images as projections and not as abstractions – a change that easily goes unnoticed, but which has great significance for the study of images and media. Considering the image as a projection indicates its ability to create a world and the inversion of orientation vectors.

Synthetic images only retain an illusory resemblance to traditional images. The distinction between the two appears more clearly in the analysis that Flusser proposes from two levels: the superficial, phenomenological, and the profound, scientific. Thus images appear superficially as images, but in-depth they are a combination of programmed points (pixels). Contemporary criticism should stick to these two points, according to Flusser. At the superficial level, the vectors of meaning between the two images point in opposite directions. While the former images are considered abstractions of the world, the latter are projections of models.

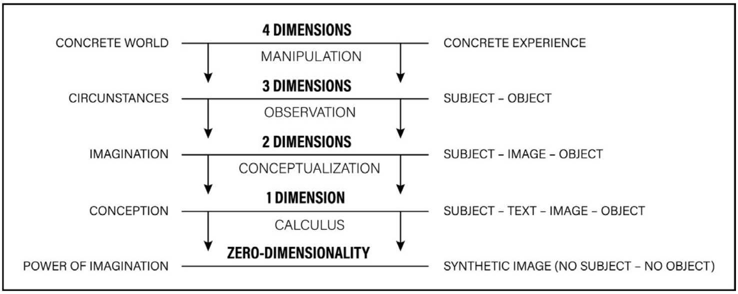
From this frozen world of zeros and ones, from this timeless non-place of calculations, there is nowhere else to go back to, only forward. The images that emerge from this advance are not representations, but images of a new type. They are projections against the world and the mankind.

2.5. Flusser, Apparatuses, and the Synthetic Images

Flusser (2012) conceptualises images as surfaces which intend to represent something that, in most cases, is external to the image. Thus, images are the product of efforts to abstract two of the four dimensions of space-time, retaining only the dimensions of the plane. This is because an image typically points to something that is out there in space and time. This type of image – designated first order, which abstracts two of the four dimensions of space-time and preserves only the plane – is called "traditional image". To decipher images is to understand this abstraction, concentrating on the resulting planes. The image's meaning is embedded on its surface.

On the other hand, synthetic images are produced by apparatuses, which are, as we described earlier, products of applied scientific text. The most noteworthy feature of computer-generated synthetic images is that they are the outcome of programming logic, resulting from computational language processing within digital apparatuses. They are indirect products of texts, which grants them special historical and ontological statuses from traditional images. All AI-generated images fit this paradigm, located after the development of specific and highly abstract scientific theories. The traditional image performs the first-degree abstraction, abstracting two dimensions from the concrete phenomenon, leaving only the plane. The synthetic image works in a more sophisticated manner, being a third-degree abstraction because it abstracts one of the traditional image's dimensions engendering texts that are a second-degree abstraction. The synthetic image is not made up of planes or surfaces, but rather by algorithmically calculated points. Thus, it is null-dimensional. The escalation of abstraction that brought us synthetic images is nothing more than an escalation of subtraction, consisting of the progressive and relentless removal of objects' dimensions, from three to two, to one and then to zero. Synthetic images do not occupy the same ontological level as traditional ones since they are new phenomena with no past parallel. Figure 1 illustrates the Flusserian ladder of abstraction, from the concrete world to synthetic images. For a more in-depth discussion about the Flusserian ladder of abstraction, see Heilmair and Poltronieri (2013) and Poltronieri (2014).

Fig. 1. The Flusserian Ladder of Abstraction.



Traditional images – such as realistic paintings – extract surfaces from volumes found in the real world, whereas synthetic ones are surfaces composed of calculated points. For example, when an artist paints the Eiffel Tower, she takes the actual tower as a model – a 3D volumetric object in Paris – and abstracts it onto the surface of a canvas or paper. This is the first degree of abstraction. When a machine learning algorithm generates an AI image of the same Eiffel Tower, the operation starts by feeding abstract equations with many images used to train the AI model. The expected outcome is the generation of new synthetic images depicting the famous Parisian tower. The high and sophisticated level of abstraction found in the synthetic images is one of the reasons that make AI-generated images so hard to explain, as these images are surfaces pointing directly to the mathematical formulas and abstract concepts behind the AI algorithms, rather than an index to something concrete in the real world.

Thus, a substantial effort is required to understand AI-generated images. Science seeks to apprehend the world in its generalizations, attempting to deal with its generalities abstractly. AI synthetic images are products of these abstract generalizations, conveying all this sophisticated conceptual thinking. They are automatically produced through the mediation of highly specialized codes and mathematical formulas. Synthetic images aim to masquerade themselves as real, intending for perfection, a final stage of improvement, representing the idealization of an impossible, but desired world.

Traditional images are created from the human hand's action, equipped with some tool – brushes, pencils, stones, pens – which transfers elaborate mental symbols onto some tangible medium, which constitutes the image's surface. Decoding these images implies knowing what was going on in the human agent's mind who dreamt up the symbols and transferred them to their hand, from there to the tool, and then to the surface.

In the case of synthetic images, the situation is not as evident. Nonetheless, synthetic images are just as symbolic as all other images and must be deciphered and criticized by those who wish to understand their meaning. There is both an apparatus and a human agent that manipulates them. The "apparatus-operator" system, however, is too complex to be understood and penetrated. It is a black box, where we see only the inputs and the outputs. The outputs are indexes of abstract symbols: the programming logic that encodes the apparatuses' algorithms. As the result of algorithms encoded into codes, codes into text, and texts into images, synthetic images are, ultimately, metacodes of algorithms. Imagination – the ability to encode texts (abstractions) into images – is the starting point of synthetic images. To decipher these images is to rebuild the abstract thought that gave rise to them. When the deciphering is correctly accomplished, the conceptual world emerges again as the synthetic image's universe of meanings. Therefore, what we see when contemplating synthetic images is not the "world", but certain concepts regarding the world and every criticism of the synthetic images should make this box more transparent (Flusser 2012). Therefore, understanding the nature and ideology of AI ideas and algorithms is pivotal to criticize AI-generated images.

3. Synthetic Deep Self-Portraits

It is deep feasible to create the self-portrait images – part of Poltronieri's "Selfie Apparatus" series of artworks – because of the recent advances in the field of deep learning.[1] To create this series, a type of deep learning neural network called Generative Adversarial Network (GAN) was employed. GANs are becoming ubiquitous, with applications ranging from the designing of new anime characters for game and animation industries (Jin et al. 2017), and video and music generation (Vondrick et al. 2016, Yang et al. 2017) to medical uses, such as anomaly and tumour detection (Schlegl et al. 2017).

1. As there is a vast literature on deep learning (Goodfellow et al. 2016, LeCun et al. 2015, Schmidhuber 2015), this will not be a topic that we will address in this paper.

Technically speaking, GANs are a class of deep neural networks used in unsupervised learning, composed of a pair of competing networks: a generator and a discriminator, which aim to generate realistic data – images, in our case – from some prior distribution. A GAN is trained, i.e., it learns, by alternately optimizing two objective functions. Throughout the training, the generator learns to produce samples resembling real images, and the discriminator, also known as a critic, learns during the training to better discriminate between real and AI-generated data. The generator does not have access to the training data, producing samples from random noisy inputs generated from a latent computational space. In turn, the discriminator takes as input two images: one real image from the dataset used to train the network and the one generated by the generator. The discriminator must learn to recognize which of the two images was algorithmically generated. A negative loss is given to the generator if the discriminator recognizes the AI-generated image. On the other hand, the discriminator gets penalized if it fails to recognize which one of the two images is not real.

GANs can be viewed as a two-player game where both players aim to minimize their losses, and the solution to this zero-sum game is a state of equilibrium where neither player can improve their loss unilaterally. At equilibrium, the discriminator should not tell the difference between the images generated by the generator and the actual images in the training set, leading the generator to generate synthetic images that come from the same distribution as the training set. Usually, GANs produce sharp images, though still in quite low resolutions and with somewhat limited variation (Karras et al. 2017). Figure 2 shows the global concept of a GAN.[2]

2. Our aim is not to provide an extensive explanation on how GANs work, let alone to discuss their technical details. More information about GANs can be found in Langr and Bok (2019), and Foster (2019).

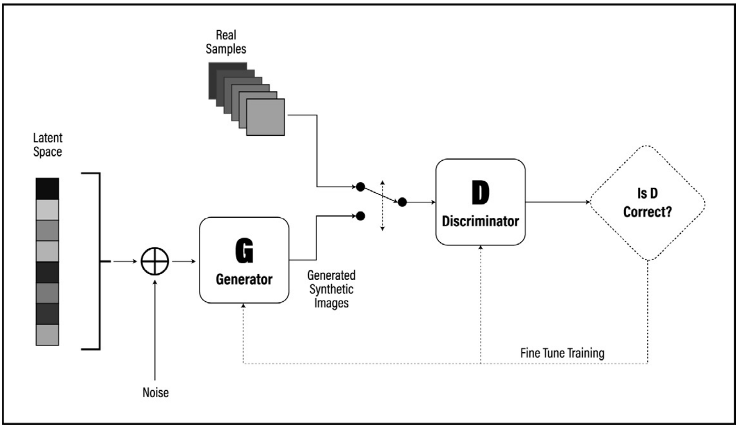


Fig. 2. Diagram exemplifying the concept of a GAN.

Our project consisted of training a GAN to generate new self-portraits of one of us. The first step, creating a dataset of actual self-portraits, was done over about three months, and consisted in collecting more than 25.000 selfies in different contexts, environments, and situations, using the frontal camera of an iPhone X in the square mode. Although 25.000 images could sound like an extensive collection, it is far from being an ideal amount. It was, however, enough for our purposes. Figure 3 presents a collection of images taken from the original selfies.

Our GAN of choice was developed by NVIDIA and is known as “Progressive Growing of GANs for Improved Quality, Stability, and Variation” (Karras et al.

2017). It has already been outperformed by a new GAN architecture called "StyleGAN" (Karras et al. 2018), also developed by NVIDIA. The original selfies straight out of the iPhone are 2320x2320 pixels. The problem with this resolution is that GANs cannot generate hi-res resolution images at their actual stage of development. This is currently one of the main setbacks of this technology. The majority of GAN generate images are 256x256 pixels. This restriction is related, among other factors, to the GPU (Graphics Processing Unit) used to train the network. Deep learning is very computationally intensive, but CPUs (Central Processing Units) are not the best choice for these algorithms' mathematical computation. Most of the deep learning computations involve matrix and vector operations, the same type of computations GPUs are designed for. Besides that, GPUs usually have hundreds of simpler cores, can run thousands of concurrent hardware threads and maximize floating-point throughput. GPUs are the heart of deep learning, as the model training process is composed of simple matrix calculations, the speed of which can be significantly enhanced if the computations can be massively carried out in parallel.

Fig. 3. Four original selfies taken from the 25.000 images dataset used to train our GAN.

Another downside of GANs is that GPUs are expensive, and their energy consumption is very high. To train our network, we used an NVIDIA GeForce GTX 2080ti, with 11GB of memory, allowing us to train the network to generate 512x512 pixels synthetic images, later resized to 4724x4724 pixels using another deep learning network (Champandard 2016). Before starting the training process, our dataset images were resized to 512x512 pixels. Our GPU is not the best one available, but it was the best consumer NVIDIA GPU when we trained the GAN.

The training was completed in about 28 days, with the system running 24x7 and the GPU using almost 100% of its processing capacity all the time. Karras et al. (2015) state that a single hi-end GPU could train a 1024x1024 network for CelebA-HQ in about two weeks. CelebFaces Attributes Dataset (CelebA), is a large-scale face attributes dataset with more than 200K celebrity images and can be employed as the training and test sets for face attribute recognition, face detection, and landmark or facial part localization (Liu et al. 2014). This dataset's images are significantly varied in terms of resolution and visual quality, ranging from 43x55 to 6732x8984 pixels. The CelebA-HQ is a high-quality version of the CelebA dataset, consisting of 30.000 images at 1024x1024 resolution. (Karras et al. 2015).

Dataset building and training time are the biggest bottlenecks in the process of generating images with GANs. For the sake of comparison, the new NVIDIA StyleGan takes 41 days to train using the Flickr-Faces-HQ (FFHQ) dataset – a high-quality 70.000 images dataset of human faces – at 1024x1024 resolution using one Tesla V100 GPU and six days to train the same dataset and resolution using eight Tesla V100 GPUs in parallel. These are high-end GPUs, costing about $6,000.00 each. The GPU used in our setup costs, at the time of writing, about $1,200.00.

After the training, the GAN could generate new, virtually endless, AI selfie images, which we divided into two series: "Selfie Apparatus " (figure 4) and "Twisted Selfie Apparatus" (figure 5), comprised of synthetic glitched images that the network generates from time to time. From the artistic point of view, these images are the most interesting ones, as they present image manipulations and distortions that happened by chance inside the neural network black box.

Fig. 4. Four GAN generated self-portraits, part of the "Selfie Apparatus" series.

Fig. 5. Four glitched GAN generated self-portraits, part of the "Twisted Selfie Apparatus" series.

Images from the "Selfie Apparatus" and "Twisted Selfie Apparatus" series have been exhibited in shows in China, the UK, Brazil, and Canada, and are part of an ongoing practice-based research project about the role of chance in computer art that has been developed by the authors for more than ten years.

Conclusion

Unlike images made up of planes representing something "out there" in space and time, synthetic images are not made up of planes or surfaces, but rather by algorithmically calculated points. When assembled, these points can appear photorealistic and believable. Both "Selfie Apparatus" and "Twisted Selfie Apparatus" series are products of the same GAN, the same artificial neural network that algorithmically defined and assembled the pixels that composed the self-portrait images. Sometimes these images are indistinguishable from a real image, and some others are ghostlike, distortions, a creative abstraction from real objects in the world – the "imaginings" of the algorithm.

GANs have not reached the limits of what they are capable of and will continue to improve for the foreseeable future. It appears inevitable that the art environment will become even more saturated with synthetic images. Indeed, much of contemporary art is at least processed, modified or augmented through some computational process. Fully synthetic images will only rise in preponderance. Though distinct in their internal structure from traditional images, Flusser (2011 and 2012) has argued that synthetic images will be increasingly impossible to distinguish from traditional images without the aid of algorithms. Only algorithms will discern the sub-surface artefacts that are distinctly technical, as synthetic images appear increasingly believable to the viewer.

Such a future scenario seems to replace humans not only in the creative process but also in the decision-making process, as Flusser (2011) has warned. An artificial agent can process millions of images and videos, learn patterns from them and automatically generate new content. As we described, recent developments in neural networks enable a new wave of algorithms capable of learning from patterns identified in large datasets, that can be automatically collected and organized by computers. Hence, AI can be understood, above all, as a revolution in decision making, as a "displacement of critical consciousness from human being to automata." (Flusser 2011, 119)

Due to the complexity of neural networks and the speed at which they produce synthetic new images, it is becoming increasingly impossible to have a "human-in-the-loop" checking all the new images. Our selfie GAN is, after training, capable of generating new images every half second. Flusser (2011) warned that such a revolution in decision making would be the "end of freedom", confronting us with fundamental moral and ethical decisions.

With the constant increase in quality of AI-generated synthetic images, purely visual methods to judge them will rapidly become impractical. It is not only a question related to the technical attributes of the images, but, more importantly, it has also to do with the aesthetic attributes of synthetic images. Soon, the only trustworthy critics and judges of art will be counter-algorithms designed to identify subtle nuances, artefacts and strategies used to produce synthetic images. One of the main reasons for that is the fact that in informatics the informational content of a given scenario is, in principle, precisely determinable, irrespective of the type of information involved (Flusser 2011). Flusser argues that

> The rarity of each element of the situation to be measured (the rarity of each bit of information) can be precisely determined. Furthermore, these measurements can be undertaken at however many levels of a situation one wishes [...] Information does, in fact, consist of so many levels that it is not humanly possible to single out each one and measure it, but artificial intelligences can calculate and compute faster [...] Automatic critics will not only replace but will also have deeper insights than human ones in the foreseeable future. (2011, 118)

This is already the case, even if currently a large proportion of AI-generated synthetic images display artefacts or distortions that, though varying in degree, make identifying them relatively easy. As AI algorithms further develop and become even better at generating automated content, they will increasingly be able to simulate an experience that is entirely algorithmically generated. The collaboration between scientific research and artistic practice has been fruitful in generating insights into AI's role in the visual field and about the level of control we have over the process of generating synthetic images. This opens new horizons for artistic practice and a possible aesthetic future, especially if artists, philosophers, and scientists engage in joint discussions about how synthetic images are generated using neural networks. As Flusser (2011 and 2012) suggested, the critique of synthetic images must be done from both, a superficial symbolic interpretation and a deep algorithmic explanation. Neural networks are particularly tricky because they are obscure, they do not easily reveal the reasoning behind any given decision. AI-generated synthetic images should, therefore, be critiqued primarily in terms of the algorithms that generate them. Failure to develop effective methods for algorithmic critique will entail a failure in understanding how the future of image is being reconfigured.

References

Belting, Hans.
1990. *Bild und Kult. Eine Geschiche des Bildes vor dem Zeitalter der Kunst*. München: C.H.Beck.

Boden, Margaret A.
1998. "Creativity and Artificial Intelligence." *Artificial Intelligence* 103(1-2): 347-56.

Champandard, Alex.
2016. *Super resolution for images using deep learning*. Accessed on January 13, 2021. Available at https://github.com/alexjc/neural-enhance

Cohen, Harold.
1995. "The further exploits of AARON, painter." *Constructions of the Mind: Artificial Intelligence and the Humanities, Special edition of Stanford Humanities Review* 4(2): 141-160.

Flusser, Vilém.
2011. *Into the universe of technical images*. Minneapolis: University of Minnesota Press.

2012. *Towards a philosophy of photography*. London: Reaktion books.

Foster, David.
2019. *Generative deep learning. Teaching machines to paint, write, compose, and play.* Sebastopol: O'Reilly.

Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. 2016. *Deep learning*. Cambridge: The MIT Press.

Heilmair, Alex, and Fabrizio Poltronieri.
2013. "Der Zufall und die Symmetriebrechung der synthetischen Bilder. *In Vom Begriff zum Bild: Medienkultur nach Vilém Flusser*, edited by Steffi Winkler and Michael Hanke. Berlin: Tectum Wissenschaftsverlag.

Jin, Yanghua, Jiakai Zhang, Minjun Li, Yingtao Tian, Huachun Zhu, and Zhihao Fang.
2017. "Towards the automatic anime characters creation with Generative Adversarial Networks." arXiv:1708.05509 [cs]. http://arxiv.org/abs/1708.05509 arXiv: 1708.05509

Kamper, Dietmar.
1994. *Bildstörungen. Im Orbit des Imaginären*. Sruttgart: Canyz.

1998. "Bild." *In Anthropologie, edited by Günter Gebauer*. Leipzig: Reclam Verlag.

1999. *Ästhetik der Abwesendheit. Die entfernung der Körper*. München: W. Fink.

2011. *Imagem*. Accessed on January 30, 2019. Available at http://cisc.org.br/

Karras, Tero, Samuli Laine, and Timo Aila.
2018. "A style-based generator architecture for generative adversarial networks." *arXiv:1812.04948* [cs, stat]. http://arxiv.org/abs/1812.04948 arXiv: 1812.04948

Karras, Tero, Timo Aila, Samuli Laine, and Jaakko Lehtinen.
2017. "Progressive growing of GANs for improved quality, stability, and variation." *arXiv:1710.10196* [cs, stat] http://arxiv.org/abs/1710.10196 arXiv: 1710.10196

Langr, Jakub, and Vladimir Bok.
2019. *GANs in action. Deep learning with Generative Adversarial Networks*. Shelter Island: Manning Publications Co.

Liu, Ziwei, Ping Luo, Xiaogang Wang, and Xiaoou Tang.
2014. "Deep learning face attributes in the wild." *arXiv:1411.7766* [cs] http://arxiv.org/abs/1411.7766 arXiv: 1411.7766.

LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton.
2015. "Deep Learning." *Nature* 521(7553): 436-44.

Poltronieri, Fabrizio.
2014. "Communicology, apparatus, and post-history: Vilém Flusser's concepts applied to video games and gamification." In *Rethinking gamification*, edited by Mathias Fuchs. Lüneburg: meson press.

Schmidhuber, Jürgen.
2015. "Deep learning in neural networks: An overview" *Neural Networks* 61: 85-117.

Vondrick, Carl, Hamed Pirsiavash, and Antonio Torralba.
2016. "Generating videos with scene dynamics." *arXiv:1609.02612* [cs] http://arxiv.org/abs/1609.02612 arXiv: 1690.02612

Yang, Li-Chia, Szu-Yu Chou, and Yi-Hsuan Yang.
2017. "MidiNet: A convolutional generative adversarial network for symbolic-domain music generation." *arXiv:1703.10847* [cs] http://arxiv.org/abs/1703.10847 arXiv:1703.10847.

Wulf, Christoph.
2004. *Antropologie. Geschichte – Kultur – Philosophie*. Hamburg: Rowohlt Verlag.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Creating Stylised Geographic Maps with Neural Style Transfer

Keywords: Computational Design, Map Art, Map Stylisation, Neural Style Transfer

André Santos
alsantos@student.dei.uc.pt
University of Coimbra, Department of Informatics Engineering, Portugal

Tiago Martins
tiagofm@dei.uc.pt
University of Coimbra, Centre for Informatics and Systems of the University of Coimbra, Department of Informatics Engineering, Portugal

João Correia
jncor@dei.uc.pt
University of Coimbra, Centre for Informatics and Systems of the University of Coimbra, Department of Informatics Engineering, Portugal

Despite regular navigational applications, geographic maps possess a strong aesthetic dimension that can be entirely separated from utilitarian tasks and purposes. We present a computational system that uses neural style transfer and open-access geographic data to generate stylised maps from any region in the world customised in the style of any given image. We showcase and analyse output maps generated by the system while offering insight into how changes to the inputs can result in clearer and more unique outputs. Finally, the real-world applicability of the output maps is addressed, leading us to conclude that they are a viable way to aesthetically establish connections to geographic places, which can happen through their application in purely decorative or more meaningful design contexts.

1. Introduction

The geographic map holds a strong historical connection to the visual arts and, throughout its extensive existence, has fulfilled both utilitarian and aesthetic needs (Rees 1980). Before science and technology reigned over mapmaking, the lack of geographic knowledge and cartographic expertise placed map creation at the hands of those proficient in the arts (i.e. people with the necessary drawing and painting skill required to translate uncertain terrain into visual elements), which is one of the reasons why, at the time, the map gained traction as a form of decorative art (Rees 1980). Centuries later, the post-digital revolution rise and development of the computer replaced the need for manual labour with autonomous digital rendering based on precise geographic data (Thrower 2008). Artistic proficiency was no longer as essential to the process of map creation as it once was, but that did not mean aesthetic interest ceased to exist. In fact, by increasing the accessibility and triviality of map creation, the computer brought about a new digitally supported interest in both the artistic and aesthetic dimensions of the map (Caquard, Piatti, and Cartwright 200; Kent 2017). These dimensions can be entirely separated from the more scientific and functional aspects, this time not due to a lack of knowledge or expertise but as a deliberate way of enhancing and focusing on the aesthetic experience of looking at a map (Kent 2017).

Aesthetically driven maps warrant visual exploration and customisation as those are the processes that lead to new creative methods of translating space into a visual medium. Artificial Intelligence (AI) presents techniques capable of assisting artists and designers in developing and experimenting with new visual styles, notably neural style transfer allows the artistic style from one image to be transferred onto another (So 2018). When used for map stylisation, this technique provides a practical way of generating a nearly limitless number of highly diverse stylised maps where the otherwise complex parameters that control the look of the output are compressed into a simple and intuitive visual input — the style input, an image file.

In this paper, we present a system[1] focused on generating stylised geographic maps through the use of a neural style transfer technique. We use open-access geographic data from OpenStreetMap[2] and other open data projects to render input maps, and an existing implementation of arbitrary neural style transfer (arbitrary meaning we can use any style image to generate outputs) to style them based on a separate input image. The output maps are generated in image format (PNG) and can serve a myriad of purposes, from purely decorative to

1. The system presented in this paper is documented online at https://cdv.dei.uc.pt/stylised-maps/

2. https://www.openstreetmap.org/#map=7/39.602/-7.839

more meaningful design objects. The driving force behind our system is creating map-like artefacts with visual interest that can fulfil aesthetic needs, thus, as it pertains to this paper, spatial accuracy and traditional communication-focused mapmaking rules are secondary to visual quality and appeal.

The remainder of this paper is organised as follows. Section 2 describes work relating to map stylisation using neural style transfer and similar artificial intelligence techniques. Section 3 provides a brief overview of our approach to develop the presented system. Section 4 showcases results and analyses their aesthetic quality and real-world applicability. Finally, Section 5 presents final conclusions and directions for future work.

2. Related Work

The primary domain of the presented system is the use of neural style transfer as a method of map stylisation. First proposed by Gatys, Ecker, and Bethge (2015), neural style transfer is a technique that uses convolutional neural networks to generate an output image that combines the semantic content of one image with the style of another. With it being a relatively recent technique, neural style transfer has yet to be fully realised in the context of geographic map stylisation. Nevertheless, while not entirely related, some projects do share some aspects, either in technique or style of output, to our own and will be presented in the following paragraphs.

Bogucka and Meng (2019) used neural style transfer to assess its capability in transferring emotions from individual paintings to a map. A group of paintings created by Berlin residents tasked with visually expressing their emotions about the city were used to create a group of stylised maps of the same place. The authors ran a survey and concluded that some emotions were successfully transferred from painting to stylised map. The attention-grabbing potential of the outputs was also noted by the authors. Although this aspect has not been explored in the context of geographic maps, there are some examples of its use to style aerial photographs. Some members of Consilium Technology (2018) developed a one-day project motivated by the team wondering how the great painters of the past would have represented the earth from an aerial top-down view. This question led them to experiment with an implementation of neural style transfer that was used to stylistically represent satellite views. Similarly, but with more selective criteria for choosing the input images, Morris (2016) managed to produce images with added visual interest using the same technique. Morris combined satellite images, mainly from NASA, that were already visually captivating by themselves with abstract expressionist paintings, resulting in colourful and unique renditions of interesting geographic locations.

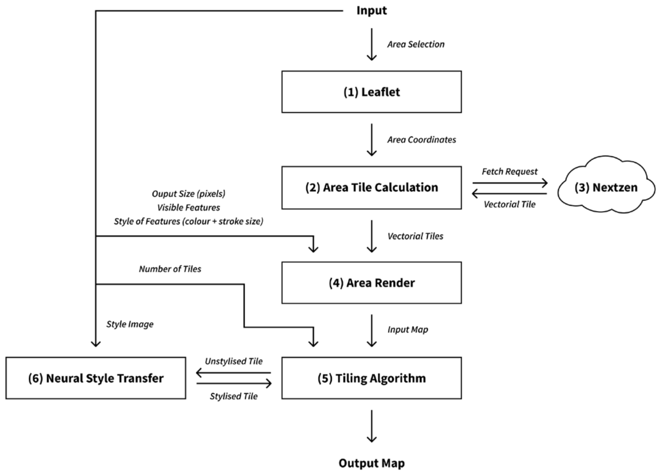
While technically not neural style transfer, other projects have used similar artificial intelligence techniques to produce stylised images based on maps. OpenDot Lab trained individual neural network models to be able to recreate a satellite view of a city from just its map. After having three models trained on different cities (Los Angeles, Milan and Venice), the team was able to feed other maps to the models and thereby generate stylised images that combine the urban layout of the input map with the top-down visual characteristics of the model's city (Kogan et al. 2016). Similarly, Clark (2017) trained a neural network model to generate images in the style of google maps and satellite imagery from just an input map. Clark then used ancient city maps to feed the trained model and obtain interpretations of what those old maps would look like in a contemporary digital format.

3. Approach

Our system generates stylised geographic maps (output maps) with control over the location, visible features, and style. Because the system uses neural style transfer to generate the output maps, it can be split into two primary inputs: the input map and the style image. The input map is generated inside the system, requiring only a geographic area composed of two sets of latitude and longitude coordinates — the top-left and bottom-right corners of a rectangular area. Secondly, the style input is an image file not limited by pixel resolution. Granted that this image controls the overall look of the output thus, whilst the system accepts any image, not all of them will produce good results. The output maps are generated in a lossless raster image format (PNG) at pre-adjustable pixel dimensions.

The following subsections provide a brief overview of the pipeline that turns the system's inputs into output maps. A diagram of the main components that constitute the system and the interactions between them is shown in figure 1. The components are numbered and will be referenced throughout the following paragraphs.

Fig. 1. Diagram showing the main components of the presented system.



3.1. Rendering Input Maps

Our initial plan was to obtain input maps from the open-access data provided by OpenStreetMap (OSM), however, because we are not able to dynamically access OSM to retrieve area maps, we had to find a less direct solution. We followed a similar approach to the one used by most slippy map (i.e. interactive web maps that support panning and zooming) frameworks around the web, which is: get area maps through individual tile requests. In short, (in this context) tiles are square sections of a world map with varying zoom indexed by three values (x, y and zoom) and hosted on the web for frameworks to dynamically fetch, assemble, and display the section of the world map visible to the user at any given time.

To make area selection more intuitive and less bothersome, we used Leaflet[3] (component 1), an interactive map framework, to display an interactive world map with location labels through which we could visually select geographic areas. With the desired area selected, the system calculates which tiles compose that region and fetches (component 2) them from Nextzen[4] (component 3), a free service that hosts vectorial tiles based on OSM data and other open data projects. As opposed to bitmap tiles, where geographic information is compressed in an array of pixel values, vectorial tiles are not image files. Instead, vectorial tiles are geoJSON[5] objects that contain a list of geographic features with the corresponding latitude and longitude coordinates and indica-

3. https://leafletjs.com/

4. https://www.nextzen.org/

5. https://geojson.org

tors to correctly translate them to visual elements (points, lines and polygons). Considering these tiles are structured data, rendering a map from them is not as simple as arranging a few images in the correct order. Because of this, we implemented a tile rendering algorithm (component 4) that uses the pseudo-Mercator projection[6] to take care of rendering the geographic areas selected using Leaflet. This algorithm can convert an however long array of geoJSON tiles into a single SVG map.

6. https://epsg.io/3857

In summary, our system can render vectorial SVG maps of any geographic area in the world. The use of vectorial tiles greatly influences the amount of customisation supported by the system because they allow us to: (i) filter geographic features, e.g. only show highways; (ii) colour and set stroke sizes, which influences how the neural style transfer model interprets the semantic content; and (iii) losslessly convert the input map into any pixel resolution.

3.2. Map Stylisation

With the process described in the previous subsection (3.1) completed, we should have a satisfactory input map with the desired geographic area, colours, stroke sizes, and visible features. At this stage, we can select a style image and the pixel dimensions for the output map and subsequently run the neural style transfer model (component 6) to generate an output map. The latter parameter (pixel dimensions of the output) is needed because said style transfer model requires its inputs to be bitmap images, therefore the input map is converted from the generated vector format (SVG) to a bitmap format (PNG). For the neural style transfer model we are using an existing implementation of arbitrary neural style transfer[7] by Reiichiro Nakano, implemented using TensorFlow.js[8] and based on a paper by Ghiasi et al. (2017).

7. https://github.com/reiinakano/arbitrary-image-stylization-tfjs/

8. https://www.tensorflow.org/js/

After running some initial tests, we noticed that, with our computer's specifications, the system was unable to generate output maps larger than roughly 1500x1500 pixels. Considering the input map is capable of representing a substantial geographic area with all its road, building, and path detail, 1500x1500 pixels is a small size. During those initial tests, we also noticed that the outputs are not stochastic — meaning that if the inputs are kept the same, input map X plus style Y will always produce the same exact output map — and, with this in mind, we devised an algorithm that uses a tile approach to allow the system to generate outputs larger than 1500x1500 pixels. Our tiling algorithm (component 5), diagrammed in figure 2, works as follows: (step 1) split the input map into an adjustable number of equally sized sections; (step 2) run each of them individually through the neural style transfer model; and (step 3) assemble the resulting tiles back into a map. Note that each tile is still constrained to a maximum of 1500x1500 pixels, but by increasing the number of tiles we can generate bigger maps (for example, a 6000x6000 pixels map can be generated from a 6x6 grid of 1000x1000 pixels tiles). As seen in figure 3, this approach proved viable but introduced some visual flaws in the borders between tiles.

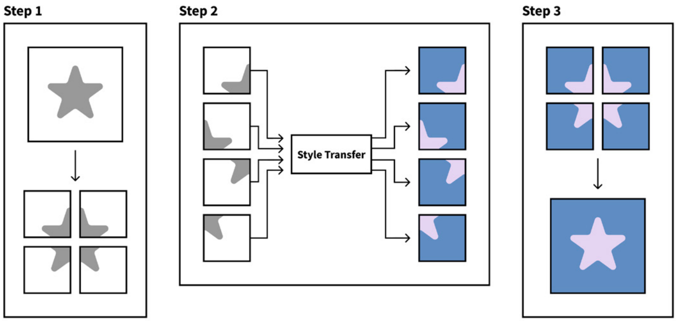


Fig. 2. Diagram visualising version 1 of the tiling algorithm used to generate outputs with larger pixel dimensions in the presented system.

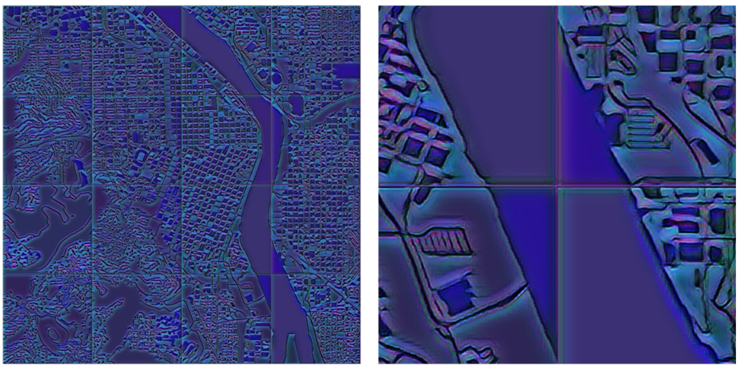


Fig. 3. Map of Portland, Oregon, generated with the presented system using version 1 of our tiling algorithm (left: entire output map; right: closeup section).

The lines visible in the tile borders are a result of the neural style transfer model, and we were unable to avoid them. As a result, we iterated over the tiling algorithm to solve the problem. The solution found (fig. 4) relied on generating each tile with a surrounding margin (step 1), which is cut out before the map gets assembled in the final step (step 3). This means that during the stage where visual flaws are introduced (step 2), each tile has a temporary buffer zone to catch them. These changes fixed the main tile border problem but, as shown in figure 5, revealed other (albeit less noticeable) visual inconsistencies between the tiles.

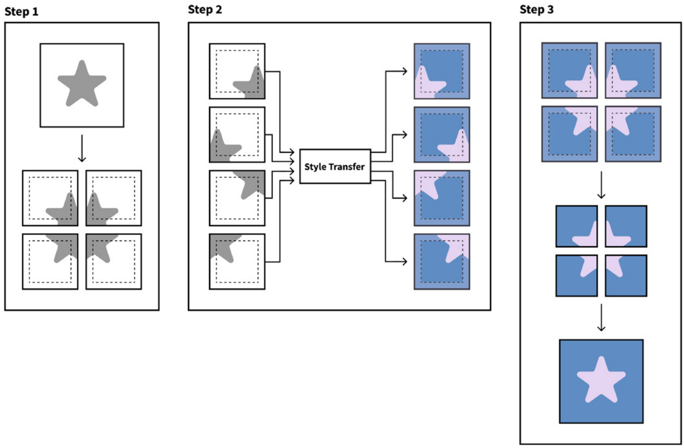


Fig. 4. Diagram visualising version 2 of the tiling algorithm used to generate outputs with larger pixel dimensions in the presented system.

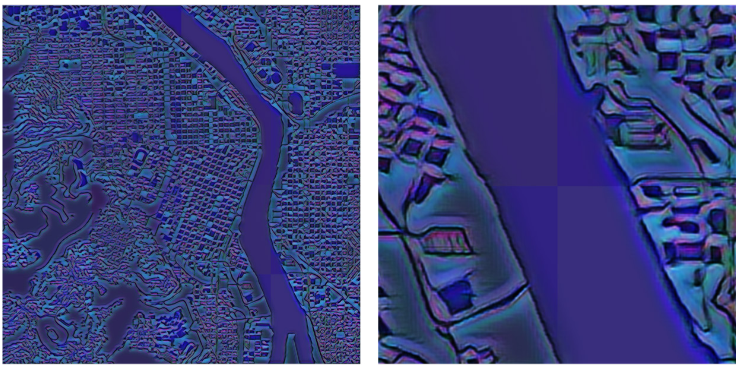


Fig. 5. Map of Portland, Oregon, generated with the presented system using version 2 of our tiling algorithm (left: entire output map; right: closeup section).

The remaining problems are most noticeable in the transition between tiles with varying amounts of negative space. Once again, these inconsistencies are caused by the neural style transfer model, and we were unable to avoid them, leading us to iterate over the tiling algorithm one last time. This time only the final step (step 3) was modified, where we faded between the tiles instead of slicing off the entire margin and leaving sharp edges between them (fig. 6). Finally, as visible in figure 7, this last version of the tiling algorithm seemed to fix the substantial inconsistencies around the transitions between tiles.

Fig. 6. Diagram visualising the final step of version 3 of the tiling algorithm used to generate outputs with larger pixel dimensions in the presented system.

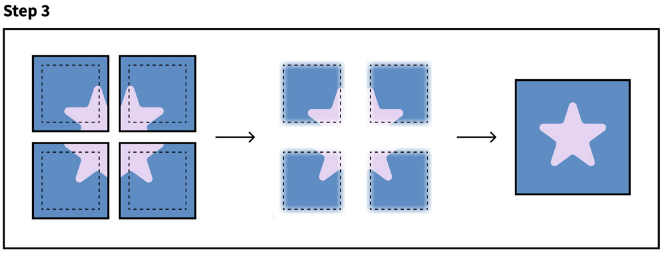
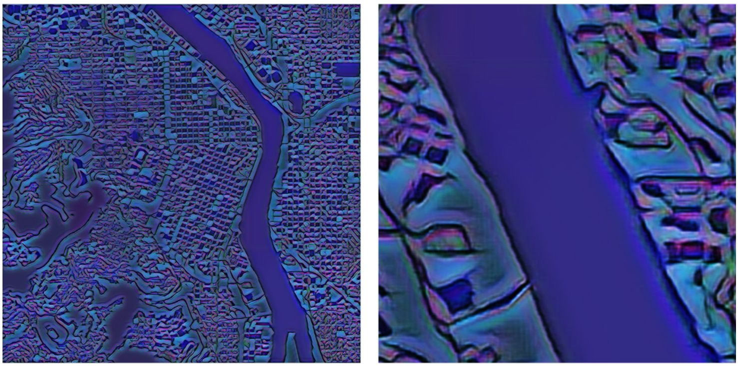


Fig. 7. Map of Portland, Oregn, generated with the presented system using version 3 of our tiling algorithm (left: entire output map; right: closeup section).



4.Results and Applications

With the system implemented, we ran some experiments to assess the visual quality of the output maps and how their appearance can be controlled by changes to the inputs. The following two subsections present the two main properties that control the visual quality of the outputs. For both subsections, the geographic area (fig. 8, left) used was kept the same because that is the one input that should not dictate the quality of the map (i.e. if we need a map of a specific city, it does not make sense to change the map location to improve the look of the output). Finally, the last subsection analyses the system and lists a few examples of how its output maps can be applied in real-world contexts.

Fig. 8. Map (left) and style input (right) used in the following examples. The map represents a section of Berlin, Germany, showing only buildings, roads and water bodies in black and white. The style is the illustration East Indian Cherry by Julie de Graag, 1919.

Map abstraction refers to how much the shapes that constitute the map differ from the original ones after stylisation. We found that abstraction is inversely proportional to the pixel dimensions of the neural style transfer output (larger images are progressively less abstracted). However, as previously explained, our system splits stylisation into a controllable number of tiles, which effectively means we have some control over the level of abstraction. Specifically, because abstraction directly correlates to the pixel dimensions of each image that passes through the style transfer model, we can increase the number of tiles which reduces the size of each one, resulting in higher levels of abstraction. For example, an output map of 2048x2048 pixels can be generated using a 32x32 grid of 64x64 pixels tiles (fig. 9, left) or using a 4x4 grid of 512x512 pixels tiles (fig. 9, middle), the output dimensions remain constant, but the level of abstraction decreases. We should emphasise, however, that we have limited control over this aspect. At a certain point, the number of tiles becomes so large that each one only represents a small fraction of the map, which introduces severe visual inconsistencies. For instance, if each tile is smaller than the average building, it becomes increasingly likely that there will be tiles completely filled with a solid colour, which the neural style transfer model interprets as being empty.

Fig. 9. Map of Berlin, Germany, generated with the presented system with three different levels of abstraction. From left to right, the geographic features are progressively more distinct, and the output is visually closer to the input map (shown in figure 8).

Abstraction affects the aesthetic quality and uniqueness of the outputs. Less abstracted maps show a clearer and more faithful view of space but, in doing so, lose what makes them unique. As seen in the rightmost map of figure 9, a map with low abstraction looks less like a stylistic rendering and more like a coloured version of the original one shown in figure 8. Customised maps that solely rely on colour and texture are already popular among the domain of map customisation and it is not our intention to further contribute to the over-saturation of these maps. We believe the best outputs to be those where the overall structure is easily recognisable but still retains a certain level of abstraction that makes it unique — in concrete terms, something like the middle image of figure 9. Due to the subjective nature of aesthetic preference, the level of abstraction we prefer is irrelevant, what matters is that our system has some control over that aspect in order to appeal to different aesthetic preferences.

4.2. Style Variation

After conducting a few experiments with different input styles, we concluded that (in our subjective opinion) the best maps stem from images with well-defined shapes, or better yet, images with borders (or strokes) between the various colours and shapes. Whenever the input possesses these properties, the neural style transfer model seems to be able to correctly translate the borders from the style to the output, resulting in most shapes having clear stroke delimitation. An apparent example of this can be seen in figure 9, where the dark bold borders of the style image (fig. 8, right) contributed to the resulting map shapes having dark edges — almost like the map was first traced with black ink and subsequently coloured following the black guiding lines.

That being said, bold strokes are not crucial to generate a clear, well-defined map. Effectively, the primary visual requirement of the style image is possessing distinct patterns and shapes. Such is the example shown in figure 10, where the thin golden strokes lining the shapes seem to be enough to generate a pleasing well-defined map. Conversely, images that lack this clear contrast and definition generate blurrier output maps with less distinct features. Unfortunately, this is the case for many hand-painted images where the natural hand-drawn brush strokes tend to leave a smooth transition between colours. An example of this is visible in figure 11, where the style has dark lines blocking the main shapes, but they fade somewhat smoothly to the surrounding colours, resulting in less clarity and shape delimitation in the output map. There are some areas where the map almost looks out of focus — especially when comparing both closeup sections of figures 10 and 11 — because colours dissolve into each other instead of having clear separations.

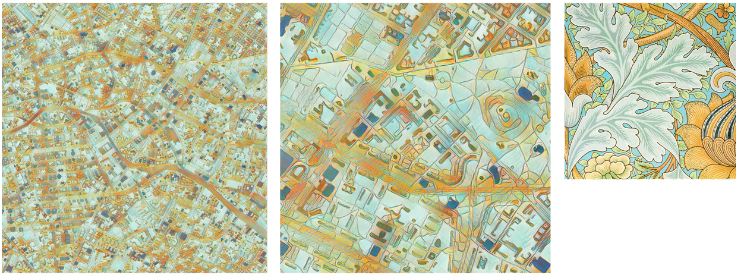


Fig. 10. Map of Berlin, Germany, generated with the presented system (left) with a closeup section (middle). The image used as the style input is the wallpaper St. James Pattern by William Morris, 1881 (right).

Fig. 11. Map of Berlin, Germany, generated with the presented system (left) with a closeup section (middle). The image used as the style input is the painting Pink Begonias by Marsden Hartley, 1887 (right).

4.3. Applications

Our first and primary motivation was to develop a system that generates visually appealing maps to be used as decorative objects. We feel this objective was achieved successfully as the maps (in our subjective opinion) do possess similar aesthetic properties to (albeit more abstract) paintings and posters commonly used to decorate interior spaces. In this regard, the output maps generated by our system could be used to decorate homes (fig. 12) and businesses alike. A real-world example of the latter would be their use to decorate the walls of a restaurant that specializes in traditional food from a particular city. Moreover, primarily decorative uses can be more than simple wall prints, there are a myriad of other contexts in which they can be used, of which souvenirs (e.g. postcards), city merchandising, and digital wallpapers are just a few examples.

Fig. 12. Map of Coimbra, Portugal, used for home decoration. The map was generated by the presented system and later digitally composed into a real-world scene using image editing software.

Ultimately, these output maps are a stylistic way of establishing a connection to a geographic space when there is no need for a readable map (i.e. when the aesthetic needs of the map supersede utilitarian ones). In this sense, our maps can also be applied in design objects that require a more or less subtle connection to a physical place, where it does not make sense (from an aesthetic or conceptual standpoint) to use a "traditional" map. Examples of these uses would be book covers, movie posters, or album covers, where the driving narrative is connected to a particular geographic place. To better illustrate the aforementioned design applications, we followed the first example and used our system to help design a mock-up cover for the 1988 book, The Twenty-Seventh City, by Jonathan Franzen. We generated a map of Saint Louis, Missouri (fig. 13), the city where the narrative takes place, with a style image that could help express the genre of the book — a complex thriller. Regarding the input map (fig. 13, left), we coloured the features so water and roads could be differentiated, thus allowing the bridges over the river to be visible in the output map. In the finished design (fig. 14), we cropped the output map and increased its contrast to better compose the book cover.

Fig. 13. Input map (left) and style image (middle) used to generate the output map (right) to be used in the book cover shown in figure 14.

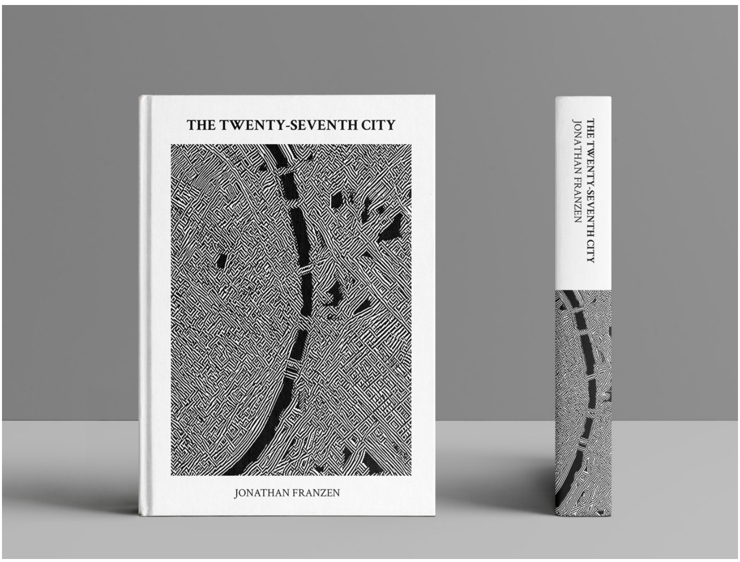


Fig. 14. Mock-up cover for the 1988 book The Twenty-Seventh City by Jonathan Franzen, using a stylised map of Saint Louis, Missouri, generated with the presented system.

5. Conclusions and Future Work

We have presented a system that uses neural style transfer to generate stylised geographic maps customised according to the style of a separate image. The presented system takes care of rendering the input maps with control over the visible features, their style, and the geographic area, thus requiring only a desired style image to generate stylised maps of any region in the world. Complete control over map area and location coupled with the freedom to use any image as the input style means the range of outputs is nearly limitless and highly customisable. We conclude that the generated maps possess visual interest and a unique aesthetic quality suited for both decorative and design applications.

Future work may include hosting the system on the web to allow anyone to create their own stylised maps. The system is already implemented in JavaScript and runs on the browser, therefore the main aspect that currently limits us from sharing the system with the public is the lack of an intuitive user interface. Additionally, should we choose to follow this approach, optimisations to the rendering process need to be implemented to decrease the time and computational power currently demanded by the system. Regarding added features, we believe the system would benefit from the possibility to add location markers to the map as a way of highlighting specific locations. We think this would help expand the output maps into more real-world contexts. For instance, a print like the one shown in figure 12 could be further connected to its owner by having markers or simple distortions in meaningful locations (e.g. the street where the person grew up). Future developments on this work will be available online at https://cdv.dei.uc.pt/stylised-maps/.

References

Bogucka, Edyta P., and Liqiu Meng.
2019. *Projecting Emotions from Artworks to Maps Using Neural Style Transfer*. Proceedings of the ICA 2 (July): 1–8.

Caquard, Sébastien, Barbara Piatti, and William Cartwright.
2009. *Special Issue on Art & Cartography*. The Cartographic Journal 46 (4): 289–91.

Clark, Jack.
2017. *Resurrecting Ancient Cities with CycleGAN*. Accessed February 7, 2021. https://jack-clark.net/2017/06/05/import-ai-issue-45/

Consilium Technology.
2018. *What If Google Maps Was Art?* Accessed February 7, 2021. https://consilium.technology/what-if-google-maps-was-art/

Gatys, Leon A., Alexander S. Ecker, and Matthias Bethge.
2015. *A Neural Algorithm of Artistic Style*. ArXiv:1508.06576 [Cs, q-Bio], September.

Ghiasi, Golnaz, Honglak Lee, Manjunath Kudlur, Vincent Dumoulin, and Jonathon Shlens.
2017. *Exploring the Structure of a Real-Time, Arbitrary Neural Artistic Stylization Network*. ArXiv:1705.06830 [Cs], August.

Kent, Alexander.
2017. *Cartographic Style and the Aesthetic Fix*. The Cartographic Journal 54 (1): 1–4.

Kogan, Gene, Gabriele Gambotto, Ambhika Samsen, Andrej Boleslavský, Michele Ferretti, Damiano Gui, and Fabian Frei.
2016. *Invisible Cities*. Accessed February 7, 2021. https://opendot.github.io/ml4a-invisible-cities/

Morris, Bill.
2016. *Deconstructed Planet*. Accessed February 7, 2021. https://billmorris.io/planet/.

Rees, Ronald.
1980. *Historical Links between Cartography and Art*. Geographical Review 70 (1): 60.

So, Chaehan.
2018. *A Pragmatic AI Approach to Creating Artistic Visual Variations by Neural Style Transfer*. ArXiv:1805.10852 [Cs], May.

Thrower, Norman J. W.
2008. *Maps and Civilization: Cartography in Culture and Society, Third Edition*. University of Chicago Press.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

@#D: Face-Filters, Satisfying Videos and Socio-spatial Justice

Keywords: Augmentation, Rendering, Socio-spatial, Platform Capitalism, 3D

Gaspar Cohen
gasp.cohen@protonmail.com
Faculty of Sciences, University of Lisbon, Portugal

Reflecting on digital poiesis and what can be thought of as 3D phantasmagoria, this paper puts forward some considerations about urban media ecologies, focusing on those that dwell directly on space. Considering visual culture indexes such as Face-Filters and the popularization of material simulation and maximalist neu grunge, computer-aided three-dimensional rendering—and its interlink with decentralized computation—will be seen as new spectra for contemporary geographies.

This text aims to create a discussion for socio-spatial justice revolving as a critique of Platform Capitalism and its ability to render power. Neither as a portal for other worlds or a long-lasting overlay, digitality rays out, glimpses from within the surfaces of material reality having 3D as a language negotiator. If the industrial machinery, the prison, and the screen designed the imaginary and social contracts of western modernity, the biopower of algorithms utilizes all space and users' bodies as quantifiable devices and exploitable resources–feeding augmentations judged desirable.

1. Introduction

Data, sounds, and images [...] invade cities, transforming spaces into sites, and reality into realty. They materialize as junkspace, military invasion, and botched plastic surgery. They spread through and beyond networks, they contract and expand, they stall and stumble, they vie, they vile, they wow and woo (Steyerl 2013).

This paper stems from a homonymous installation series[1] and aims to investigate relationships between contemporary cultural production, the economic system it is inserted in, and an expected symbiose responsible for a perceived crisis in material culture in digital turmoil. A wide range of cultural artifacts will be seen having *rendering* and *augmentation* as conceptual keys to address social paradigms. These are seen as central for a critique of capitalism through its geographies, and a current state diagnosed as a digital precarization of space and territories (Badie 1995 in Haesbaert and Bruce 2002).

1. First presented at the School of Fine Arts Porto, this is a two-channel video installation. It shows a television screen lying horizontally on the floor of the exhibition space and a tripod set up perpendicularly on top of it. Attached to the tripod, a smartphone is positioned vertically. This series is meant to be reproduced in any pair of screens and different combinations are encouraged. The videos for each channel can be found here: http://www.130-ivxx.com/23d.html

This analysis is shaped through a non-hegemonic, post-Marxist optic, where we interrogate media praxes and the aesthetics of Capitalist Realism (Fisher 2009). Supported by—and mirrored in—a visual culture of hegemonic-computational characteristics, we recognize logics of semiotic consumption and reproduction that are specific of an operative process of augmentation; of intellect, of body or space (Engelbart 1964; LeBreton 2000; Manovich 2005). However, it is here argued that the dynamic, potent nature of such a term is limited to the capabilities of capitalism itself, in its competences, not the human cogs of its systematic array. Such operates indissociable from a social engineering and cultural narrative that aims to distance the concepts of reality and the real (Zupancic in Fisher 2009), which *render* epistemological frontiers and capture deviating movements through oppression and modulated desire.

Through the term “@#D” we use the coincidence of keys “2” and “3”, “@” e “#” in computer keyboards (US-Int. and PT standards) as a theoretical device to interrogate this extractivist modality of technology: of somatic and cognitive processes that hybridize while numb both two- and three-dimensional spaces (2D, 3D), virtualities, locality (@) and information itself—from the *WWW 2.0 folksonomy* to the barely outdated term *Big Data* (#).

2. @#D, The Confusing State of Things

On the 22nd of December 2019, videos posted by *Watch People Die Inside* on Twitter (@theydeadinside, suspended and cloned in July 2020) call attention, and are described below:

> A baby is carried in the arms of a woman close to a store mannequin. The baby smiles and reaches for the inanimate face. At the first touch, the head falls off. Baby cries. [7 seconds];
>
> Mom and baby record a selfie video, both looking at camera and screen seriously. As mom opens a smile, she activates a "smart filter" where eyes, mouth, and nose disappear leaving a blank, rubbery face. Baby cries and screams. [11 seconds].

Similar to the contribution of the Global-North film industry to society in the 20th Century, we observe here technologies of translation and quantification of space and body as structure-territory for numerous contemporary paradigms. This work believes that the current condition of digitization and its implications for data analysis in information sciences ask for a new take on the *Spatial Turn* (as clustered in Michel Foucault, Henri Lefebvre, The Situationist International, Michel de Certeau) in societies of control connected in globalized financial capitalism (Deleuze 1992).

While cinema inaugurates the process of digitization in cultural production in the 1980s and 90s, as a spectacle illustrative to Baudrillard's simulation (1983), the workplace sees increasing stillness in the cubicle-grid abstraction. The mainstream extent of digital cinematography (CGI, computer-generated imagery) is the final installment of abstract space in culture, which will come to complement the digitization in bureaucratic structures and work relationships until the currently defined 4.0 industry.

Likewise the transition to Web 2.0, in its fertilization through venture capital, we see the introduction of *smartphones* and the *Internet of Things* as a finely orchestrated moment of technological governance which defines Platform Capitalism (Srnicek 2016). As usual, the early investment in a new economic model anticipates social domination to make sure its financial return. Such control is installed only when we accept a device as support (as done with TVs and PCs) through which attention can be seized. In our proliferating net of *screen-objects* with pluri-dimensional, multi-platform span, a normalization of "a gaze of space-and-screen" (Cohen 2019) seems only a first step in a total apprehension of the sensorial spectra. Often referred to as "popularization" or "democratization", such implementations have little to do with the interests of the people, as we see their needs and wills are ultimately bypassed.

Since the 1990s, cultural software for special effects, three-dimensional modeling, virtual reality, GPS, leave the one-way exclusivity of the big film studios, and culture becomes permeated by tools of creation and occupation of other "worlds" and second "lives". When we address 3D, we go further than visual culture towards interactive media, multimedia installations, and spatialized sound. In this transfiguration and acknowledging the material needs (hardware) of such practices, it is concerning to understand which artistic productions work as creators and dissolvers of a 3D *phantasmagoria* (Cohen 2019), a "confusion" in the interlacing of usage and interface, of encounter with artifacts and existence itself, presence in concrete space. This condition is seen as a ghostly offset of what serves as reality in a hauntological system of knowledge.

In the following sections, we will interrogate such an ambiguous social period of accessibility and constraint Nake defines as algorithmic revolution (2016), interested in perceiving to which extent certain cultural objects, often referred to as therapeutical (or mindful), design a subliminal automatization of productivity rather than healing states. In contemporary audio culture as an example, we can analyse the *continuum* of streaming services, an era of ambient music reissues, cloud rap, and "24/7 chill beats to relax to" as serving an underlying tempo for capitalist reproduction.

3. Render Politics

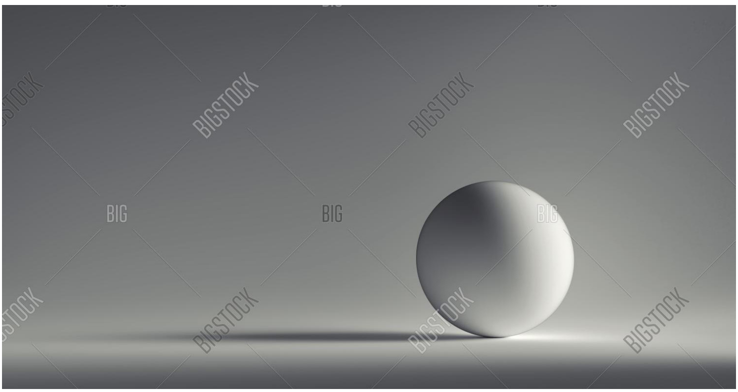


Fig. 1. BIGSTOCK: white on white, ready-made, 2021.

> [in] art: represent or depict artistically. [in] computing: process (an outline image) using colour and shading in order to make it appear solid and three-dimensional. (Render, as defined by Oxford Languages and Google)

In bringing rendering operations to social realms and the concept of Realism, one looks at the substitution of embodied experience by an image, an amalgam of projections of something that can be called the *world*. In the politics of rendering, experience takes place in the spatialized visualization of what's not there; a technological update of the modern screen but the maintenance of its ontological trait: "you can see, but you can't touch or have it". Or a step further, in ambisonics and space, "you can listen as-if, but you can't go anywhere".

To access such propositions, Instagram and Youtube and the sky-rocketing Tik Tok will be taken as media for analysis, not only for their expressive number of users and frequency of posts but its algorithmic components. When in 2016, Instagram premiered its stories, it cannibalized not only the interaction model of competitor Snapchat but followed up with what the latest called "selfie stickers" and "geosticker" (now "face-filters" and "geotag").

As these features became extremely popular, they were also targets of pertinent critiques on privacy, the beauty industry, and racial justice for their impact on mental health and increasingly exposed biases. (Elle 2019; Tolentino 2019; Peters 2019; Noble 2018; Silva 2020). As facial recognition becomes a device of capture of identity and affects in a "selfie culture", the apprehension of the face is symbolic to "perceive perceiving", remembering, recognizing, and systematizing other urban agents, human or not. Such *digital physiognomy* and the rise of *deepfakes* become the foremost concern in the practice of identity and it is highly instrumentalized for state enforcement (See *Algorithmic Justice League* and Silva 2020). However seen mostly as a villain, the culture of images has shown to be also an important empowering territory for body-positive stance and aesthetic avant-garde in the LGBTQA+ and BIPOC collectivities, historically destitute of the right to occupy physical and social spaces.[2] This sort of counter-practice will be brought forward again in the conclusion of this paper as prefigurative examples and experimental media politics.

2. This paper was originally inspired by and honors the work of recently departed SOPHIE, with emphasis on her 2018 music video "Faceshopping". Following her passing, relevant discussions have emerged about the aesthetic landscape and futurity in technology. See Matt Bluemink's series on Anti-Hauntology in Blue Labyrinths and Acid Horizon's Podcast "PC Music, Accelerationism, and Xenofeminism".

Moving away from the face, in diametric opposition, we observe different phenomena of the 3D phantasmagoria, still less popular and subtler. What we call here *satisfying videos* seem to have a strong relationship with personalized suggestions from the algorithms of video platforms in their insistent "explore" section, inhabited in large numbers by automatic profiles (bots) and promoted content (ads).

Opposite to the mirror dynamics of an image of oneself projected to the collective, these videos and *ASMRs* (Autonomous sensory meridian response) are characterized by an intimately reverse practice of the audiovisual, where content substitutes action, portraying hands and objects constantly. While they refer to a *do-it-yourself* attitude, satisfaction and comfort encapsulated in these media artifacts (loops, process videos, ultra-slow macro photography, and amplified micro-sounds) viewers are fulfilled by the experience of others as theirs (Mulvey 2009). Either through slimes, hyper-elaborated cheesy-melting food porns, life hacks, ... the user rapidly falls in this *fétiche* stream.

Those operate among what Han puts as "The Smooth" (2018b). Be it in live-action or animation, in the aesthetic palette of current graphic design and filmmaking we observe hyper-and-*quasi*-realistic renderings, "kinetic sand", shiny and reflexive bubbly shapes as a motif. Creative uses of material simulation, eased-in and -out, ultimately aim at challenging our understanding of physical behavior, either by perfectly fitting or breaking expectations (mind-bending/"is it cake?"). Among others, the TV shows like *Nōkabe* (Brain Wall), Sasuke and its western reboot American Ninja Warrior bring an interesting fold to abstract space in television, where a gamified scenographic space feedbacks a learning curve initiated on games such as Pitfall! (1982) and Prince of Persia (1989). In visual effects, Tryptyc's shiny ball shading technique and ILM's dynamically animated green-screen technology (as recently featured in *Vox's* Design series) are other noticeable examples of virtuality in novel applicabilities.

The persistently hermetic order of the images provided by these virtualities blur the distinction between user-spectator and their environment; to the extent where it doesn't matter if events even take place, contents are or not real, artificial, truthful or possible, recorded or rendered by a computer. All these instances are in check, while the cognitive reward of seeing and hearing is not.

The operative-ness of algorithmic procedures has a unique role in this social narrative. In opposition to modern images of control in mass media systems, shaped as satisfactory to be forged and disseminated as one, the personalized flow of content in Platform Capitalism segments the internet. As it collects preferences, it retains itself as a feedback loop of bubbles or echo chambers. Differently from political views or digital activism, satisfying videos and similar media objects are mostly experienced alone, fed in pleasing domesticity, with its reach beyond language, to the core of subjectivities and behaviors of those relating to those systems (Han 2018a).

As a prime example of this intimate spectacle we mention the "Sharpest Knife" series, from user "kiwami japan'' on Youtube. Visualizing (instead of carrying out) a perfectly clean kitchen counter and a methodical process are performativities of perfection equivalent to the face-filters and plastic surgeries, which distort domestic and social standards. In this example and others, a common denominator is the level of detail, the high definition, and perfect lighting that *exceeds* the real, giving an almost tacit quality to these images. These triggers for haptic pleasure atomize a teleological confusion effect, the sensation of a mission accomplished, of fine motricity leading to a desirable form. This *voyeurism* (or a neologism for a sound equivalent) contains a tension interfacing the apathetic materiality and the activity portrayed on the glass slab. The annex of this paper brings a mosaic of tags extracted from original posts on Instagram, aiming at illustrating the aesthetic path we reference here.

> In this way, the AMSR video functions like a prayer wheel—a doubly interpassive ritual which can run autonomously, without our active participation. Our ambivalence towards the video is echoed also in Gibi's ambivalence towards the objects. The entire scope of variance in value has been flattened into one dollar ("100 Dollar Store Triggers''). Its intended use is reduced to a single purpose, noise-making (or percussive potential). (Hays n.d.)

4. Augmentation

> (...) the space of state control, being for him 'optical and visual' (2009b: 234), is not a space in which the body can survive. The body is instead 'only represented, in a spatial environment reduced to its optical components' (Lefebvre 2009 in Jones 2013)

In order to expand on how the phenomena listed above relate to production and consumption means of Platform Capitalism, *augmentation* becomes the operation at hand, in its role of providing prompt manifestations of media and goods. The encapsulated and granular format of the videos we observed is seen here as having an intense relationship with the transition from an early industrial productive society to the (perceived) absence of a final product. In this model, the immaterial component of profit is key to analyze its ability to intervene materially in urban territories, the spatial quality and the experience of individuals in this neoliberal space made augmented.

Following a psychoanalytic thread of Marx and Žižek highlighted by Lib Hays in "The Non-Relation in ASMR and 'Satisfying' videos" (n.d., 3), we see a possible pathology of the "weirdly satisfying" as interpassive obsessive-compulsion, driven by capitalist alienation. When we consume images of hydraulic presses, chemical reactions, compilations of fast workers, deep-cleanings, we reiterate the distance of product and process, resource and commodity, reality and beyond-reality (fiction).

As material conditions remain precarious for most and living spaces ever more utilitarian in the urban centers, they are normalized and remediated in a palliative manner. Rendering and augmentation form societal noise, where media systems do not come out as solutions to common problems, but in creating and commercializing the non-essential as the bare expected normal. These so-called platforms show themselves more paralyzing than supportive of a step further, less of a safe stable altiplano than an exiled island in cosmic emptiness.

Decentralized computation is seen here as the hauntological *milieu* in which Fisher puts forward as Capitalist Realism (2009), a hazy horizon of possibilities other than capitalism as it presents itself. Instead of the purity a cloud metaphor can render, current conditions appear more as a thick fog where few own the navigational instruments. Luke Munn proposes a question that we can take as ours: "how does an algorithmic procedure attain and exert power?" (2018). On their study case Uber, says "the forces exerted by the 'merely' technical operations of the algorithmic—storing, searching, indexing, presenting—must accumulate into meta-operations: encapsulating life, enlisting subjects, remaking space, and enchanting users." (Ibid.)

Before 2020 and a novel spatial urban condition brought by the COVID-19 outbreak, the usage of services such as Google Maps, Uber, AirBnb, Glovo–digital market systems based in locative media–has been justified by the possibility of doing more with less investment, of augmentation of capabilities or exertion of power in less time. This logic of "don't work harder, work smarter" (at the expense of others) shapes contemporary liberalism and evokes colonial pasts and a face of Social Darwinism that echo from the Global-North since the 14th century.

Among the *crescendo* of social movements in 2020 such as Anti-Racism and Women's Rights, it is of special interest for us to fight for Gig Workers' and App Workers' Rights, with unionization efforts looking for better working conditions and payment. After their work rose to the forefront amid the (still ongoing) measures for containing 'The Virus', the situation of frontline and essential workers such as messengers and stock-workers brought new meaning to the concept of *hyperlocality* (Hochman, Manovich and Yazdani 2014; Hu et al. 2013), both in cooperative and coercive ways. Though mutual aid groups and Uber drivers used geolocation and computer vision to assure a series of needs during the pandemic and have helped each other assemble, these have worked vigorously as control mechanisms in the all-out workplace. Justified as social distancing measures, Uber and Amazon workers would get notified or punished if clustered; a device coming hand in hand with the companies' anti-unionizing guidelines (see Antunes 2020).

Through productivist digital facilitation, Capital keeps its individual enchantment, where the search for self-optimization sets other potencies of the establishment in motion. The constant technological reconfiguration seems to always remediate haptic constraints that its own poiesis hijacks. This contradiction tangents Byung-Chul Han's thesis in "Psychopolitics" (2017), of a fold in the biopolitics it draws from. "Smart power", instead of prohibiting and enclosing, asks for more; "the operative technology of power does not negate or repress freedom so much as exploit it." (Ibid.). The materiality of coercive power over bodies in disciplinary societies sees in digital nature not a de-materialization, but an opportunity to parasite space itself as it transits between devices and manifests precisely. Groys gives us a conclusion useful both for media and concomitant exercises of power: "Our experience of contemporaneity is defined not so much by the presence of things to us as spectators, but rather by the presence of our virtual souls to the gaze of the hidden spectator."(2016)

5. Conclusions

> What happens when fiction (itself) propagates, contaminating the Real? [...] What happens, to fiction [...] when the relation between the Real and its simulations is cybernetically reconfigured? (Fisher [1999] 2018)

The more these augmentations are judged desirable, the more we are confronted with the inherently contradictory action of seeking ethical consumption under capitalism. If on one side, there is an urgency in reshaping economic and legislative structures, there is also an underlying philosophical friction to be resolved.

The search here is for a political philosophy that works directly on such an overcast view of the experience a community wants to be part of, what this community even is, or, more importantly, *comes into being*. The economic process of western society has weakened community literacy, individual agency becoming withered by a crisis in the production of subjectivity. Such a composite condition is often referred to as "suffocation" and "migraines" in Berardi's latest writings (2019a, 2020), due to a collective confrontation with the problem of time: "When it is said that time is ending, this does not mean abstract, empty time, but rather liveable time (Garcés 2017).

Views that aim to reconfigure this status quo are faced with a force-field between aesthetics and process that concerns the very question of time while discussing reality and fiction. As seen in Accelerationist writing, a cybernetic approach to these has a contingent of simplification, a tendency to fall under the same mistakes 1950s cybernetic theorists have in describing a "self-regulating ecosystem" or a pessimistic acceleration towards the end. While a clear path for the heavily debated "new materialisms" is still unknown, we argue there is an urgency for digital culture studies to dislocate their framework and attach to intersectionalities, post- and decolonial thought as an escape from the very structure the first was founded on. To recall Arthur C. Clarke's quote "Any sufficiently advanced technology is indistinguishable from magic", our conclusions could be of denial of all magic until our historical materialism can have its turn in interrogating the pace of technology — or until the magicity of native communities and a pre-colonial world would be taken in consideration when steering the behemothic concept of technology.

However, in the realm of the graspable, we see in *digital maximalism* a tool equally powerful in today's counter-culture, guiding experimental modes of existence to be taken in consideration in finding alternatives. Taking the music industry and the club scenes as subjects, we can analyze *Deconstructed Club* and *Avant-Garde Pop* as frantic takes on helplessness. Heavy users of 3D rendering,[3] this new popular music seems to reveal all the restlessness this text sees in dealing with space and liberty under a digital dualism. In a nutshell, the music lashes warped vocals, melodic crystal reverbs, compressed ambiences, and hyper-sped algo-glitchy reworks of what Fisher saw in 2010s as euphoric pop (Barrow 2011; Fisher 2014).

3. As an overview of prominent artists see: Ines Alpha, Jennifer Mehigan, Michael Staniak, James Merry, Dirk Koy, Johanna Jaskowska, Maxim Zhestkov, Lucas Gutierrez's Cyberia 2021, Bruno Sarttori, Cool 3D World, CTM 2020, by VOJD, Jon Noorlander, Gabriel Massan, Serafim Mendes, Caio Reis, Rimbawan Gerilya.

Fig. 2. *Untitled*, from MS Paint 3D 2018 series, Che F. Kirk, 2018.

> A good party is, among other things, an affront to capitalism. It can provide a collective escape from drudgery, a sanctuary from oppression, a chance to transcend. It revives our utopian imaginations. A good party has elements of prefiguration, glimpses into a better future; it gets you high on hope. (Rosa 2021)

The aural chaos of today's music can only be accessed when acknowledged together with the technocratic socio-economics described above, from which these subgenres emerge: that of a global mental health crisis and socialized anxiety. In our age, the trope femininity of pop stardom has transformed into non-binary and transgender icons that have nothing of hauntological. In their affirmative presence, artists like Linn da Quebrada and Arca disregard promises of the past while giving a new sense of futurity, one shaped by those who historically are the first to experience 'cancelled futures'.

It is no news to say that grassroots organizations in LGBTQA+ and other marginalized communities have a strong sense of mutual aid and care (see 'The Care Manifesto' 2020). These provide not only a collectivized remedy for material precarity, but a vernacular practice of mental healthcare for those deemed deviant and often denied kinship from their own family. The cultural potency of these communities help shape a media ecology that escapes the neoliberal subject, new circuits of the real that consider arts as means but also a colonizing, limiting infrastructure, therefore always put into question. The digital then avoids being seen through a technocratic cannon, but that of hacking and cyborgianism, a recombination and deformation of digital reproduction. Through amplified bodies, the encounter is a post-screen technology that emancipates us from the distinction of body and thought. They form a critical mass activating spaces and proposing an ecology of dialogs. *Techné* is not at center stage but *poiesis*, in re-territorializing processes of being, trans-formatting and opening relational surfaces on a web made halt.

6. Annex

#balloon #bubble #bubbly #sphere #glassy # #cgi #3d #3dart #satisfy #satisfying #oddlysatisfying #satisfyingsounds #relax #relaxing #relaxation #amazing #chill #asmr #digitaldesign #acidgraphics #3dinspiration #3drender #3darchive #3dgraphics #3dartist #digitalarchive #chrometype #3dartwork #foodporn #cookies #awesome #perfect #tutorial #blogger #nice #hairstyle #style #makeup #nail #foodietutorial #colorful #diy #diyvideos #diyfuture #diyfashion #diycraft #diyvideo #diyfood #lifehacks #awesome #delicious #creative #soyummy #ideas #tips #tasty #howto #desserts #chefclub #foodgram #cooking #tweegram #usa #melting #kitchen #incredible #timelapse #blossom #cake #diyslime #diymakeup #diygift #diygifts #diyqueen #diyproject #5mincrafts #doityourself #cool #good #crafts #diylife #diyblogger #diyideas #withlove #heart #decor #dicas #homedecor #bedroom #display #hola #cute #pink #videodiy #lamp #joy #nifty #savemoney #moneysaver #stylish #slime #slimetutorial #crunchy #slimeusa #fluffyslimetutorial #waterslime #asmr #kwai #slimevideo #soft #slimef4f #slimeislife #slimeyhoez #prettyslime #basicslime #slimekit #slimekoreaç #viralposts #oddlysatisfyingvideo #satisfyingposts #satisfyingvid #satisfyingvids #satisfyingpost #satisfyingslimevideos #satisfyingfood #satisfyingcontent #satisfyingart #satisfyingsoap #satisfyingslimevideo #satisfyingfloam #satisfyingvideosdaily #fastworkers #tech #techdeck #techies #techworld #techie #techhouse #technews #techtrends #techlife #technics #technologies #techgadgets #technologynews #technologytrends #smarttechnology #newtechnology #technologyrocks #technologyfacts #technology #technologysolutions #mechanicaleducation #engineering #engineeringpost #electricalgram #specializedtools

References

Antunes, Ricardo.
2020. *Uberização, Trabalho Digital e Indústria 4.0*. Boitempo Editorial.

Allahyari, Morehshin and Daniel Rourke.
2017.*The 3D Additivist Manifesto*. Institute of Network Cultures, Amsterdam

Barrow, Dan.
2011. "A Plague Of Soars - Warps In The Fabric Of Pop", theQuietus. https://thequietus.com/articles/06073-a-plague-of-soars-warps-in-the-fabric-of-pop

Baudrillard, Jean.
1983. *Simulacra and Simulation*. Semiotext(e)

Berardi, Franco "Bifo".
2020. Extremo: *Crônicas da Psico-deflação*. Ubu Editora.
2019a. *Breathing*. Semiotext(e) Intervention Series. 26.
2019b. *Depois do Futuro*. Coleção Exit. Ubu Editora.

Breton, David Le.
2007. *Adeus ao Corpo: Antropologia e Sociedade*. Editora Papirus.

Bridle, James.
2017 'Something is wrong on the internet'. https://medium.com/@jamesbridle/something-is-wrong-on-the-internet-c39c471271d2

Bruno, Fernanda, Bruno Cardoso, Marta Kanashiro, Luciana Guilhon and Lucas Melgaço .
2018. *Tecnopolíticas da Vigilância: Perspectivas da Margem*. Boitempo

(The) Care Collective.
2020. The Care Manifesto, Verso.

Cohen, Gaspar.
2019. "Towards a Techno-Flâneur", #18.ART International Meeting of Art and Technology. Lisboa

Deleuze, Gilles.
1992." Postscript on the Societies of Control "October, Vol. 59. (Winter, 1992), pp. 3-7.

Engelbart, Douglas.
[1962] 2003. "Augmenting Human Intellect: A Conceptual Framework". In The *New Media Reader*. Cambridge: MIT Press.

Fisher, Mark.
[1999] 2018. *Flatline Constructs: Gothic Materialism and Cybernetic Theory-Fiction, Exmilitary.*

2013. *Ghosts of My Life: Writing on Depression, Hauntology and Lost Futures*. Zero Books.
2009. *Capitalist Realism: Is There No Alternative?*. Zero Books,.

Garcés, Marina.
2017. "Conditio Posthumana" in *The Great Regression*, Wiley.

Groys, Boris.
2016. *"Modernity and Contemporaneity: Mechanical vs. Digital Reproduction"* in In the Flow. Verso Books.

Haesbaert, Rogério and Glauco Bruce.
2002. "A Desterritorialização na obra de Deleuze e Guattari". GEOgraphia 4, nº 7.

Han, Byung-Chul.
2017. *Psychopolitics: Neoliberalism and New Technologies of Power*. Verso.
2018a. *The Expulsion of the Other: Society, Perception and Communication Today*. Polity.
2018b. *Saving Beauty*. Polity.

Hays, Liby.
n.d. " The Non-Relation in ASMR and "Satisfying" Videos" https://www.academia.edu/39398193/The_Non_Relation_in_ASMR_and_Satisfying_Videos

Hochman, Nadav, Lev Manovich and Mehrdad Yazdani.
2014. "On Hyper-locality: Performances of Place in Social Media" in *Proceedings of 2014 International AAAI Conference on Weblogs and Social Media* (ICWSM).

Hu, Yuheng, Shelly D. Farnham and Andrés Monroy-Hernández.
2013. "Whoo.ly: Facilitating Information Seeking For Hyperlocal Communities Using Social Media." ACM Sig CHI https://www.microsoft.com/en-us/research/publication/whoo-ly-facilitating-information-seeking-for-hyperlocal-communities-using-social-media/

Hunt, Elle.
2019 . "Faking it: how selfie dysmorphia is driving people to seek surgery", The Guardian https://www.theguardian.com/lifeandstyle/2019/jan/23/faking-it-how-selfie-dysmorphia-is-driving-people-to-seek-surgery

Jones, Nick.
2013 "Quantification and Substitution: The Abstract Space of Virtual Cinematography". Animation 8 253–66.

Kiwami japan.
"Sharpest Knife" series, Youtube. https://www.youtube.com/channel/UCg3qsVzHeUt5_cPpcRtoaJQ

Maclean, Julie, Yeslam Al-Saggaf and Rachel Hogg.
2020. "Instagram photo sharing and its relationships with social rewards and well-being" in *Hum Behav & Emerg Tech* 1–9.

Manovich, Lev.
2005. “The Poetics of Augmented Space” http://manovich.net/index.php/projects/the-poetics-of-augmented-space

Mulvey, Laura.
2009. *Visual and other pleasures*, Houndmills, Basingstoke, Hampshire England New York: Palgrave Macmillan

Munn, Luke.
2018. “Rendered Inoperable: Uber and the Collapse of Algorithmic Power”, APRJA Volume 7, Issue 1.

Nake, Friede.r
2016. “The Disappearing Masterpiece: Digital Image and Algorithmic Revolution.” In Proceedings of the Conference on Computation, Communication, Aesthetics and X, 16.

Nelson, Peter A.C..
2020. *Mod Theory Seminar Series*. https://www.peteracnelson.com/mod-theory

Noble, Safiya Umoja.
2018 *Algorithms of oppression*: How Search Engines Reinforce Racism. New York: NYU Press.

Peter, Alex.
2019 “*Instagram is Removing All Plastic Surgery-Effect Filters”* Dazed Beauty. https://www.dazeddigital.com/beauty/head/article/46506/1/instagram-is-removing-all-plastic-surgery-effect-filters

Rosa, Sophie K..
2021 “In Defence of Sex and Parties” Novara Media. https://novaramedia.com/2021/02/05/what-happened-to-the-lefts-love-of-partying/

Silva, Tarcízio.
2020. “Racismo Algorítmico - entre a desinteligência artificial e a epistemologia da ignorância” Revista Select. ORG. 2020. *Comunidades, Algoritmos e Ativismos Digitais: Olhares Diaspóricos*. LiteraRUA.

Srnicek, Nick.
2016. *Platform Capitalism*. Polity.

Steyerl, Hito.
2013, “Too Much World: Is the Internet Dead?” e-flux Journal #49 https://www.e-flux.com/journal/49/60004/too-much-world-is-the-internet-dead/

Tolentino, Jia.
2019. *“The Age of Instagram Face: How social media, FaceTune, and plastic surgery created a single, cyborgian look.”* New Yorker. https://www.newyorker.com/culture/decade-in-review/the-age-of-instagram-face

Ulrik Andersen, Christian and Søren Bro Pold.
2018. *The Metainterface: The Art of Platforms, Cities, and Clouds*, MIT Press

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Autonomous Creation of Musical Pattern from Types and Models in Live Coding

Keywords: Live Coding, Musical Artificial Intelligence, Computational Creativity, Algorithmic Pattern, Human-Computer Interaction

Elizabeth Wilson
elizabeth.wilson@qmul.ac.uk
Queen Mary University, London, UK

Shawn Lawson
shawn.a.lawson@asu.edu
Arizona State University, Tempe, USA

Alex McLean
alex@slab.org
Research Institute for the History of Science and Technology, Deutsches Museum, Munich, DE

Jeremy Stewart
jeremy.ste@gmail.com
Rensselaer Polytechnic Institute, Troy, NY, USA

In this paper we describe the implementation of an autonomous agent for live coding—the practice of creating art in real-time by writing computer code. The TidalCycles language (an extension of the strongly typed functional programming language Haskell) is used for the generation of new musical patterns. This is integrated as part of a system which allows automatic suggestion of the agent's patterns to a live coder. We aim for this to be a co-creative system, using machine agents to explore not-yet conceptualised code sequences and support coders in asking new questions.

1. Introduction

This paper investigates the autonomous generation of musical pattern through the practice of *live coding*—a term used to refer to performers creating art by writing computer code, usually in front of an audience (Collins et al. 2003). In live coding, computer language is the primary medium for notation and describing the rules with which to synthesise artworks, in this case we consider the case where the output is musical pattern. The practice of live coding places a strong focus on liveness, embracing error, indeterminism and clear mappings between syntax and output. It constructs a paradigm for musical interaction and forms the basis with which we explore creating an autonomous agent.

1.1. Musical Pattern in TidalCycles

For this system of autonomously generated live coded music, the TidalCycles language is used (commonly denoted as *Tidal*). Tidal is a real-time, domain-specific language (embedded in the strongly typed functional programming language Haskell) used for pattern construction. The Tidal language itself does not produce any audio, rather it produces patterns of Open Sound Control (OSC) messages. These are most commonly sent to a sampler and synthesizer engine in the SuperCollider software, which handles the audio synthesis and rendering. However, it is also applicable to other types of pattern, and has indeed been used to pattern live choreographic scores (Sicchio 2014), woven textiles (McLean 2018), lighting, and VJing. Here is a trivial example of a pattern in the TidalCycles language:

```
d1 $ fast 2 $ sound “bd sn”
```

In the above, ‘`d1`’ stands for a connection between Haskell and SuperCollider. The ‘`sound`’ function specifies outgoing OSC messages and the double quotes denote a pattern of samples to be played using Tidal’s ‘mini-notation’, in this case a bass drum followed by a snare drum sample, played in a loop or *cycle*. The Tidal-specific function ‘`fast`’ speeds up the pattern by the given factor, in this case the pattern would be played two times per cycle. The dollar operator is inherited from Haskell, giving function application with low precedence, therefore passing the ‘sound’ pattern as the second argument of ‘`fast`’. The live-coder evaluates this in their text editor of choice, causing the pattern they have constructed to begin to play, which it does until they decide to edit and re-evaluate the pattern, causing a change in the music on-the-fly.

Tidal was chosen as the target for our creative agent for two main reasons (other than the authors' familiarity). Firstly, although known as a popular live coding environment for human musicians, it originally stemmed from a representation for machine learning and generation, through a project modelling rhythmic continuations based on Kurt Schwitters' sound poem "*Ursonate*" (McLean 2007), and so is designed to be straightforward to parse and manipulate for computers as well as humans. Secondly, in typical models of musical generation, representation of musical structure is usually limited, due to the tendency of these models to use low-level symbolic representations, most often in MIDI format. Although MIDI allows a certain level of expressive completeness in its representation, many generation algorithms reduce these to impoverished note representations of pitch number and velocity, thus losing nuance around timbre, expression and structure. We want a richer representation of music in the generation process for greater depth of musical expression and more learning opportunities for our machine counterparts.

An extensive framework for the description and evaluation of music representation systems suitable for implementation on computers is provided in (Wiggins et al. 1993). Coding languages are a particularly strong way to do this, due to their relation to natural language. Although natural language and programming languages are ontologically distinct, programming languages provide a means for human expression due to the way that syntax can be used to convey musical meaning. Coding presents the musician with the ideal set of tools and performance context for algorithms to be written in the form of instructions (Magnusson 2011).

1.2. Motivation

Many musical generation systems posited as artificially intelligent are often trained on corpuses of musical pieces in which the outcome has already been predetermined. The training corpus provided is usually a set of works by a composer or composers of a certain era or musical genre. Music where some of the elements of the composition are left to chance is often known as *aleatoric*, *stochastic* or *indeterminate music*. Examples include John Cage's *Music of Changes* to determine music structural elements by chance, using methods derived from the I Ching, or procedures of graphic notation scores, used in the works of André Boucourechliev and Sylvano Bussotti, in which drawings, images, or other non-musical symbols are used to suggest musical ideas to the performers (Brown 1986). Indeterministic music is an under-explored area in the field of musical artificial intelligence, mostly due to the inherent challenges posed by training on a corpus that is not fixed. Live coding provides a conceptual framework for this work to exist, as randomness is often encoded inherently in its structure. This is true of algorithmic music in general, although live coding adds an additional level of indeterminacy, as the notation is designed to be changed while it is followed.

Another of the main motivations in creating this autonomous agent is to provide a way of generating musical ideas that have not previously been conceptualised by human live coders. Perhaps this can be used as a way to combat forms of what Wiggins (2006b) describes as 'uninspiration' by traversing across (and beyond) a search space for novel ideas. Here Wiggins builds on the pseudo-formal definition of creativity provided by Boden as "the generation of novel and valuable ideas" (Boden 2004, 3). We can see how a co-creative system might arise under this definition of creativity, where the machine agent can generate *novel* patterns whilst the human live coder can determine the *value* of these novel ideas. Starting from this point it is clear how to form an interaction loop, where the live-coder generates patterns and a machine agent can also develop a sense of value for these.

Perhaps surprisingly, as practising live coding musicians ourselves, we find that listening to code can be a more important part of live coding than writing it in the first place. In other words if code is a map and music is the territory, then the code can only be read and understood when you listen to the territory that it generates. This is true also of the person who is writing the code, who has the experience of editing the code, hearing the result, and only then being able to fully understand their edit and decide what to change next in response. By writing and editing code, the live coder may be making imperative statements (stating how they want music to be made) or declarative statements (stating what music they want to be made) but they are doing so in order to ask questions - which aren't about *how* or *what*, but *what if*? From this perspective, our project aims to support live coders in asking new questions.

Beyond the practical implementation of such a new interface, we hope this system can augment our understanding of how humans and machines can improvise together. The abstraction of human creativity into computer systems is useful for developing an understanding of how co-creativity with a machine musician aids in the development of methodologies for human-machine improvisation strategies (Wilson et al. 2020). The motivation for creation of this system is to understand more about co-creativity rather than solely machine creativity using search-based techniques and looking at knowledge-based systems exploring conceptual spaces.

Whilst individualistic self-expression is essential to any composer, it should be acknowledged that composition itself does not occur in a vacuum, but rather emerges from community traditions, practices and styles. Likewise, the ethos of live coding is built around community and knowledge-sharing and in turn, the music a live coder makes is interdependent on the communities they exist in. Integrating an autonomous agent serves as an expansion of creative and collaborative practice and thus is hoped to better the live coding community as a result.

Moving further into the territory of autonomous generation of musical pattern, it is important to take stock of the ethical implications of such a system. Music generation systems face ethical minefields around issues of authorship, licensing, data-privacy and inherited societal biases reflected in the music produced. We want to acknowledge that these are potential issues for our system but defer addressing these questions currently, focusing instead on discussion of how our system was developed for its aim of creating musical patterns with code.

2. Background

2.1. Autonomous Agents in Live Coding

Autonomous generation of music has been well explored in recent computer music history, spanning from the first attempt at generating scores, often cited as Hiller's Illiac Suite (Hiller 1957) for the Illiac I computer, through to the deep learning works of Google's Magenta project (Huang et al. 2018) and entries to the AI song contest (Huang et al. 2020). Of particular interest is the work of George Lewis in creating Voyager (Lewis 2000) — an interactive improvisational system with a machine counterpart. Lewis's work was particularly influential as it acknowledged music was more than just data about note relationships but rather music was a product of community and he attempted to encode these aesthetic values into his work. Lewis's work was also particularly relevant as it saw automation as an opportunity for augmentation of the creative process and these ideas align strongly with our motivations.

Given the prolific climate for artificial intelligence and live coding's grounding in human-computer interaction, it is unsurprising that the challenge of co-creation with machine musicians has already been attempted. Co-creation collaborative configurations (human-machine, machine-machine) in various contexts are explored in (Xambo 2017), identifying potential synergies and novel insights of co-creativity applied to collaborative music live coding. Notable examples that generate Tidal code include an autonomous performer, Cibo, which tokenises Tidal code and uses a sequence-to-sequence neural network trained on a corpus of Tidal performances to generate novel patterns (Stewart and Lawson 2019) or using a defined-grammar and evolutionary algorithms to evolve patterns, using the collaborative live-coding platform Extramuros (Hickinbotham and Stepney 2016).

2.2. Creative Systems

To contextualise this work, we look to some definitions of creative systems. Margaret Boden, a prominent figure in the philosophy of computationally creative systems, defines the notion of a "conceptual space" as a set of artefacts which, in some quasi-syntactic sense, are deemed to be acceptable examples of whatever is being created. From Boden's definition of creativity (2004) arises the ideas of exploratory creativity (the process of exploring a given conceptual space) and transformational creativity (the process of changing the rules which delimit the conceptual space). A formalism of creative systems, the Creative Systems Framework, provided by Wiggins (2006a), defines an exploratory creative system (such as the one here presented) in mathematical representation. This formalism can also be expanded to transformationally creative systems, by considering transformational creativity as exploratory creative on the meta-level. Considering creativity as a search through conceptual space there are clear similarities between this and traditional AI search techniques (Wiggins 2006b). Particularly the notion of a state space (i.e. the space of partial or complete solutions to a particular algorithm) is closely related to Boden's idea of a conceptual space. Many strategies used by humans in creative practice closely resemble algorithms too, artists often use generate and test strategies (Buchanan 2000).

The creative system framework has been applied to create conceptual spaces for possible creative agents in Tidal in (Wiggins and Forth 2018) and a discussion is offered on where creative responsibility in live coding can be shared with a computer. When sharing creative responsibility with a machine agent in Tidal, Wiggins and Forth advocate for three key components. The first is the ability of a computer to relate the meaning of a program to its syntax. Secondly, the computer should have some model for the coder's aesthetic preferences. Finally, the system should have the ability to manipulate the available constructs to take some creative responsibility for the music. This work focuses mainly on the latter aspect of this proposition.

3. Creative Search

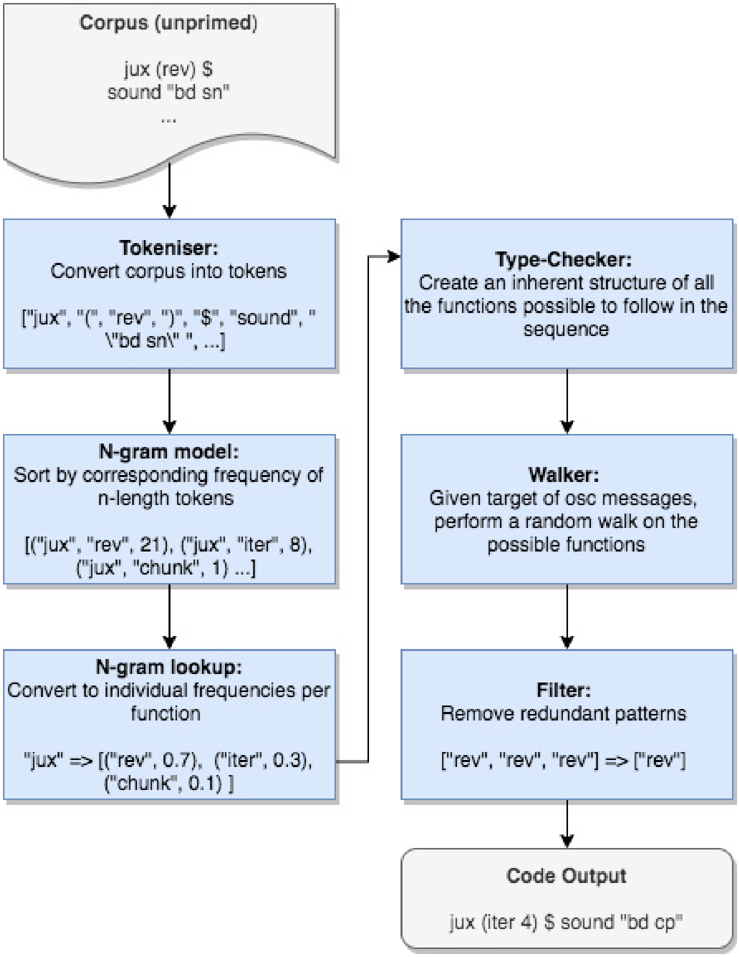


Fig. 1. Flow of the different components of the algorithm needed to produce code sequences, from generating the model from the data to creating syntactically correct code by type-checking.

The search strategy for generating the Tidal agent's outcomes combined a random walk process with Haskell's type system. The possible states for the walker are the various type signatures of functions. The aim was to create a walker agent that could navigate through the conceptual space of all possible syntactically valid Tidal code. Weightings for this walk process were supplied by an n-gram model: a contiguous sequence of n-functions generated from a corpus of existing Tidal patterns. From this model, potentially infinite strings of code can be generated, providing the search space for the creative agent. However, derived rules and constraints are necessary components of the model to produce useful, executable code. The overall flow from the tokenisation of the corpus, through to creative search and generating code can be seen in Figure 1.

3.1. The Tidal 'Universe'- the Types

Being embedded in the Haskell language means TidalCycles inherits Haskell's system of static, pure types. The type of every expression is known at compile time, leading to safer code. Haskell has type inference which means types don't have to be explicitly specified where they can be inferred by the compiler. Nonetheless in Haskell all functions and other values have an underlying "type signature", defining the types of pure inputs and outputs. Tidal's representation of musical pattern applies the principles of Functional Reactive Programming (FRP), so rather than representing music as data structures, it instead represents it as behaviour—as functions of time.

Tidal's representation of pattern in the Haskell type system has profound impacts on the functionality of the language. For example, instead of representing a sequence as a list of events, it represents sequences as a function, taking a timespan (or rather, a time arc, as time is treated as cyclic) as input, and then returning all the active events during that timespan (McLean 2020). These types are defined as instances of standard Haskell type-classes, including functors, applicative functors and monads. As a result, Tidal patterns are highly composable, at different levels of abstraction. By composable, we first mean in the computer scientific sense — that as functions, patterns can be flexibly composed together into new patterns, but also in the musical sense, in that complex musical behaviour can be composed together from simple parts.

This type system forms the basis with which our autonomous agent can construct new patterns of code. The implementation of this occurs as follows. We start with a dictionary of available functions/values in Tidal, each with a representation of its type signature and the number of times it should occur within any Tidal pattern. An initial target is specified as a pattern of synthesiser control messages as this is the standard output from any Tidal pattern. The walker starts by randomly choosing any function that could produce a pattern of the type of the target. Based on the system's implicit weightings and rules, which are outlined in the following sections, the algorithm recurses through the possible functions and chooses a function that can fit with the next pattern in the sequence, where the possible permutations of functions that fit together are also explicitly defined. Figure 2 shows the implementation of this. Finally, the recursion ends once the target sequence has been fulfilled. The code generated in the instance of Figure 2 would be:

```
d1 $ jux (rev) $ sound "bd sn"
```

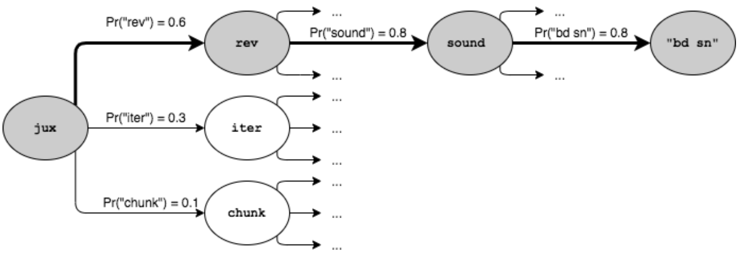


Fig. 2. A directed acyclic graph to illustrate the construction of the simple pattern - `jux (rev) $ sound "bd sn"` - where the highlighted nodes are the functions chosen by the algorithm at each recursive step. The arrows represent the possible transition probabilities to any other possible states.

In this example, the target is 'Pattern Control Map' (a pattern of synthesiser control messages) and the walker randomly chooses the function `'jux'` as a starting point. This is a function with two arguments, the first argument is a function to apply to the pattern given as its second argument, but it does so only in the right-hand audio channel, giving a stereo juxtaposition where one channel is transformed and the other is not. The result of `'jux'` is a new pattern, but in order to arrive at this we must provide the functions inputs. The walker therefore recurses, calling itself with the type of each argument. This recursion allows for one of the arguments to itself be a function that requires further arguments, although that is not the case with this simple example. Note that while `'rev'` is a function, in this case it is treated as a value to pass to `'jux'`; in other words, 'jux' is a higher-order function. The walker continues to recurse and produces a sequence, until it meets the target type signature, where the process terminates.

3.2. Reducing the Search Space

The walker can generate code that is syntactically correct and therefore executable. However, the demands of live coding as a musical practice mean code should be kept concise enough to create a pattern that is both able to be processed by the audio engine without excessive latency, and also with brevity required for both the musician and audience to have some understanding of its relation to the musical output. It was therefore necessary to reduce the options in the search space to those which resembled code a human live coder might produce, although arguably, machine generated code does not have to directly resemble a human's output: human coders have learnt coding behaviours (style, function choice, sample choice) whereas machine generated code is stylistically agnostic and this agnosticism could prove beneficial for creative ideation.

The generation method has similarities with evolutionary computing's ideas of search and optimisation, and accordingly techniques were borrowed from this field, particularly for reduction of the code. The first search reduction technique incorporated into the algorithm was *bloat*, i.e. where there was an increase in mean program size without improvements in fitness and where the output generated grows excessively due to redundant operations (Luke et al. 2006). For this pattern generation algorithm, function selection was limited to those functions that had not been seen previously. In practice, this reduces bloat by ensuring two functions that have the same action can not be applied in succession, preventing excessive growth. For example, in the TidalCycles language, the 'rev' function will play a pattern in its reverse order, however applying this twice is equivalent to not applying at all and thus adds bloat to the pattern generation.

Further pruning was applied to the search, similar to those seen in search-based algorithms (Garcia et al. 2006). Another of the goals in pruning was removing idempotent functions, i.e. with set E and function composition operator $\circ$, idempotent elements are the functions $f: E \rightarrow E$ such that $f \circ f = f$, in other words such that $\forall x\ E, f(f(x))=f(x)$. This was removed by the algorithm in the case where the function '`every 1`' was applied to another function. This is analogous to the function itself being applied and was thus removed.

3.3. Navigating the Search Space

To navigate a creative search space it was important to be able to steer this walk. To achieve this, weights were applied to all of the possible functions that could occur next in the sequence, corresponding to their respective transition probabilities. A corpus of code patterns created from TidalCycles users was provided as the source for the weightings. The code patterns were used as the source for an algorithm written to tokenise the functions and convert them into an n-gram model. This provided a data structure which, when picking any function at random, can provide the next function to be picked based on its weighted likelihood.

These weights were not static and the weights would redistribute throughout the pattern generation process to ensure excessive and impractical (or potentially infinite) code was not generated. The possible values for the next function in the sequence were chosen using a squared reciprocal factor as the *arity* (how many arguments the function takes) and *depth* (how many functions have already been chosen prior) parameters increased. A user-controlled environment variable was included in this reweighting factor modifying the overall decay rate of these weights, allowing control over the rate at which the weights decayed to zero and thus the length of sequence generated.

Finally, the walker finishes navigating once it arrives at an expression that meets the target type signature. There are fairly rare cases where it reaches a dead-end - applying functions to functions until it finds a type signature which is not possible to meet with the functions and values available to the walker. Currently if this happens the walker gives up, although in the future we intend to investigate a back-tracking procedure.

3.4. Evaluating Patterns

The current state of the algorithm has no particular faculties for evaluation of its own output, other than the listener's perception. Evaluation is a crucial part of any system that claims computational creativity, yet this is often done with the researcher's subjective claims of creative behaviour (Agres et al. 2016). Human evaluation may still be the best way to judge whether a produced piece sounds aesthetically pleasing, however there are drawbacks to this method. Requiring human participants to rate the algorithm's output over multiple iterations of generated code could take an excessive amount of time for the listener. Furthermore participant fatigue is a commonly noted, yet often ignored, problem with listening tests (Schatz 2012) affecting the reliability of the results.

Additionally, human evaluation might never reach an empirical consensus on what is aesthetically pleasing due to the vast differences in listener preferences. If our goal is simulating some form of artificially intelligent musical behaviours, then the capability of a system to reflect on its productions should be an important functionality of a computationally creative system.

4. Challenges in Code Generation

One of the challenges in creating our autonomous agent was steering throughout the space in a logical way, similar to how a live-coder might produce a coherent musical pattern in Tidal. The first iterations of code generated by the algorithm were often found going down unsolvable or infinite paths. We found weightings from the n-gram model worked well to keep the code produced reasonable, by contextualising code generation in what is likely to happen.

Another of the main problems encountered with this system was with the *mini-notation* within the Tidal language. This is a terse way to represent events within a pattern in Tidal syntax. The mini-notation in TidalCycles is based on the Bol Processor (Bel 2001). Within the mini-notation, polyrhythms, polymeter, repetition, and rhythmic subgrouping can all be described as part of the string passed to the sound function. These additional complexities of notation were omitted in this early version, where mini-notation strings are treated as single tokens. Future work will incorporate generation of mini-notation strings into the process.

5. Outcomes

The overall system as it can be used in performance is seen in Figure 3. This includes building a custom Haskell listener module to request a pattern when a command from the Atom Editor is executed. The listener module, on receiving an OSC message from the Atom editor, then requests a pattern from the walker module. This is then sent back to the listener, parsed into JSON format and then sent to the Atom editor, where the pattern is displayed as a suggestion to the user. This can then be evaluated by the human live coder, which sends the pattern to the SuperCollider sound synthesis engine, rendering the pattern into the acoustic domain for the live coder to listen to, evaluate and then continue to edit their performance.

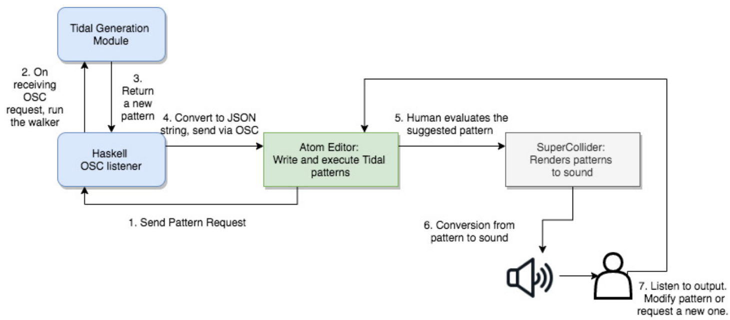
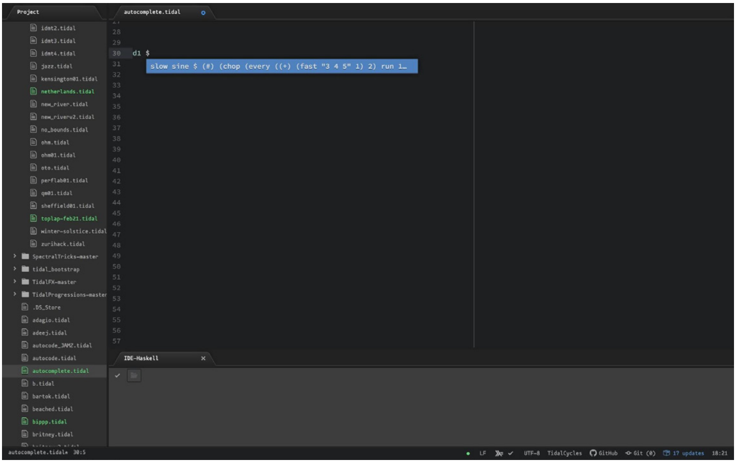


Fig. 3. The overall structure of the system as used in performance.

5.1. Auto-suggestion of Patterns in the Atom Editor

An autocomplete package was written for the Atom text editor software, where Tidal code is usually evaluated, so that the agent could suggest code patterns in real-time. The autocomplete package requests code sequence options from the autonomous agent. These options are returned, displayed to the user in a typical format of a dropdown menu of options to select. Three potential use-cases were thought of during the development using the code generation as a suggestion engine: education, collaborator, and auto-performer.



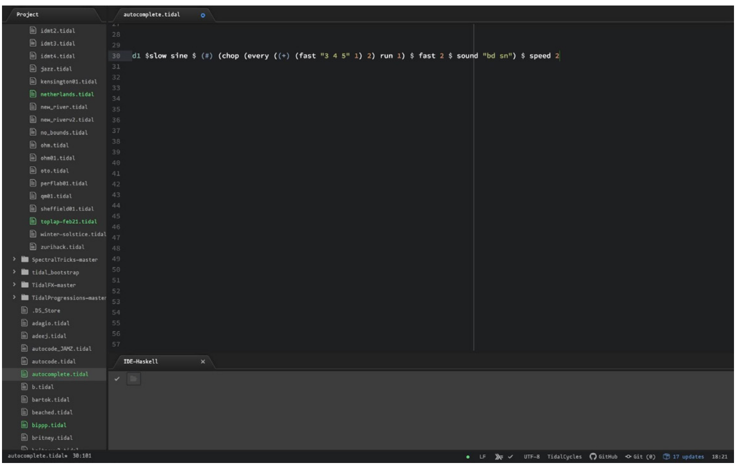


Fig. 4. The Atom Text Editor Package auto-suggesting a syntactically valid code sequence, which would produce a musical pattern when evaluated.

In the education context, the autonomous agent can be called upon to supply someone learning TidalCycles with possible code sequences. The student would be able to see and then select valid code sequences. This helps reduce the learning curve by having small examples at-the-ready, overcoming blank-slate situations of not knowing what to type, and to reinforce learning by doing. The live-coder is allowed control over the length of sequences generated, allowing those using in the learning context to generate manageable pattern suggestions. These suggestions can deepen their knowledge of how the language is used.

For the experienced TidalCycles user, the autonomous agent could be a creative collaborator. In the process of creating new live-coded audio, a user may look to the autonomous agent for inspiration or something completely random that the user may not have thought of. In a sense, consider this as a creative bump or push. Additionally, as a thought experiment, the user may employ the autonomous agent as an antagonistic collaborator. This antagonistic collaborator may insert short sequences of code that the user must work with or work around - not unlike setting up a Surrealist's game.

In the last example of the auto-performer, additional system structure can be added to facilitate the autonomous agent to become a performer for either solo or ensemble member contexts. While similar in outcome to other machine agent performers, the methods of code sequence generation are unique and may lead to new sound producing practices and ideas within live performance.

5.2. Pattern Production

Although this system is still in the early stages of development, its results have been promising with its capabilities to produce syntactically correct and executable code. Sequences where weighting was decaying faster produced results like that below, similar to the trivial short phrases a live-coder might write.

```
fast 2 $ jux (rev) $ sound “bd sn”
```

With an optimal decay rate, patterns that produced some interesting (and sometimes unpredictable) behaviours were produced:

```
(#) ((#) (chop ((+) 1 "3 4 5") $ vowel $ fast (rev 1) "a e i o u") $ speed
2) $ slow (rev $ fast "3 4 5" 1) $(#) (shape $ rev $ fast 2 1) $ slow 2
$ slow 2 $ sound $ every (rev 1) rev "bd sn"
```

```
chop (fast "3 4 5" $ (+) (fast 2 $ rev 1) 2) $ slow "3 4 5" $ fast "3 4
5" $ (#) (sound "bd sn") $ shape 1
```

```
(#) ((#) (rev $ fast 1 $ speed 2) $ shape $ every  (rev $ run $ every
(slow 2 1) (every 2 rev) 1) rev 2) $ sound "bd sn"
```

The former creates a combination between Tidal's granular synthesis function '`chop`' and vowel formant resonances effects '`vowel`', producing a staccato vocaloid pattern. The second pattern takes the same chop function, but alternates the size with which to chop the samples up by, creating a delay effect. The latter creates a pattern out of the shape effect (a form of amplification) on the bass drum and snare drum sample. It does this to such an extent that it produces a pitched sound, by pushing the clipping towards a square wave.

Some more examples of sonic patterns produced by the autonomous live-coding agent can be found at https://soundcloud.com/tidal-bot-main.

Live performances using patterns from the autonomous coding agent can be found at https://www.youtube.com/channel/UCEkXT_natfoK8Kwy3z5hLRw

6. Future Work

The models for generating patterns could be extended in future work as follows. Firstly, although the system has the capability to generate and make use of n-grams, these were restricted to bigrams as a proof-of-concept. When generating the transition probabilities to the next possible functions, the agent only has contextual awareness of one function ahead in the sequence. Whilst this works to some extent, given that some functions in Tidal often are composed of two or more parameters, the agent is not aware of wider context. Extension to tri-grams or n-gram models for any $n \in N^*$ is possible and should be included in future implementations.

Currently the user interaction with the system is limited to only controlling the length of sequences produced. Future versions of this project could look further into the role of the human in such a system, looking for any particular tradeoffs that might occur between how much control is given to the human over the computer. In the Conductive system (Bell 2013) (a Haskell live coding environment), "players" are introduced as a means with which the human can interact, where the programmer is in control of semi-autonomous agents. The autocomplete package is designed to act as a similar mechanism to the players in the Conductive system, where the live coder can retain control over the agents suggestions and ultimately view this as a creative partnership.

For true two-way creative partnership to occur, additional evaluation of the success of the system is required. Moreover, for it to be considered as a computationally creative system some capacity for self-reflection is needed, arguably this a necessary facet of a truly creative system (Agres et al. 2016). As it stands we are not making any assertions on its capacity for creativity, rather are investigating how it can be used as part of a creative process.

Finally, the *live* in live coding suggests that future iterations of this work would benefit from live performance and evaluation of these performances. This would allow the audience to participate in the evaluation by offering feedback and reflections on both the system's outputs and the creative processes that produce them.

7. Conclusion

The work here presents an autonomous agent for live coding in the TidalCycles language. This agent can produce syntactically correct code by piecing together functions from a random walk process. Using Haskell meant that the type system could easily be leveraged to ensure sequences fit together in a way that would produce syntactically correct code. The agent is provided as a proof-of-concept and we have discussed various future extensions to this work. Most importantly, we emphasise the role of automation as an opportunity for augmentation of the creative process.

Acknowledgements. McLean's contribution to this work is as part of the PENELOPE project, with funding from the European Research Council (ERC) under the Horizon 2020 research and innovation programme of the European Union, grant agreement no. 682711. Wilson's contributions were supported by EPSRC and AHRC under the EP/L01632X/1 (Centre for Doctoral Training in Media and Arts Technology) grant and the Summer of Haskell programme, part of the Google Summer of Code.

References

Agres, Kat, Jamie Forth, and Geraint A. Wiggins. 2016. "Evaluation of musical creativity and musical metacreation systems". In *Computers in Entertainment* (CIE) 14(3), 1–33.

Bel, Bernard. 2001. *Rationalizing musical time: syntactic and symbolic-numeric approaches*

Bell, Renick. 2013. "An approach to live algorithmic composition using conductive". In: *Proceedings of LAC*. vol. 2013

Boden, Margaret A. 2004. *The creative mind: Myths and mechanisms*. London: Weidenfeld and Nicolson.

Brown, Earle. 1986. "The notation and performance of new music." *The Musical Quarterly 72*, no. 2 (1986): 180-201.

Buchanan, Bruce G. 2000. "Creativity at the Meta-level," *AI Magazine*. Reprint of keynote lecture to AAAI-2000.

Collins, Nick, Alex McLean, Julian Rohrhuber, and Adrian Ward. 2003. "Live coding in laptop performance". In: *Organised sound 8*(3), 321–330.

Garcia-Almanza, Alma Lilia, and Edward PK, Tsang. 2006. "Simplifying decision trees learned by genetic programming". In: *2006 IEEE International Conference on Evolutionary Computation*. pp. 2142–2148.

Hickinbotham, Simon, Susan Stepney. 2016. "Augmenting live coding with evolved patterns". In: *International Conference on Computational Intelligence in Music, Sound, Art and Design*. pp. 31–46. Springer.

Hiller, Lejaren, Jack McKenzie, and Helen Hamm. 1957. *Illiac suite*.

Huang, Cheng-Zhi Anna, Hendrik Vincent Koops, Ed Newton-Rex, Monica Dinculescu, and Carrie J. Cai. 2020. "AI Song Contest: Human-AI Co-Creation in Songwriting." *arXiv preprint arXiv*:2010.05388.

Huang, Cheng-Zhi Anna, Ashish Vaswani, Jakob Uszkoreit, Ian Simon, Curtis Hawthorne, Noam Shazeer, Andrew M Dai, Matthew D Hoffman, Monica Dinculescu, and Douglas Eck. 2018. "Music transformer: Generating music with long-term structure". In *International Conference on Learning Representations*.

Lewis, George E. 2000. "Too many notes: Computers, complexity and culture in voyager". In: *Leonardo Music Journal*. pp.33–39.

Luke, Sean, and Liviu Panait.
2006. “A comparison of bloat control methods for genetic programming”. In: *Evolutionary Computation* 14, no.3: 309–344.

Magnusson, Thor.
2011. “Algorithms as scores: Coding live music.” *Leonardo Music Journal* (2011): 19-23.

McLean, Alex, and E., Harlizius-Kluck.
2018. “Fabricating algorithmic art”. In *Austrian Cultural Forum*.

McLean, Alex.
2007. “Improvising with synthesised vocables, with analysis towards computational creativity.” PhD diss., Master’s thesis, Goldsmiths College, University of London.

McLean, Alex.
2020. “Algorithmic pattern”. In *NIME*.

Schatz, Raimund, Sebastian Egger, and Kathrin Masuch.
2012. “The impact of test duration on user fatigue and reliability of subjective quality ratings.” *Journal of the Audio Engineering Society 60*, no. 1/2 : 63-73.

Sicchio, Kate.
2014.“ Data management part iii: An artistic framework for understanding technology without technology”. In: Media-N: *Journal of the New Media Caucus 3*(10).

Stewart, Jeremy, Shawn Lawson.
2019. “Cibo: An autonomous tidalcycles performer”. In: *International Conference on Live Coding*.

Wiggins, Geraint, Eduardo Miranda, Alan Smaill, and Mitch Harris.
1993. “A framework for the evaluation of music representation systems”. In: *Computer Music Journal 17*, no.3. pp 31–42.

Wiggins, Geraint A.
2006a. “A preliminary framework for description, analysis and comparison of creative systems”. In: *Knowledge-Based Systems 19*, no.7. pp 449–458.

Wiggins, Geraint A.
2006b. “Searching for computational creativity”. *New Generation Computing 24*, no.3 (2006): 209–222.

Wiggins, Geraint A, and Jamie, Forth.
2018. “Computational Creativity and Live Algorithms” In: Alex McLean and Roger Dean, eds. *The Oxford Handbook of Algorithmic Music*. Oxford, UK: Oxford University Press.

Wilson, Elizabeth, György Fazekas, Geraint Wiggins.
2020. “Collaborative human and machine creative interaction driven through affective response in live coding systems.” In: *International Conference on Live Interfaces* (2020)

Xambó, Anna, Gerard Roma, Pratik Shah, Jason Freeman, and Brian Magerko.
2017. “Computational Challenges of Co-Creation in Collaborative Music Live Coding: An Outline.” In *Proceedings of the 2017 Co-Creation Workshop at the International Conference on Computational Creativity*.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Synthesis and Operation Flows

Keywords: Synthesis, Algorithms, Signal Flows, Sound Streams, Sound Transformation

Bjarni Gunnarsson
bjarnig@gmail.com
Institute of Sonology, Royal Conservatoire

Digital sound synthesis can be described in terms of discrete operations applied to signals according to given criteria. The process of organising such operations can be subject to creative variation and generative algorithms. This article presents proposals for how a sound construction process can be thought of as a combination of synthesis and applied transformations. Operational spaces are examined and how process configuration and incompleteness can serve as creative models for synthesis. Properties of sound streams are also considered and how they can involve liveness and unpredictability. A software framework is finally introduced followed by a reflection on its use in creative practice.

1. Introduction

Algorithmic music procedures often involve generating data that requires mapping to a musical domain. Sound synthesis on the other hand usually concerns a more direct description of a signal flow. Instead of using predefined algorithms during composition what is proposed here is to use dynamic workflows inspired by data transformation pipelines and signal flows. Such processes are adapted in order to produce algorithmic sound based on synthesis, transformations and the manipulation of sound streams.

The goal here is to propose a model of a *synthetic sound stream* as a *pipeline of transformations* that can be freely manipulated or changed while they run. A related concern is how to generate transformation pipelines in order to produce evolving sounds. Focusing on synthesis and sequences of sound transformation reveals a working mode centred entirely around sound itself. It also introduces a functional strategy that concerns treating sound as an *operation sequence*. Finally, it questions how dynamic changes in synthetic sound streams can work as a flexible interaction mode and how the attitudes of evolving algorithms can be made audible through the resulting sound.

A software framework named OF (Operation Flows) will be introduced that implements some of the ideas covered here in this text. It consists of four main process categories:

1. Synthesis processes with dynamic waveform generation

2. Atomic sound transformations that adapt to incoming signals

3. Operation pipelines and algorithms to control and generate them

4. Direct access, observers and reactions for content-based triggers and actions

The framework allows for experimenting with synthesis and algorithmic pipelines of sound transformations. It is designed to be configured with common existing workflows and to be easily extensible. Examples that demonstrate the relation between the text and the system will be presented here below.

2. Background

2.1. Operational Spaces

Computer music processes consist of transformations that are applied to musical material in order to develop and extend it over time. Such transformations fluidly translate into algorithms allowing for automation, iteration or generative possibilities. The construction of automated processes, or the encoding of *"frozen thought"* (Chaitin 2005, 24), preferably involves transparent, elementary operations that are combined into precise steps and a clear sequence of actions. How mechanically executable tasks are defined and a chain of operations is arranged is something considered here as part of original sound synthesis and the becoming of electronic sound.

Creative intentions take shape during the activity of sound production and not only prior to it. By focusing on the operational as 'on-going', the aim here is to explore conditions where one continuously engages with generative sound processes and how they are constructed. The arrangement of synthetic sound streams and how connecting to them can be part of a creative process creates a bridge between algorithms and the operations of electronic music production. Focusing on the actions and algorithms behind sound streams allows for data processing to be considered as a fruitful model for sound composition.

In her book *Programmed vision* Wendy Hui Kyong Chun refers to the process of mechanization as *'Automatic programming'* (Kyong Chun 2011, 41). She argues that it contributes both to a certain deskilling but also to the forming of craftsmanship where *"through automation, expertise is both created and called into question"*. The particularity of a given task is highlighted here through repetition and purification of the steps it consists of. Kyong Chun also emphasises the specificity of the programmable medium where algorithms translate to "this thing called software—something theoretically (if not practically) iterable, repeatable, reusable, no matter who wrote it or what machine it was destined for".

Kyong Chun's vision brings about the idea of operational space, afforded by software, where elements enter into dynamic relations and display a rich possibility of connecting. This malleable nature of software allows for *"making possible the transformation of anything into anything else via the medium of information"* (Kyong Chun 2011, 57). It is particularly useful to compare sound creation to information processing in order to think of synthesis as the selection of operations that are combined from a larger set of possible actions. The idea of Action space shaping (Kanervisto, Scheller and Hautamäki 2020) can be useful when addressing the arrangement of available operations. It refers to the modification of action space and how it can be refined within a given context. For example, how the number of potential actions can be restricted or how actions can be combined to better address any task at hand.

For our current purposes, it is important to think of an action sequence as something that can be composed or transformed but that remains in a tight relationship with any material or data that it processes. It is also important to note that an operation selection is made from the action space afforded by available material. Operation sequences then execute over time and leave traces through the action space with a strong imprint on the resulting sound.

2.2. Configuration

For the composer Gottfried Michael Koenig the concept of musical material includes not only sounds but also the method by which they are treated. Koenig introduced compositional processes where musical form appears as the result of sound operations and the production technique of derived materials (Koenig 1987). Methods thus become structurally bound to material and provide a direction of how sounds are ordered through their operational history. Furthermore, formal relationships between sounds are highlighted by the way they have been treated where *"work-processes, composed in detail, are related to each other, and these relationships come into evidence at the surface of the sounds. Each sound is therefore not a blotch of colour but itself a form, as it owes its existence to a formal construction, to a form process."* (Koenig 1965, 8).

The point of view Koenig proposes emphasizes how a sound creation process becomes part of the structural possibilities the sound material offers. Extending this idea, the models presented here below combine synthesis with operations of transformation and control. How the operations are applied and the consequence that has on working with the generated sound becomes an important focus point for creative treatment.

Thinking material together with its treatment requires highlighting the concept of what it consists of and the element it connects to. In the context of human-machine interaction, Lucy Suchman proposes the term configuration to assist us in thinking about technological processes with a *"particular attention to the imaginaries and materialities that they join together"* (Suchman 2012, 48). The nature of applied methods plays a key role where, instead of existing as independent of their application, *“they are figured within design and engineering discourses precisely not as already existing and independently agential, but as emerging from and dependent upon the actions of their (human) makers.”* (Suchman 2012, 55).

Configuration brings elements together, it enables the separate existence of processes while extending the boundaries of what their combination can produce. By joining together, configuration contributes to the wholeness of technical processes.

On a similar thread, sociologist John Law proposes the notion of method assemblage that *“detect, resonate with, and amplify particular patterns of relations in the excessive and overwhelming fluxes of the real”* (Law 2004, 14). He believes that a research method is constructed in parallel with what it achieves. It allows for discovering realities but also to be produced along the way and to assist in the attempt to *“recognise and treat with the fluidities, leakages and entanglements that make up the hinterland of research”* (Law, 41). Sound synthesis can be considered for such a purpose as it offers ideal dimensions for investigating the imprints of automated operations and context-sensitive processing.

A tight coupling between method and material highlights the importance of direct access and situated actions (Suchman 2006). Instead of forming abstract plans, every action is situated around the context it will occur in. This could translate to investigate sound-itself as having potential characteristics of dynamic activities, continuous change, uncertainty and a tendency of becoming. The goal is to arrive at a contact point where sound synthesis, the construction of compositional action plans and development of formal ideas are all more or less the same thing. This bundling (of material and method) is achieved by constructing pipelines of transformations (discussed below) that are applied to synthetic sound.

Of great importance are the direct actions that can be applied once the pipeline executes and interact with the way it unfolds. Instead of applying musical algorithms as mechanical sequences of actions, the idea is rather to apply the transformations over time with a possibility of articulating key aspects of how each transformation becomes audible. Manual interaction with the automated pipeline pervades the operational configuration and allows for an enhanced engagement with its processes.

2.3. Incompleteness

In her book *Software Theory*, Federica Frabetti examines the ephemeral nature of software, the distinction between system conception and realisation, and the difference between *"software as a product and software as a process"* (Frabetti 2015, 104). She draws attention to the difficulty of detaching a system from its development and the importance of iteration where implementation informs specification while also being conditioned by it. This highlights the strange incompleteness of system building where *"writing, experimentation, "working out" are essential disciplines for the theoretician"*. It also questions the boundaries between intentions and results and how implementations can bring about unexpected consequences. Such repercussions (or accidents) can in turn *"'reveal' the underlying assumptions of software—the ones we rely upon in order to make software intelligible."* (Frabetti, 161).

Frabetti reflects on how unexpected system behaviour contributes to a perceived sense of separation through the novelty it creates where at *"the moment when we are 'surprised' by software—is the moment when we form a 'point of view' on software that aporetically separates ourselves from it."* (Frabetti, 160). Both her 'assumptions' and 'surprises' can be understood as processes emerging from systems (or software) without having been part of their initial specification. Assembling automated processes can introduce a sense of incompleteness that can bring about side effects, expanding the potential behaviour realised with such systems.

For many musical works based on algorithmic processes, large-scale form is still done manually and without any computer assistance (Eigenfeldt 2014). The ephemeral nature of creative generative applications involves uncertainty and incompleteness. This often makes it ideal for local experimentation but difficult for any kind of global organisation. Perhaps that is the nature of electronic music somehow. Still, models can be developed that take advantage of such tendencies. Instead of composing with fixed systems, one can imagine working out musical material while setting up the operations it will be organised through. Instead of having positive accidents occurring during development, they become part of an automated synthesis process that can then be executed in various ways.

Another aspect of local contact between methods and material is how difficult it is to predict the long-term results of an action procedure. Although extended sequences of operations can easily be calculated, their relevance tends to stay the strongest around the local conditions from where they originate. However, events that are generated further away in time remain more uncertain to be of any use. A tension, therefore, emerges between perceived local sound and the direction of a technical process that has been pre-computed and put in motion. Addressing such tensions highlights the importance of an interactive relationship with algorithms on different levels.

3. Streams

3.1. Flow

A characteristic of raw electronic sound is how it unfolds like an endless stream. Unlike most naturally caused sounds, the synthetic ones last forever. Stopping a sound or making it disappear becomes something that requires decision making instead of being caused by properties of a sound-producing object. Synthetic sound, therefore, exists as a continuous flow waiting to be further transformed without any "limitations of human performance" (Holmes 2015, 123). For sound synthesis, this can mean to apply operations that disturb or halt a sound stream. The same principle can be applied to how a sound starts or changes.

Sound composition becomes the activity of managing a sonic flow from which things appear and later disappear. Streams of sound are characterised by their behaviour over time and the way they start and stop.

In his study of flow in television, media scholar *Raymond Williams* proposes a three-tier categorisation based on the order of detail. He claims that flow takes place over an evening programme, between events or on the detailed level of a particular movement where *"the characteristic experience, is one of sequence or flow"* (Williams 2003, 86). A flow consists of discrete items that are designed to appear in a sequence to bring about the flow and perception of progress. How the succession of the elements is designed is what contributes to their flow, motion and continuity. His investigation highlights how switching between various sources can in itself contribute to a flowing quality. A televised flow does not begin or end but takes shape once one engages with it while it unfolds.

Flow sequences can be extended to sound synthesis where transformation pipelines are activated but take place in time through programmatic switching. Algorithmic sound reflects the struggle of putting together discrete elements as unified and contributing to a coherent flow. A technical process contains a distinct flow, (or will) and directionality that potentially *"wants to sort itself out,* *to self-assemble into hierarchical levels [...] to perpetuate itself, to keep itself going. And as it grows, those inherent wants are gaining in complexity and force."* (Kelly 2010, 25). Tuning into televised flow bears a similarity of connecting to information streams that possess their own will, goals and direction. Coupling such streams with operations such as switching, following or influencing can be a way of turning their treatment into a shared creation process.

3.2. Liveness

The audible streams discussed here are constructed in real-time and through attaching methods that transform a sound flow. An essential aspect is the 'liveness 'of the processes and algorithms that execute the synthesis and transformations. This occurs not only as part of the final outcome in a piece or a performance but through the liveness of the software operations themselves that are executed while a sound is being put together or refined. Context-sensitive sound transformations become concrete while operating and belong to what Wolfgang Ernst labels as time-critical actions (Ernst 2013, 143). They allow for experimentation, the building of actions chains but are also *"sensitive to micro-temporal intrusion, irritation and manipulation"* (Parikka 2018). Algorithmic sound makes the impact of its constituting operations audible. The liveness of synthetic sounds takes shape during the activation of the real-time operations it consists of. Listening to the influence these operations have highlights the technical causalities responsible for their behaviour.

The malleable behaviour of sounding algorithms can be thought of in terms of liveness but also as an example of performative action. Highlighting how they perform, Parisi & Portanova suggest that we can look at algorithms as continuously emerging from within computational processes instead of as a pre-defined collection of instructions (Parisi & Portanova 2011). Technical operations perform through the material they operate on and leave traces of how they execute. Andrew Murphie suggests that performant computational procedures can be studied on the lower-level of signal processing allowing to think *"performance more generally in terms of signal flows and breaks, signal events and signal work, relations and varying intensities."* (Murphy 2013, 2). Performance should be understood here as working with flows, including signal flows, intensities and the tendencies that generate signals. Thinking sound development through operations that deal with signals allows for approaching liveness and performability through the different levels where sound synthesis takes place.

3.3. Unpredictability

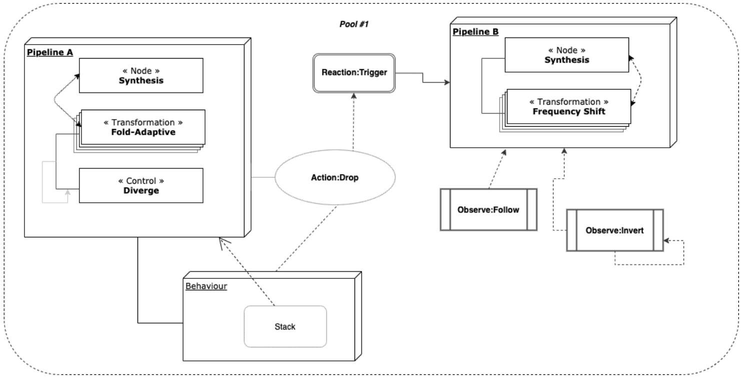
Artist-researcher Winnie Soon proposes to investigate the live dimension of code inter-action in software through the three vectors of "unpredictability, temporality and automation". (Soon, 2016, 115). She underlines how unpredictability entails the possibility of disruptions but also the uncertainty it brings. Her view resonates well with the synthesis models proposed here below where unpredictability occurs on various levels. For example how the stochastic sound-producing methods remain difficult to predict or how processes can be activated or ordered through unpredictable methods. Another aspect relates to the development of the synthesis pipelines in time. The choice of operations, their change, external influence and behaviour takes place through declarative descriptions of the processes that are made before they run. As they run, the context will always have slightly changed causing unforeseen consequences.

Unpredictability is a big factor when putting pipelines together that reveals itself when they run and become audible. This speculative aspect is fundamental to the project as it demonstrates the many experimental aspects a computational system has where many extend beyond properties of algorithms. Configurations of operations and synthesis combine, where instead of being pre-programmed they can be subject to conditions or triggering behaviour of the running pipelines. Control then moves from being imposed to occurring through the balance of system components. Automation thus contributes to situations of unpredictability through the complexity of component interactions it causes.

4. System

OF (https://github.com/bjarnig/OF) is a software framework realised as part of this project and enables the construction of sound streams and operation pipelines. OF is implemented in the SuperCollider (McCartney 2002) environment and builds on the conventions of the JITLib (Rohrhuber, de Campo, and Wieser 2005) paradigm. The models for shaping algorithmic processes and sharing information are partially inspired by data transformation pipelines and signal flows. Related approaches for transforming signal flows and streams exist such as Faust for digital sound synthesis (Orlarey, Fober and Letz 2009) or Haskell for dataflow programming (Uustalu and Vene 2005).

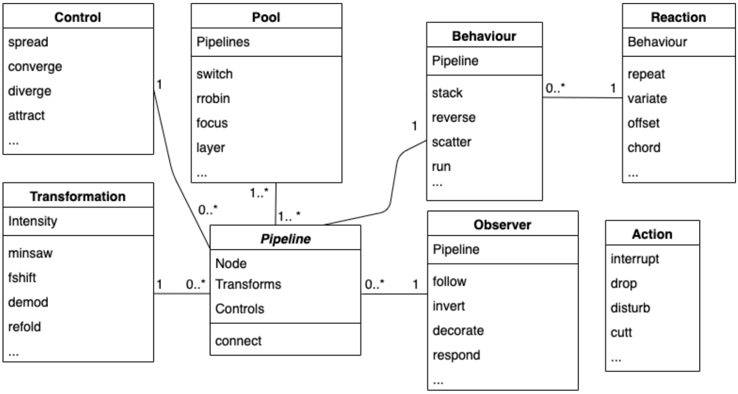
Fig. 1. *OF* Process Example.



The central element in OF is the *pipeline* that encapsulates a *synthesis* process, multiple sound *transformations* and various parameter *controls*. The pipeline is executed through entities called *behaviours* that define how a pipeline is played. A behaviour takes care of how the control and transformation operations are activated and the synthesis is made audible. The behaviours also contain different methods that a pipeline can be played with. This usually means further audio treatment of the pipeline as a whole. In OF there can be many pipelines, each with its own synthesis and associated operations. A collection of pipelines is managed through a *pool*. Pipeline pools can be treated in many similar ways as individual ones. A pipeline can also be subject to intervention or functionality change through *actions*. A pipeline can be *observed* for creating activity based on how it develops and includes *reactions* that trigger when certain conditions are met once it executes.

The OF architecture has been designed to support an open configuration where many kinds of SuperCollider objects such as *NodeProxies* and *Patterns* can be used in addition to those included. The framework supports an interactive working-mode for the creation of pipelines, how they are arranged in time and the direct access to sound streams while they execute. The pipelines follow a modular construction approach that allows addressing each of its components individually. For example to replace or modify operations or events while a pipeline runs. The pipeline operations are divided into phases in order to change between them and to support multiple starting points. Each phase represents a certain state of the pipeline that can in itself be extended in different directions. An important requirement is to always provide a minimum level of development and continuous change. To provide varying states while being capable of focusing on a specific area until the next incoming pipeline change.

Fig. 2. *OF* Entity Diagram.



4.1. Automation

Using *OF*, development takes place through sequences of transformation that are performed on initial input. Instead of expressing how a certain algorithm operates, it can be described in a declarative manner, stating what it will do (not how). The *OF* pipelines follow a declarative convention which makes them easy to define. Configuring pipelines, their structure and behaviour and how they will be executed are fundamental operations when using the framework. Through automation, the processes become fluid and autonomous and by iterating a sequence of transformation a sound shape is produced. Most of the transformations that are included with OF simply are turned on or off but are dynamic by design. Their transformation behaviour occurs by generative principles, or by analysing the incoming sound stream. By minimising the need to change the parameters of a process while it runs, a sharper focus can be put on how operations are turned on and off and the sequence they appear in. Instead of working with parametric spaces, the idea is to allow for the opening of operational spaces that are then traversed in various ways.

An operation sequence starts on the basis of a sound synthesis algorithm. *OF* contains a small collection of sound synthesis methods that all generate waveforms that are continuously changing as they play and vary from within by definition. Both initial and runtime parameters are supported and a waveform can always be regenerated by invoking the constructor function with different initial inputs. The resulting sound streams are full in terms of spectrum and ideal for raw, rough or gritty sonorities. The audio transformations that are applied to those are of various kinds, modifying both amplitude and frequency through techniques such as waveshaping, clipping, amplitude modulation and frequency shifting. Thinking transformations as operations sequences enforces a kind of mechanical workflow. Sound comes about through chains of behaviour, operations sequences and tight automation.

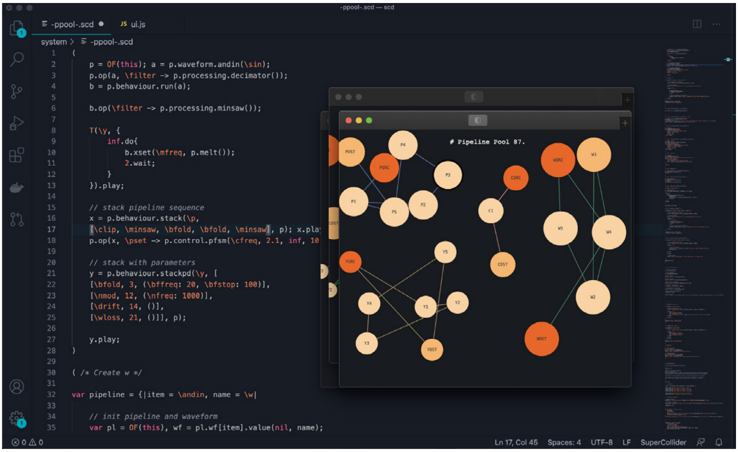


Fig. 3. *OF* Code with Pipeline GUI.

4.2. Directness

An important part of the *OF* framework is how pipelines are manipulated while under operation. Actions can be applied during runtime that can, for example, halt, or disturb a running pipeline. The working mode then changes from specifying how things happen to prevent them from doing so. From internal refinement to external forcing. Such intervention offers a very direct contact that allows focusing on the minute detail of a dynamic sound instead of the factors making it change in time. Algorithmic sound streams offer rich possibilities for new sounds (or those requiring more attention) in which case the framework allows for actions to halt sequences and highlight desired aspects of a complex sound.

Sound streams and associated operations can be combined with others of a similar kind. Instead of making links between sounds that happen simultaneously, relations unfold through the pipelines themselves and how their transformations take place. Each pipeline is isolated and unaware of others. The act of binding them together can take place by switching between streams or blending them in various ways. The way the output is treated is therefore unrelated to the pipeline behaviour itself since it occurs on the output-level only. Switching still has plenty of creative potentials and can, for example, include other actions that trigger once a switching occurs. Sound stream continuity comes to the foreground where many pipelines can be activated but only a few that are audible. The creative problem then revolves around how one connects, interprets and makes audible a running process. If the pipelines are programmed to execute, the switching can also be done manually, introducing liveness, and a possibly more sensitive approach to micro-temporal details. Finally, algorithmic switching can be introduced for further exploration, for example through methods using probabilities or permutation principles.

4.3. Boundaries

The workflows described here serve as an attempt to combine attitudes of system building, sound synthesis and composing with process. The pipelines function as configurations, binding together synthesis and processing while also delineating the whole audio flow as an entity. Pipelines can be combined in sequence or in parallel, allowing for transitions from one to the next in various ways. They can run on their own, or be set in relations to others. Pipelines can also be algorithmically generated. For example by using different selections from the transformations or using stochastic processes to order them. The same applies to their duration and the delay between each transformation. One can think of the operation sequences as a driving force behind generative processes and their outcome. They shape the whole ensemble and the distribution of information. They resemble algorithms, consist of precise, programmed steps and are enacted by different software components.

Collective behaviour can also arise once several pipelines are running at the same time that are possibly influencing each other. Registering some as observing or reacting can lead to a deferral of any centralised control and move things more towards distributed chains of behaviour. Music then occurs as a result of how relations are arranged. The system develops according to local changes and can even be thought of as an emergent complex system. Such attempts deserve further investigation. However, the fundamental *OF* features are the most notable. To set up audible transformations pipelines, to manipulate those algorithmically and to manipulate sound streams using audio domain processes. A certain workflow often appears, but also a sonic imprint, a characteristic behaviour that emerges from the basic principles the framework is built around.

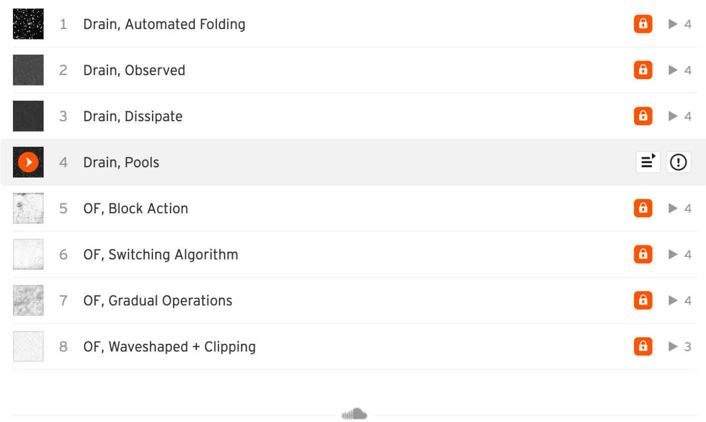
The *OF* software framework and the ideas that have been covered in this text are grounded in the author's creative practice and approach to synthesis and composition. The framework reflects a process-oriented attitude and should not be considered as something fixed but rather as evolving and context-sensitive.

The composition *'Drain'* (2021) is a recent practical example. The piece explores synthetic sound streams developed in-time through transformational pipelines and various behaviours for activating those. The pipelines are pre-configured and then activated. The live element evolves around switching, processing and modifying the pipelines while they run.

Many processes are continuously running, even in the background and later receive focus by being switched on (or off). Such manual actions often introduce new events and other processes and so the piece unfolds. Somehow the idea is of an operator connecting to an autonomous process and interpreting it while it runs.

Recorded examples from *OF* and the piece can be found here:

Fig. 4. *OF* Sound Examples. https://soundcloud.com/bjarni/sets/research



5. Conclusion

This article has presented an approach to synthesis and composition based on sound streams, operation pipelines and data processing. Pipelines have been defined as bundles of synthesis and transformation and how they bring about possibilities for process and development has been a central concern. Operational spaces, process configuration, automation, direct access, liveness, incompleteness and unpredictability have all been discussed as possible dimensions that augment a creative approach to sound composition. A software framework, *OF*, was introduced that implements many of concepts that have been covered and its software architecture was demonstrated.

The OF components should be extended in various ways to better address the framework purpose. The synthesis modules are similar in nature and broadening their scope will allow for enacting the operations in more ways. The behaviours are also rather narrow and given the tight relationship between the synthesis and processing, adding more experimental behaviours is needed in order to fully explore the pipeline possibilities. Finally, the transformations (and algorithms that manipulate them) offer great potential for further development. Processing based on self-analysis and time-domain distortions seems to be a fruitful area to explore. In addition to the component improvements, an investigation is needed for how interaction occurs within the framework, for example how pipelines are made to start, stop or change. Concerns that further question the boundaries of sound, treatment and algorithm.

References

Chaitin, Gregory.
2006. *Meta Math! The Quest for Omega*. New York, NY: Vintage Books.

Chun, Wendy Hui Kyong.
2011. *Programmed Visions : Software and Memory*. Cambridge, MA: The MIT Press.

Eigenfeldt, Arne.
2014. *Generating Structure – Towards Large-Scale Formal Generation*. Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, 10(1).

Ernst, Wolfgang.
2013. *Digital Memory and the Archive*. Edited by Parikka Jussi. University of Minnesota Press.

Frabetti, Federica.
2015. *Software Theory: A Cultural and Philosophical Study*, London: Rowman and Littlefield International.

Holmes, Thom.
2015. *Electronic and Experimental Music: Technology, Music, and Culture*. London. Routledge.

Kanervisto, Scheller and Hautamäki.
2020. *Action Space Shaping in Deep Reinforcement Learning*. EEE Conference on Games 2020. arXiv:2004.00980.

Kelly, Kevin.
2010. *What Technology Wants*. New York, NY: Viking Press.

Koenig, Gottfried Michael.
1965. The Second Phase of Electronic Music. http://koenigproject.nl/download-pdfs/ (accessed 10 Jan 2021).

Koenig, Gottfried Michael.
1987. *Genesis of Form in Technically Conditioned Environments*. Interface 16, no.3. 165-175.

Law, John.
2004. *After Method*. New York, NY: Routledge.

McCartney, James.
2002. *Rethinking the Computer Music Language: SuperCollider*. In Computer Music Journal, 26(4), 61-68. Cambridge, MA: MIT Press.

Murphie, Andrew.
2018. *Convolving Signals Thinking the performance of computational processes*. Performance Paradigm, (9). http://www.performanceparadigm.net/index.php/journal/article/view/135 (accessed 11 Dec 2020).

Parikka, Jussi.
2018. *Ernst on Time-Critical Media: A mini-interview*. Machinology. https://jussiparikka.net/2013/03/18/ernst-on-microtemporality-a-mini-interview/ (accessed 22 Jan 2021).

Parisi, Luciana and Stamatia Portanova.
2011. *Soft thought (in architecture and choreography)*. Computational Culture 1 (November 2011). http://computationalculture.net/soft-thought/. (accessed 18 Dec 2020).

Rohrhuber, Julian, Alberto de Campo Alberto, and Renate Wieser.
2005. *Algorithms Today: Notes On Language Design For Just In Time Programming*. International Computer Music Conference. Volume 2005.

Soon, Winnie.
2016. *Executing Liveness: An Examination of the Live Dimension of Code Interactions in Software (Art) Practice*. PhD dissertation, Aarhus University. http://siusoon.net/home/me/doc/soon_PhD_FINAL.pdf (accessed 24 Nov 2020)

Suchman, Lucy.
2006. *Human-Machine Reconfigurations: Plans and Situated Actions* (2nd ed., Learning in Doing: Social, Cognitive and Computational Perspectives). Cambridge: Cambridge University Press.

Suchman, Lucy.
2012. Configuration. In Celia Lury and Nina Wakeford (Eds.), *Inventive Methods: The happening of the social*. London. Routledge. 48–60.

Uustalu, Tarmo, and Varmo Vene.
2005. *The Essence of Dataflow Programming*. Central European Functional Programming School, First Summer School, CEFP 2005, Budapest, Hungary.

Williams, Raymond.
2003. T*elevision : Technology and Cultural Form*. New York :Schocken Books.

Yann Orlarey, Dominique Fober, and Stéphane Letz.
2009. Faust : *r*. Editions Delatour France. New Computational Paradigms For Computer Music, 65-96. Hal-02159014.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Poking Holes: Distributed Ambivalence and Aesthetics in Sound Networks

Keywords: Network Music, Network Analysis, Systems Aesthetics, Relational Aesthetics

Stefano Kalonaris
stefano.kalonaris@riken.jp
RIKEN AIP, Tokyo, Japan

Robin Renwick
robin.renwick@trilateralresearch.com
Trilateral Research Ireland, Waterford, Ireland

Iannis Zannos
zannos@gmail.com
Ionian University, Corfu, Greece

Amid the current pandemic (COVID-19) disembodied presence has emerged as the new norm, revealing a world increasingly entangled with the technological and conceptual paradigm of the network. In this scenario, it is crucial to reconsider core axioms of the pervasive connectionist credo, acknowledging the empty space that a network subtends, the hollowness of its lattice, the ambivalence of its membership, the weave and web of its relational embodiment. This paper enquires on how such notions map onto the music/sound domain by drawing on aesthetics for a more lucid account, while also proposing a speculative approach to tracing inner layers of these networks, through three modalities: Artificial Neural Networks, Audible Ecosystems, and Networked Music Performance.

1. Networks

> What I want is a network. What do you have to change in your whatchamacallit to do a network? (Latour 1996, 116)

Networks might not be an intrinsic property of the universe, notwithstanding they have acquired a remarkable significance in the collective imaginary; the dominant paradigm which "makes scarcely imaginable the possibility of an alternative or an outside uninflected by networks" (Jagoda 2016, 221).

Beyond the technical definitions at a mathematical level, the specifics of a myriad structural and operational variations and models, or the graphical conventions for representing it, a network is a conceptual subset of a system. The general systems theory, although initially posited in the 1930s, was formalised by Ludwig von Bertalanffy (1969), and was characterised by a move towards interrelations and interdependence. To describe a system, normally one would specify who/what interacts with whom/what, and how entities behave in their response to the other. Interaction involves reciprocal influence, which modifies behaviour, actions and reactions either directly (through communication) or indirectly (stigmergic).

When systems are governed by non-linear interactions amongst entities and through feedback processes with the environment, they are often referred to as 'complex'. These, in turn, are normally and non-exhaustively associated with the following characteristics: *autopoiesis* (self-organisation), locality of interactions, defiance of a single rule or level of explanation, emergence, sub-optimality, connectivity, iterativity, decentralisation, adaptation, amongst others. The theory regarding complex systems is not a single body of theory, and it comprises contributions from different fields such as cognitive and behavioural science, evolutionary theory, social science, computer science, mathematics, philosophy, to name but a few.

The notion of a network, which weaves together these viewpoints, has become a ubiquitous approach for the modelling of complex systems. It has been argued (Jagoda 2016) that three major and parallel developments contributed to the emergence of the network as a leading explanatory paradigm: the theoretical/mathematical framework spanning Graph Theory to modern Network Theory, the implementation of an informational architecture (the Internet), and neoliberalism and finance capitalism, which resulted in the adoption of the network as the key organisational and conceptual model, and key driver of socio-economic development. These framings, in isolation, do not adequately elucidate the role, function or form of music networks, and deeper enquiry is required to understand how networks aid performative topo[typo]logy.

Turning to aesthetics might help overcome partial accounts, beyond rational descriptions or representations, even if the illusory search for the rhizomatic origin may remain fruitless, due to the abstracted relational assessment of intra-partial interconnection (Deleuze & Guattari, 1988).

1.1. Network Aesthetics

In this paper, aesthetics does not refer to those viewpoints predicating objective and universal laws that map perceptual analyses of the aesthetic object to notions of beauty or hedonic value. Instead, we consider the lineage originating from Dewey's art as experience (2005) and include aesthetic viewpoints based on relational and pragmatist axioms. The relational stance had originally been highlighted in systems aesthetics, when it was posited that "there are no contrived confines such as the theater proscenium or picture frame. Conceptual focus rather than material limits define the system" (Burnham 1968, 32). It has been argued that one can truly experience the network at a "level of imperceptible flux — of things unforming and reforming relationally" (Munster 2013, 3). According to Rancière, aesthetics is "a mode of articulation between ways of doing and making, their corresponding forms of visibility, and possible ways of thinking about their relationships" (Rancière 2005, 10). The political reading of aesthetics professed by Rancière or Bourriaud, however, is not entirely unquestioned, and some (Potgierter 2018) argue that the folding/collapse of art and everyday life incurs the danger of depriving life-enhancing experiences. A suitable aesthetic framework for dealing with the network must come "to terms with conflict, boredom, confusion and stagnation" (Munster & Lovink 2005) as well as intricate and nuanced notions of social complexity. The need for the acknowledgment of stagnation, contradiction, misalignment and discomfort is echoed in the notion of ambivalence, put forward by Jagoda as an alternative to moving beyond networks or opting out of them. Ambivalence in this sense is seen as extreme presence, beyond apathy, cynicism, disengagement, or hopelessness, and "it demands risking non sovereign experiences of absence, uncertainty, boredom, complexity, and disconnection without promises of instant gratification, certainty, discovery, closure, or reconnection" (Jagoda 2016, 225). Accepting ambivalence and uncertainty is thus a *sine qua non* of networked being.

In this paper, we are interested in investigating the construct of the network, through the domains of music and sound.

2. Music & Sound Networks

There are countless expressions of the network in the context of music and sound, all affording different interpretations of the connectionist imperative. Of these, those that do not have the generation of music/sound as the ultimate output will not be considered. These could include social networks formed amongst music professionals (*e.g.,* Linkedin, Bandcamp, Instagram, etc.), supporters, fans, collectors, forum users, music communities, and so on. Moreover, we limit the discussion to those networks that are technologically assisted, thus omitting, for example, pre-digital networks of embodied culture and collective memory, as in the case of oral transmission of musical practices and knowledge. Amongst the music and sound networks that we are interested in, three can be considered as the leading paradigms.

2.1. Artificial Neural Networks

Artificial Neural Networks (ANNs) are speculative digital re-workings of processes that normally take place in the human brain; surrogates of electro-chemical interconnections of neurons and synapses, used to model learning in all domains of artificial intelligence. In the last few years, ANNs have also become a principal model for music and audio endeavours, from information retrieval (Choi et al. 2018) to digital signal processing (Purwins et al. 2019) through to generation and composition (Briot, Hadjeres & Pachet 2020). Different network architectures are normally used depending on the task (e.g., convolutional networks for classification tasks, recurrent neural networks for temporal dependencies, etc.) but in the last few years self-attention-based models (Vaswani et al. 2017) are increasingly used for most generative music tasks. The use of networks for music generation, however, extends further back before ANNs, for example as in the augmented networks-based Experiments in Musical Intelligence (EMI) (Cope 1996) or the MUSACT system (Bharucha 1993).

2.2. Audible Ecosystems

Pioneered by Agostino Di Scipio, audible ecosystems (AEs) and emergent sound structures, instead, are tightly bound to the philosophical discourses revolving around autopoiesis. AEs are, in fact, complex adaptive systems; dynamic feedback and interaction between a human agent, a digital signal processing unit and the external environment give rise to seeming sonic self-organisation that cannot exist in isolation from the listener's cognitive processes. AEs "prompt not only a reconsideration of the way we do performance, but also an examination of our practice in a more diachronic sense: as the weave of activities and relationships through which we bring forth work" (Green 2014, 62). Under the umbrella of AEs other musical practices can be included by virtue of some common conceptual axioms. An example is the sonic practice of Onkyokei (Plourde 2008) and the so called "no-input" or "empty" instruments (Novak 2010; Moriaty 2016) pioneered by Toshimaru Nakamura and Sachiko M, respectively. These instruments presuppose no sound sources other than their own self-noise. *No-input* mixer, for example, involves looping the output of a mixer back into the input, to amplify the inner circuitry sound and shape by means of the parametric equalisation afforded by the desk itself (although throughput devices such as FX pedals might be used to enhance specific behaviours of the system).

2.3. Networked Music Performance

Finally, we consider networked music performance (NMP). While some (Lemmon 2019) argue for a subtle distinction between telematic music (more concerned with cybernetic and technologically leveraged political themes) and NMP (musicians performing together in remote locations leveraged by modern networking technologies), we ignore this debate and, hereinafter, view NMP as pointing at both practices. NMP predominantly is seen to emerge sometime in the mid 20th century, bringing with it a diverse collection of creative and technological paradigms, description of which would far exceed the scope of this paper (c.f. Joy 2011). For a brief introduction to NMP the reader is encouraged to consult Carôt, Rebelo & Renaud (2007). NMP enjoyed a relative increase in popularity from the early 2000's, having been a marginal phenomenon for 30 years prior, mostly due to technological developments (high-speed network communication protocols, increased bandwidth affordance, etc.) in conjunction with increasing recognition of net/web art (Schroeder 2009). From the participants' perspective, in the manner of experience and action, NMP provides a certain degree of independence from three basic factors: spatial proximity, temporal synchronicity, and bodily (physical) presence. These factors afford a 'parralistic' dichotomy to emerge; both enabling and disabling through juxtaposition of intra- and supra- relationism. Involvement in a NMP demands reassessment of aspects involved in collective music making. Listening is perhaps one of the more crucial ones, as it becomes, at times, uncoupled from the perceptual experience of the body and subject to varying degrees of network latency and audio fidelity; “listening in the network [...] can be seen as an activity and an interactivity that not only shapes our perception of a musical work but also, ultimately, performers as (listening) subjects themselves” (Schroeder 2013, 223). Sá and Tanaka describe three planes of performance, the local, the distributed, and the extended, where the extended affords a “subjective sense of presence beyond the physical performance space” (Sá and Tanaka 2019, 15). The extension into the digital world is likened to an extended notion of semantic typology, where the habitat of the performer is augmented through a digitally interfaced divide. Oneself now becomes the interface mediated through sound and perception, as one extends from the ‘here’ into and unto the ‘there’.

2.4. Music & Sound Network Aesthetics

These three paradigms outline different accounts of the network, highlighting how heterogeneous and complex a notion it is. Comparable definitions foreground situatedness, disembodiment, and inter-subjectivity as performative companions, whilst technological dependency provide distinct avenues for hindrance and affordance, an intricate dance of unconscious agency. Adkins has proposed a connectionist frame for understanding the inter relational nature of his own artistic practice, drawing on the connectionist paradigm to understand how “networks of ideas or connectionist neural models of cognitive behaviour can be used to contextualize, understand and become a creative tool” (Adkins 2014, 51). He draws on the musical assemblage framing of Born (2010) and the nodalistic model of Gouchenour (2011), by proposing a network mediated lens to understand contemporary culture. Like system components which “derive their value solely through their assigned context” (Burnham 1968, 34), so are performers, musicians and programmers linked “together in social forms which are invariably historical.” (Bourriaud 1998, 7). However, these ‘components’ are complex and nuanced individuals, not only endowed with decision-making skills, but also subject to bounded rationality. This is a key factor which sets these systems radically apart from static abstractions of the network. In the context of proposing a *nodalist* (Gochenour 2011) reading of network music to overcome the plethora of idiosyncratic definitions available, Renwick reminds us that “viewing network music as a set of ‘selfs’ organised within a coherent and cogent structure, allows one to garner a better understanding of what it means to be a participatory ‘self’” (Renwick 2016, 24). Drawing on the aesthetic framing of the sublime by Iris Murdoch (1959), one’s relation to the other provides the basis upon which one fully comprehends oneself.

In the wider domain of aesthetics in the arts and music it is now common to acknowledge the sense of uneasiness, discomfort (Aldama and Linderberger 2016) or failure (Cascone 2000), whilst relatively new fields of enquiry, such as experimental aesthetics, are also open to a disquieting dimension. Brincker, for example, argues for an aesthetic stance "to capture the temporally extended and complex processes that seem to characterize the broad embodied conditions of aesthetic experiences and responses" (2015, 4). The notion of *edge of action* is also formulated and identified as being of particular importance in non-artistic contexts (a distinction that evaporates under relational aesthetics lenses), and paramount in forming the experiences of beholding, co-beholding, vulnerability and appraisal. Adopting an aesthetic stance can be a useful for thinking about distributed aesthetics in network music, as it describes "the sense of being an active and physical bodily positioning and psychological attitude, and yet responding to and embedded in environment affordances" (Brincker 2015, 21).

Relational viewpoints on aesthetics and socio-political discourses are not uncommon in the context of NMP (Schroeder 2013; Vorster 2015) and AEs (Di Scipio 2011; 2015). In the music and sound ANNs domain, on the other hand, discussions of aesthetic nature are seemingly unrelated to the concerns and themes developed in philosophy of art. There are, of course, discussions around machine aesthetics (Rutsky 1999) or machine art (Taylor 2014; Broeckmann 2016), but in creative AI for music and sound, these discourses are limited. Normally, they relate only to the application of ANNs for the aesthetics judgment/evaluation of music artefacts/output, according to rules distilled from the human experience of music. Usually these are heavily skewed towards information-based accounts of perceptual features, and often implemented as one-factor explanations (Kalonaris, Gifford and Brown 2019). Alternatively, they may be focused on the integration of aesthetic evaluation into seemingly creative generative systems (using more or less the same rules, *e.g.,* in the optimisation process in the generation of machine music), or towards human aesthetic evaluation of the music artefacts produced by ANNs. What is missing, to date, is a holistic, multi-disciplinary discussion on the aesthetics of music/sound neural networks.

3. Objective

Normally, the network is perceived as ontologically ambivalent: allegedly an objective entity (e.g., physical or virtual cables and connections, routers, performers, artifacts, environments, digital neural layers, etc.) as well as a metaphor to understand emergent qualities of other entities. The three music and sound networks seen above all “share an anti-reductionist view of what count as actors and agency. Action is afforded by socio-material circumstances or, indeed, dispersed among collectives of human and non-human entities co-operating via associations or networks” (Krogh 2018, 548). The inclusion of non-sentient entities in the workings of the network is explicitly stated and programmatically specified in AEs. In ANNs, too, most agents apart from the programmer(s) who developed and runs the code or the listener(s), will be inanimate (*e.g.,* nodes and edges forming neural “layers”, CPU, GPU, circuitry, software, etc.). As for NMP, it also comprises a wide array of agents/actors, both sentient and not (*e.g.,* LAN, Wi-Fi, computers, musicians, instruments, and so forth), with the environment (whether seen at situated or not) breathing performative agency in itself (e.g., latency, packet loss, inter-spacial resonance). This extended notion of network is characterised by non-free, traceable, empirically recorded point-to-point connections which leave empty most of what is not connected, needing the passage of other circulating entities in order to be traced back. How fulcral is this idea of trace? Arguably, “nothing, either in the elements or in the system, is anywhere simply present or absent. There are only, everywhere, differences and traces of traces” (Derrida 1981, 26).

How, then, does one go about tracing? Would doing so afford us novel insights on the relational nature of the system itself? Would poking holes in the network’s lattice reveal different views of its ontological complexity and ambivalence?

4. Tracing: Part One

Arguably, tracing the displacement of data, information and/or sound along edges and between nodes, can be associated with the notion of flow. Networked flow has been used to investigate creative networks, such as NMP, in Gaggioli et al (2013), and it is based on the systems model of creativity developed by Mihaly Csikszentmihalyi (2014) which outlines a triumvirate of society (field), culture (domain) and person (individual). Network flow in creative domains is predicated upon six conditions (i.e., shared objectives/emotions, transition from one state to a future one, collective intention/strategy for exiting liminality, belief in transforming intention into action through group involvement, interactions between the group and the outside, and creation of narratives for making sense of the emergent concepts/ideas/artifacts) and then further hypothesised to be a process of six successive stages. This notion of flow involves the adoption of sequential/linear accounts of processes which might instead not be reducible to phenomenological timelines.

Gaggioli et al proceed to analyse flow by employing Social Network Analysis (SNA), a common tool used to model complex interactions between human actors. SNA often uses mapping and visualisation techniques to investigate network properties. It is based on the foundations laid by Graph and Network Theory, and is focused on connections between nodes (what have so far been referred to as entities) and edges (the links between nodes). SNA is mostly interested in the properties regarding connections, distributions and segmentation/clustering. This strategy has been often flagged for being rather partial and for offering an impoverished and flattened representation of the complex dynamics emerging from social networks. For example, it has been said that SNA-based approaches seem to ignore that "networks engage and are engaged by current political, economic and social relations." (Munster & Lovink 2005). The political, and by politics we mean "the experience and configuration of space, time, and social relations" (Jagoda 2016, 19), aspect of social networks has been revealed more explicitly during the COVID-19 pandemic, which has forced global adoption of remote connectedness as the modus operandi for shared experiences, whilst restricting physical inter-situatedness. Creative networks such as AEs and NMP are also imminently social, and not politically agnostic: the former, for example, are contingent on reconfigurations of relations between the audience/listeners, the sound designer/composer, and the environment as it exists in the collective socio-political imaginary. The latter (NMP) has further dependencies relating to quality of service, equipment, and monetary resources. As for ANNs, they, too, are nowadays dependent on vast amounts of data and GPU affordance, which has led to explicit centralisations of power towards big tech, with obvious political and ethical implications.

Besides these considerations of a political nature, there are more fundamental issues in the endorsement of graphical methods for the tracing and "re-assembling" the network; these representations can induce what has been termed network *anesthesia* (Munster 2013), a perceptual numbness that prevents us to experience the network in its complexity, which is reduced to "a problem of managing the quantity of connections among elements" (Munster 2013, 5). Furthermore, they are prone to ignore "experiences of stagnation within network formations and for coupling these networked experiences with a network's potential to transform and mutate into something not yet fully codified" (Munster & Lovink 2005). While graphical representations of networks often portray a network that never sleeps, by projecting static snapshots of a complex phenomenon in perpetual becoming, our experience of being in the network at times speaks of something rather different: information bottlenecks, retroactive flow, stagnation, wait times, lag, disconnection, data corruption, packet-loss, etc.

Similar arguments can be made when considering ANNs, notoriously impervious to scrutiny. Due to the increased affordances in GPU computing power, ANNs can be modelled to comprise deep architectural structures, with hundreds of layers and millions of parameters. This makes it difficult to understand or grasp what is actually happening inside them (*i.e.,* the "black box" paradigm). Graph-based representations are normally used for the visualisation and interpretation of the training datasets used for ANNs, by means of techniques such as 2D projections of highly dimensional data, correlation network graphs, or data-derived flowcharts such as decision trees. As for the inner workings of the ANNs, whose response functions are, in the majority of cases, non-linear and non-monotonic, attempts are being made on this front, which will be discussed in Section 5.3.

While graphical representations can help tracing (some of) the connections in a sound network, they remain a partial tool which cannot fully account for the complexity involved and accrued by the creative nature of this setting. We thus turn our inquiry to investigating how probing the latent space of a sound network might be a feasible proxy for tracing.

5. Tracing: Part Two

When discussing the difference between "traditional" interactive music systems and AEs, Di Scipio describes it as "a shift from creating wanted sounds via interactive means, towards creating wanted interactions having audible traces" (Di Scipio 2003, 271).

Network music or sound is then "heard as the empirical epiphenomenon of that network of interactions" (Di Scipio, 2005, 385) and this is arguably equally true for any of the paradigms seen earlier (ANNs, AEs, NMP). Since sound is the interface, what is heard is, then, the trace, the network itself: the "sound bears traces of the structural coupling it is born of" (Di Scipio 2003, 275). While this is true at a philosophical and sonic level, it leaves the mapping of complex interweaving of heterogeneous interactions which takes place in networked music and sound unquestioned and unscrutinised, except for the final output. On one hand "we are listening at the same time to the process and to the sound" (Meric & Solomos 2014, 12). On the other hand, it would also be valuable to have access to intermediate levels of the process, more explicitly. To this end, we propose some speculative methods, with in view to develop these more formally in the near future.

5.1. Tracing AEs

Conditioned upon the design and practical constraints, one could insert peripheral, intermediate sonic outputs in the lattice of the sound network. If allowed to feed out into the environment, these "traces" would naturally and recursively contribute back to the overall sonic construction, rendering the concept of "output" irrelevant at large. However, one could instead route the inner layers to hard disk or memory, to be used at a later stage and separately from the performance. Figure 1, for example, is a possible implementation based on the diagram in (Di Scipio 2003).

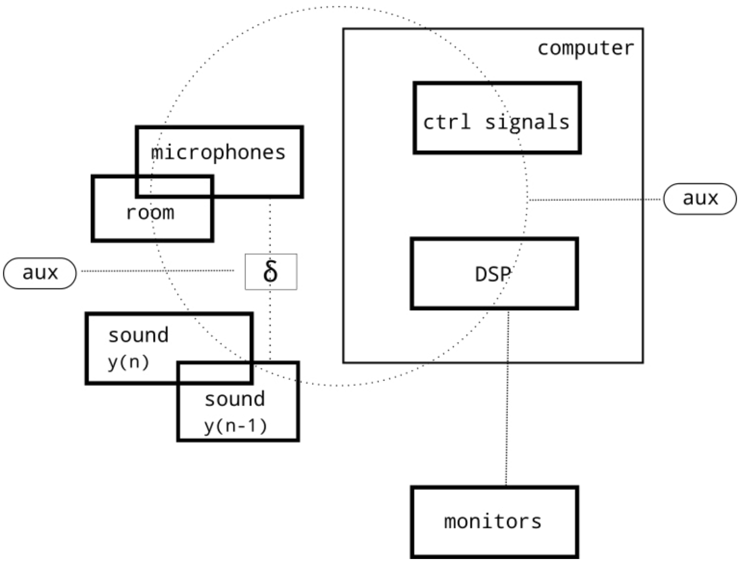


Fig. 1. Probing AEs with auxiliary outputs which can be written to file, memory, or used (in case of parametric output) for subsequent auditory or visual display, for example.

5.2. Tracing NMP

In (Gabrielli & Squartini 2016) a formal taxonomy for NMP is offered, based on eight structural features. Of these, topology is particularly important for the current discussion on probing, and can be characterised according to centralised/decentralised and synchronous/asynchronous axes (Weinberg 2003), with variations contingent upon having symmetric/asymmetric, weighted/unweighted connections. As an experiment, we consider a fully connected, unweighted and interdependent star topology where each node can only listen to the adjacent node. The direction is one way, therefore players in a node pair do not have knowledge of each other's sound; what each node interacts with is (eventually and after the sound has "travelled" through the star at least once) but a trace of the global (supra-local) sonic network. The latter remains, however, inaccessible to the individual player.

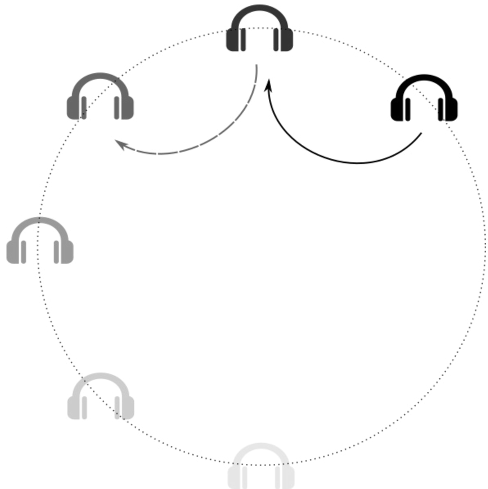


Fig. 2. Diagram of *Traces*: the global sonic output is obtained/experienced as indirect inference of the sequential propagation of one-way pairwise sound interactions.

An example of this experimental probing is Traces[1], a triptych of improvised pieces that were recorded so that each player had an independent booth and was able to listen only to the player to their left (see Figure 2). Thus, the information that each player received was some sort of propagated inference about what the totality of the music could have been at any given point in time, given what could be heard from a single adjacent player: a chain of blind interactions which, nevertheless, carried traces of the global sound network. Because of the independent multitrack recording procedure, Traces could be also broken down into separate duets, to offer a defragmented view of the sound total. The simultaneously inter- and dis- connected duets afford the listener to reflect on supra-local sound network's becoming.

1. ΣK, 2021. "Traces". Accessed April 4, 2021. https://skalo.bandcamp.com/album/traces

5.3. Tracing ANNs

Efforts on the front of Explainable AI (XAI) have been informed by social (e.g., trust, understanding) and commercial (e.g., regulatory compliance, adoption & acceptance, risk reduction) motivations. Many interpretability techniques are being used (Samek et al. 2019) but, while these offer insight as to how the input and output of ANNs models are related, they say little in terms of explanatory power on the internal mechanisms. It is, however, possible to inspect specific layers of the network and to obtain feature visualisations (Nguyen, Yosinski & Clune 2019), for example. As for music and sound ANNs, to date, little has been done. Similarly to what proposed above for AEs and NMP, one could envisage probing inner layers' sound output for ANNs. Figure 3, for example, shows the attention maps for the same input to an attention-based model used for counterpoint generation (Kalonaris, McLachlan & Aljanaki 2020), for two different layers.

As one can see, different layers respond differently, potentially providing useful probes if used to generate intermediate music/sound outputs. The exploration of inner representations of the network in the sound domain is almost exclusively done in the context of Variational Autoencoders (VAEs) (Roberts et al. 2019), but we contend that it would be a valuable strategy for other neural network architectures, too.

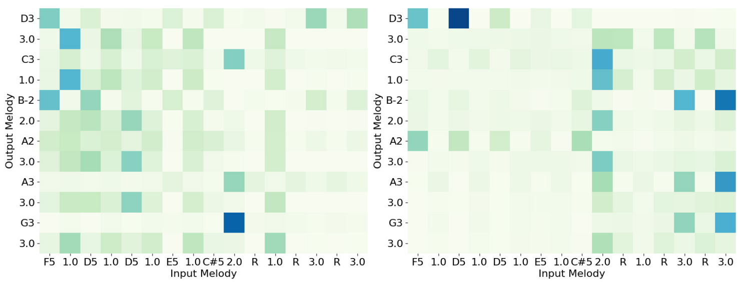


Fig. 3. Attention maps for layer 2 (left) and 4 (right) of the 8th attention head in a *Transformer* model used in a two-voice counterpoint generation task.

6. Conclusion

We set to investigate and re-contextualise our experience of sound and music networks by adopting viewpoints normally argued for in the sociological branch of network science and in postmodern aesthetic stances foregrounding relational and dialogical approaches.

We argued for the importance/potential of providing practical ways for "tracing" or "probing" the network of interactions, in NMP, AEs and ANNs alike. Despite discussions in this realm on a philosophical level, there is at times a lack of pragmatism when it comes to suggesting how to implement these notions so that an external observer/listener (e.g., the audience) can have a window into the theoretical underpinnings and make sense of them. Conversely, we hope to have provided a more philosophical, aesthetic framework for the use of AI in music and sound: this is a field which is seemingly lacking an integrated way to think about the aesthetics of the (neural) network, beyond the perceptual analysis or hedonic value of the sound object that these systems produce or evaluate.

The construct of the network is as complex as the phenomena it stands for and it defies single levels of explanation or representation. More importantly, it requires us to radically accept uncertainty and ambivalence as part of our experience of it, with far reaching implications in philosophical and socio-political spheres. Our enquiry focused on the sound and music domain but, while much remains to be experimented with, we hope that insight at this level might be beneficial for a more holistic experience and understanding of the network at large.

References

Adkins, Monty.
2014. *"A Manifesto of Nodalism"*. Journal of Science and Technology of the Arts, 6(1): 51–60.

Aldama, Frederick Luis and Herbert Lindenberger.
2016. *Aesthetics of Discomfort: Conversations on Disquieting Art*. University of Michigan.

Bertalanffy, Ludwig von.
1969. *General System Theory*. New York: George Braziller.

Bharucha, Jamshed.
1993. "MUSACT: a connectionist model of musical harmony". In *Machine models of music*, edited by Stephan M. Schwanauer and David A. Levitt, 497–509. Cambridge, MA: MIT Press.

Born, Georgina.
2010. "Listening, Mediation, Event: Anthropological and Sociological Perspectives". *Journal of the Royal Musical* Association, 135(1): 79–89.

Bourriaud, Nicolas.
1998. *Relational Aesthetics*. Les Presse Du Reel.

Brincker, Maria.
2015. "The Aesthetic Stance–On the Conditions and Consequences of Becoming a Beholder". In *Aesthetics and the Embodied Mind: Beyond Art Theory and the Cartesian Mind-Body Dichotomy*, 117-138. Springer Netherlands.

Broeckmann, Andreas.
2016. *Machine Art in the Twentieth Century*. Cambridge, MA: MIT Press.

Burnham, Jack.
1968. "Systems Esthetics, Artforum". In *Open Systems: Rethinking Art C. 1970*, edited by Donna de Salvo (reprinted in 2005), 166–69. London: Tate.

Carôt, Alexander, Pedro Rebelo and Alain Renaud. 2007. "Networked Music Performance: State of the Art". In *Proceedings of the 30th AES International Conference*.

Cascone, Kim.
2000. "The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music". *Computer Music Journal 24*(4): 12–18. https://doi org/10.1162/014892600559489

Choi, Keunwoo, György Fazekas, Kyunghyun Cho and Mark Sandler.
2018. "A Tutorial on Deep Learning for Music Information Retrieval". Available at: https://arxiv.org/abs/1709.04396

Cope, David.
1996. *Experiments in Musical Intelligence*. A-R Editions.

Csikszentmihalyi, Mihaly.
2014. *The Systems Model of Creativity: The Collected Works of Mihaly Csikszentmihalyi*. Dordrecht: Springer. https://doi.org/10.1007/978-94-017-9085-7

Deleuze, Gilles and Félix Guattari.
1988. *A thousand plateaus: Capitalism and schizophrenia*. Bloomsbury Publishing.

Derrida, J.
1981. *Positions. Chicago*: University of Chicago Press.

Dewey, Jaques.
2005. *Art as Experience*. Perigee Books.

Di Scipio, Agostino.
2003. "'Sound is the interface': From interactive to ecosystemic signal processing". *Organised Sound*, 8(3): 269–277.

Di Scipio, Agostino.
2005. "Due di Uno. A composition dedicated to Horacio Vaggione". *Contemporary Music Review*, 24(4+5): 383–398.

Di Scipio, Agostino.
2011. "Listening to Yourself through the Otherself. On Background Noise Study and other Works". *Organized Sound*, 16(2): 97–108.

Di Scipio, Agostino.
2015. "The Politics of Sound and the Biopolitics of Music: Weaving together sound-making, irreducible listening, and the physical and cultural environment". *Organised Sound,* 20(3): 278–289.

Gabrielli, Leonardo and Stefano Squartini.
2016. "Networked Music Performance". In *Wireless Networked Music Performance*. Singapore: Springer. https://doi.org/10.1007/978-981-10-0335-6_2

Gaggioli, Andrea, Giuseppe Riva, Luca Milani and Elvis Mazzoni.
2013. *Networked flow: Towards an understanding of creative networks*. Dordrecht: Springer.

Gochenour, Philippe.
2011. "Nodalism". *Digital Humanities Quarterly*, 5(3): 1–10.

Green, Owen.
2014. "Audible Ecosystemics as Artefactual Assemblages: Thoughts on Making and Knowing Prompted by Practical Investigation of Di Scipio's Work". *Contemporary Music Review,* 33(1): 59–70.

Jagoda, Patrick.
2016. *Network Aesthetics*. University of Chicago Press.

Joy, Jerome.
2011. Networked Music Sound Art Timeline, Locus Sonus. Accessed April 2, 2021. https://joy.nujus.net/w/index.php?page=NMSAT.en

Kalonaris, Stefano, Toby Gifford and Andrew Brown.
2019. "Computational Aesthetics and Music: the Ugly, the Small and the Boring". In *Proceedings of 7th International Workshop on Musical Metacreation*.

Kalonaris, Stefano, Thomas McLachlan and Anna Aljanaki.
2020. "Computational Linguistics Metrics for the Evaluation of Two-Part Counterpoint Generated with Neural Machine Translation". In *Proceedings of the 1st Workshop on NLP for Music and Audio* (NLP4MusA), 43–48. Association for Computational Linguistics.

Krogh, Mads.
2018. "A Beat is a Hybrid: Mediation, ANT and Music as Material Practice". *Contemporary Music Review*, 37(5-6): 529–553.

Latour, Bruno.
1996. *Aramis, or the Love of Technology*. Cambridge, MA: Harvard University Press.

Lemmon, Eric.
2019. "Telematic Music vs. Networked Music: Distinguishing Between Cybernetic Aspirations and Technological Music-Making". *Journal of Network Music and Arts*, 1(1).

Meric, Renaud and Makis Solomos.
2014. "Analysing Audible Ecosystems and Emergent Sound Structures in Di Scipio's Music". *Contemporary Music Review*, 33(1): 4–17.

Moriaty, Manoli.
2016. "Unsound Connections: No-Input Synthesis System". *Contemporary Music Review,* 35(2): 184–201.

Munster, Anna.
2013. *An Aesthesia of Networks: Conjunctive Experience in Art and Technology*. Cambridge, MA: MIT Press.

Munster, Anna and Geert Lovink.
2005. Theses on Distributed Aesthetics. Or, What a Network is Not. *The Fibreculture Journal*, 7.

Murdoch, Iris.
1959. "The Sublime and the Good". *Chicago Review*, 13(3): 42–55.

Nguyen Anh, Jason Yosinski and Jeff Clune. 2019. "Understanding Neural Networks via Feature Visualization: A Survey". In *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning,* edited by W. Samek, Montavon G., Vedaldi A., Hansen L. and Müller KR. Lecture Notes in Computer Science, vol 11700. Springer, Cham. https://doi.org/10.1007/978-3-030-28954-6_4

Novak, David.
2010. “Playing Off Site: The Untranslation of Onkyô”. *Asian Music*. 41. 36-59. 10.1353/amu.0.0054.

Plourde, Lorraine.
2008. “Disciplined Listening in Tokyo: Onkyō and Non-Intentional Sounds”. *Ethnomusicology*, 52(2): 270–295.

Potgieter, Frederick.
2018. “Critique of relational aesthetics and a poststructural argument for thingly representational art”. *Cogent Arts & Humanities*, 5(1). https://doi.org/10.1080/23311983.2018.1531807

Purwins, Hendrik, Bo Li, Tuomas Virtanen, Jan Schlüter, Shuo-Yiin Chang and Tara Sainath.
2019. “Deep Learning for Audio Signal Processing”. In *IEEE Journal of Selected Topics in Signal Processing*, 13(2): 206–219.

Rancière, Jaques.
2005. *The Politics of Aesthetics: The Distribution of the Sensible*. Continuum.

Renwick, Robin.
2016. “The Relation of Nodalism to Network Music”. *The International Journal of New Media, Technology and the Arts*, 11(2).

Roberts, Adam, Jesse Engel, Colin Raffel, Curtis Hawthorne and Douglas Eck.
2019. “A Hierarchical Latent Vector Model for Learning Long-Term Structure in Music”. Available at: https://arxiv.org/abs/1803.05428

Rutsky, R. L.
1999. *High Techne: Art and Technology from the Machine Aesthetic to the Posthuman*. University of Minnesota Press.

Samek, Wojciech, Grégoire Montavon, Andrea Vedaldi, Lars Kai Hansen, Klaus-Robert Müller.
2019. *Explainable AI: Interpreting, Explaining and Visualizing Deep Learning. Springer*, Cham. https://doi.org/10.1007/978-3-030-28954-6

Schroeder, Franziska.
2009. “Dramaturgy as a Model for Geographically Displaced Collaborations: Views from Within and Views from Without”. *Contemporary Music Review*, 28(4-5): 377–385.

Schroeder, Franziska.
2013. “Network[ed] Listening—Towards a De-centering of Beings”. *Contemporary Music Review*, 32(2-3): 215–229.

Sá, Adriana and Atau Tanaka.
2019. “The variables of spatial presence: a parametric model”. In *Proceedings of the Conference on Computation, Communication, Aesthetics & X* (xCoAx). Milan, Italy.

Taylor, Grant.
2014. *When the Machine Made Art: The Troubled History of Computer Art*. Bloomsbury Academic.

Vaswani, Ashish, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan Gomez, Łukasz Kaiser, and Illia Polosukhin.
2017. “Attention is all you need”. In *Proceedings of the 31st International Conference on Neural Information Processing Systems* (NIPS’17), 6000–6010. Red Hook, NY: Curran Associates Inc.
Vorster, Stacey. 2015. “Telematic art across the North–South divide”. Critical Arts, 29(4): 460–478.

Vorster, Stacey.
2015. “Telematic art across the North–South divide”. *Critical Arts*, 29(4): 460–478.

Weinberg, Gil.
2003. “Interconnected Musical Networks - Bringing Expression and Thoughtfulness to Collaborative Group Playing”. PhD thesis, MIT.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Generative Scores and Data Mining: W.E.I.R.D. Enters the Stage

Keywords: Generative Musical Score, Generative Composition, Data Mining, W.E.I.R.D.

Nicola Privato
nicola.privato@gmail.com
Conservatorio C.Pollini of Padua, Italy

Alberto Novello
alberto.novello@conservatoriopollini.it
Conservatorio C.Pollini of Padua, Italy

W.E.I.R.D. **is a suite for piano solo combining the practice of data mining with a generative musical score. Data mining is deployed to extract tweets containing a set of keywords related to the sociological perspective on post-modernity proposed by Zygmunt Bauman. Such keywords are used to trigger the generation of a score written in common music notation, to be performed in real time by a soloist. Through the combination of data mining and generative scores,** ***W.E.I.R.D.*** **introduces the influence of a large sample of society on the stage, thus expanding the performance to emerging contemporary social dynamics. The first two movements of the suite are described from a technical and compositional perspective, and two demonstrative videos are presented outlining how the COVID-19 pandemic has influenced their implementation. Finally, a brief outlook of this work within the field of modern aesthetics and a series of possible developments for such compositional approach are proposed.**

1. Introduction

1.1. Data Mining in the Arts

Data mining is the practice of extracting valuable information from a vast set of raw data. The growing amount of information available in social media is favouring an extensive application of such techniques, for the most part automatically performed by software called *bots* (Maynard et al. 2012). The open structure of Twitter and the easy access to its Application Programming Interface (API) set this network apart from other social media platforms, in that most of the content is easily accessible and extractable (Kateb and Jugal 2015). Since Twitter's foundation in 2006, the number of active bots inside the platform has been rapidly increasing, reaching in 2012 a proportion of 1:1 compared to real users (Chu et al. 2012), attesting the strong interest of private and public entities towards Natural Language Processing (NLP) technologies for the prediction of public sentiment on relevant social themes, commercial products and services.

Twitter bots are commonly used for sentiment analysis, viralization of contents, data-set development and research, but since their introduction artists have included them in their practices to playfully develop artworks both inside and outside the internet. For the purpose of this work, three categories of use for the creation of artistic outputs are described: bots analyzing Twitter and posting the content on the medium itself, bots mining content from Twitter and posting it on the web, bots extracting content from Twitter and projecting it into the real world.

The examples of bots that scrape Twitter, process and rearrange the content, and publish it inside the platform are numerous. *@Oliviataters*, programmed by Rod Dubbin, automatically tweets snippets of text posted by teenagers, in order to simulate Olivia's fictitious existence. *@Anagramatron* searches for anagrams and retweets the matched pairs. *@Haiku9000* retweets sentences that each fit the rules to become a one line haiku, thus depriving the author's words of their original meaning. *@Pentametron* uses tweets to form iambic pentameter poetry (Oliviataters 2021; Haiku9000 2021; Anagramatron 2021; Pentametron 2021). The approach of using the content produced by the community for the community itself is the most common because of the great advantage of an easy and broad diffusion granted by the medium, even though such bots might at times suffer the limitations imposed by Twitter's policies to accounts posting repetitive or non consistent automated information.[1]

1. https://help.twitter.com/en/rules-and-policies/twitter-automation

Other bots mine Twitter to create original works outside the platform, and publish elsewhere on the web. The *Re*-Twitter*ing Machine* (Plessas 2012) downloads tweets containing the word 'freedom', and incorporates them in an online dynamic drawing similar to Klee's Twitter*ing Machine. WeFeelFine* (Harris and Kamvar 2011) is a complex website and artistic creation delving inside human emotions: a bot looks on platforms and blogs across the internet for sentences starting with "I feel". The process repeats every ten minutes. The extracted data is then processed in a series of six movements, or graphic compositions. Each one represents a specific emotional nuance and displays information about the authors of the twitter content.

Less numerous are the works extracting information to display into the real world. The data is usually rearranged in order to build visual processes, as in the case of the *Mood Map* (Lee, Brush, Younse 2013) which displays through light the prevalent mood of people tweeting in South Korea , or the *Hello Cube* (Hellicar and Lewis 2012) which exists both in the real and virtual world, and dynamically changes in colour and shape following people's instructions received on its 'personal' account. Still visually oriented, but incorporating sounds and lights in a physical sculpture is *Bias* (Apnoa 2017), triggered by tweets containing one of the keywords monitored by the American Department of Homeland Security. More rare is the case of tweet bots interacting with the physical world only through sound. An interesting example of such an approach is Twitter*radio* (Morreale, Miniukovich, De Angeli, 2014). This interactive installation consists of a *graphical user interface* (GUI), a tweet bot, a server for *natural language processing* (NLP) query and an algorithmic composition software. The system retrieves all the tweets published during the preceding five hours and containing the keyword selected by the participant through the GUI. The tweets are analyzed through the MPQA Subjectivity Lexicon[2] which assigns them an emotional valence, from very positive to very negative. The result, normalized by the number of tweets, triggers an algorithmic composition software based on Markov chains. The average valence of the incoming tweets affects the acoustic outcome in real time.

2. https://mpqa.cs.pitt.edu/lexicons/subj_lexicon/

1.2. Notation as a Dynamic System

The amount and the nature of the instructions given to performers through graphic signs have been changing throughout time, depending on the praxis, the available medium and the intention of the composer, but in all cases information is necessarily lost in the bidirectional process of fixation and translation of sound. In the Middle Ages the atomic written element of *plainchant* was the *neuma* (Grove Music 2001), a graphic sign representing a combination of sounds to be performed on a single syllable. The score was a set of symbols depicting musical gestures (Latin 776). Since it lacked fixed reference points, it was used as a study and memorization tool rather than a complete notational system. During the 11th Century Guido D'Arezzo addressed the representational limitations of such an approach by adding two lines over F and B to indicate the half tone, thus allowing for monodic sight reading (Palisca and Pesce 2001). Still, the main technique adopted to vertically embellish the music over iterative motives was improvisation (*Cantare Super Librum*) (Vicentino 1555). With the development of polyphony (*Cantus Mensurabilis*), the need for a more precise notational system, especially in the rhythmic realm, got urgent: squared notes over a quadrigram were introduced to represent durations (Apel 1961). Notational praxis was adapting to the context, to the requirements of the music and the role entrusted by it to the musician.

During the sixteenth century, intervening over a score to introduce extemporary variations was common practice. Scores were often written assuming a deep stylistic comprehension by the performer as a necessary premise for his active intake. The most diffused approach to the extemporary intervention over a written score was *diminution*, the practice of introducing shorter notes inside longer ones in order to embellish the melodic line. Diminution was taught as a systematic method, by providing students with a set of examples on how to fill a specific interval (Gatti et al. 2015).

With time, publishing music with written diminution became common practice, providing the composer with more control and the performer with defined constraints. A radical paradigm shift emerged in the midst of the nineteenth century, fostered by the effects of industrialization on academic art and by the secularization of repertoire: the figures of composer and performer began to walk on different paths, and the mediating role of the score became critical (Moore 1992). Even though some musical parameters had necessarily to be entrusted to the performer (Rink 1995), the scores became rigid and the musician's interpretative freedom extremely limited.

At the beginning of the 20th century the perspective shifted once again. The direct fixation and reproduction of sound provided by the phonograph coupled with the diffusion granted by the radio, allowed for the diffusion of improvised genres of popular derivation (Zenni 2012). At the same time, the pressure towards the dissolution of the tonal system after the post-romantic era, which culminated with dodecaphony, set the foundation for the emergence of a plethora of original approaches. The explicit attempt to defy the narrative continuity represented by tonality and the development of new approaches and technological means implied an adaptation of notational systems. In *Fontana Mix* and Aria (1958), John Cage superposes transparent papers to build generative scores and Cornelius Cardew in Treatise (1967) adopts lines, symbols and abstract geometric shapes as the basic elements of the score.

With the birth of computer music the possibility to automate the score's changes during performance was introduced, thus opening to an unprecedented palette of behavioral implementations inside the medium. Thanks to the aquired dynamic dimension[3] the scores began to react to the context with different degrees of freedom, shifting the composer's role towards the construction of structures containing a variable set of possibilities: a third way, in between the realms of improvisation and execution of written music had been introduced (Winkler 2004).

3. Animated scores by Steinn Gunnarsson and Ryan Ross Smith

In generative scores, the sources providing data affecting the algorithm's behavior are usually sought inside the performative context, alternatively assigning the role of direct agents on the score's variability to the musicians, to the audience or to the algorithm itself. *The Anticipatory Score* (Wyse and Yew 2014) is an example of a generative score controlled by the performers themselves. Here, notation becomes a communication strategy for real-time musical interventions. In other cases the audience is endowed with the control of the generative algorithms. McAllister proposes a technique for using handheld computers as inputs of the audience's gestures affecting the score in front of the performers (2004). Freeman introduces the use of video cameras pointed towards the audience as the input for score generation (2008). Burtner's *Auksalaq* NOMADS (2012) app and thematic opera collects, merges and displays the textual and graphical outputs from the audience's smartphones, organizing it in semantic fields affecting the performance. Burtner's opera unfolds around the listeners that, in real life as in the fiction of the play, are active participants in the dramatic process of ice melting in Alaska and Canada. Eigenfeldt suggests incorporating performing instrumentalists, instead of synthetic sounds, inside evolutionary computer-generated music. In his work An *Unnatural Selection*, common notation is displayed for the musicians and the conductor via eight iPads. The whole composition is generated by an evolutionary algorithm, thus remaining completely independent from the context yet different in every performance (Eigenfeldt 2015).

In all the aforementioned works, real time score modifiers are generated from within the performative space with musicians, audience or computer as agents. In search for further destabilization, I introduced a new unpredictability element from the outside. The piece described in this paper extends the agency to society as a whole by affecting the score in real time through the contribution of social media. Such an approach allows for the extension of the performance way beyond the walls of the concert hall, and provides a new, strong conceptual ground for the adoption of independent triggering variables in performative musical practice.

2. W.E.I.R.D.

W.E.I.R.D. stands for *Western, Educated, Industrialized, Rich, Democratic*. The acronym was first introduced in the 2010 meta-analysis *The Weirdest People in the World* by Henrich, Heine, Norenzayan. Their research exposed a bias affecting behavioural sciences, characterized by the false assumption that the small sample of population traditionally subject to experimental research and responding to the w.e.i.r.d characteristics, represented a reliable model for all mankind. The w.e.i.r.d. sample is traditionally defined within the realm of social sciences, but the geographical pattern of Twitter accesses and posting can be easily juxtaposed to the common indexes of wealth and education all over the world (Leetaru et al. 2013). At the core of *W.E.I.R.D.* is the work of Zygmunt Bauman, and the ideas proposed in Liquid Modernity (2000) and other coeval essays. Three keywords were chosen out of the reflections on postmodernity developed by Bauman, each one giving the title to a specific movement: *Uncertainty, Emergency, Identity*.

2.1. Technical Description

W.E.I.R.D. is a suite for piano solo, consisting of three components: a generative score in three movements, a tweet bot and a Max[4] patch. During the performance, the three movements should be sequentially projected on a large surface, so that the musician and the audience share the same point of view. On the right vertical half of the screen the composition unfolds. The left half of the screen displays tweets containing the keyword giving the title to the movement as they are posted all around the world. The tweets influence the score's behavior in accordance with a different set of rules for each movement. The details on how tweets and notation interact are not explicitly explained to the audience, but given the synchronicity of the events between the two halves of the screen, a correlation can be clearly perceived. Such an approach endows

4. https://cycling74.com/

every listener with the freedom to correlate words, concepts and sounds, and grants intimacy and uniqueness to the experience.

The first component, common to the three movements and necessary for *W.E.I.R.D.* to access social media, is the bot. The Twitter API is accessed with *Tweepy*[5], an open source Python library. Once activated, the script downloads all the tweets containing the chosen keywords, divides them in short/long tweets — classification threshold is by default 140 characters — and new tweets/retweets. The tweets are then routed to Max via *Open Sound Control* (OSC) and displayed on the left side of the screen.

5. https://www.tweepy.org/

The way the tweets trigger events on each score is strictly correlated to the conceptual representation of the chosen keywords and to how each movement is imagined to act. Inside *Uncertainty* three scores coexist: an empty staff, the final refined version of the piece (A), and a score containing a more essential version of the composition, devoid of one melodic line (B). The three scores are divided into 24 parts, each one containing the equivalent of one bar. For each bar, a switch controls which of the three scores will provide the output image. The score displayed by default is the empty one. Every time a tweet containing the keyword *Uncertainty* is downloaded, the program assigns a bar from A or B to one of the 24 empty units. Tweet after tweet the composition appears on the screen, and since A and B are randomly assigned to each bar, the overall result is somewhere in between the two but always different. When most of the score has emerged—after about two minutes from the beginning—the musician starts playing. During the performance, the tweets trigger random variations between A and B thus producing unexpected results, but the coherence of the composition is preserved by the common origin of the two scores. A final, conclusive form is never reached though: uncertainty feeds the tension towards a defined structure, but at the same time prevents its achievement. The piece ends after one iteration.

In order to allow the live execution while the score changes in front of the player, many compositional aspects had to be taken into account. The most critical of them was the tempo, which had to be very slow for the musician to be capable of reacting to any sudden variation. This necessity became an interesting compositional artifice: the first movement, if played at normal tempo, has a pseudo tonal character. The tempo should be slowed down just enough for the horizontal, melodic element to lose its coherence and become a subliminal glue between isolated, vertical units of sound.

The second movement was conceived as a rhythmical and melodic counterpart to the first. In *Emergency* the score is divided in sections that are numerically ordered from one to five. The higher the section number, the more dense and dynamically tense the composition gets. Once started, the software checks the average number of tweets containing the word *Emergency* inside a nineteen-second span. The process repeats four times, and the lowest value obtained is associated with the first section, which then appears on the screen. The musician starts playing. If the number of tweets in the next nineteen-second slot is higher than in the preceding one, the next section appears, otherwise the score does not change and the player keeps repeating section one. From section two on, a higher number of tweets moves the composition to the next section, and a lower number to the preceding one. Once the last section is reached the tweet counting stops, and the whole movement ends after one repetition. The right half of the screen turns from black to white and vice versa every time the musician has to change sections, while the left one, like an alarm, blinks at a higher rate as the piece progresses.

2.2. Compositional Approach

Compositional choices were made to provide balance and coherence among the three different movements of this work. *W.E.I.R.D*. is composed over a twelve-tone series. The series is a constant compositional reference but it poses no strict rule: it is rather an artifice to establish a sense of harmonic ambivalence in each movement, and overall consequentiality throughout the composition.

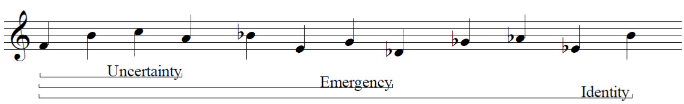


Fig. 1. *W.E.I.R.D.* Dodecaphonic Series.

The first four notes of the series, which overlap in *Uncertainty* to produce chords, can be seen either as a Csus triad with a major 7th or a FMaj7 with a sharp 11th. In the first case (CMaj7Sus4), the missing 3rd does not consent a clear interpretation of the chord, while in the second case (FMaj7 #11) the Lydian derivation of the chord is a modal point of gravity from which any other possible outcome originates (Russell 1953). *Emergency* adds another set of four notes to the first four of the series. This second group forms a diminished chord and since in such chords all notes are a minor third apart, any of them can be perceived as the root of four equal inversions (Bbdim - Edim - Gdim - Dbdim). Once again, harmonic ambiguity and ambivalence are used as a metaphor of the rootlessness and uncertainty of modern times. *Identity*, the third movement of *W.E.I.R.D*, will include the whole dodecaphonic series, with the addition of another group of four notes that, similarly to the first movement, can be interpreted as an Ab Lydian Dominant devoid of the third.

Even though its primary purpose is performative, W.E.I.R.D. can become a testimony of specific social dynamics, common emerging fears, issues at the center of the political agenda as in the case of the two demonstrative videos presented in this paper and recorded during the COVID-19 lockdown.

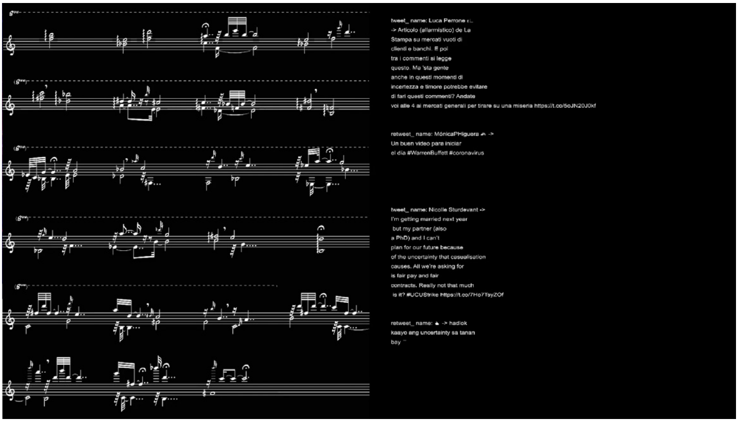


Fig. 2. *Uncertainty* (https://youtu.be/p_iR8aKaLJs)

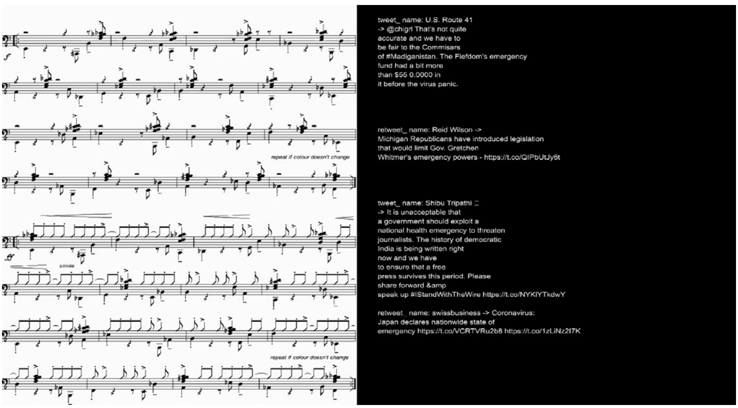


Fig. 3. *Emergency* (https://youtu.be/AD1hY5-Kk2s)

3. Conclusions

W.E.I.R.D. is a suite in three parts for piano solo, combining the practice of data mining with a generative musical score. Tweets, containing keywords that give the title to each of the movements, are analyzed in real time and trigger the generation and modification of a score performed by a soloist on stage.

Uncertainty, the first of the three movements, was composed in January and February 2020. My aim was to look for diffused states of anxiety inside society, that might be integrated into the composition. I had been inspired by Bauman's reflections on uncertainty as a trait of postmodern society caused by the rise of diffused precarization processes inside the public and private sphere (Bauman 2006). The successive recording coincided with the announcement and diffusion of the COVID-19 pandemic across the globe and the successive lockdown in Northern Italy.

The second movement, *Emergency*, was written in May 2020, in the midst of the first COVID-19 wave, when most countries were being severely affected by the pandemic and people's freedom of movement and social gathering had been reduced in an unprecedented way for western democracies. The dialectic between personal and collective freedom was at the core of complex political choices induced by the present state of emergency. Twenty years before, Bauman—in exploring the blurred line between public and private realms in postmodern democracies—stated:

> It is possible that an increase of personal freedom coincides with a growth in collective impotence in that the bridges between public and private life were broken down or never existed in the first place (Bauman 1999).

However, COVID-19 is not an isolated crisis in the unfolding of social experiences: emergencies pervade the public sphere as a destabilizing roller-coaster ride. It can safely be assumed that the second movement of *W.E.I.R.D.* will never be devoid of triggering tweets.

Because of social distancing imposed by pandemic restrictions, the first two movements of *W.E.I.R.D.* could not be performed in a public space yet. Nevertheless the two attached videos were sent to art galleries and journals as self-standing artworks. The video recordings were positively welcomed by numerous contemporary art organizations. Among others, *The Blackwood Gallery* published the movements in two successive issues of their journal *Tilting*, which brought to a positive review by *Cmagazine*; *Gallery Lane Cove* displayed the works in the virtual exhibition Shelter Domestics; Artveine selected the suite for the exhibition *What About Tomorrow*; *TERA, Magazine for Technologies, Ecologies and Risk Assemblages*, covered it in its opening issue.[6]

6. https://www.blackwoodgallery.ca/publications/sduk/tilting/uncertainty

On different occasions I was asked how the frequency of use of the selected keywords had changed with the pandemic. The usage rate of 'uncertainty' jumped from an average of a hundred per minute in January 2020 to about three hundred and fifty in March. When I tested it in May, the score was changing so rapidly that the system crashed several times. The frequency of use of the word 'emergency' has not changed much since May 2020: its variability is mainly correlated with the time of the day. When most of the w.e.i.r.d. sample is awake—the evening in Europe and afternoon in the U.S.— 'emergency' appears in around three hundred tweets per minute, decreasing to about one hundred a few hours later. Since the composition of *W.E.I.R.D.* coincided with an unprecedented collective sanitary crisis and got deeply intertwined with it, the third and final movement, *Identity*, will be composed and recorded in the next months in order to explore how our relationship with each other through social media will have changed after months of exacerbated physical isolation.

The introduction of a sample of society inside the performative dynamics opens up new scenarios to explore. It might be interesting to parse the tweets with *A.I. Emotion Analysis* tools, attributing emotional values to the text and affecting the composition in much varied ways. *YouTube* might become a new source of content to analyze with speech-to-text software. Alternatively, other literary sources might be used to affect score generation and changes. The compositional approach itself might be investigated in search for a higher number of possible outcomes, incorporating probabilistic systems like *Recursive Neural Networks* or *Markov Chains*, that would allow the composition to evolve beyond the composer's initial intentions, and unpredictably evolve in close relationship with the changes in the social dynamics. Finally, the role of the musician, here frantically trying to react to the musical stimuli in a way similar to how people might get overwhelmed by social media's compulsive notifications, deserves to be further investigated. It would be interesting to explore the limits of human reaction to a dynamic score by providing the player with more information than he can handle, and force him to make choices in order to get to the end of the performance: in a rather paradoxical way, an overload of instructions would return the possibility of a conscious choice.

Social fragmentation, the radicalization of change, the blurred boundaries between the public and personal dimensions, the unpredictability and indefiniteness that permeate postmodernity, all resonate within the perspective of the modern work of art as a conscious act of expansion towards a plurality of visions and possible semantic interpretations: the revolutionary awareness entitled to the modern artist is the inevitable responsibility to depict the present (Eco 1962). *W.E.I.R.D.* is in this sense an attempt to represent the liquid era we live in, its loss of geographical distances and the urge to find a place of unity and cohesion. Postmodernity is a collection of disconnected episodes: the absence of permanent social structures and durable relationships, the continuous bouncing from a state of emergency to the other and the preoccupation with precarity, all concur to the dissolution of the perceived continuity of temporal social planes (Tarkowska 2006). The inquiry inside the deceptivity of the present and on what synchronicity has become in the context of globalized communication are therefore fundamental aspects to investigate. Through *W.E.I.R.D.*, I attempt to imagine a work of art capable of structurally adapting to the time being, making use of elements that exist necessarily in the 'now' and emerge from beyond the walls of the concert hall, liquid in shape and structure, yet vertically over-connected in an ubiquitous present tense.

References

@anagramatron
https://twitter.com/anagramatron – last accessed Jan. 2021.

@HAIKU9000
https://twitter.com/haiku9000 – last accessed Jan. 2021.

@Oliviataters
https://twitter.com/oliviataters – last accessed Jan. 2021.

@pentametron
https://twitter.com/pentametron – last accessed jan. 2021.

Gatti, Enrico, Giovanni Acciai and Konrad Tavella.
2015. *Regole per ben Suonare e Cantare. Diminuzioni e Mensuralismo tra XVI e XIX secolo.* Quaderni del Conservatorio Giuseppe Verdi di Milano. Edizioni ETS p.71-75.

Apel, Willi.
1961.*The Notation of polyphonic Music*. Cambridge, MA: The Medieval Academy of America.

Apnoa.
2017. *Bias*. https://apnoa.space/work/bias – last accessed Jan. 2021.

Bauman, Zigmunt.
1999. *La Solitudine del Cittadino Globale*. Feltrinelli Editore. ISBN 8807884836.

Bauman, Zigmunt.
2000. *Liquid Modernity*. Polity Press. ISBN 0745624103.

Bauman, Zigmunt.
2006. *Liquid Times: Living in an Age of Uncertainty*. Polity Press. ISBN 0745639879.

Burtner, Matthew, Steven Kemper and David Topper.
2012. *Network socio-synthesis and emergence in NOMADS*. Organised Sound. 17. 10.1017/S1355771811000501.

Cage, John.
1958. *Fontana Mix and Aria*. Peters Editions EP 6712 https://johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=79 – last accessed Jan. 2021.

Cardew, Cornelius.
1963-1967. *Treatise, for any number of musicians with any instruments*.

Chu, Zi, Steven Gianvecchio, Haining Wang and Sushil Jajodia.
2012. *Detecting Automation of Twitter Accounts: Are You a Human, Bot, or Cyborg?* IEEE Transactions on Dependable and Secure Computing, vol. 9, no. 6, pp. 811-824, doi: 10.1109/TDSC.2012.75.

Eco, Umberto.
1962. *Opera Aperta: Forma e Indeterminazione nelle Poetiche Contemporanee*. Bompiani 2000. ISBN 8845274853.

Eigenfeldt, Arne.
2015 *Generative Music for Live Musicians: An Unnatural Selection*. International Conference on Computational Creativity.

Freeman, Jason.
2008. *Extreme Sight-Reading, Mediated Expression and Audience Participation: realtime music Notation in Live Performance*. Computer music Journal 32:25-41.

Hellicar & Lewis.
2012. Infinite Kusama Exhibition, Tate Modern.

Henrich, Joseph., Steven J. Heine and AraNorenzayan.
2010. *The Weirdest People in the World*. Behavioral and Brain Sciences, 33(2-3), 61-83. doi:10.1017/S0140525X0999152X.

Ju, Yong L., Brian Brush and Noa Younse.
2013. *Mood Map*. 'Data Curation', Museum of Art at Seoul National University. http://www.noayounse.com/projects/moodMap/moodMap.html - last accessed Jan.2021.

Kamvar, Sepandar D. and Johnatan Harris.
2011. *We Feel Fine and Searching the Emotional Web*. Proceedings of the fourth ACM international conference on Web search and data mining Association for Computing Machinery, New York, NY, USA, 117–126.

Kamvar, Sepandar D. and Johnatan Harris.
2011. *We Feel Fine and Searching the Emotional Web*. Proceedings of the fourth ACM international conference on Web search and data mining Association for Computing Machinery, New York, NY, USA, 117–126.

Kateb, Faris and Kalita Jugal.
2015. *Classifying Short Text in Social Media: Twitter as Case Study*. International Journal of Computer Applications.

Latin 776.
XI dC. *Graduale Albiense*. Bibliothèque nationale de France, Département des manuscrits https://archivesetmanuscrits.bnf.fr/ark:/12148/cc62232g.

Leetaru, Kalev, Shaonwen Wang, Guofeng Cao, Anand Padmanabhan and Eric Shook.
2013. *Mapping the Global Twitter Heartbeat: The Geography of Twitter*. First Monday, 18(5) https://journals.uic.edu/ojs/index.php/fm/article/view/4366.

Maynard, Diana, Kalina Bontcheva and Dominic Rout.
2012. *Challenges in Developing Opinion Mining Tools for Social Media.*

McAllister, Graham, Michael Alcorn and Philip Strain.
2004. *Interactive Performance with Wireless PDAs*. Proceedings of the 2004 International Computer Music Conference. Miami 702-5.

McKinnon, James.
2018. *The origins of Gregorian Chant*. Grove Music Online. https://doi.org/10.1093/gmo/9781561592630.article.11726.

Moore, Robin.
1992. *The decline of Improvisation in Western Art Music: An Interpretation of Change*. International Review of the aesthetics and Sociology of Music, Vol 23, N. 1.

Morreale, Fabio, Aliaksei Miniukovich and Antonella De Angeli.
2014. *Twitterradio: Translating Tweets into Music*. Conference on Human Factors in Computing Systems - Proceedings. 567-570. 10.1145/2559206.2574790.

Neumatic Style.
2001. *Grove Music Online*. https://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000019788
Last accesses Jan. 2021.

Palisca, Claude V. and Dolores Pesce.
2001. *Guido of Arezzo*. Grove Music Online. https://www.oxfordmusiconline.com/grovemusic/view/10.1093/gmo/9781561592630.001.0001/omo-9781561592630-e-0000011968 - Last accessed Jan. 2021.

Plessas, Angelo.
2012. *Re-Twittering Machine*. http://www.angeloplessas.com - last accessed Jan. 2021.

Rink, John.
1995.*The Practice of Performance: Studies in Musical Interpretation*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511552366.

Russell, George.
1953. *The Lydian Chromatic Concept of Tonal Organization*. Concept publishing Co. ISBN 0970373902.

Tarkowska, Elżbieta.
2006. *Zygmunt Bauman on Time and Detemporalisation Processes*. Polish Sociological Review - POL SOCIOL REV. 357-374.

Vicentino, Nicola.
1555 *L'antica Musica Ridotta alla Moderna Prattica*. https://tmiweb.science.uu.nl/text/critical-edition/vicant.html – last accessed Jan 2021.

Winkler, Gerhard E.
2004. *The Realtime Score*. A Missing Link in Computer Music Performance. Proceedings of sound and Music Computing Conference, Paris.

Wyse, Lonce and Jude Yew.
2014. *A Real-Time Score for Collaborative Just-in-Time Composition*. Organised Sound. 19. 260-267. 10.1017/S1355771814000247.

Zenni, Stefano.
2012. *Storia del Jazz.* Una Prospettiva Globale. Nuovi Equilibri. ISBN 978-88-6222-184-9 p. 163-165.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Making the Computational Physical Through Digital Craftsmanship

Keywords: 3D Printing, Metal Foundry, Digital Fabrication, Craftsmanship, Materiality

Andrew Sidsworth
ASidsworth@outlook.com
York University,
Toronto, Canada

The forms that can be created through computational methods are infinite in both their number and complexity. However, in order to exist in the real world, the given form must be negotiated with reality through a material. The most direct and accessible form of digital to material translation is 3D printing. However, much of the knowledge required to perform this digital-material translation exists in an embodied state, taking a form similar to the embodied knowledge of craftsmanship. There are underappreciated constraints in all materials that must be taken into account when making with any given process, and the use of 3D printing to give materiality to ethereal, computationally generated forms highlights these constraints. Metal foundry, as an example of one of the oldest forms of traditional fabrication, can be made to utilize computational design by using 3D printing as an intermediary step between computation and craft. Through the examination of several works of sculpture and works in progress, this paper demonstrates the strengths, shortcomings and general use of 3D printing as a form of expressing the computational in the physical, and will use foundry as an example of an extension of this.

1. Introduction

The constraints of digital forms are almost entirely defined by those creating them. Reality rarely affords this same luxury to the forms that exist within it. The most direct and accessible way to take the digital and bring it into reality is 3D printing, which has been used effectively by the collective, the studio, and individual for countless projects. 3D printing bridges the gap between computational creativity and the constraints reality imposes, reshaping what forms can be brought into existence from the creative vision of the artist, designer or engineer by translating a 3D model into an actual 3D object. Despite this nearly direct translation, the 3D printing process is still constrained by the embodied rules of the materials it uses. A kind of craftsmanship, like that found in more traditional forms of fabrication, is required to produce something with this embodied set of rules. Foundry, in a similar way, offers the opportunity to use much more robust and enduring materials, using a craftsmanship that has been iterated over in more traditional forms of fabrication, production and art making for thousands of years (Treyger n.d.). Unlike 3D printing, due to the processes involved in most metal casting, foundry can not fully take advantage of computer aided design fundamentals on its own. By using both processes, through an embodied, combined craftsmanship of both the traditional and the digital, the two processes can be used to create forms, sculpture and components that they would not be able to without the other.

In the same way that previous pieces have combined other forms of traditional sculpture with computational design through the use of a combined craftsmanship, metal foundry, through the intermediary step of 3D printing, is more than capable of being used in as a tool for the expression of computational creativity, to create forms that could not otherwise be made in foundry, and to allow the control and adaptability of 3D printed objects to take advantage of the strengths of the heavy materials of foundry.

1.1. Digital and Traditional Methods of Production

There are already multiple examples of ancient or traditional forms of art being reproduced through modern technologies. The same fundamentals of translation between those traditional techniques and modern ones exist for the translation between digital design, 3D printed plastic and foundry as well. Several of the works of Tobias Klein and his collaborators demonstrate this translation of material through the use of both traditional and digital craftsmanship. In *Chemical Skin*, Klein uses UV activated materials to allow 3D printing to behave in a similar way to Chinese pottery, a traditional form of craftsmanship, by extending and augmenting the function of the 3D printer. He and his collaborators create parallels between the process of painting and firing glazes within the process of 3D printing, which while closely replicating the original work, still leaves many of the same artifacts common in that method of production (Klein and Leung 2018).

In Klein's examination of *Vessels of Vanitas*, he details how much of an impact the limited, non-tactile experience of working with digital "material" can have on the shape and form of an object. By making the semi-natural form of the Rococo in such a non-traditional way, the forms are able to take on qualities and shapes that would be impossible to create, or even envision, through the use of only hand tools (Klein and Kraemer 2019). Ultimately, the only effective way to reproduce those forms physically would be to use 3D printing. These show that some forms that were previously impossible to make in traditional methods of making can now be made through an application of CAD principles. 3D printing is the mediating element between these forms and the traditional making practices.

The augmentation of these traditional artforms through the application of 3D printing demonstrate just how useful a tool it can be to extend what these artforms are capable of. In the same way that Klein and his collaborators extended the Rococo and pottery, 3D printing can extend foundry. The traditional knowledge of the craftsman, and the embodied knowledge of that practice is what combines with the technical knowledge of the digital to form what Klein describes as digital craftsmanship (Klein 2018). Digital craftsmanship is the same type of knowledge applied to a digital medium as opposed to a material one, and can be brought into the material through the use of 3D printing. In the same way that 3D printing and foundry interact, these two kinds of craftsmanship will as well.

The embodied knowledge of craftsmanship is stored in an object being produced, in the same way a mathematical equation is stored on a piece of paper (Wilson and Clark 1999). Not only is this knowledge stored in any tooling marks left by a process, but as later demonstrated, is inherent to the structure of that object. The object can not be brought into existence without a negotiation with reality, and this negotiation is done through craftsmanship. The material and the craftsmanship required to work with it are inseparable, but can be translated from one material to another due to similarities between process. Zheng and Nitsche (2017) describe this inseparability in their analysis of the combined usage of ceramic pottery and LED lighting to create novel decorative forms. They use this example to highlight the need to relay on the embodied knowledge of the expert they worked with to create these forms, and how everything from the shape of the object to the glazed use to finish the surface of them has an effect on the electronic components of the form. It also shows, through the authors' anecdotes, the importance if interdisciplinary research and exchange of information from areas outside academia. This outside knowledge is a sorely underutilized part of making and creativity in the context of computational arts, and so collaborations like those previously mentioned have the capacity to better both parties by bringing more and more outside knowledge into academic circles.

2. Embodied Material Translation

In the case of 3D printing and foundry, both are essentially additive processes. Both require a disposable supporting structure in order to bring certain forms into being. These support structures leave marks on the final process that must be removed manually. There is an embodied process in the object and the material it is made out of in the same way that there is an embodiment of the craftsmanship necessary to create it. When creating an object in digital space, there is still a kind of embodied knowledge, even if it does not exist physically. Digital craftsmanship is used to first create this form, and when 3D printing it, that craftsmanship must then communicate with the physical in order to render that digital form into reality. The form being made passes through several different modes of being, and is affected by every translation to each. In a similar way to translating between languages, a form must be made within the constraints of the material. Some details will be lost, and others added, but the fundamental form will be the same if translated correctly. Also like spoken or written languages, the rules and constraints of a material can be used to accentuate the form or emphasize certain elements of the design.

2.1. The Embodied Language of 3D Printed Plastic

The process of 3D printing, regardless of the material used, consists of building up layers of material on top of one another. In order to print certain forms, it is necessary to create a kind of scaffolding that can support the material being added, so that the object being produced doesn't fall apart before it is finished, and so that there will be material to build up layers upon. While designed to be removed from the final object, this scaffolding will still show through in some ways on whatever is produced. What's more is that those marks of process will be just as prevalent on the interior of the object produced as they will be on the outside, and should be taken into just as much consideration when working with an object that has been 3D printed, regardless of material. These marks of process can be seen more obviously when certain processes are applied to a 3D printed object. Some examples of these artifacts can be seen in Figure 1.

Exterior Artifacts The scaffolding required to build overhanging layers on top of pre-existing ones do not always come off cleanly. Occasionally, remnants of the scaffolding can be fused to the main body of the object and will have to be removed manually. Artifacts can also be introduced into the surface of the object if the temperature of the material or the speed of the printing head is not constant, or within manufacturer recommendations.

Interior Artifacts Unless printing an object that is completely solid, the object will be filled with geometric pattern in order to support the rest of the surface and provide structure to the form. These patterns can be exposed if the surface has been finished aggressively, such as with heat or sanded down to past the outer layers in the case of plastic. They will also be visible if a transparent material is used.

Printing Errors The layers of a 3D print may not fuse correctly, resulting in something that looks closer to a birds nest or bowl of spaghetti than the object being produced. There is usually no recovery from this state. The head of a 3D printer may also clog, resulting in a half made object. In both cases, the objects may have to be reprinted.

Finishing Plastic 3D printed plastic can be smoothed and sanded through traditional means, but it can also be smoothed chemically through the limited application of some solvents, such as turpentine. This process may leave the surface tacky if too much is applied. While plastic can also be painted, it is important to ensure that a given paint won't react with the plastic when applied, as it may deform the outer layers of the print. Plastic can also be smoothed through the limited application of heat, such as with a heat gun or bunsen burner. The printed layers will blend together, but too much heat may deform or burn the plastic.

Fig. 1. (a) The supports required to print an overhanging object. (b) A 3D printed object smoothed with a heat gun. The heat warped the plastic to show the structure inside the object. (c) The aftermath of a failed print. Images by author.

2.2. The Embodied Language of Metal Casting

The foundry process consists of liquid metal being poured into a mould and given time to solidify. An object is given form not by removal of material, but by the shaping of a set amount of material by the mould. Other materials, such as sand or ceramic, must be used as well, and are usually consumed by the process. The construction of these moulds can sometimes take days, depending on the method used and the size of the object. Part of this mould making process involves creating a network of plumbing for the metal to safely flow into the mould, which will then have to be removed later, in a similar way to the supports and rafts of a 3D print. This network is usually referred to as sprue, gates or runners, depending on their size and their role in the network of the pour (Treyger n.d.). An example can be seen in Figure 2.

Gating The application of gates onto the surface of the object being cast will remove a section of surface detail. When the gating is removed by the maker, the only thing left in that place will be small lumps of excess metal, which will then have to be smoothed down and retextured by hand.

Air Pockets As liquid metal rushes into the mould, air must be pushed out through either a porous material or a specially made channel. However, in cases where the air cannot escape while the metal is still forming, these air pockets will show through on the final product, either as nodules or indentations on the surface.

Incomplete Pours In some situations, an air pocket may be so large that it prevents the formation of a large portion of the object. In other cases, part of the mould may collapse in on itself, leading to a similar effect. When the object is removed from the mould in either of these cases, it will have a large cavity.

Finishing Cast metal can be refined by mechanical and chemical means, such as through sanding blasting, mechanical polishing, or through the application of chemicals called patinas to change the texture, colour and sheen of the surface. Most metals can be brought to a high degree of polish, unlike 3D printed plastic. One of the most important processes in finishing the metal object is the complete removal of the excess material left by the mould.

Fig. 2. The hole in the side of this sculpture was caused by an air pocket, whereas the texture on its surface was caused by the metal hardening before it could fill in the entire. A patina was then applied to darken and highlight these textures, using them as sculptural features left by the process. Image by Elizabeth Tsu (2021).

3. Using 3D Prints with Metal Foundry

Snelling et al. (2013) discuss the use of 3D printed materials in the process of mould making for metal casting. The study finds that using a 3D printed material could negatively impact the tensile strength of cast objects, and while this fact should be considered, it should not dissuade from it's usage. However, this study focused on the use of 3D printing material that is specifically designed for metal casting, and may not be available to those with consumer grade printers. The following section will outline experimentation with using consumer grade PLA plastic in the context of three different foundry techniques with mixed results.

3.1. Moulds for the Lost Wax Process

Lost wax is the process of rendering an object in metal by first sculpting it in wax to be used as a positive to create a mould of ceramic around that wax form. The wax is then melted out of the ceramic, which is fired to make a heat resistant mould for casting metal. When attempting to render a pre-existing object in metal through this process, a mould of it would be made by submerging it in some form of media such as silicone or alginate, where wax would be poured to make the wax positive. However, 3D printing offers an alternative to this by allowing the direct creation of a mould for the wax positive, without the need for a physical original object.

In the example shown in figure 3, a cavity was modeled into a cube by performing a boolean difference between said cube and the desired object. The cube was then sliced digitally into several components so that the desired object could be removed without damaging the wax form. It was then printed in PLA plastic.

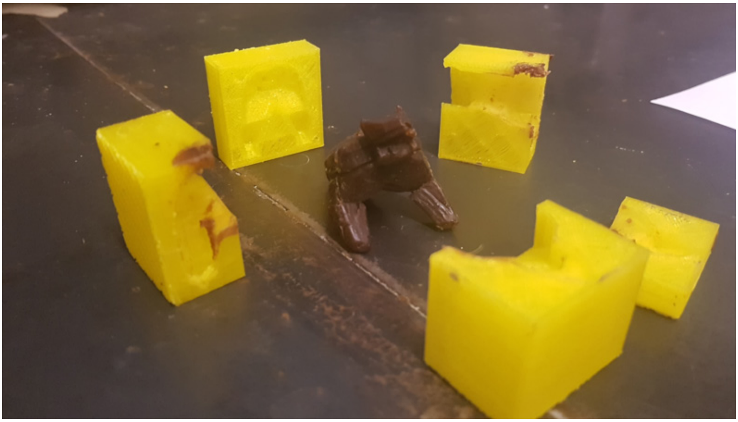


Fig. 3. The components of a 3D printed mould, and the closest thing to a full wax rendering of the desired object achieved by this method placed in the center. Image by author.

While the printing of the mould components were successful, the heat from the liquid wax ended up melting the plastic around it, fusing the wax and the plastic together in such a way that a release agent could not be used to separate the two. Several attempts were made with varying heat of wax. In the attempts with cooler wax, the wax would not fill the entire mould. If the wax was too hot, it would destroy the mould and spill into the gaps between the inner and outer walls, as seen in figure 4. However, in figure 5 we can see the artifacts that the 3D printing process would have left in the final version had the wax positive been cleanly removed from the 3D printed mould.

Fig. 4. The remnants of a 3D printed mould that hot wax was poured into. On the right of the image, it is possible to see where an interior cavity of the 3D printed mould was filled with wax. Image by author.

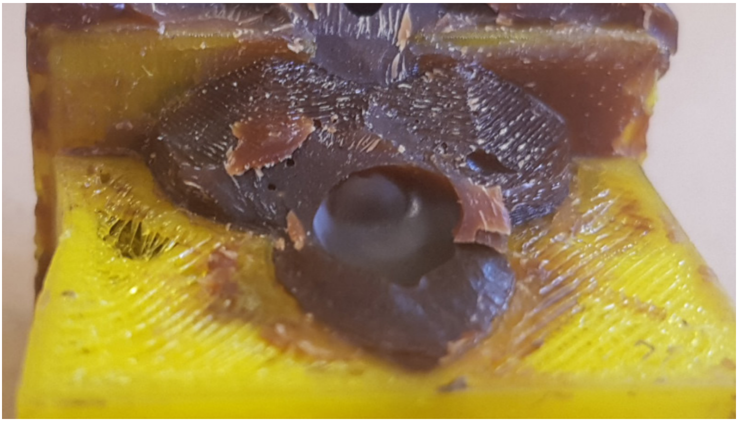


Fig. 5. Surface detail from the layers of the 3D printed plastic can be seen on the wax. Small particles of plastic can also be seen stuck in the wax. Image by author.

This failure could potentially be alleviated by using a more heat resistant plastic such as ABS, or by using 3D printed clay or cement (Rael and Fratello 2018). While printing more robust materials would change the language of the print by increasing the distance between layers, or the texture of the surface, they would allow for any mould made out of them to be heat resistant to the hot wax. It is also more than apparent that if the PLA moulds can not handle the heat from melted wax, they absolutely *should not* be used with the metals commonly used in foundry.

3.2. 3D Printing and the Sand Casting Process

While a much quicker and more simple process, sand casting imposes certain limitations on the kind of objects that it can produce. In order for a mould to be created for the sand, an object must not have any overhangs that would disrupt the removal of the object from the sand. If an object were to have an overhang, it would take with it some of the sand inside the mould, potentially destroying it. Since this process requires the creation of two halves of a mould, the object must cleanly pull away in both directions.

Figure 6 illustrates the changes suggested by the foundry operator in order to use the given 3D printed components. These changes were made after a short deliberation, in which he outlined the requirements of his foundry's process. Without his expertise applied to the form of the object through the changes suggested, it would not be possible to produce. Of course, it would have been equally impossible without his technical skill in mould making as well.

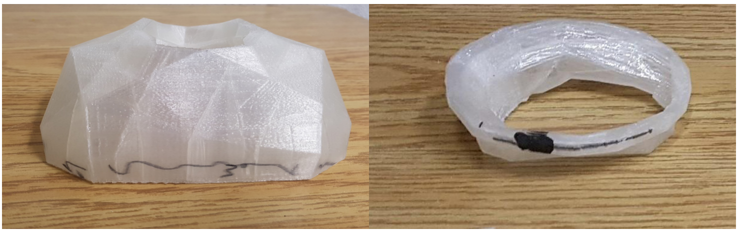


Fig. 6. The plastic original of a 3D printed object to be sand cast. Markings in black clay and pen are modifications suggested by the foundry operator. These changes to the geometry of the object were trivial to make to the original CAD files, meaning a new object could be printed the same day. Image by author.

In addition to this, sand casting creates more artifacts which must be removed manually, as shown in figure 7. While the surface detail of the 3D printed material still shows through, the rough surface creates more air pockets where nodules of metal can form when the mould is poured. The texture left by the complete removal of the gating network can be seen in figure 8.

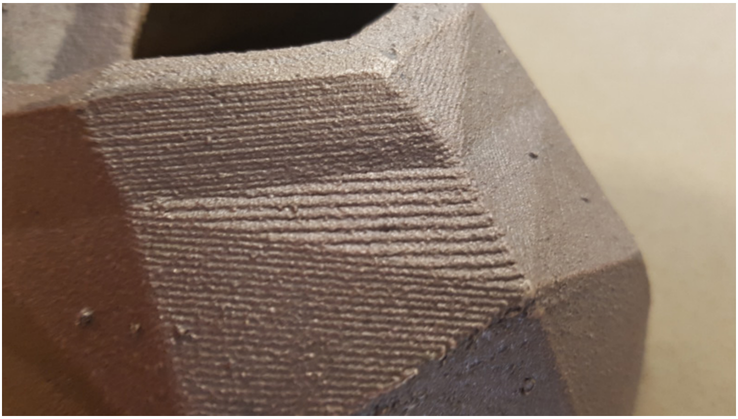


Fig. 7. A bronze version of the object in Figure 4. While the detail left by the 3D printing process can still be seen, nodules of metal can be seen on the surface, caused by the irregular surface of the plastic original. Image by author.

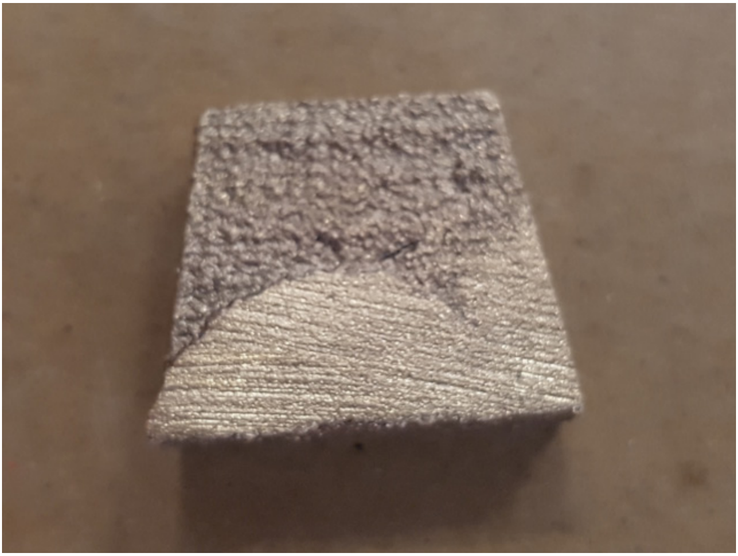


Fig. 8. Another component cast in bronze. The change in surface texture was left by removing the connective gating between that allowed the metal to flow into the object. Image by author.

3.3. 3D Printing and the Process of Burnout

A 3D printed object can be used in a burnout in a similar way to using a piece of styrofoam or biological material such as a porous wood. This use of the printed object provides the highest levels of detail, including the previously mentioned artifacts from the process of printing, such as the layering of plastic shown in figure 9. This method is most similar to lost wax casting, in which foam objects are gated, covered in some kind of ceramic or plaster, and then burnt out in the same way a wax mould would be.

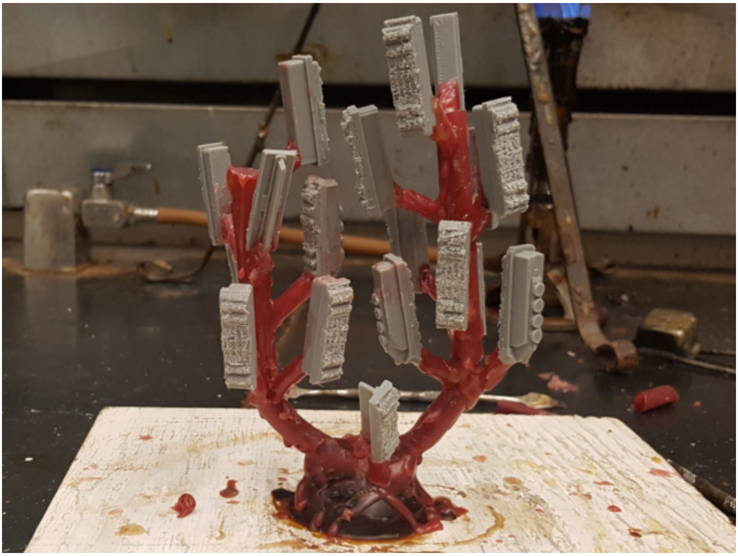


Fig. 9. Several 3D printed components in preparation to be burnt out. They are connected with wax to a central point where the liquid metal will be poured. Image by author.

The artifacts left by this process are very similar to the ones left by the lost wax process, and include the details lost in the connection points between the gating and the 3D printed objects. Most of these can be removed by hand tools such as a hacksaw and file. The removal of these artifacts can often damage or remove the texture left by the 3D printing process. While this process does create a high quality metal rendering, the burning out of material, especially plastics, can create harmful vapours. It also completely destroys the original object in order to create the mould. In figure seven, several 3D printed objects have been attached to a wax framework. This was later covered in plaster to create the mould, then burnt away to create a cavity for the metal to take the form of. The end result of this process can be seen in figure 10.

Fig. 10. The structure in Figure 7 after it has been used in the burnout. Both the plastic and wax have been replaced by metal, but still retain their original textures. The gating will have to be manually removed. Image by author

4. Conclusion

The synthesized use of two materials is not as simple as using one, then the other. Each process of creativity brings with it its own processes, which will change not only the final appearance of the object, but may fundamentally change its structure, its geometry, and what it can be used for. This is just as applicable to the ethereal material of the computational arts. There is a negotiation between one material and the other, in the same way that there is a negotiation with reality to first bring an object into being. The process of making with material acts as a set of embodied rules for its use. The way that these materials interact with each other to create the final form of a sculpture or component is a culmination of both sets of rules for each material. In the same way that translating a passage of text from one language to another will subtly change its meaning due to the grammar and vocabulary of the two given languages being similar, but not quite identical, the subtle difference in the properties of each material will change the final form. Like those languages, it requires a thorough knowledge and understanding of both to be utilized to its fullest extent.

In order to fully utilize a material, process or medium, an understanding of its embodied language will be necessary. While there may be academic sources on any given material, the most effective way to gain this understanding is through direct participation in the making process, or a participation in the oral tradition of whatever community is most involved in that particular form of making, be that a loosely organized internet community, or a private industrial practice. The knowledge that these communities possess may not be as well documented academically, but is just as important when working with the practicality of a material as an academic foundation. Additionally, a closer study or interaction with these groups may allow their knowledge to be incorporated into the broader body of academic knowledge.

3D printing has been shown to be useful to directly create moulds for metal to be poured into. PLA plastic, one of the most popular consumer grade printing materials, is able to be used in some aspect of the printing process with mixed results, and only if that part of the process does not directly interact with high heat. A more robust study into the effects of using this material, and other 3D printed materials, in the same way that Snelling et al. could provide useful insight for future directions of research. As another possible avenue to apply 3D printing to foundry, 3D printed ceramic could be printed, and then fired to create a mould without the need for any wax, in a similar way that Snelling et al. used sand and binding agent. Using any of the methods stated previously, gating and channels could be created parametrically with specially designed software. Alternatively, the gating network could be printed, either out of plastic or wax, and could then be used to create a ceramic mould in a more traditional way.

Additionally, further study into the differences between the method described in this paper and methods like CNC milling and more common fabrication methods would be useful in placing 3D printing in the broader context of metalworking, and as an intermediate step to augment other methods. Similarly, other processes such as laser cutting cardboard for use in burn out, for example, would benefit from a similar exploration. Finally, as the technology of metal 3D printing becomes more prevalent and widely available, the translation between the digital and the material becomes even more direct, which itself warrants its own study in terms of how this streamlining affects the realization of digital forms.

Acknowledgments. The objects shown were cast at the L.L.Odette Centre for Sculpture at York University, and Joseph Robertson Foundries in Toronto, Ontario. The expertise of the technicians and machinists of both institutions was invaluable in the writing of this paper.

References

Klein, Tobias.
"Augmented Fauna and Glass Mutations : A Dialogue Between Material and Technique in Glassblowing and 3D Printing." Leonardo 51, no. 4 (2018): 336–42. https://doi.org/10.1145/3202918.3203082.

Klein, Tobias and Harald Kraemer.
(2019). Imitation - Classification - Construction Vessels of Vanitas and the Changing Meaning of Ornament In Proceedings of the 25th International Symposium on Electronic Art (ISEA) (pp. 428-433). Gwangju Korea: Asia Culture Center.

Klein, Tobias and Victor Leung.
(2018). Chemical Skin - Computer Numeric Controlled Craftsmanship. In Proceedings of the 24th International Symposium on Electronic Art (ISEA) (pp. 54-60). Durban South Africa: Durban University of technology (DUT).

Rael, Ronald and Virginia San Fratello.
Printing Architecture: Materials and Methods for 3D Printing. First edition. Hudson, New York: Princeton Architectural Press, 2018.

Snelling, Dean, Heather Blount, Charles Forman, Kelly Ramsburg, Andrew Wetzel, Chrisotpher Williams and Alan Druschitz.
"The Effects of 3D Printed Molds on Metal Castings." (2013).

Tarasiewicz, Matthias.
(2016). Artistic Technology: Coded Cultures, "Making" and Artistic Research . In Proceedings of the 22th International Symposium on Electronic Art (ISEA) (pp. 344-346). Hong Kong.

Treyger, Aleksandr.
(n.d.). *Overview of Foundry Processes and Technologies: Manufacturing Metal Castings*. Overview of Foundry Processes and Technologies: Manufacturing Metal Castings Course No: T02-007 Stony Point, NY: Continuing Education and Development, Inc.

Tsui, Elizabeth
(2021). *Jumpman? I don't feel so good...*[Bronze] York University, Toronto.

Wilson, Robert A. and Andy Clark.
(2001). How to Situate Cognition. *The Cambridge Handbook of Situated Cognition*, 55–77. doi: 10.1017/cbo9780511816826.004

Zheng, Clement, and Michael Nitsche.
(2017). *Combining Practices in Craft and Design*. 331-340. 10.1145/3024969.3024973.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Cyprus as AI Saw It: Digital Colonialism and AttnGAN Text to Image Synthesis

Keywords: GAN, Text to Image Synthesis, Cyprus, Digital Colonialism, Decolonisation

Marinos Koutsomichalis
marinos@madlab.cool
Media Arts & Design Research Lab, Cyprus University of Technology, Limassol, Cyprus

Alexia Achilleos
alexia.a@madlab.cool
Media Arts & Design Research Lab, Cyprus University of Technology, Limassol, Cyprus

This paper discusses an ongoing project pivoting on an AttnGAN Text to Image synthesis as the means to critically comment on affairs of bias in historical and digital colonialism. It zooms in on Cyprus — a geographic region that is largely underrepresented in AI programming — as seen through the lenses of 19th century colonialism. A well-known AttnGAN pipeline is appropriated and trained over a DIY dataset to produce images that more genuinely reflect the (post-)colonial Cypriot reality — thus giving agency to a geographic region, the cultural and historical idiosyncrasies of which are generally not reflected in AI programming. Sample imagery is presented and the results of a qualitative survey are discussed in some detail. In this fashion, the authors intend to contribute empirical data to the ongoing discussion about digital colonialism, and to initiate a broader conceptualisation process about methodologies to decolonise current affairs in AI research. Technical, critical and ethical implications of the above are further discussed, with references to Digital Colonialism and AI-driven Text-to-Image synthesis.

1. Introduction and Motivation

This project draws upon a body of prior artistic experiments broadly taking a critical stance on the current state of affairs in AI-driven image synthesis, in an attempt to raise issues of historical and digital colonialism and zooming in on Cyprus — a geographic region that is grossly underrepresented in AI programming. To give a relevant example, consider *The New Riviera,*[1] wherein a pre-configured AttnGAN Text-to-Image (hence on, T2I) model is fed with real estate promotional text that targets foreign investors interested in the Cyprus citizenship investment program (via which one may easily acquire an EU passport). The resulting imagery, however, bears little, if any, resemblance to the Eastern Mediterranean landscape the input texts refer to; generated images are rather reminiscent of Western or North-European landscapes and architecture. Similarly, this endeavour zeroes in on Cyprus as seen through the eyes of a typical 19th century colonialist. The focus is on the *Cyprus, as I Saw it in 1879* book, wherein Sir Samuel Baker presents his impression on the British Empire's newly annexed colony (Baker 1879). Excerpts from the book are used to label training data, as well as the input to a T2I system that, as to be seen in a subsequent section, generates imagery that is expected to better resonate with Cypriot (post-)colonial state of affairs.

1. https://alexiaachilleos.com/thenewriviera March 2021

The overall motivation behind the project is to comment on digital colonialism related affairs in a hands-on critical design fashion. Accordingly, the authors intend to contribute empirical data to the broader discourse as well as to give agency to a geographic region, the cultural and historical idiosyncrasies of which are generally not reflected in present day AI research. In this fashion, the method discussed here aspires to become a paradigm of how questions of digital colonialism in AI-related research could be concretely raised in similar contexts. It should be underscored that the authors do not approach the local (post-)colonial reality from the outside — that is, they are not speaking on behalf of some oppressed other in some other part of the world. Being based in the East Mediterranean region they are themselves subjected to digital colonialism in its disparate manifestations.

Following this brief introductory section, the article proceeds with some background context on GAN-driven image synthesis and digital colonialism. The section after that is a technical overview of the T2I pipeline. Following, sample imagery is illustrated and the results of a qualitative survey concerning them are discussed. A Discussion section follows, wherein critical/ethical implications delineated. Concluding remarks and notes on future work sum up this paper.

2. Background

Following the emergence of AI systems that pivot on intelligent critics over the last few years, GAN-driven image synthesis has emerged as a prominent area of research with many relevant systems discussed in literature. Zooming on T2I pipelines, the first milestone has been achieved with Reed et al. (2016), wherein Natural Language Processing techniques are first used alongside the original GAN architecture introduced in Goodfellow et al. (2014). Improvements and variations of this approach are encountered in a number of other resources, such as in Zhang et al. (2017), discussing a 'stacked' T2I pipeline: the first stage GAN sketches the primitive shape and paint the colour of an object with respect to arbitrary text input, while the second stage employs a second GAN to rectify the latter and to amplify their resolution. The authors have further refined this system using multiple generators and multiple discriminators arranged in a tree-like structure to achieve better performance and to deliver even more persuasive photo-realistic imagery (Zhang et al., 2018). Zhu et al. also follow a multi-staged approach with a Dynamic Memory GAN model that allows the original text representation to change in between the different stages, in this way promising to deliver high-quality images even when the original ones are not very well generated (Zhu et al., 2019). Other models introduce Attention (AttnGAN), typically through a Deep Attentional Multimode Similarity Model (Show and Xu, 2015). In (Emir et al., 2019) we see an enhanced AttnGAN architecture featuring an attention module that performs Feature-wise Linear Modulation (FiLM) on text features. The authors argue that their model outperforms state-of-the-art methods in the generation of fashion-related imagery. With their MirrorGAN architecture, Qiao et al expand the AttnGAN model: here, images are generated from text with one GAN and then translated back to text via another GAN; cycle-consistency (a technique drawing on CycleGAN models) is then applied between the original and generated text descriptions (Qiao et al., 2019). A final example, of an altogether different approach, is (Dong et al., 2020), wherein the system is unsupervised and entirely relies on visual concepts that bridge two independent datasets comprising, respectively, image and text — no (labour-intensive to collect) pairwise image-text data are necessary here. The authors conclude that their model yields promising results that, occasionally, even outperform supervised pipelines.

Despite the abundance of working T2I pipelines, research of sorts primarily, if not exclusively, revolves around certain benchmarks that relate with the resolution of the resulting images, their fit for some particular task, or the overall performance of a model. That is to say that the subarea is largely governed by a certain techno-solutionist/techno-fetishist paradigm. In reality, in all the above mentioned — as well as in the sheer majority of similar systems — the employed GANs are intentionally or unintentionally pre-configured to largely reflect a 'Westerner's gaze' — one that implicitly favours the point of view of white, male, first-world, mid/high class, occidental perspective. This is, of course, well reflected in the training datasets that are readily available and most typically encountered in AI-driven image synthesis contexts. The field is currently almost exclusively governed by the logic of certain databases wherein non-western realities are scarcely — if at all — represented. Consider what is probably the three most important datasets at the moment: 'The Oxford Flowers' (Nilsback and Zisserman 2008), 'The Caltech-UCSD Birds' (hence on, CUB) (Wah et al., 2011), or the 'Microsoft Common Objects in Context' (hence on, COCO) (Lin et al., 2014) datasets. All of these former datasets have been created by major Western universities/organisations and, arguably, can be said to embody the present-day (digital) colonialist reality.

Accordingly, it can be taken for granted that the vast majority of existent T2I pipelines is not meant, and would in fact most often fail, to generate images accounting for non-western landscapes or for ones relating with other cultures even if fed with textual descriptions thereof. More than an assumption, this has been pragmatically confirmed to be the case in experimental settings such as, e.g., *The New Riviera* mentioned above, and is also demonstrated through example in Section 4 below. Western bias has been generally shown to surface AI-related systems of all disparate sorts and on many different occasions. A case worth referring to is that of the Beauty.AI AI-judged beauty contest that has been shown to significantly favour white individuals of Caucasian origin. Its creators have, indeed, acknowledged the inherent racism in their system and attribute it specifically to the fact that *"you might not have enough data, or the data might be biased".*[2] That is, they point at the very real problem of most, if not all, existent datasets being colonised and Western-biased. In such a vein, this project is a very concrete attempt seeking to contribute non-biased DIY datasets that could be used to train AIs so that feminist and other intersectional ways of thinking can be better represented and made resonate across digital media (Sinders, 2019).

2. https://www.theguardian.com/technology/2016/sep/08/artificial-intelligence-beauty-contest-doesnt-like-black-people March 2021

Beauty.AI is a rather indicative case of digital colonialism; that is, of practices that, deliberately or not, result in dominant cultures imposing their ideas upon others. Affairs of digital colonialism are actively accounted for and studied in a number of contexts; for instance, with respect to the impact of information and communication technologies on non-western knowledge systems (Young

2019), economic and political neo-imperialist practices (Kwet 2019), or third-world user-data exploitation (Coleman 2018). A critical perspective to digital colonialist practices suggests that there is a very real confrontation that oscillates between control and freedom and concerning individuals, populations, and entire geographic regions (Pinto 2019). This confrontation is simultaneously relevant at many different levels of cultural and political organisation and manifests by means of controlling digital assets, data, computational power, as well as by a variety of other means. Questions of sorts are very urging when it comes to AI-related research, of course; AI is already advertised as the flagship of a forthcoming new digital revolution and, as such, is expected to shape culture and governance in future societies. Even so, related technological infrastructure is being developed by a very small group of predominantly western countries, so that they end up ascribed with the symbolical, ethical and ideological values of the latter.

Benjamin (2019) Benjamin argues that algorithms do often accelerate hierarchies and do sustain or impose social divisions in various levels of organisation. Insofar AI in particular is concerned, Benjamin argues that cases such as the AI-judged beauty content mentioned above or, to give another example, Twitter's cropping algorithm that seems to privilege lighter faces over darker ones, all account for the New Jim Code — that is, a very contemporary manifestation of a discriminatory architecture wherein racist assumptions are made intrinsic to the world's technological infrastructure. Benjamin's argument echoes concerns of Digital Colonialism and adds up to a body of work indicating that the technology upon which the contemporary world is run is alarmingly biased. To give a few more relevant examples, consider Noble (2018), discussing how search engines appear to systematically misrepresent black women with derogatory or overly sexualised images, or Daniels (2015), raising concerns of colour-blind racism throughout the way the internet manifests in the 21st century and arguing that racial inequality is a sad reality in the tech industry.

Under these premises, this project is part of a broader research endeavour taking a critical and de-colonialist stance on the current state of affairs in AI-driven image synthesis. It has surfaced critical reflection and prior experimentation with pre-configured AttnGAN models for image synthesis that would largely result in images that would still resemble western topography or architecture even when fed with descriptions of Eastern Mediterranean cultural affairs. In a fashion that is rather similar to the Feminist Data Set, this project revolves around the careful re-configuration of an existent AttnGAN model to arrive at a system that would genuinely account for non-western affairs.

3. Method

The employed pipeline builds upon the AttnGAN Fine-Grained T2I synthesis model introduced in Xu (2018). This is a multi-staged system, featuring a Text Encoder, an AttnGAN, a Deep Attentional Multimodal Similarity Model, and a CNN-driven image encoder. The Text Encoder is a bi-directional LSTM that maps the input to R^{DxT}, D, being the dimension of the word vector T and the number of words. The last column $\bar{e}$ is attached to the AttnGAN stage that, in this incarnation, features 3 hidden layers h_i that are sequentially inter-connected by means of an attentional model (a neural network):

$$F_i^{attn} : R^{DxT} x R^{\hat{D}xN} \rightarrow R^{\hat{D}xN}$$
$$e, h_{n-1} \mapsto h_n$$

Note that for h_0, F^{ca} is used instead of, F^{attn} to convert $\bar{e}$ into a conditional vector e that can be further propagated into the pipeline. Each column of h_i is a feature vector of a sub-region of the image so that F^{attn} returns a word-context vector to the next layer. Each h_i is also attached to an image generator (also a neural network) ; G_i these generators produce images of successively greater resolution, so that for each input two intermediate images are created alongside the resulting final one (generated by G_3). Fig. 1 illustrates the final and the intermediate images on a given input.

The final objective of the AttnGAN in Xu *et al* model is defined as

$$\mathcal{L} = \sum_{0}^{i} \mathcal{L}_{\mathcal{G}_i} - \lambda \hat{\mathcal{L}}$$

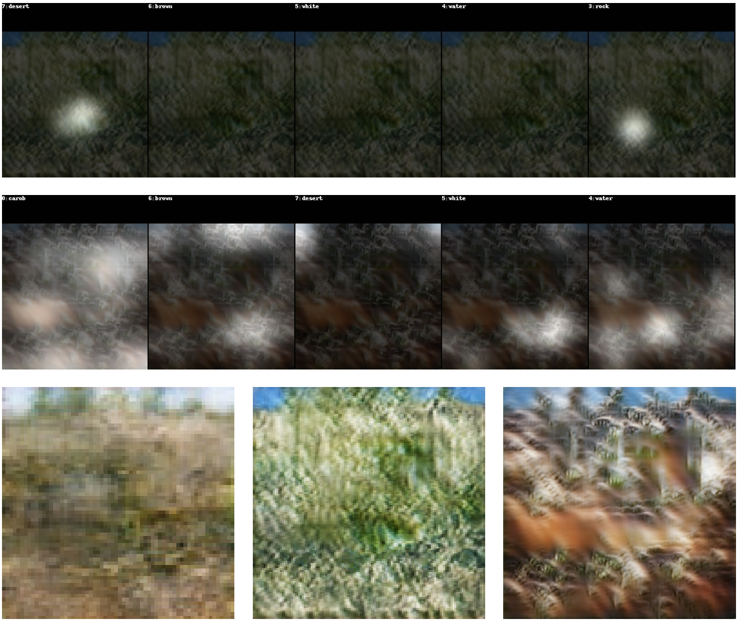
where λ is a hyper-parameter to balance the two terms: the GAN loss as an approximation of conditional and unconditional distributions, and the word level fine-grained image-text matching loss $\hat{\mathcal{L}}$ that is computed as follows:

$$\hat{\mathcal{L}} = \mathcal{L}_1^w + \mathcal{L}_2^w + \mathcal{L}_1^s + \mathcal{L}_2^s$$

where $\mathcal{L}_1^w$ and $\mathcal{L}_2^w$ are the negative posterior log probability the images are matched with their corresponding text descriptions at word level and, symmetrically, *vice versa*; and where $\mathcal{L}_1^s$ and $\mathcal{L}_2^s$ the equivalent probability that images are matched with their descriptors at a sentence level and, symmetrically, vice versa. In other words, the model is designed to learn the attention model in a semi-supervised manner and with respect to the matching between images and sentences (sequences of words), yet in a fine-grained fashion. Note that $\hat{\mathcal{L}}$ sees images as semantic vectors. It is, then, the Image Encoder's task to encode them appropriately. The latter is a CNN that builds upon Inception-v3 (Szegedy et al., 2016) to learn both global and local (concerning sub-regions of the original image) features.

The entire architecture is discussed in great detail in the original paper (Xu et al., 2018). Xu et al have trained the original model on the COCO and CUB data-sets. The idea herein is to, instead, employ a DIY dataset pivoting on Cyprus and the broader region as seen by Baker. This is a decision of a rather conceptual character. Colonialism cannot be undone; so precisely because it is an integral part of the region's history, it has to be reflected on the training data. Data that should, nevertheless, still refer to this particular part of the world. Baker's book becomes, then, an invaluable resource precisely in that it does reflect a strictly colonialist view of Cyprus. Creating a custom dataset for AI training purposes is not trivial, however. Currently, the dataset is rather small in size, featuring hand-picked images from various sources that loosely concern Eastern-Mediterranean/Cypriot region that are labelled using excerpts from Baker's book. The dataset follows the structure of COCO in that the images are similarly complex and depicting a variety of objects and landscapes. In some detail, it comprises: (a) j-peg images of landscapes, buildings, plants/trees, cityscapes, and similar; (b) a text description file for each image including five caption sentences; (c) a 'pickled' Python dictionary that maps keywords to numbers. In this way numeric lists can be generated that fully encode each image's textual descriptors.

Fig.1 . First two rows illustrate the output of F^{attn} and F^{attn}, respectively, indicating the five most attended words. The images on the last row are, from left to right, the 64 × 64 image generated by G_0, the 128 × 128 generated by G_1 and the final 256 × 256 image output generated by G_3. As is the case with the original AttnGAN pipeline, this system is also limited to 256 x 256 sized images, due to programming complexity (The text input is the same as the one in Fig. 5 below).



4. Results

Figures 3-7 illustrate some sample generated images (the final iteration) for a number of different text inputs passed through the pipeline. Figures 8-11 are given for reasons of comparison: these have been generated with the very same text inputs, yet this time employing the original (Xu et al., 2018) model without any modifications and trained on the COCO dataset. The difference between the two sets of images is striking, with the latter having nothing reminiscent of an Eastern Mediterranean region and been altogether different to the former. In order to better understand the results, the authors have conducted a formal, albeit short-scale, qualitative survey. A total of 27 people of various ages and socio-cultural backgrounds — as illustrated in figure 2 have responded to a set of questions about some generated images. The survey is structured in three parts: In parts (a) and (b) participants were asked to describe in their own words what they see in each image, their overall quality/aura and, for some images, the country or the geographic region they would associate them with. In part (c), they were given a text caption (the original input text used to generate the image) and they were asked to select the one, out of the three possible, image that best approximates/depicts it.

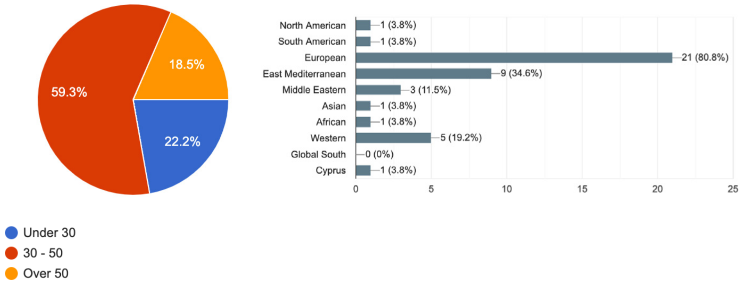


Fig.2. Survey demographics, note that participants were allowed to select more than one options insofar as their socio-cultural background is concerned.

Fig.3. Input text: *"The ruins of ancient cities offer no attraction to the traveller in this island, as nothing is to be seen upon the surface except disjointed stones and a few fallen columns of the commonest description".*

Considering the image in figure 3 the vast majority of the respondents see some structure with *'rocks'/'stones'* (16 mentions) — possibly a *'hill'*, *'mountain'* or a *'cliff'* (12 mentions) in a *'barren'/'desert'* landscape (11 mentions); some specifically mention *'archaeology'* (7 mentions). Then, 92.6% of participants did match this image correctly with the *"an archaeological site in Cyprus with disjointed stones"*. Responses about the overall aura/mood thereof vary; *'sun', 'heat' ,'age', 'calmness', 'haziness', 'surreal/strange'* qualities are mentioned, inter alia. To give a couple of example responses: *"peaceful atmosphere that can become intense or emotional"; "something surreal, something familiar"*. Most (at least 16) agreed that this image depicts an East-Mediterranean landscape, with 7 of them correctly identifying Cyprus.

There is a general consensus (18 mentions) that the image in figure 4 depicts *'vegetation'*, possibly with *'yellow flowers'* (8 mentions); there are also some references to the dryness of the landscape (6 mentions). Concerning the overall aura/mood here, responses oscillate between some positive/soothing atmosphere and a moody/uneasy feeling of discomfort. E.g.: *"dusk, like something is about to happen... but it doesn't''*. Here, 74.1% of the participants correctly matched this image with *"trees crowded with oranges and lemons in a desolate land''*. At least 9 individuals see Eastern Mediterranean here, while another 5 see Northern Europe.

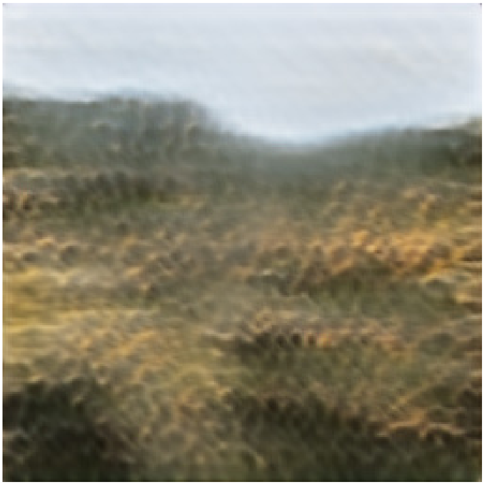


Fig. 4. Input text: *"Lemon and orange-trees of the largest size were crowded with fruit, and exhibited in the midst of a treeless and desolate country".*

Several responses (8) also mention *'vegetation'* on some *'cliff'/ 'mountain'/ 'rocky terrain'* (6 mentions) in the case of the image in figure 5. The overall aura here is described as having an *'abstract'/'messy'/'fractal'* quality (9 mentions) that is potentially *'dangerous'/'hellish'/'intense'/'violent'/'psychedelic'*/etc (16 mentions). Then, 59.3% of the participants correctly matched this image with *"Land covered with carob trees, whose dark green foliage gave a rich appearance to the shore''*, and most (12 individuals) correctly see an East Mediterranean landscape — with 6 of them pointing at Cyprus.

For the image in figure 6, the majority (7 mentions) of respondents sees '*vegetation'* on a *'dusty'/'sandy'* landscape (9 mentions), possibly on a *'mountain'* (4 mentions). Interestingly, many see water-related phenomena (7 mentions). There are also several responses suggesting a more abstract/fuzzy landscape, such as *"city on the clouds''*. This image also brought up unsettling feelings, with the vast majority of responses (14 mentions) concerning *'mystery', 'gloom'*, and *"something bad about to happen''*. Some participants described this image as

“Rough, dream-like, a real sense of distance’’, or *“unsettled, alien landscape’’*. Most (12 individuals) see Eastern Mediterranean here, while 6 of them correctly identify Cyprus. There are also some mentions to other Mediterranean regions (5 individuals) and U.S.A. (3 individuals). (This image was not featured in the third part of the questionnaire, so there are no data regarding how well it is matched to its generating text.)

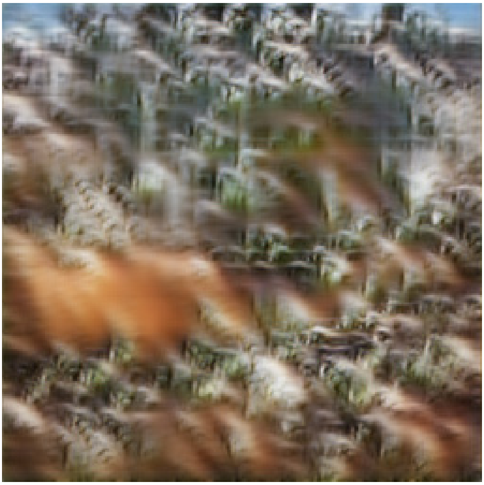


Fig. 4. Input text: *“Land covered with carob trees, whose dark green foliage gave a rich appearance to the shore, broken by countless rocky bays and coves, filled with the waters of the Mediterranean. This was a lovely scene; I could not believe that I was in Cyprus–that whitey-brown-paper-coloured, desert, smitten, God-forsaken isle!”.*

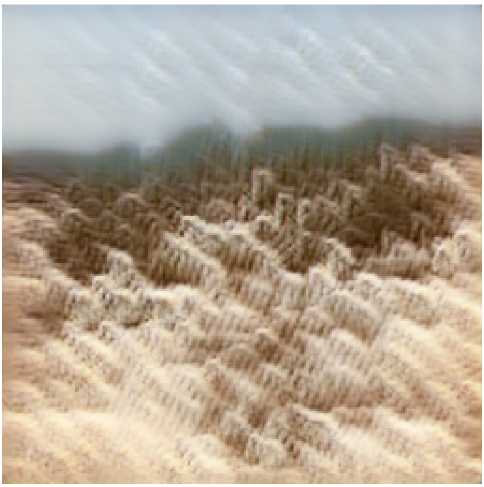


Fig. 6. Input text: *“There are man stone columns lying useless among the heaps of ruins so common in Cyprus, that would form excellent rollers, but the idea of such an implement has never entered the Cypriote head.”*

Fig. 7. Input text: *"Close to a cypress tree were rocks; steps led into a cave, where water dripped from the roof."*

Fig. 8. Generated with Xu et al. (2018) model trained on COCO; input text same as in Fig. 3.

Fig. 9. Generated with Xu et al. (2018) model trained on COCO; input text is the same as in Fig. 4.

Fig. 10. Generated with Xu et al. (2018) model trained on COCO; input text is the same as in Fig. 5.

Fig. 11. Generated with Xu et al. (2018) model trained on COCO; input text is the same as in Fig. 6.

Fig. 12. Generated with Xu et al. (2018) model trained on COCO; input text is the same as in Fig. 7.

5. Discussion

Drawing upon the survey, it can be argued that to some significant extent the generated images (a) relate with the input text and sustain some traits found therein, and (b) somehow exhibit Cypriot or otherwise Eastern Mediterranean characteristics. Participants' responses vary significantly, of course, also depending on the image; notwithstanding, the above two conclusions are explicit in the results and safe to be considered largely granted. The situation is more convoluted when considering the overall aura/quality of the images. Still, there seem to be at least two distinct loci of convergence: (a) several responses suggest a rather uncanny, dream-like, and often unsettling/alien, quality insofar as all images are concerned — even if the exact wording is eclectic; (b) several other responses point at their abstractness/blurriness — this of no surprise of course since AI-generated imagery generally tends to be blurred. Note that these two characteristics do not contradict one another; imagery can be blurry/abstract and at the same time subjectively evocative/reminiscent of something. It is indeed often the case in the survey responses that the very same individual somehow refers to both qualities. To sum up, it can be said that the generated images appear somehow abstract and alien, yet sustaining qualities inherent to the Cypriot landscape and their generating text.

Can it, then, be argued that they also sustain traces of an explicitly biased view of Cyprus (as seen through Baker's gaze)? While there are some very strong indications pointing in that direction, this would be a largely unsupported claim to make based on the available data. The input text employed in all cases is taken from Baker's book, so that to find traces of the former in the resulting image is a very strong indication that Baker's gaze has left a prominent footprint therein. Even if the same text is used, the images in Fig. 8-12 are of a very different style so that, when trained with our database, the system does indeed acquire an overall different quality—one that could be thought of as reflecting a colonialist's gaze. A gaze, that nevertheless had a significant role in the island's modern history and in the formation of the national narrative. Yet, the possibility of dealing with a different phenomenon here, however feeble, cannot be excluded altogether—given, also, that there is not enough data concerning other non-western regions with which to compare the results. On the other hand, several of the participants' responses account for a 'weird', 'alien', and somehow exotic landscape in all the examples, which is exactly what Baker's view of Cyprus boils down into. Again, even if this is a strong indication pointing at this direction, the possibility that such qualities are merely congenital to the generating process cannot be proven false. So, while it cannot be argued that Baker's colonialist look is specifically encoded in the pipeline, it can be supported that the latter does reflect the Cypriot geographical and socio-cultural reality to some significant extent. This may not sound as an achievement of some particular importance — in the end of the day it is not strange that the output of an AI architecture trained over some appropriate dataset is reminiscent of the former — to the authors' understanding, however, it is an important first step towards a conceptualisation process about post-colonial Cyprus and how is can claim presence in a digital reality that is being actively colonised at the moment.

From an ethical point of view, this project functions as a commentary on a much broader discourse: who creates vs who consumes the world's digital infrastructure? How can the non-western, second, or third world regions claim cultural presence in an ever-digitised world the governance of which is progressively trusted to intelligent technologies? What is the specific role of a small satellite and ex-colonised country such as Cyprus within such a context? These are very topical questions with deep ethical hues that concern all, but a few powerful, of the world's nations. Today, an ever-greater part of the world's population has online presence, while the AI-related technologies that are expected to shape the future of our societies are being developed and deployed by a very small group of powerful, and predominantly western, countries. When existent AI models already fail to account for anything that cannot be well appropriated with a Westerner's (white/male) perspective, and when AI research agenda is predominantly focused on performance and scalability (rather than ethics and equity), what is the future place of countries such as Cyprus in the world map of this emergent digital era?

To those claiming a multi-cultural digital era, the need to have off-centres somehow represented therein is a very pragmatic concern. Accordingly, this project is a concrete, albeit infinitesimal, step to speculate about how it may look like and to explore how it may be brought forth. What does it take to have traces of an individual (non-western) Cypriot cultural reality somehow still resonate through digital realms that have already been (digitally) colonised in many respects? And how would a non-colonised cyber-Cypriot culture look like? A lot of further research is necessary, of course, to even properly formulate questions of sort. Still, the authors aspire to contribute some valuable empirical data to a broader body of research that seeks to delineate the kind of tactics that are necessary for underrepresented territories/cultures to claim their genuine voice in a domain already ascribed with colonialist western ideals.

In tandem with the above, this endeavour ascribes to a broader critical and speculative design approach (Dunne 2008; 2013) where technology — AI programming in this particular case — is no longer thought of as the means to a solve some more or less well-defined problem. That is to say that whether the resulting imagery herein is indeed reminiscent of Cypriot landscapes/culture or not is not a question to be approached functionally and in a techno-solutionist fashion. The aim here is to rather arrive at a process and a series of artefacts that articulate some kind of critique and that echo a broader anti-colonialist ethos. In its essence, this is a political approach that is pursued in a hands-on research through (critical) design manner. The real methodology here lies in 'hi-jacking' and appropriating existent technology — one that generally reflects neo-colonialist digital ideals — to become a critical apparatus that reveals cracks in our understanding of everyday affairs. More importantly, to bring forth biases and inequalities, and, eventually, to speculate on alternative views of the world with more space for underrepresented and oppressed subjects.

6. Conclusion

It has been shown heretofore that it is indeed possible to appropriate an existent T2I GAN pipeline so as to arrive at results that properly reflect the local Cypriot reality — ones that, additionally, could be possibly shown to echo the region's colonial past. Given that the employed model is almost identical to the one introduced in Xu et al. (2018) — a system originally designed to be an improvement over a series of other functional GANs — it is easy to see that in this particular case the possibility for not inherently western-biased imagery arises largely because a nonstandard DIY dataset is used. This is to have the focus shifted from how to improve performance, to how to derail it away to the implicit commands that are congenital to most readily available datasets. (An approach that is arguably similar in spirit to that of the "Feminist Data Set''.) Thus, the work hypothesis brought forth herein is rather simple: 'hi-jacking' some existent AI model, train it over some nonstandard dataset, and maybe employ it for purposes other than its original. In this fashion, they should turn into critical apparatuses that may potentially serve a broader (digital) de-colonialist agenda; both by means of expanding the polyphony of related research, and conceptually, bringing forth ethical and political questions.

Even if it is nontrivial to attach some model to a nonstandard, non-readily available, dataset, the approach looks and is straightforward. However, the importance of such an experiment lies not in the possibility of realistic imagery that meets some functional goal. But, rather, in that it concretely speculates on a plausible cybernetic presence for the local Cypriot (post-colonial) society — thus, pragmatically suggesting a way out of the ongoing (digital) neo-colonialism. So to say, local affairs are empowered to generate upon their (AI-driven) cybernetic avatars and drawing upon local contexts, rather than upon what already offered by digital colonialism. In this vein, the herein described AttnGAN T2I pipeline aspires to become a de-colonialist critical apparatus — one that is not intended as the solution to some technological or design problem, but that rather raises ethical and political concerns.

Accordingly, the overall project is a very conscious attempt to critically engage with the possibility of alternative realities and research paradigms within AI-programming in general (with Cyprus as a point of reference). It is hoped that similar experiments therein, as well as in other off-centre regions, would eventually help produce a 'toolkit' of integrated tactics that could be applied to raise concerns of digital colonialism in AI research. This is a long-term affair, of course; nevertheless, this project is envisioned as contributing empirical data to this end: the output imagery and, most importantly, an account of a process that succeeds in giving some agency to local contexts in AI research.

7. Future Work

Future work primarily zooms in the production of a larger and much broader dataset that better reflects the local post-colonial reality. Manually doing so is labour-intensive, so that we also plan to trust algorithmic approaches, as well as ones pivoting on contributions by peers. Work could extend to include inherent biases within the software beyond the dataset. As a region of historical ethnic conflict, investigating possible biases within locally developed AI technologies and its impact on local communities is also considered for future work.

References

Baker, Samuel White.
1879. *Cyprus as I saw it in 1879*. London: Macmillan.

Benjamin, Ruha.
2019. Race after technology: Abolitionist tools for the new Jim Code. *Social Forces*, Volume 98, Issue 4, June 2020, Pages 1–3.

Coleman, Daniel.
2018. Digital colonialism: The 21st century scramble for Africa through the extraction and control of user data and the limitations of data protection laws. Mich. J. *Race & Law. 24*, 417.

Daniels, Jessie.
2015. "My brain database doesn't see skin color" Color-blind racism in the technology industry and in theorizing the web. In: *American Behavioral Scientist 59*(11), 1377–1393.

Dong, Yanlong, Ying Zhang, Lin Ma, Zhi Wang and Jiebo Luo.
2020. *Unsupervised text-to-image synthesis*. Pattern Recognition p. 107573.

Dunne, Anthony.
2008. *Hertzian tales: Electronic products, aesthetic experience, and critical design*. Cambridge, MA: MIT press.

Dunne, Anthony, and Fiona Raby.
2013. *Speculative everything: design, fiction, and social dreaming*. Cambridge, MA: MIT press .

Emir Ak, Kenan, Joo Hwee Lim, Jo Yew Tham and Ashraf Kassim.
2019. Semantically consistent hierarchical text to fashion image synthesis with an enhanced-attentional generative adversarial network. In: *Proceedings of the IEEE International Conference on Computer Vision Workshops*. pp. 0–0 .

Goodfellow, Ian, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville and Yoshua Bengio.
2014. Generative adversarial nets. In: *Advances in neural information processing systems*. pp. 2672–2680.

Kwet, Michael.
2019. Digital colonialism: US empire and the new imperialism in the global south. In: *Race & Class 60*(4), 3–26.

Lin, Tsung-Yi, Michael Maire, Serge Belongie, James Hays, Pietro Perona, Deva Ramanan, Piotr Dollár and C. Lawrence Zitnick.
2014. Microsoft COCO: Common objects in context. In: *European conference on computer vision*. pp. 740–755. Springer.

Nilsback, Maria-Elena and Andrew Zisserman.
2008. Automated flower classification over a large number of classes. In: *2008 Sixth Indian Conference on Computer Vision, Graphics & Image Processing*. pp. 722–729. IEEE.

Noble, Safiya Umoja.
2018. *Algorithms of oppression: How search engines reinforce racism*. NYU Press.

Pinto, Renata Avila.
2019. Digital sovereignty or digital colonialism? *In International Journal on Human Rights.*

Qiao, Tingting, Jing Zhang, Duanqing Xu and Dacheng Tao.
2019. MirrorGAN: Learning text-to-image generation by redescription. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. pp. 1505–1514.

Reed, Scott, Zeynep Akata, Xinchen Yan, Lajanugen Logeswaran, Bernt Schiele and Honglak Lee.
2016. *Generative adversarial text to image synthesis*. arXiv preprint arXiv:1605.05396.

Sinders, Caroline.
2019. Making critical ethical software. In: The Critical Makers Reader: *(Un)learning Technology* p. 86. Amsterdam: Institute of Network Cultures.

Szegedy, Christian, Vincent Vanhoucke, Sergey Ioffe, Jonathon Shlens and Zbigniew Wojna.
2016. Rethinking the inception architecture for computer vision. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. pp. 2818–2826.

Wah, C., Steve Branson, Peter Welinder, Pietro Perona, and Serge Belongie.
2011. *The Caltech-UCSD birds-200-2011* dataset.

Xu, Kelvin, Jimmy Ba, Ryan Kiros, Kyunghyun Cho, Aaron Courville, Ruslan Salakhutdinov, Richard Zemel and Yoshua Bengio.
2015. Show Attend and Tell: *Neural image caption generation with visual attention*. arXiv Pre-Print 23.

Xu, Tao, Pengchuan Zhang, Qiuyuan Huang, Han Zhang, Zhe Gan, Xiaolei Huang, and Xiaodong He.
2018. Attngan: Fine-grained text to image generation with attentional generative adversarial networks. In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. pp. 1316–1324.

Young, Jason C.
2019. The new knowledge politics of digital colonialism. In: *Environment and Planning A: Economy and Space* 51(7), 1424–1441.

Zhang, Han, Tao Xu, Hongsheng Li, Shaoting Zhang, Xiaogang Wang, Xiaolei Huang and Dimitris Metaxas.
2017. Stack-GAN: Text to photo-realistic image synthesis with stacked generative adversarial networks. In: *Proceedings of the IEEE international* conference on computer vision. pp. 5907–5915.

Zhang, Han, Tao Xu, Hongsheng Li, Shaoting Zhang, Xiaogang Wang, Xiaolei Huang and Dimitris Metaxas.
2018. Stack-GAN ++: Realistic image synthesis with stacked generative adversarial networks. In: *IEEE transactions on pattern analysis and machine intelligence 41(8)*, 1947–1962.

Zhu, Minfeng, Pingbo Pan, Wei Chen and Yi Yang.
2019. Dm-GAN: Dynamic memory generative adversarial networks for text-to-image synthesis. In: *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. pp. 5802–5810.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Granular Dance

Keywords: Generative Art, Dance, Artificial Intelligence, Machine Learning, Granular Synthesis, Concatenative Synthesis

Daniel Bisig
ad5041@coventry.ac.uk
Coventry University, Coventry, United Kingdom

daniel.bisig@zhdk.ch
Zurich University of the Arts, Zurich, Switzerland

This publication presents a tool that can be trained with motion capture data and then used to generate new dance movement sequences. This tool combines two different components: a deep learning model based on a recurrent adversarial autoencoder architecture, and a sequence blending mechanism that is inspired by granular and concatenative sound synthesis techniques. The publication contextualizes this tool with respect to other artificial intelligence inspired approaches in dance. Subsequently, the implementation of the tool is detailed and results from its usage are presented. These results are discussed in terms of their artistic potential. Finally, the publication provides a brief outlook into possible future research directions.

1. Introduction

Research from the field of artificial intelligence (AI) has a long history of providing inspiration and informing novel techniques for creative practitioners, in particular those who work with algorithmic and generative methods. Recent progress in machine learning has led to a surge of interest in data-driven approaches. Compared to the more established rule-based methods that have so far formed the foundations of algorithmic and generative art, data-driven approaches offer different challenges with respect to their adoption by artists. Some of these challenges are related to issues of originality, idiosyncrasy, and mastery. The issue of originality arises from the fact that many machine learning systems excel at imitating the data on which they have been trained. Accordingly, the capability of such systems to create novel and original output is limited. The issue of idiosyncrasy is caused by the large amount of data that is typically required to train deep learning models from scratch. This requirements forces artists to resort to the use of standardized datasets rather than their own personal and unique material. The issue of mastery has to do with the specialized expertise that is required to make informed decisions when modifying existing machine learning models or designing new ones. As a result, many artists are tempted into using off-the-shelf models as black box mechanisms.

The publication tries to address some of these issues by presenting a hybrid tool. This tool combines a machine learning model with a rule-based algorithm for the purpose of generating new dance movement sequences from previously recorded motion capture data. This combination offers a balance between exploiting the impressive imitation capabilities of state of the art deep learning models and the creative development of and experimentation with rule-based algorithms.

The publication starts with an overview of AI-inspired approaches in dance. This overview is divided into two sections, one focusing on artistic motivations and the other on technical principles. It then describes in some detail the tool's implementation. After that, preliminary results are presented that have been obtained through the author's own experimentation with the tool. These results are then discussed in terms of their artistic potential. Finally, the publication concludes with an outlook into possible future research directions.

2. Artistic Background

While artistic applications of machine learning for the purpose of creating imagery and music have garnered much public visibility, the field of dance has an enthusiastic community of its own that experiments with creative uses of machine learning.

The *Open Ended Group* (OEG) has played a pioneering role at the intersection of AI and dance. In 2001, OEG collaborated with choreographer Merce Cunningham on the development of an AI that could record and analyze Cunningham's hand movements for the purpose of controlling live visuals (OEG 2001). In a subsequent collaboration between OEG and choreographer Wayne McGregor, the *Choreographic Language Agent* was created. This software operates as partially autonomous sketchbook that translates phrase-based instructions into abstract geometric animations which can be interpreted by dancers through body movements (Church et al. 2012). In 2016, OEG and Wayne McGregor collaborated again on the development of *Becoming*, an AI-controlled abstract and fully autonomous dancer that was displayed during dance rehearsals (Leach and Delahunta 2017).

Many topics that motivate artistic interest at the intersection of AI and dance are already present in these pioneering examples. These motivations can be roughly grouped into four categories: gain novel insights into dance, enable intuitive forms of interactions, create artificial dancers, and enhance a choreographer's own creativity.

The tool that is presented in this publication is meant to be used in co-creative scenarios. For this reason, the topic of creativity enhancement is addressed in a bit more detail than the other topics.

2.1. Insights into Embodied Creativity

Marc Downie, one of the two members of OEG, proposes in his PhD thesis that metaphors taken from biology and AI can serve as foundations for developing a 'theoretical, technical, and aesthetic framework for the innovative art form of digitally augmented human movement' (Downie 2005). The multi-year interdisciplinary research project *Entity* was initiated in 2000 by Wayne McGergor and dance scholar Scott deLahunta with the purpose of studying the potential of AI to 'broaden understanding of the unique blend of physical and mental processes that constitute dance and dance making' (deLahunta 2009). Mariel

Pettee and colleagues argue that machine learning can be used as tool to 'spark introspection and exploration of our embodied knowledge'. They suggest that machine learning can shift our description of movement away from culturally centred opinions and encourage 'normative discussion about what it means to choreograph' (Pettee et al. 2019).

2.2. Intuitive and Embodied Interfaces

A popular use of machine learning in the context of interactive media performance is to design interactivity through demonstration rather than by specifying rules and algorithms (Gillies et al. 2016). The authors argue that this approach is particularly suitable for creative practices in that it emphasizes the exploratory, playful, embodied, and expressive aspects of the design process (Fiebrink and Caramiaux 2016). One example is a two user training scenario for an interactive artificial dancer in which one user plays the role of the human dancer and the other user performs the artificial dancer's intended responses (Gillies, Brenton, and Kleinsmith 2015).

2.3. Artificial Dancers

AI-inspired methods have also been used for the creation of systems that can be used as autonomous artificial dancers. These methods aim to endow the system with the capability of making creative movement decisions on its own. One example project places an artificial dancer at the center of its artistic concept by exposing the system's learning during the performance to the audience (Berman and James 2018).

2.4. Creativity Enhancement

The integration of AI-inspired methods into software tools has been explored with the purpose of supporting the creative workflow of choreographers and dancers. Here, the biggest potential lies in the development of co-creative systems whose functionality is between that of a creativity support tool and a fully autonomous creative system (Carlson et al. 2016). Many software tools for enhancing a choreographer's creativity have been proposed, a small selection of which is presented here. Kristin Carlson and colleges have developed several tools such as *Scuddle* (Carlson, Schiphorst, and Pasquier 2011) and *Cochoreo* (Carlson et al. 2016). These tools combine genetic algorithms with a fitness function that quantifies movement based on Laban effort qualities and Bartenieff movement patterns. The output of these tools is meant to foster the exploratory creativity of choreographers. Other researchers have presented deep-learning based software tools that can be trained on a choreographer's own pose or movement material. These tools can generate output that is stylistically similar to the movement material that they have been trained with. For their system Chor-rnn, the authors suggest a form of creativity facilitation that involves the system and the choreographer taking turns in creating movement material (Crnkovic-Friis and Crnkovic-Friis 2016). Similarly, Pettee et al. (2019) present a suite of deep-learning based tools whose output is meant to be more or less directly used for creating a new choreography.

3. Technical Background

The tool presented in this publication is trained to generate short movement sequences for a single dancer which can then be combined into longer sequences. There exists a large diversity of technical approaches for generating synthetic dance movements. Some of these approaches are based on machine learning, others use more conventional statistical approaches, and still others resort to entirely different techniques.

The following section provides a brief overview over some of these techniques. For a much more exhaustive review of machine learning techniques for synthesizing body movements, the reader is referred to Alemi and Pasquier (2019).

3.1. Concatenation and Interpolation

Conventionally, in computer animation and game design, character movements are created either by interpolating between poses that serve as key-frames or by concatenating shorter movement sequences into longer ones. One example of combining these operations with machine-learning is through the use of autoencoders. An autoencoder is an architecture that operates as information bottleneck by encoding and mapping high-dimensional information into a low-dimensional latent-space. To make this compression as lossless as possible, the autoencoder learns to extract the statistically most significant features of the original information. When using an autoencoder, mathematical operations can be conducted in latent-space and the result then converted back through decoding into poses and movement sequences. Some examples of this approach include (Augello et al. 2017; Berman and James 2018). The benefits of this approach over more conventional methods is that a latent space not only reduces the amount of data the computer has to deal with but also captures in its spatial organization some of the fundamental principles of a human body's morphology and movement capabilities. This can be exploited for a variety of purposes such as: correcting corrupted poses/movements, avoiding movement blending artefacts, and employing euclidean distances as movement similarity measures (Holden et al. 2015).

3.2. Direct Sequence Generation

Alternatively or in combination with the previous approach, machine learning can also be used to directly create movement sequences. Since a movement sequence can be represented as time series, any model that is able to be trained on and predict time series could in principle be used for this purpose. Auto-regressive systems are able to learn sequential relationships in training data which enables them to predict the continuation of sequences. In the context of deep learning, the most frequently used auto-regressive systems are Recurrent Neural Networks, in particular those that maintain and transmit an internal memory state alongside the neurons' regular output such as Long Short-Term Memory (LSTM) Networks (Hochreiter and Schmidhuber 1997) or Gated Recurrent Units (GRU) (Cho et al. 2014). Some example applications of recurrent neural networks for human motion synthesis include (Crnkovic-Friis and Crnkovic-Friis 2016; Li et al. 2017). More recently, recurrent neural networks are facing competition from Temporal Convolutional Networks (Lea et al. 2016) since the latter can handle very long time sequences and be trained in parallel. A comparison between the two approaches for the purpose for movement generation can be found in Pavllo et al. (2019).

3.3. Combined Approaches

Each of the two previously mentioned approaches offers its own benefits and drawbacks. The creation of movement sequences by navigating latent space provides ample possibilities for manual control but makes it difficult to obtain aesthetically convincing movements. Auto-regressive systems excel at creating aesthetically interesting movements but they offer limited means for manual intervention and control.

In two publications, autoencoders and auto-regressive systems are compared from a choreographic point of view. Based on a subjective evaluation of Mixed Density Networks, autoencoders, and LSTMs that have trained on poses and pose sequences, respectively, the authors conclude that only LSTMs perform well on criteria such as posture prediction, temporal coherence, motion consistency, and aesthetics (Kaspersen et al. 2020). Another comparison between autoencoders and LSTMs places a stronger focus on the creation of movement variations (Pettee et al. 2019). This comparison ends up given more attention to autoencoders than LSTMs.

Accordingly, it seems reasonable to combine auto-regressive systems and auto-encoders. Such a combination has been undertaken by several researchers such as Holden et al. (2015), Fragkiadaki et al. (2015), Habibie et al. (2017), Holden, Saito, and Komura (2016).

3.4. Alternative Approaches

It is worthwhile to mention some entirely different approaches to generate movement sequences. Many of these alternative approaches focus on the agency exhibited by an artificial character and how movement emerges from the interplay between character and environment.

Reinforcement Learning is an approach to machine learning that allows an agent to learn through trial and error from rewards or punishments it receives when interacting with its environment. This approach has for example been used to create locomotion animations across varied and difficult terrain (Peng, Berseth, and Van de Panne 2016).

Other approaches focus on the cognitive plausibility of their models rather than their performance. One example is the work by Infantino et al. (2016) which employs a sophisticated cognitive architecture for the purpose of controlling the movement of a humanoid robot in response to music.

Finally, some researchers follow an Artificial Life approach by implementing a computational ecosystem within which agents struggle for resources. Here, body movements result from behaviors that are selected by agents to increase their chances of survival. An example of this approach is Antunes and Leymarie (2012).

4. Implementation

The system presented in this publication combines a deep-learning model for pose sequence generation with a sequence blending mechanism. The model and the blending mechanism are implemented in Python and make use of the *Tensorflow* machine learning platform (Abadi et al. 2015).

4.1. Machine-Learning Model

The architecture of the machine-learning model is depicted in Fig. 1. The model consists of an encoder, decoder, and discriminator and follows one of the designs proposed by Wang et al. (2020). The encoder takes as input a sequence of poses in which each pose is represented by joint orientations in the form of unit quaternions. This input is passed through a two layer LSTM network followed by a two layer Dense network before being output as latent vector. The decoder operates in reverse. It takes as input a latent vector which is passed through a two layer Dense network followed by a two layer LSTM network before being output as a sequence of poses. The discriminator takes as input a latent vector which passes through a three layer Dense network before being output as scalar value. The purpose of the discriminator is to force the latent vectors to follow a specific prior distribution, which in this case is a Gaussian distribution. It does so by entering into an adversarial game with the encoder in which the discriminator is rewarded for successfully distinguishing between vectors coming from a true Gaussian distribution and latent vectors output from the encoder, whereas the encoder is rewarded for fooling the discriminator. Controlling the prior distribution ensures that the latent space is free of gaps and that distances within it represent a measure of similarity. This ensures that arbitrarily chosen latent vectors can be converted by the decoder into meaningful pose sequences.

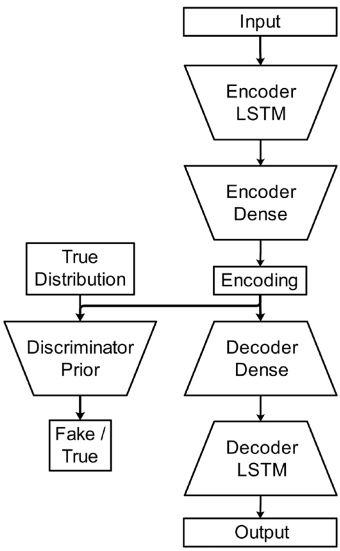


Fig. 1. Architecture of a Recurrent Adversarial Autoencoder. The inputs and outputs of the autoencoder are pose sequences. The trapezoid shapes with which the LSTM and Dense networks are depicted indicate the dimension reduction and expansion that is performed by the encoder and decoder, respectively.

During training, the loss function used for the discriminator is based on the cross entropy between the discriminator's output and a vector of zeros for the encoder's output and a vector of ones for samples taken from a true Gaussian distribution. The autoencoder is trained on four different loss functions that quantify its error in reconstructing a pose sequence and its capability to fool the discriminator. The loss functions associated with the reconstruction error are based on the deviation of quaternions from unit length, the difference in joint orientations between input and output, and the difference between joint positions between input and output. Joint positions are derived from joint orientations through forward kinematics. This combination of quaternion-based joint orientations with a loss function operating on joint positions has been suggested by Pavllo et al. (2019). In contrast to Pavllo et al. (2019) it was found that using both orientation difference and position difference as loss criteria improved the quality of the output.

4.2. Sequence Blending Mechanism

The sequence blending mechanism is inspired by two methods from computer music that combine short sound fragments to generate longer sounds: Granular Synthesis and Concatenative Synthesis. In a nutshell, Granular Synthesis employs very short (microseconds to milliseconds) sound fragments, whose amplitude fades in and out by means of a windowing function. By combining a large number of grains, new sounds can be generated that, depending on the length of the grains, are acoustically more or less similar to the sounds contained within the grains. This approach has been popularized among others by composer Curtis Road (Roads 2004). Concatenative Synthesis is a more recent method. Contrary to the former method, the sound fragments are typically longer (milliseconds to seconds) and their combination is based on finding best matches (Schwarz et al. 2004; Zils and Pachet 2001).

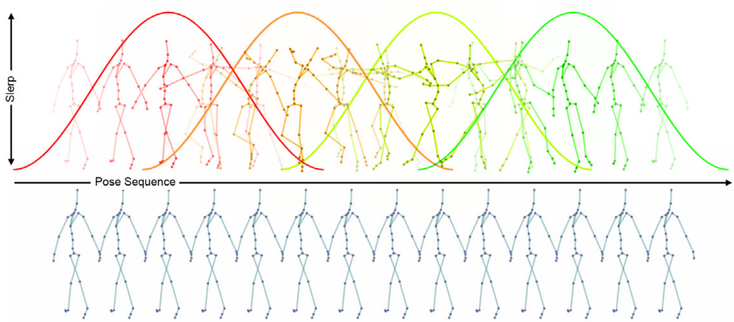


Fig. 2. Pose Sequence Blending. This figure schematically depicts the operation of the pose sequence blending mechanism. Prior to blending, the result pose sequence is populated with a base pose (bottom). Short pose sequences are blended one after the other with the result pose sequence (top) using quaternion SLERP. The bell shaped curves represent Hanning windows which control the amount of SLERP.

For this project, the sequence blending mechanism is used to combine short pose sequences generated by the decoder into longer pose sequences. To obtain smooth transitions between successive pose sequences, two approaches are employed. Similar to Granular Synthesis, a window function (Hanning in this case) is superimposed on the pose sequence. But rather than controlling an amplitude, this function blends the joint orientations of the overlapping pose sequences by spherical linear interpolation (SLERP) (Shoemake 1985). This method is depicted in Fig. 2. Similar to Concatenative Synthesis, sequences are selected for blending based on similarity criteria. Since the latent encodings follow a Gaussian distribution, the euclidean distances between them can be used as measure of similarity between pose sequences. Fig. 4 shows two example distributions of sequence encodings in latent space.

5. Data Acquisition

Training data for machine learning was acquired using a markerless motion capture system (*The Captury*). The recording was conducted at MotionBank, University for Applied Research Mainz. The recorded subjects were professional dancers specialized in contemporary dance. The recording used for training was taken from a single male dancer who was freely improvising to excerpts of music including experimental electronic music, free jazz, and contemporary classic. This recording is about 9.5 minutes in length which corresponds to a sequence of 28600 poses consisting of 29 joints each and taken at 50 frames per second. This data was cleaned using the software *MotionBuilder*.

6. Results

The results presented here stem from experiments with two versions of the machine-learning model. These versions differ with respect to the length of pose sequences they operate on and the encoding dimension. One model works with sequences of 128 poses and an encoding dimension of 64. The other model works with sequences of 8 poses and an encoding dimension of 16. From now on, these models are referred to as model128 and model8. The models have been chosen with two application scenarios in mind. Using sequence blending on the output of mode128 largely preserves the recognizability of the individual sequences with blending having little influence on this. With model8, the recognizability of the individual sequences is mostly lost but blending provides more control on the dynamics of the resulting sequence.

The publication documents results obtained with both models when conducting the following types of experiments: movement reconstruction, latent space organisation, latent space navigation.

6.1. Movement Reconstruction

An obvious thing to do when analyzing a trained machine learning model is to evaluate its performance on data that it has not been trained with. This evaluation provides some insights into the kinds of materials the model works best width and the types of artifacts it introduces. For this analysis, the data has been split into an 80% training set and a 20% validation set. The movement reconstructions tests where conducted on the validation set and involved a subjective comparison between the original and reconstructed pose sequences. An example of a reconstruction test is shown in Fig. 3. Additional reconstruction examples are provided online as videos.[1 2 3 4]

1. https://player.vimeo.com/video/507600887
2. https://player.vimeo.com/video/507600952
3. https://player.vimeo.com/video/507595938
4. https://player.vimeo.com/video/507595896

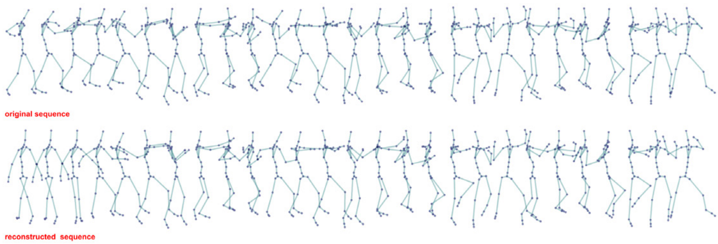


Fig. 3. Pose Sequence Reconstruction Test. The figure depicts the first 30 seconds of an original (top) and reconstructed (bottom) pose sequence with individual poses drawn at ten frames intervals. The deviation between the two sequences at their beginning is due to the SLERP algorithm gradually fading in a pose sequence on top of a base pose with which the result pose sequence has initially been populated with.

6.2. Latent Space Organization

Gaining an understanding for the organization of latent space forms an important prerequisite for creative experimentation with autoencoders. One approach is to visualize the distribution of the training data within latent space. Such a visualization conveys information about which regions in latent space are densely populated and this in turn points to locations from which familiar or unfamiliar pose sequences can be decoded. Latent space visualizations for model128 and model8 are depicted in Fig. 4.

In latent spaces that follow a Gaussian distribution, the euclidean distance between latent vectors represents a measure of similarity between their decoded outputs. This can be exploited to identify similar pose sequences that smoothly transition when concatenated by sequence blending. Several similarity tests have been conducted based on a pairwise comparison of pose

5. https://player.vimeo.com/video/507947066
6. https://player.vimeo.com/video/507946028
7. https://player.vimeo.com/video/507945397
8. https://player.vimeo.com/video/507962838
9. https://player.vimeo.com/video/507962433
10. https://player.vimeo.com/video/507962060
11. https://player.vimeo.com/video/507947528
12. https://player.vimeo.com/video/507948141
13. https://player.vimeo.com/video/507948603
14. https://player.vimeo.com/video/507960527
15. https://player.vimeo.com/video/507961391
16. https://player.vimeo.com/video/507961782
17. https://player.vimeo.com/video/507668465
18. https://player.vimeo.com/video/507682338
19. https://player.vimeo.com/video/507682930
20. https://player.vimeo.com/video/507683557

sequences that follow each other in the original motion capture recording. The results of these tests are available as online videos. Three videos display those paired sequences with smallest euclidean distances between their encodings by model128[5 6 7] and model8.[8 9 10] Another three videos display those paired sequences with largest euclidean distances between their encodings by model128[11 12 13], and model8. [14 15 16]

One of the biggest challenges in working with latent space concerns the typically inapprehensible relationship between latent vectors and their decodings. Usually, there exists no direct correspondence between dimensions of latent space and perceptual aspects of the decoded output. Nevertheless, it is possible to examine this relationship by systematically varying the values of each latent vector dimension, one at a time. Fig. 5 shows such a variation for the first four dimensions for model128. Online videos of variations for the first eight dimensions are available for model128[17 18] and model8.[19 20]

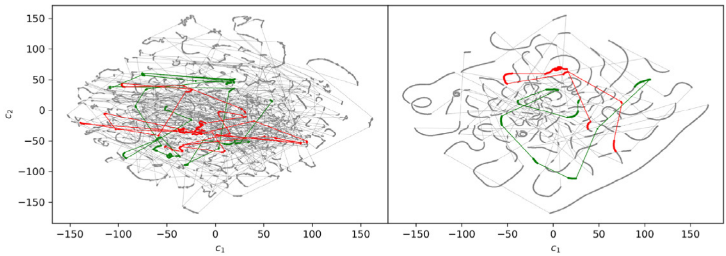


Fig. 4. Pose Sequence Encodings in Latent Space. The two figures show two-dimensional representations of the distribution of all encoded pose sequences that have been used for training model8 (left) and model128 (right). For dimension reduction, the t-Distributed Stochastic Neighbouring algorithm has been used. In these figures, individual pose sequences are represented as dots. »

6.3. Latent Space Navigation

A popular approach of using autoencoders for the purpose of movement generation is to navigate through latent space and collect latent vectors along the way which are then decoded and concatenated into a sequence. This approach has been chosen both by researchers working with encodings of poses e.g. Berman and James (2018); Kaspersen et al. (2020); Pettee et al. (2019) and researchers working with encodings of pose sequences e.g. Holden et al. (2015); Holden, Saito, and Komura (2016); Habibie et al. (2017). Using model128 and model8, the following latent space navigation experiments have been conducted: random walk, trajectory offset following, trajectory interpolation.

» Thin lines connecting these dots represent pose sequences that follow each other in the original mocap recording. Colored dots and lines highlight those pose sequences which have been used for sequence reconstruction and latent space navigation experiments. All other pose sequences are shown as grey dots and lines.

Random Walk

In this experiment, the encoding of a pose sequence is chosen as starting point for a random walk within the neighboring latent space. During the random walk, a random offset is repeatedly added to the latent vector. If the latent vector exceeds a user specified distance limit from the starting position, the offset reflects the vector back towards the starting position. The latent vectors that have been obtained from the random walk are decoded and the resulting pose sequences are concatenated. An example of this approach is shown in Fig. 6. An online video is available for model128[21] and model8.[22]

21. https://player.vimeo.com/video/508401476

22. https://player.vimeo.com/video/508445339

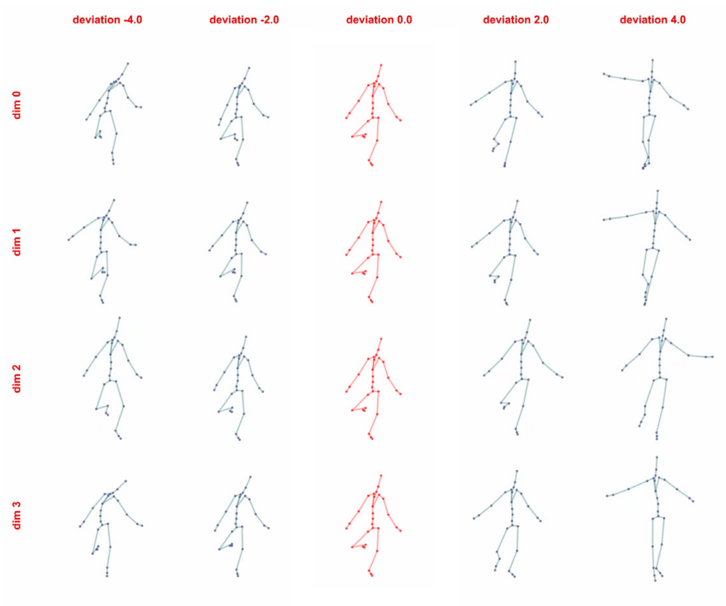


Fig. 5. Value Variations Along Latent Vector Dimensions. The figure shows a single pose from a pose sequence that has been encoded by model128. The latent vector representation of this pose sequence is varied by changing its value for each dimension in turn. In the figure, value changes run along the horizontal axis with no change in the center (red poses), and increasingly negative and positive changes (blue poses) to the left and right, respectively. The dimension increases from top to bottom. For space reasons, only changes for the first four dimensions are shown.

Trajectory Offset Following

A consecutive set of pose sequences is encoded into a series of latent vectors that describe a trajectory through latent space. Then a user specified fixed offset is added to these latent vectors. This creates a second trajectory that runs at a distance in parallel to the original trajectory. Latent vectors from this second trajectory are then decoded and the resulting pose sequences are concatenated. An example of this approach is shown in Fig. 6. An online video is available for model128[23] and model8.[24]

23. https://player.vimeo.com/video/508402996

24. https://player.vimeo.com/video/508446279

Trajectory Interpolation

An intuitive approach that provides fairly predictable results is to interpolate between two (or more) trajectories through latent space. These trajectories can be obtained for instance by encoding different consecutive pose sequences. A new trajectory can then be created by following the given trajectories while gradually approaching one trajectory and withdrawing from the other. The latent vectors from this new trajectory are then decoded and concatenated. A similar but less predictable approach can be chosen to obtain more original pose sequences. In this case, a new trajectory is created by extrapolating between the given trajectories, i.e. moving away from one trajectory in the opposite direction of the other trajectory. The decoded latent vectors can then be concatenated into a new pose sequence that increasingly exaggerates the differences between the two given pose sequences. Two examples of this approach, one for interpolation and one for extrapolation, are shown in Fig. 6. Online videos of each approach are available for model128[25] [26] and model8.[27] [28]

25. https://player.vimeo.com/video/508403507
26. https://player.vimeo.com/video/508404186
27. https://player.vimeo.com/video/508449003
28. https://player.vimeo.com/video/508450467

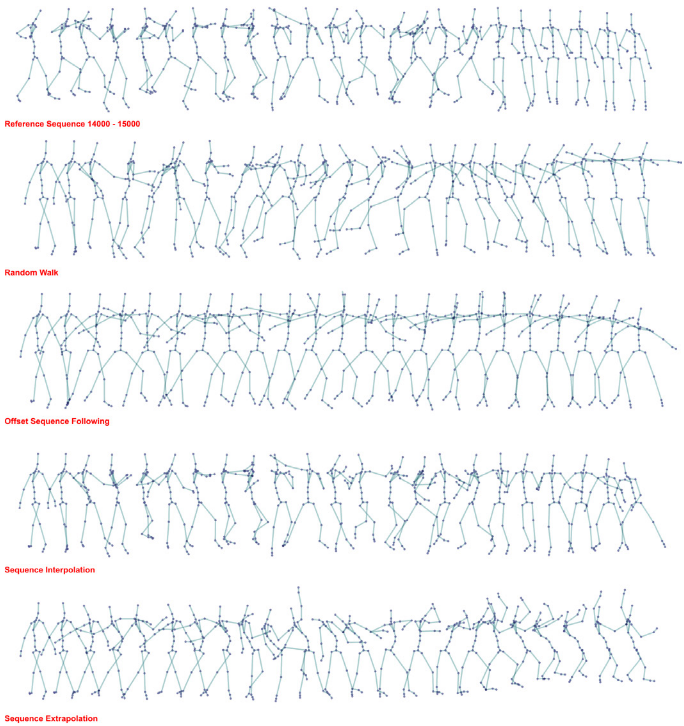


Fig. 6. Latent Space Navigation. The figure depicts several approaches of navigating latent space in combination with sequence blending. The latent space used in this example corresponds to model128. The sequences are depicted as poses taken at intervals of 20 frames. From top to bottom, the sequences represent: an original sequence, a sequence created from a random walk starting at the encoded beginning of the original sequence, a sequence created by adding an offset of 2.0 in all dimensions to all encodings of the original sequence, a sequence obtained by interpolating between the encodings of two original sequences, a sequence obtained by extrapolating between the encodings of the same two original sequences.

7. Discussion

The experiments conducted so far highlight some of the benefits of combining a machine learning system with a sequence blending mechanism for the purpose of creating new pose sequences. The latent space of sequence representations that autoencoders establish offers an interesting environment for exploration and discovery. Since the principle of navigation is easy to understand, users with very different levels of technical expertise can devise their own methods for navigation. The chosen autoencoder only operates on sequences containing a fixed number of poses. The use of sequence blending overcomes this limitation. This blending mechanism is also easy to understand and use. But in addition, it provides the opportunity for creative experiments that draw inspiration from musical approaches of working with Granular and Concatenative Synthesis.

In the following, the results from the previous section are discussed with respect to their artistic potential.

7.1. Latent Space Organization

Visualizations of latent space can grant new insights into movement material that choreographers or dancers are working with. These visualizations can for instance be interpreted in terms of the diversity of material that is available, the duration of movement phrases, the number of phrases in a sequence, or the difference that consecutive phrases exhibit with respect to each other. This information might be helpful to find aligned and contrasting movement phrases that can then be used either sequentially in time or simultaneously for different dancers.

Comparing the similarity of encodings of pose sequences with one's own perception of these sequences raises interesting questions concerning the universality and characteristics of salient movement features. For practical applications, the similarity of encodings can be used as measure of originality of movement material. If movement material ends up in a location within latent space that is sparsely populated, then this movement is under-represented in the material that has been used for training. An alternative and stronger indication of originality is a failure of the autencoder to reproduce the movement. Errors in reproduction are exploited for detecting anomalies, an application of which is the forecasting and prevention of catastrophes such as earthquakes. In dance, an anomaly would be a strong indicator of a very original movement.

The systematic variation of values in a latent vector is a tedious method for creating new movement material. Nevertheless, this approach might be useful for introducing very nuanced deviations in a pose sequence, for instance for the purpose of creating movements for a group of virtual characters in which each character should exhibit some degree of individuality.

7.2. Latent Space Navigation

Navigating a latent space of encodings is a popular method for creating new movement material. This method is useful for a variety of purposes, including data cleaning, the design of behaviors for artificial characters, and choreographic ideation.

The mundane task of data cleaning benefits from the fact that autoencoders discard features that appear seldomly. Therefore, autoencoders can eliminate non systematic artifacts in a mocap recording (Holden et al. 2015). From an aesthetic point of view, this effect might be useful to smooth out small variations or rare extremes in a pose sequence. To achieve either of these goals, latent space navigation would exactly follow the trajectory of encodings from a movement sequence and then reconstruct this movement through decoding and sequence blending (see 6.1 Movement Reconstruction)

Similar random walks in latent space as described in section 6.3 have been employed by Berman and James (2014;2018). In these publications, a random walk is used to create improvisation-like movements for an artificial dancer. Contrary to these previous examples, the random walk presented here operates on pose sequence encodings rather than pose encodings. This requires the use of sequence blending to prevent movement discontinuities. But even with sequence blending, it is difficult to obtain movements that look plausible. Often, the resulting movements are repetitive and erratic. This issue is more pronounced for model8 than model128. To obtain somewhat interesting results, it is necessary to balance the size of the random steps taken in latent space and the size of the overlap used for sequence blending.

Following a trajectory through latent space at a fixed offset provides an alternative to a random walk. This method avoids the occurrence of repetitive movements while still succeeding in creating new movement material. The size of the offset can be used to control the amount of novelty. The examples presented so far are quite rudimentary in that they employ the same offset value for all dimensions of latent space. A more sophisticated approach would take into account how variations along individual dimensions affect the resulting pose sequence. Also, rather than being fixed, the offset could change while it follows a trajectory. This would result in an output that exhibits varying levels of similarity with the original material. But even the current rudimentary implementation provides some interesting results, in particular concerning the size of the pose sequence that the autoencoder and sequence blending operate on. The result obtained from model128 is a pose sequence that changes minimally and slowly. This is not the case for the result obtained from model8. This points to an interesting difference in application for the models. Model128 is more useful for creating more or less faithful reconstructions of the original movement but generates less interesting results when exploring neighboring regions of latent space. Model8 is more useful for the opposite application.

The interpolation and extrapolation between multiple trajectories constitutes the possibly most productive approach to latent space navigation that is described in this publication. Both methods offer intuitive means of controlling the similarity and variability of the resulting movement material. In case of interpolation, the given trajectories provide boundaries for latent space navigation. In most cases, the regions between those boundaries have become densely populated with encodings during training. Therefore, interpolation typically generates a movement sequence that blends properties of the target sequences in a predictable and plausible manner. In case of extrapolation, the generated results are more varied and unpredictable but this comes at the cost of plausibility and realism. One reason for this is an increased likelihood that extrapolated trajectories cross parts of latent space that have been scarcely populated during training. Extrapolation frequently results in the generation of pose sequences that are neither plausible or realistic and that differ so much from each other that they are difficult to combine by sequence blending. Since interpolation and extrapolation are not mutually exclusive, the strengths and weaknesses of each approach can be balanced against each other.

8. Outlook

The results obtained from combining a recurrent adversarial autoencoder with a grain-based sequence blending mechanism seem promising enough to warrant further research and development. So far, sequence blending has been used to seamlessly concatenate decoded pose sequences. A next step would be to experiment with additional uses of sequence blending. This includes working with a larger range of different sequence lengths and experimenting with more varied sequence combinations such as: non-consecutive placement of grains, different grain weightings, additive and subtractive grain combinations, stacking multiple grains on top of each other, etc.

It also seems promising to explore additional methods for navigating latent space. The simplest improvement would be to employ more sophisticated versions of random walks. Rather than directly randomizing position offsets, randomization could be applied to first or higher order derivatives to obtain smoother trajectories. More sophisticated approaches could be based on the simulation of flocking behavior. This would allow to create multiple trajectories that are clustered and aligned but still vary from each other. Such trajectories could be used to control the movement of a group of virtual characters. It might also be interesting to extract features from an external modality such as music and use them to control navigation in latent space. Such an approach has been used for instance by (Augello et al. 2017).

It's also worthwhile to address the difficulty of obtaining an understanding for the relationship between latent vectors and their decodings. One approach would be to condition the autoencoder on higher level control parameters (e.g. Wang et al. 2020). Another approach is to extend an autoencoder with a control network that learns to disambiguate latent space (e.g. Li et al. 2017).

The possibly most promising improvement would combine machine-learning with a simulation of the bio-mechanical properties of the human body. Such a combination would get rid of a common problem that plagues purely data-driven approaches: the generation of physically impossible movements. But since training neural networks is based on gradient decent and gradients typically don't propagate through a physics' simulation, a different learning paradigm is needed. This is the paradigm of reinforcement learning. Reinforcement learning is still in its infancy but has recently attracted significant research interest. Accordingly, its likely challenging to come up with an implementation that is both robust and accessible to artists for creative experimentation.

Acknowledgements. The author's thanks go to the dancers who have contributed countless hours of their spare time to the motion capture recordings. Further thanks go to MotionBank for providing their infrastructure. This publication forms part of research conducted in the context of a Marie Curie Fellowship and funded by the European Union.

References

Abadi, Martín, Ashish Agarwal, Paul Barham, Eugene Brevdo, Zhifeng Chen, Craig Citro, Greg S. Corrado, Andy Davis, Jeffrey Dean, Matthieu Devin, Sanjay Ghemawat, Ian Goodfellow, Andrew Harp, and Geoffrey Irving. 2015. TensorFlow: Large-Scale Machine Learning on Heterogeneous Systems. Software available from tensorflow.org.

Alemi, Omid, and Philippe Pasquier. 2019. "Machine Learning for Data-Driven Movement Generation: a Review of the State of the Art." arXiv preprint arXiv:1903.08356.

Antunes, Rui Filipe, and Frederic Fol Leymarie. 2012. "Generative choreography: animating in real-time dancing avatars." International Conference on Evolutionary and Biologically Inspired Music and Art. Springer, 1–10.

Augello, Agnese, Emanuele Cipolla, Ignazio Infantino, Adriano Manfre, Giovanni Pilato, and Filippo Vella. 2017. "Creative robot dance with variational encoder." arXiv preprint arXiv:1707.01489.

Berman, Alexander, and Valencia James. 2014. "Towards a live dance improvisation between an avatar and a human dancer." Proceedings of the 2014 International Workshop on Movement and Computing. 162–165.

Berman, Alexander, and Valencia James. 2018. "Learning as Performance: Autoencoding and Generating Dance Movements in Real Time."International Conference on Computational Intelligence in Music, Sound, Art and Design. Springer, 256–266.

Carlson, Kristin, Philippe Pasquier, Herbert H Tsang, Jordon Phillips, Thecla Schiphorst, and Tom Calvert. 2016. "Cochoreo: A generative feature in idanceForms for creating novel keyframe animation for choreography." Proceedings of the Seventh International Conference on Computational Creativity.

Carlson, Kristin, Thecla Schiphorst, and Philippe Pasquier. 2011. "Scuddle: Generating Movement Catalysts for Computer-Aided Choreography." ICCC. 123–128.

Cho, Kyunghyun, Bart Van Merriënboer, Caglar Gulcehre, Dzmitry Bahdanau, Fethi Bougares, Holger Schwenk, and Yoshua Bengio. 2014. "Learning phrase representations using RNN encoder-decoder for statistical machine translation." arXiv preprint arXiv:1406.1078.

Church, Luke, Nick Rothwell, Marc Downie, Scott DeLahunta, and Alan F Blackwell. 2012. "Sketching by Programming in the Choreographic Language Agent." PPIG. Citeseer, 16.

Crnkovic-Friis, Luka, and Louise Crnkovic-Friis. 2016. "Generative choreography using deep learning." arXiv preprint arXiv:1605.06921.

DeLahunta, Scott. 2009. "The choreographic language agent." Conference Proceedings of the 2008 World Dance Alliance Global Summit.

Downie, Marc Norman. 2005. "Choreographing the Extended Agent: performance graphics for dance theater."Ph.D. diss., Massachusetts Institute of Technology, School of Architecture and Planning .

Fiebrink, Rebecca, and Baptiste Caramiaux. 2016. "The machine learning algorithm as creative musical tool."arXiv preprint arXiv:1611.00379.

Fragkiadaki, Katerina, Sergey Levine, Panna Felsen, and Jitendra Malik. 2015. "Recurrent network models for human dynamics." Proceedings of the IEEE International Conference on Computer Vision. 4346–4354.

Gillies, Marco, Harry Brenton, and Andrea Kleinsmith. 2015. "Embodied design of full bodied interaction with virtual humans." Proceedings of the 2nd International Workshop on Movement and Computing. 1–8.

Gillies, Marco, Rebecca Fiebrink, Atau Tanaka, Jérémie Garcia, Frédéric Bevilacqua, Alexis Heloir, Fabrizio Nunnari, Wendy Mackay, Saleema Amershi, Bongshin Lee, et al. 2016. "Human-centred machine learning."Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. 3558–3565.

Open Ended Group. 2001. Loops. http://openendedgroup.com/artworks/loops.html. Accessed: 2021-01-29.

Habibie, Ikhsanul, Daniel Holden, Jonathan Schwarz, Joe Yearsley, and Taku Komura.
2017. "A recurrent variational autoencoder for human motion synthesis." 28th British Machine Vision Conference.

Hochreiter, Sepp, and Jürgen Schmidhuber.
1997. "Long short-term memory." Neural computation 9 (8): 1735–1780.

Holden, Daniel, Jun Saito, and Taku Komura.
2016. "A deep learning framework for character motion synthesis and editing." ACM Transactions on Graphics (TOG) 35 (4): 1–11.

Holden, Daniel, Jun Saito, Taku Komura, and Thomas Joyce.
2015. "Learning motion manifolds with convolutional autoencoders." In SIGGRAPH Asia 2015 Technical Briefs, 1–4.

Infantino, I, A Augello, A Manfré, G Pilato, and F Vella.
2016. "Robodanza: Live performances of a creative dancing humanoid." Proceedings of the Seventh International Conference on Computational Creativity. 388–395.

Kaspersen, Esbern Torgard, Dawid Górny, Cumhur Erkut, and George Palamas.
2020. "Generative Choreographies: The Performance Dramaturgy of the Machine." Proceedings of the 15th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications-Volume 1: GRAPP. SCITEPRESS Digital Library, 319–326.

Lea, Colin, Rene Vidal, Austin Reiter, and Gregory D Hager.
2016. "Temporal convolutional networks: A unified approach to action segmentation." European Conference on Computer Vision. Springer, 47–54.

Leach, James, and Scott Delahunta.
2017. "Dance becoming knowledge: designing a digital "body"." Leonardo 50 (5): 461–467.

Li, Zimo, Yi Zhou, Shuangjiu Xiao, Chong He, Zeng Huang, and Hao Li.
2017. "Auto-conditioned recurrent networks for extended complex human motion synthesis." arXiv preprint arXiv:1707.05363.

Pavllo, Dario, Christoph Feichtenhofer, Michael Auli, and David Grangier.
2019. "Modeling human motion with quaternion-based neural networks." International Journal of Computer Vision, pp. 1–18.

Peng, Xue Bin, Glen Berseth, and Michiel Van de Panne.
2016. "Terrain-adaptive locomotion skills using deep reinforcement learning." ACM Transactions on Graphics (TOG) 35 (4): 1–12.

Pettee, Mariel, Chase Shimmin, Douglas Duhaime, and Ilya Vidrin.
2019. "Beyond imitation: Generative and variational choreography via machine learning." arXiv preprint arXiv:1907.05297.

Roads, Curtis.
2004. Microsound. MIT press.

Schwarz, Diemo, et al.
2004. "Data-driven concatenative sound synthesis."

Shoemake, Ken.
1985. "Animating rotation with quaternion curves." Proceedings of the 12th annual conference on Computer graphics and interactive techniques. 245–254.

Wang, Qi, Thierry Artières, Mickael Chen, and Ludovic Denoyer.
2020. "Adversarial learning for modeling human motion." The Visual Computer 36 (1): 141–160.

Zils, Aymeric, and François Pachet.
2001. "Musical mosaicing." Digital Audio Effects (DAFx), Volume 2. Citeseer, 135.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Know thy Flesh: What Multi-disciplinary Contemporary Art Teaches Us about Building Body Knowledge

Keywords: Bioart, Self-tracking, Multi-disciplinary Art, Biological Materials, Human-computer Interaction

Kit Kuksenok
ksenok@protonmail.com
Independent, Berlin, Germany

Marisa Satsia
m.satsia@gmail.com
Independent, Nicosia, Cyprus

Building body knowledge is a multi-disciplinary, interpersonal endeavor that implicates medical imaging capabilities, scientific institutions, and datafication of personhood in popular culture. Drawing on existing scholarship in critical digital health studies, we contribute an articulation of how self-tracking leads to a paradox of control: the motivation to extend body knowledge is complicated by the experience of available consumer tools. Self-tracking as a mechanism of biopower underpins this paradox of control and contextualizes the subversive or resistant aims of the proposed resolutions. Prior work has suggested paths of subversion and resistance through available consumer technologies, as well as a critique of how these technologies are designed. Our work focuses on relating biotechnologically mediated art to the use of self-tracking tools more generally. This article is intended for both artists working with biological data or matter, and consumers of self-tracking technology who are interested in adapting these tools as creative means for building body knowledge. We turn to contemporary artworks constructed using biological material or bodily observation to find resolutions to the paradox of control, which include (1) renegotiating the relationship to institutions, (2) mobilizing available tools for unconventional narratives, and (3) embracing biological material.

1. Introduction

How do you know your own body? One increasingly common route of exploration uses consumer self-tracking technology. For example, wrist-worn devices promise the visibility of the unseen experience of sleep. Although self-tracking is motivated by building body knowledge, and although available devices reveal an otherwise-unobservable bodily reality, these methods also introduce new tensions (Lupton 2016). In Section 2, we describe how consumer self-tracking has been informed by advances in biomedical understanding and imaging, measurement, and extraction technologies, as well as the popular-culture relationship to them. Challenging these normative aspects of self-tracking from the intersection of human biology, science, biotechnology, and contemporary art (including bioart, sciart and or biotech-art), we demonstrate how this tension can be resolved while using the tools that are already available. As Sanders (2017) notes, “calls to opt out of self-tracking obscure the fact that all individuals remain subject to regulatory forces” and suggests that “it may be more fruitful to theorize resistance (1) from the perspective of the user and (2) in terms of subversion rather than renunciation.”

In this article, we focus on visual observation, whether medically or artistically, as the primary vehicle for building body knowledge. We draw on multidisciplinary artworks constructed using the body as a site for self-knowledge, observation, and exploration using medical imaging techniques and biotechnology. Our key arguments are:

Section 3 - A paradox of control arises in self-tracking.

Motivations for self-tracking include not only observation,
but gaining control:

- reducing or eliminating uncertainty
- truthfully observing a bodily experience
- directing behavior change

However, methods for self-tracking entail losing control, such as when:

- new sources of uncertainty are encountered
- “objective” data brings disconnection from the subjective experience
- behaviors are influenced in unintended ways

Section 4 - Possible resolutions to the paradox of control are suggested by artworks that:

- Renegotiate the relationship to institutions
- Mobilize available tools for unconventional narratives
- Embrace biological material

We illustrate this resolution through several multidisciplinary artworks that utilise and embrace biological material and data in unusual ways outside of conventional institutional and medical use, emphasizing instead rich subjective bodily experiences. Technoscientific advances, biological materials, and biological data can be used in subversive ways, resisting their own algorithmic authority and normalising medical gaze. We consider: Orlan's artwork *La Liberté en écorchée*, Mona Hatoum's *Corps Étranger*, Laura Splan's *Embodied Objects*, Susan Aldworth's *Out of the blue* and *Brainscape 24*, Marc Quinn's *Genomic portrait of Sir John Sulston*, WhiteFeather Hunter's *Mooncalf*, and Rebecca D Harris's *Symbiosis*.

We contribute an articulation of the paradox of control in self-tracking, which draws on existing scholarship in critical digital health studies (inc. Lupton 2016; Sanders 2017) and human-computer interaction. Prior work has suggested paths of subversion and resistance through available consumer technologies (Sanders 2017; Nafus and Sherman 2011). Our work focuses on applying subversive technobiological mediated art (e.g., Šlesingerová 2018) to the use of self-tracking tools generally.

2. Background

Through medical imaging technologies, deep empirical observation, and data mining, the human body becomes a site of knowledge-building; however, visibility can come at a cost. We include in this account consumer self-tracking technologies, which also include technologies of digitizing observation and storing memory of these observations over a long term to render them computationally workable. First (2.1), we discuss how visibility of the body can be in tension with trusting one's own experience. Next (2.2), we review how developments of these technologies displaced artists and anatomists as natural philosophers and thereby replaced narrative depiction of the dissected human body with more standardized and disembodied representations. Lastly (2.3), we outline the power dynamics of building personal and institutional body knowledge. Self-tracking as a mechanism of biopower underpins the paradox of control

(Section 3) and contextualizes the subversive or resistant aims of the proposed resolutions (Section 4).

2.1. The Body Made Visible

Unconventional narratives in multi-disciplinary art practices convey new enriching and immersive dimensions in building body knowledge. Research in human biology and public health "illuminates" artistic work in its "quest to understand ourselves and the nature of life" (Wilson 2010, 64). Scientific epistemologies do not typically center human narrative, but artists do: "Scientists may be able to explain how the brain works in terms of mapping the cortex or understanding synaptic connection making or the function of neurotransmitters, but they cannot convey how experience feels the way it does to us as individuals" (Ede 2000, 3-5). Contemporary artists engage with the subject of the human body "at the service of self-perception and self-knowledge" (Di Marco 2015, 37); and "although contemporary artists are not looking for a divine order, they are nevertheless in search of a deeper understanding of what (they) call the 'interior space' of the body, which is at the same time physical and spiritual" (Di Marco 2015, 37). The body is furthermore made visible through long-term and large-scale storage, comparison, and mining of data (Lupton 2016; Neff & Nafus 2016; Meyer et al. 2020; Borbély et al 2017).

Consider two artworks by Susan Aldworth that embrace biological data (cerebral angiograms of hospital patients) and demonstrate unconventional narratives (embroidered texts). These works center the subjective, lived experience; and combine qualitative and quantitative data. In *Out of the blue* (2020), 100 items of clothing were embroidered with personal testimonies contributed by people living with epilepsy and their carers, hung from the gallery ceiling by wires, and programmed to move patterns associated with epilepsy (Aldworth, 2020). Through Aldworth's use of patient data and testimonies, she creates a vessel for personal and collective healing while renegotiation of institutional relationships of bodily knowledge. For Aldworth, working as an artist-in-residence in a medical or academic setting is central to her practice (Aldworth, 2020). In *Brainscape 24* (2006), Aldsworth used cerebral angiogram data of thirty hospital patients to make etchings of the arteries of the brain. Imaging techniques in medicine offer alternative and enriching views of the inner body; however, they "do not provide unadulterated access to core levels of reality, but rather produce screen images based on sets of decisions embedded in the technologies that underpin them" (Wilson 2010, p.64). Here, cerebral angiograms, which are "an X-ray of a high-contrast dye flowing through the arteries of the head or brain", are mobilized against the normalization of institutional medical understanding, conveying a plurality and subjectivity of experience.

Lupton observes that the cultural prevalence of medical images, in addition to widespread use of self-tracking devices, has shifted the sense of objectivity outside the body, to the devices used to observe it: "where once people relied upon the sensations they felt in their bodies and reported to their physicians, medical technologies devoted to producing images of the body have altered the experience and treatment of bodies. The optic has come to take precedence over the haptic in revealing the 'truth' of the body" (2016). Such technologies produce a virtual patient, a "screen body". The visual image of the data they generate are often privileged as more "objective", and "as part of the project of seeking security and stability, such technologies attempt to penetrate the dark interior of the body and to render it visible, knowable and thereby (it is assumed) manageable" (ibid.). The term "transparent body" is a "complex product of our culture" and a "cultural construct mediated by medical instruments, media technologies, artistic conventions, and social norms", and describes a body characterized by "perfectibility and malleability" (Van Dijck 2005, 3-4).

What we refer to as the paradox of control is therefore an instance of a broader tension introduced by standardized tools for rendering the body visible, not only by their technical capacity, but their cultural and institutional context of production and use. Next, we consider the development of such tools and their relationship to power from the Renaissance until today.

2.2. Building Institutional Body Knowledge

Both artists and anatomists sought basic knowledge of the human body, and this professional and intercultural exchange has enabled the mapping of the human body (Rifkin 2006, 6). In Vesalius' *De Humani Corporis Fabrica* (1543), shown in Figure 1, artist Jan Stephan Van Calcar portrayed the dissected body (*écorché*) in animated poses across natural landscapes, and involved it in various narratives (Rifkin 2006, 7). Through artists' representations, the body started becoming "more transparent" (Di Marco 2012, 35), making the Renaissance era "a major turning point for the representation of the body," with Leonardo Da Vinci as one of the "prophets and pioneers of a revolution in the representation of the human body". Da Vinci's "deep seeing" (deep empirical observation) skills were developed as a tool for understanding natural phenomena (Wilson 2010, 13). His "deep seeing" and application of "the theory of proportions as an empirical science" (Wilson 2010, 13) allowed him to become a master visualizer of the human body. He was the only known artist-anatomist that managed to "capture" and "isolate" parts of the body with his drawing techniques before the invention of Magnetic Resonance Imaging (MRI) and X-rays. (Kemp 2005, 49).

Fig. 1. Vesalius' *De Humani Corporis Fabrica* (1543). Images in the public domain.

Prior to the invention of microscopes, X-rays, radiographs, MRI, and PET SCANs, medical professionals had to depend primarily on their own senses (sight, touch, hearing) to visualize the inner body and determine a diagnosis. Such "direct sensory perceptions are still important diagnostic means for physicians, even though they depend increasingly on the optical-mechanical eye" (Van Dijck 2005, 5). Scientists, like artists, need to "see" or visualize ideas to understand the human body and other phenomena (Ede 2000, 11). The invention of instruments for extending human sight replaced the skills of artists, their empirical observations, and their senses, which inspired skepticism (ibid., 72).

From the 19th century onwards, these innovations ultimately revolutionized the visual sciences and the arts (Ede 2000, 72), and, by extension, way we see ourselves. More widespread use of microscopy and the invention of x-rays in 1895 introduced a new world of visual access to the inner body (Kemp and Wallace 2000, 18), displacing artists and anatomists as natural philosophers; deep seeing as the primary tool; and the depiction of the dissected human body in a humanizing narrative. The emergence of these imaging technologies coincided with the introduction of a "new medical gaze", and apart from medical visualization tools, "media technologies have also substantially contributed to the body's transparency" by revealing and disseminating a variety of documentaries on different medical conditions, viruses, etc. (Van Dijck 2005, 4).

Technoscientific advances have made the dissected human body accessible to a wider audience, beyond a limited elite. These images have become an inseparable part of our everyday visual culture and cultural mainstream. Increasingly, visibility extends also to micro-organisms and microbial communities: for example, consider *Symbiosis* (2015) by Rebecca D. Harris (Harris 2020), shown in Figure 2. Today, self-tracking makes a continuous measurement of the body possible. For example, over the course of three decades, a researcher used a "self-contained battery-powered wrist-worn electronic accelerometer" to collect actimetry data (Borbély et a. 2017). This is one of many examples of self-tracking undertaken not by consumers of a general technology, but by "bona fide researchers, with a background in experimental science ... [some] using grant money and lab resources to perform long-term vertical studies," as Gimbert and Lapointe (2015) write regarding microbiome self-tracking in particular. At the outset of data collection, the device was self-assembled by a research team; today, wearable activity and sleep tracking technologies (still often using accelerometer data) are widely available and used, as we will discuss in Section 3.2.

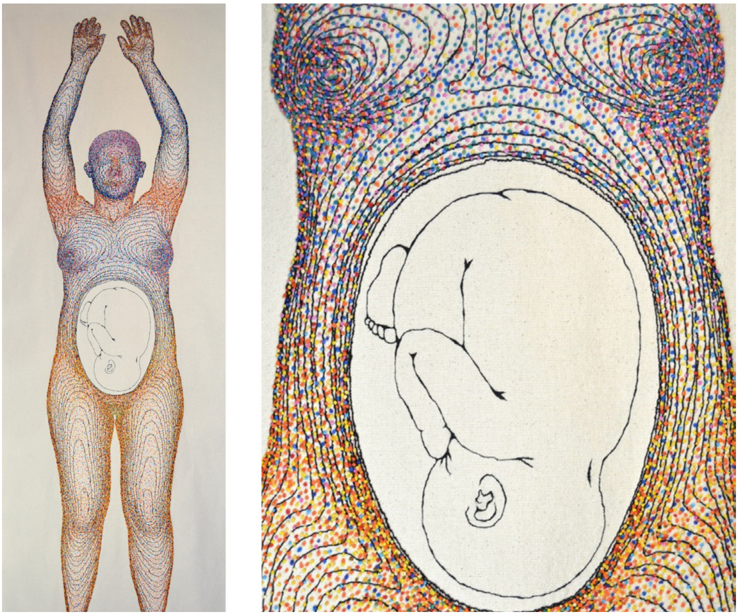


Fig. 2. "Symbiosis" (2015) by Rebecca D. Harris, working with microbial community data from University College London microbiologists working as scientific advisers on the commission for the Eden Project, supported by the Wellcome Trust. The detail (b) contrasts how "in the womb we are microbe free, 100% human ... it is through birth we acquire the first stage of crucial development of human health, microbes" (Harris, 2015). Images courtesy of the artist.

2.3. Self-Knowledge and Power in the Anatomised Body

The "know thyself" ethos ("γνῶθι σαὐτόν" in ancient Greek, originating from understanding or exploring, "γιγνώσκω", and the word for self, "εαυτός") originates from the Apollo Temple in Delphi (Kemp and Wallace 2000). Re-introduced during the Renaissance, this ancient tag not only justifies the dissections carried out in the early Renaissance period, but also informs the work of every medical image produced until the 19th century along with the work of today's contemporary artists (Kemp and Wallace 2000, 13-14). In the 21st century, the "know thyself" ethos also informs both the development and widespread use of self-tracking technologies, with quantification of the self via digital devices as a fundamental aspect of contemporary selfhood (Lupton 2016,9-13). The biomedicalization of society and the human body and the synthetic engineering of life have also significantly influenced contemporary art (Šlesingerová 2017, 3).

Technoscientific advances, including medical imaging and self-tracking, transform the human body into a site of data mining and knowledge building with the aim of control. Building body knowledge can become a form of biopower that "manifests itself in the form of daily practices and routines through which individuals engage in self-surveillance and self-discipline, and thereby control themselves" (Foucault 1976, in Pylypa1998, 21). Lupton (2016, 45-51) notes that "neoliberal political rationalities rely on apparatuses of 'soft' rather than 'hard' power" under which practices of self-optimization "appear to emerge from personal desires and voluntary objectives related to the achievement of health, happiness, and success rather from imperatives issued by the state of other sources of authority" (ibid.). Sanders additionally recognizes gendered dynamics, wherein these devices "foster increasingly rigorous self-policing mentalities in women" (Sanders, 2017, p.18). Emerging evidence suggests that "the tendency to experience one's body principally as an object [that is] evaluated for its appearance," which also has a gendered component, can be associated with lower "interoceptive awareness, assessed by heartbeat perception" (Ainley and Tsakiris, 2013).

To connect our discussion of the anatomized body to self-tracking through the lens of normative observation, consider Gunther von Hagens' *Body Worlds* expositions, which explicitly present posed plastinated cadavers and human organs as vehicles for projecting a self-improvement narrative, in addition to its stated general anatomical education goals. When one of the authors visited Berlin's exhibit, many plaques highlighted pathologies in organs (e.g., effect of smoking on the lungs) and, at the exit, directly asked visitors to votes which healthy habit (more exercise, healthier eating) they would commit to after leaving. Survey findings ("The Philosophy behind BODY WORLDS", 2021) states that "68% left the exhibition with valuable incentives for a healthier lifestyle", and that "a follow-up survey... [showed that many] changed behavioral patterns according to their resolutions to lead a healthier life." Another survey found that although "49.8% visitors ... felt disturbed," "42.6% resolved to pursue a healthier lifestyle" (Leiberich et al. 2006). The presentation of plastinated cadavers employs visual presentation of disease and pathology within human specimens that are made observable in a way that the viewer's own body is not. The cadavers presented are posed with an "artistic dimension" (Burns, 2016, p. 14) though the creator "has claimed that his craft is not an essentially artistic enterprise" (ibid., 19). Though the stated aims are educational, the impact is only through visitor exit polls (ibid.).

Today, general anatomical knowledge can be accessed in many ways, and mobilized for one's own self-knowledge. Self-tracking provides additional direct access to one's own inner bodily space, mediated by external tools. Responding to the claim that self-tracking is "a profoundly different way of knowing what data is, why it is important, who gets to interpret it, and to what ends" (Nafus and Sherman 2014), Lupton (2016) suggests this is insufficient for "resistance against algorithmic authority:" "while a small minority of technically proficient self-trackers are able to devise their own digital technologies for self-tracking ... the vast majority must rely on the commercialized products that are available and therefore lose control" over the resulting data.

The act of dissection and observation of the human body, and the resulting knowledge, was historically itself an act of biopower (Foucault 1976) in which only spectators of certain social and economic standing could participate. To artists and anatomists of the time, the scrutinization of human anatomy was considered an artistic, cultural, and social achievement (Foucault, 1997, in Di Marco 2015, 34). In *The Birth of the Clinic* (1975), Foucault (as cited in Pylypa 1998, 23) describes how the medical profession gained prestige by employing "scientific" knowledge, which gave it considerable power in defining reality. Today, this ''scientific knowledge'' is being reproduced and disseminated in the media, cadavers can be dissected virtually, and medical and anatomical images have become widely accessible aspects of everyday visual and aesthetic culture (Ede 2000, 71).

Contemporary artists apply these techniques outside of their everyday institutional and medical diagnostic use. Working with available techniques can help regain control, building “knowledge that can be used to defy the normalizing gaze” (Di Marco 2015, 35). Artist Laura Ferguson works with representations of the body, such as her own X-Ray and CT scan imagery of the unusual structure of her skeleton, to “regain a sense of ownership of the body that is usually lost when one’s experience of disease or disability is taken in charge by doctors” (ibid.). Artist Laura Splan uses Electromyography (EMG) and other forms of biometric data (EEG, EKG) that are extracted from the body itself to create a series of “Embodied objects” which interrogate technological representations of the body through sculptures, weavings and works on paper (Splan, 2021a). One of the artworks, *Manifest* (2015), shown in Figure 3, consists of 3D-printed sculptures that use EMG sensors to visualize the fluctuating levels of electricity in stimulated facial muscles during expressions. Through the extraction of intangible biometric data, Splan can re-materialize intangible bodily processes. These practices may require technical skills that are not widely taught; hardware that is not widely accessible; and potentially limited institutional connection, so, as an alternative practice, this may also be limiting.

Fig. 3. *Manifest* (2015) by Laura Splan: “data-driven 3D-printed sculptures using electromyography (EMG) readings of facial expressions ...The project examines the potential for objects to embody human experience and to materialize the intangible ” (Splan, 2021b). Installation view (a); *Blink Twice, Swallow, Squint* (b-d) and *Frown, Furrow, Smile* (e-g). Images courtesy of the artist.

3. The Paradox of Control

Self-tracking, as a set of tools and methods, makes the body visible through widely available technologies. The newfound visibility contextualizes the paradox of control. In this section, we first introduce this paradox along three different aspects of control: reducing uncertainty, truthful observation, and taking action. Second, we use sleep tracking as a case study of how each aspect of this paradox plays out in one specific domain of a previously inaccessible human experience.

3.1. Reducing Uncertainty, Truthful Observation, and Taking Action

A paradox of control arises in self-tracking. The word paradox was chosen to highlight the difference between expectation (more control) and reality (less control). This concept builds on research by Lupton (2016), Sanders (2017), and others. This section reviews the tensions that arise in three different aspects of control. First, the motivation to reduce or eliminate uncertainty through self-tracking is met by new sources of uncertainty associated with self-tracking. Second, the motivation to truthfully observe a bodily experience can be associated with disconnection from the felt experience. Third, the motivation to direct behavior change may result in behaviors being influenced in unintended ways.

Observation of the body is entangled with expectation of manageability: "[sociologically] self-tracking might be understood [as a] response to the problem of dealing with the uncertainties ... of late modernity" (Lupton 2016). In a study of wearable activity trackers (WATs), Duus et al. (2018) note that the devices "not only contributed to skills related to capturing, storing, and visualizing performance data, but were also expected to provide certainty and reassurance." However, self-tracking itself also introduces uncertainties. Knowles et al.(2018) distinguish input uncertainty ("whether the data coming into a system is sufficiently accurate to produce meaningful outputs—where 'meaningful' is defined in relation to the user's needs"); output uncertainty (regarding "the meaningfulness of the inferences or recommendations produced by a system"); and functional uncertainty ("how, why and by whom their data is being used", including concerns about privacy and security). Our examination of sleep tracking (3.2) refers to studies that compare the many available devices, attempting to characterize the accuracy and bias. However, comparative studies must speculate over specific mechanisms and be limited to black-box experimentation with proprietary closed-source consumer tools.

The truth of the object itself stands in conflict with the truth of the experience. The "screen body" that is rendered visible through biomedical visuals appear more "objective" than the experiences in the "real, fleshly" body (Lupton, 2016). Duus et al. (2018) note the "the perception that health-related decisions that were informed by data were better decisions than those simply informed by their own opinions, feelings, and experiences," adding that biometric data collection led to "a sense of bodily disconnect for some [which was] was expressed as a form of alienation between the participant and her own body", including "experiences of stress, disappointment, and self-blame".

In Orlan's 2013 artwork, *La Liberté en écorchée* (2013) her body becomes a virtual flayed muscle figure, resembling the flayed figure in Vesalius's *Fabrica* (1453) and in Gunther Von Hagens's plastinated flayed men. Her transhumanist muscle figure poses as the animated figures in historical anatomical illustration books. The visual language evokes the uncompromising gaze of truth; and though it is not the literal flayed body of the artist, it has a truthful connection to the object being represented. Meanwhile, in reaction to "Body Worlds," which contains actual flesh, visitor comments reveal themes of questioning truthfulness, asking whether posed bodies (for example, "yoga lady") are "real practitioners'' of a stated activity (Moore and Brown, 2007).

Self-tracking may be motivated by seeking behavior change, but the relationship becomes interactional. The devices and our bodies "respond to and alter" one another (Lupton 72). At the level of specific instances of daily decision making, "the human is enabled to affect and create change; in other situations, it is the WAT that influences and impacts decisions and behaviors'' and that "some participants had developed an intensive dependency relationship with the data, feeling obsessed with checking it" (Duus et al. 2018). Lupton (2016) also mentions how "self-tracking can begin to make people feel as if they are losing control when it descends into an obsession", and in the next section we consider potential anxieties specific to sleep-tracking. Transhumanist and cyborg imagery might suggest that observational devices can be "prosthetic devices, intimate components, friendly selves'' (after Haraway, p.61). However, as in the following example of sleep-tracking, the relationship between the device and its wearer is not only intimate; it also a site of cultural norms and institutional relationships.

3.2. Observing an Unobservable Bodily Experience: Sleep

Sleep tracking is a now-commonplace encounter with the invisible and uncontrollable body through wearable sensors. Although some new multi-sensor devices are said to be more accurate and are commercially used for detecting sleep phase, most of the established research validating wearable sleep trackers concerns actigraphy-based approaches. Polysomnography (PSG) is the laboratory gold standard for sleep assessment and is expensive and cumbersome. Actigraphy works by collecting accelerometer data via "a portable wrist-worn sleep monitoring device" and using a classification algorithm, rendering it into legible data about when the wearer is sleeping or not. These are "used in clinical sleep medicine for assessing certain sleep disorders, such as circadian rhythm sleep-wake disorders, and for characterizing day-to-day patterns or sleep disturbances in insomnia" (Kolla et al. 2016). Actigraphy has a relatively high sensitivity and accuracy, but low specificity, compared to the gold standard approach, polysomnography (PSG) (Marino et al. 2013), although "validity in special populations such as the elderly, in subjects with poor sleep quality, or in those with major health problems is not well established" (Kolla et al. 2016).

This approach introduces its own uncertainties. For example, specific biases in which measures are over- or under-estimated may interact with the biases that consumers may meanwhile hold: "[Two specific devices] have shown a tendency to overestimate [sleep onset latency, SOL: the amount of time it takes to fall asleep]. Patients with insomnia already tend to overestimate SOL, and data from these devices could perpetuate their cognitive errors" (ibid.). Some medical professionals have coined the term "orthosomnia" to describe as preoccupation with sleep tracker data that may "reinforce sleep-related anxiety or perfectionism for some patients" (Baron et al, 2017). This anxiety has been observed in subsequent qualitative human-computer interaction study of 75 individuals in a multi-week study design considering multiple available wearables, most of which provide as "an objective measure" a score out of 100 to describe sleep quality (Aupetit et al. 2019).

Subjectively, uncertain accuracy of a device can be one barrier to long-term continuous sleep tracking (Liang and Ploderer, 2016): in the words of one interview respondent, "it never takes me zero minutes to fall asleep. I know that at the time that [my wrist-worn wearable] said I was asleep, I was actually reading." Because it is difficult to export and integrate data from any one tool (Liu et al. 2015; Lupton 2016, 33; Meyer et al. 2020), individual consumers are not able to validate the accuracy of these methods. It is also unclear to users of these devices "whether their readings are normal, exceptional, or worrying" (Knowles et al. 2018). The difficulty of interpretation (e.g., in the words of a study participant, "I don't know whether that's normal, because I don't know what's normal for other people") is a barrier to long-term continuous sleep tracking and unclear connection to potential contributing factors (Liang and Ploderer, 2016), and supports the critique of sleep trackers as fueling "orthosomnia."

In addition to scoring sleep on a scale of 100 (Aupetit et al. 2019), devices and associated applications support explicit goal setting. However, "established approaches like goal setting do not work well with sleep, because goals like falling asleep quicker or not waking up at night are typically not things a person can control" (Liang and Ploderer, 2016). Regarding insufficiently motivating sleep goals, one study participant noted: "Of course I want to get 8 hours sleep every day. But how to control that? If I try to get 8 hours sleep, I have to go to bed early, and that's just not feasible," due to existing "work and family commitments" (ibid.). There is an assumption that the design of this tool should bring about greater control; meanwhile, these design attempts may instead highlight uncontrollable aspects of daily life. The anxiety reported in the case studies by Baron et al. (2017) does lead to seeking intervention, but not sustained behavior change, outside of monitoring.

The sensors and charts render some data available, but the relationship between that data (processed accelerometer and other data) and the object of observation (sleep quality, duration, and so on) have a relationship that itself resists observation. In the case of sleep tracking, low level data (accelerometer) is not useful/legible, while high level data (score) requires a series of inferences and transformations, each of which may introduce new biases. Furthermore, the process of interpretation is itself unobservable. Observing sleep, which hinges on a variety of factors and cannot be quickly or effortlessly influenced, can highlight the false expectation that visibility leads to manageability.

After thirty years of continuous activity tracking, including movement during the day and rest at night, the reported visualization (Borbély et al. 2017, 191) not only renders the intimate details visible (like timezone adjustments) but also changes in technical efficacy of the device itself, demonstrating the interconnectedness of observation and its object. This report includes technical and analytic notes on the changes in sleep duration during retirement, in addition to personal narrative regarding weekday alarms prior to retiring: "The subject of the present study has not perceived the reduced sleep time on weekdays as a real problem ... He regards the pre- and post-retirement phases essentially as different modes of living" (ibid., 194).

4. Resolution

In the previous section, we demonstrate that observation is not passive: not at the level of daily action, and not at the levels of personal narratives and institutional relationships. The fact that observation itself has agency complicates the motivation to control. Across the artworks reviewed, we see recognize recurring methods to resolve this tension, illustrated by these guiding questions:

» Renegotiate relationships to institutions: how can we be collaborators and co-creators of the data collection method rather than isolated users of technical tools?

» Mobilize tools for unconventional narratives: how can I draw on (quantitative or objective) data and localized biomedical understanding of body parts/processes in service of investigating (qualitative or subjective) experience of the body as a whole?

» Embrace biological material: how can I engage not only with useful abstractions but also with direct, subjective bodily reality and experience?

Sanders (2017, 21-22) suggests "potentially subversive body projects by counterposing them to conventional self-improvement projects." First, instead of an emphasis to use quantification to "discover an authentic self has always already existed," Sanders suggests users "treat digital self-tracking devices not as means of self-discovery but as tools for inventing oneself as something new and not yet imagined". Second, rather than "[defining goals] in terms of the exterior form of the body," Sanders suggests "purposefully goal-unoriented" body projects. Lastly, with respect to exercise behavior-change related tools, Sanders suggests replacing "game design elements" with a "focus on the quality of one's interior." (Sanders 2017, 21-22). Returning to cyborg imagery, we hope it "can suggest a way out of the maze of dualisms in which we have explained our bodies and our tools to ourselves" (Haraway, 67), which here means using biological material and tools for bodily observation in an open-ended way (as in 4.2).

These ideas are consistent with our themes. The critique of authenticity here aligns with what we discuss in Sections 2.1, and 3.2. However, because we have focused on artworks, our proposed resolution highlights narrative and creative aspects, which we believe is generally informative. In the following two sections, we consider the construction of immersive experiences (4.1), and the growth of biological material (4.2) as case studies where all three of the above resolutions are present.

4.1. Immersion

Aldworth, whose work was introduced in (2.1), works as an artist-in-residence in a medical or academic as a central part of creating an immersive installation based on bodily data. Other works (for example, those in Figure 4) also entail engaging, evocative objects. We use the notion of "immersion" broadly, as an invitation to actively engage with these objects of bodily knowledge. We now consider another example, Mona Hatoum's ''Corps étranger'' (Foreign Body) installation related to the digestive tract. The representation and observation of the inner fabric of the human body in endoscopic visualization techniques is depicted as hostile, alienating, and standardized.

This work highlights not only the boundary between self/other, but also personhood/institution. In Hatoum's installation, procedures including endoscopy and colonoscopy penetrate the interior landscape of her own body, turning the invisible internal workings of her bodies to visible circular tiny visceral landscapes enclosed in a circular structure. The internal landscape is exposed without the human body having to be ''sacrificed'' (after O'Reilly 2009, 130). The ''foreign body'' of the camera, like an alien probe, enters the stoma (mouth) and colposcopic cavities recording the visuals and the geography of the visceral bodily landscape. According to Hatoum, ''the camera is in a sense this alien device introduced from the outside'' and the "foreign body also refers literally (and metaphorically) to the body of a FOREIGNER" (cited in Hatoum 2002, 125).

Truthfulness arises from centering the personal experience. Hatoum emphasizes that "it had to be my body" in the artwork, centering her own experience of being "probed, invaded, violated, deconstructed" (ibid.) by medical procedures and their representational visualization techniques. The video recording of the deconstructed ''woman'' is projected onto the floor and enclosed within a circular structure. The projected moving image in an otherwise dark space is complemented by audio recordings from the echogram of her heartbeat and breathing, creating a strong audio-visual force that reconfigures the spectator as the camera, the ''foreign object''. The camera travels past the eyes and the skin, then ''enters an orifice, dividing into the, moist, pink, depths ... on a spectacular enigmatic journey" (O'Reilly 2009, 132). Hatoum works against the penetrating and normalizing gaze of these technologies by embracing biological material through immersive audiovisual aspects, collapsing the audience/artist distinction. Her body is looked at so closely, it becomes alien and foreign itself, as well as genderless: “You have the body of a woman projected onto the floor. You can walk all over it. It is debased, deconstructed, objectified. It’s the fearsome body of the woman as constructed by the society” (cited in Hatoum, 2002, 125-126).

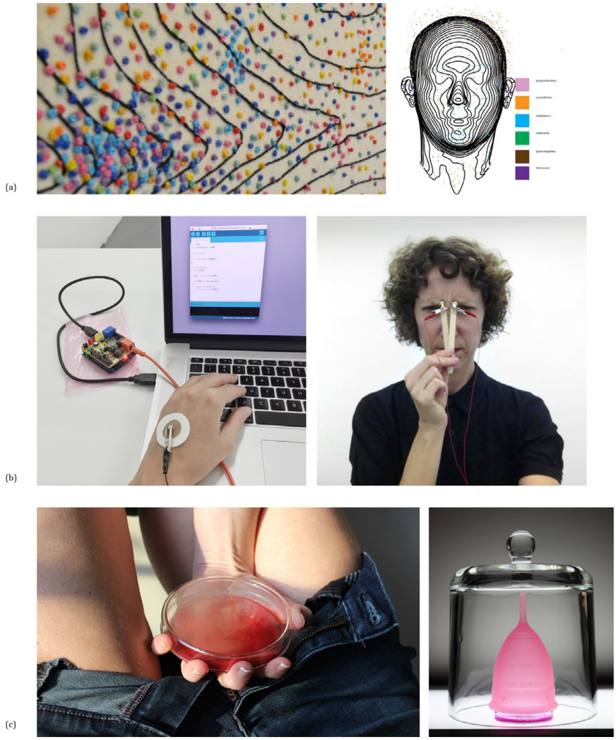


Fig. 4. Engaging Objects: (a) in Harris’s *Symbiosis* data is made tangible, soft, and narrative; (b) in Splan’s *Manifest* (2015) the body is measured on its own terms; and (c) in Hunter’s *Mooncalf* (2019-present), Hunter’s own body materials are centered. Images courtesy of the artists.

4.2. Growth

Biotechnology and imaging techniques expand the modes of portraiture and bodily biographies, “revealing our internal selves as ‘functioning and intact systems’ without having to sacrifice life itself” (O’Reilly 2009, 130). Beyond such non-destructive seeing, biotechnology also enables the growth and generation of further biological matter, such as in the following examples.

In Marc Quinn’s *The Genomic Portrait of Sir John Sulston* (2001), no anatomical parts are visible, the self “reduced” and “compressed” to DNA (Anker and Nelkin 2004, 10). Sir John Sulston played a major role in the international effort for mapping and sequencing the human genome (ibid., 9). His DNA forms the basis of the portrait: generic material harvested from sperm, replicated in bacterial colonies, and mounted on a mirror-like frame. Thus, “this portrait reflects the gazing viewer’s image while encasing a centered overall field of creamy blots” (ibid., 10). Quinn describes this portrait as “the most realistic portrait in the Portrait Gallery” (cited in ibid., 11). Sir John Sulston himself comments of his genomic portrait: “It is not me, it is my starting point,” and “there is enough genetic information there to identify me” (Anker and Nelkin 2004, 10).

Another example is WhiteFeather Hunter’s use of endometrial stem cells from her menstrual blood in *Mooncalf* (2019-present), a prototype of which is shown in Figure 5. In *Mooncalf*, her own biological material forms a new nutrient media for tissue culture, which “could constitute a more ethical and alternative way to the fetal calf serum used in cellular agriculture” (Debatty, 2020). Hunter’s collection and development of tissue cultures from her own menstrual blood during her PhD research stirred institutional reactions related to “the common cultural perception of menstrual blood as somehow tainted, ‘unclear’ or dirty” (ibid.). However, as Hunter points out “the actual production of menstrual blood is still a material outside the control of the patriarchal capitalist economy” (ibid.). Rebecca D. Harris also directly addresses the common value judgments toward microorganisms through her work, writing: “When we normally think of microbes we think of those bad for our health” and how the “bright and tactile” embroidery of *Symbiosis* (2015) shows that “our bodies are not blemished by the microbes” but rather embellished (Harris 2020).

Fig. 5. “Mooncalf prototype: Constructed prototype of the imagined final product. Digital photograph. Object constructed of bacterial cellulose and polymer clay” (Hunter, 2021). Image courtesy of the artist.

Working with microorganisms for Hunter entails “a state of perpetual curiosity” though she is “always aware of the systems of control that are in play when generating the work. Ultimately, we are all co-creating our realities with innumerable microorganisms, electronic and other systems every day” (Debatty, 2020). Gimbert and Lapointe (2015) consider the use of self-tracking and self-experimentation in microbiome research; they not only recognize limitations but overview a variety of methods for addressing scientific validity concerns, as well as precedent of using self-experimentation in a scientific setting. Working with microorganisms can be a subversive, imaginative experimentation without a set self-improvement goal (after Sanders, 2017) that embraces flesh as a creative medium. Even in cases of isolated observation or analysis of a particular part of the body, a direct and/or expressive engagement with biological materials supports embodiment rather than disembodiment or alienation. These examples, in addition to Aldworth’s *Brainscape 24* (2.1) re-negotiate institutional relationship, requiring institutional support and exploring notions of truthfulness in representation, as well as expectations of agency between observer, subject, and tools used.

5. Conclusion and Future Work

When artists use self-observation technologies and body data mining methods to renegotiate relationships to institutions, construct unconventional narratives, and work with direct biological material, they can subvert the normative medical gaze and self-disciplining dynamic of the self-improvement ethos. Self-tracking as an alternative data practice (Neff and Sherman, 2014) can also have a subversive character (Sanders 2017). Through practice-based research, we have taught classes open to the public, and encountered often-ambivalent interests in self-tracking and self-observation. We found that taking direct inspiration from such artworks can be an effective tool for the public to resolve a tense and paradoxical relationship to self-tracking. In this article, we have outlined the basis for our approach. In future work, we aim to explore its application further, addressing some of the limitations of the current work.

This article does not address all self-tracking. We focus on individualistic control-oriented motivations and uses. We do not directly consider neutral curiosity as a motivation, although it is one (Neff and Nafus, 2016; Lupton, 2016, p.33). Our lens of “know thyself” is tied to the self-improvement ethos as it is (re)produced by the institutions involved. Additionally, we do not address the design of self-tracking tools, which is a major subject in human-computer interaction research. Existing literature in this area identifies similar tensions and proposes recommendations for design (e.g., Purpura et al., 2011). Although it is desirable that self-tracking tools ultimately support, rather than hinder, bodily awareness, both through design and through the ways in which these tools mediate their users' relationship to institutions, these tools overwhelmingly still currently embody the "soft" authority of normative self-surveillance (Lupton, 2016). Therefore, our future work focuses on "subversion rather than renunciation" (Sanders, 2017) through expressive practice.

Although a deeper look into collaborative dynamics is out of scope for this article, themes of collaboration recur across the works discussed: collaboration with scientific advisors (e.g., Harris's *Symbiosis* or Aldworth's *Brainscape 24*) or direct use of technoscientific methods (e.g., Hunter's *Mooncalf* or Splan's *Manifest*), as well as bringing collective narrative into focus (e.g., Aldworth's *Out of the blue*). On the other hand, citizen science projects, which focus on collective motivations, and engage with scientific institutions in some forms, are not addressed. All three of our proposed resolutions accommodate and benefit from substantial collaborative elements, and interrogating the possibility for expressive, data-informed collective knowledge-building about the body is the subject of our ongoing research and practice.

Lastly, this article focuses on various types of visual observation, whether medically or artistically, as the primary vehicle for building body knowledge, but in ongoing work, we have expanded the notion of body knowledge to include proprioception (the sense of a body's position in space) and interoception (the sense of a body's internal experience). The methods for building knowledge can also include movement practices: different methods of seeing can inspire experiences of embodiment or dis-embodiment. Furthermore, "body knowledge" may not be literal, verbal, or medical. In future work, we will also study movement practices explicitly aimed in building body knowledge.

Technoscientific advances for observing the body, which include sophisticated self-tracking technologies, have shaped the tools available for artistic practice and building personal self-knowledge. These extensions of our human senses can help us realize patterns in our bodily biological processes, though at the cost of potential for disembodiment. We demonstrate how inter- or multi- disciplinary contemporary art inspires resolutions for this paradox of control.

Acknowledgements. Our research drew substantial inspiration from both authors' experience of teaching "Medical Bodies" and "Radical Imperfection in Self-Tracking" at Berlin's School of Machines, Making and Make-Believe, and we are grateful to all who participated in class discussions and projects. We thank the artists Rebecca D. Harris, WhiteFeather Hunter, and Laura Splan for providing images of their work to use in this publication. We thank Saga Briggs for editing and feedback.

References

Ainley, Vivien, and Manos Tsakiris. 2013. *Body conscious? Interoceptive awareness, measured by heartbeat perception, is negatively correlated with self-objectification*. PloS one, 8(2), e55568.

Aldworth, Susan. 2020. *Illuminating the self, Out of the Blue*. Retrieved from https://susanaldworth.com/exhibitions/illuminating-the-self/ (February 14, 2021).

Anker, Suzanne, Susan Lindee, Edward A. Shanken, and Dorothy Nelkin. 2008. *Technogenesis: Aesthetic dimensions of art and biotechnology*. In: Lustig BA, Brody BA, McKenny GP (eds) Altering Nature. Netherlands: Springer, 275–321.

Aupetit, Samuel, Gäetan Dubroca, Sara Escaich, and Philippe Cabon. 2019. *A qualitative study of sleep trackers usage: evidence of orthosomnia*. In Contemporary Ergonomics and Human Factors. Eds. Rebecca Charles and David Golightly.

Baron, Kelly Glazer, Sabra Abbott, Nancy Jao, Natalie Manalo, and Rebecca Mullen, R. 2017. *Orthosomnia: are some patients taking the quantified self too far?* Journal of Clinical Sleep Medicine, 13(2), 351-354.

Borbély, Alexander A., Thomas Rusterholz, and Peter Achermann. 2017. *Three decades of continuous wrist-activity recording: analysis of sleep duration*. Journal of sleep research, 26(2), 188-194.

Burns, Lawrence. 2007. *Gunther von Hagens' BODY WORLDS: Selling beautiful education*. The American Journal of Bioethics, 7(4), 12-23.

Case, Meredith A., Holland A. Burwick, Kevin G. Volpp, and Mitesh S. Patel. 2015. *Accuracy of smartphone applications and wearable devices for tracking physical activity data*. Jama 313 (6), 625 626).

Debatty, Régine. 2020. *WhiteFeather Hunter, 'The Witch in the Lab Coat'*. Retrieved from https://we-make-money-not-art.com/whitefeather-hunter-the-witch-in-the-lab-coat/ (February 14, 2021).

Di Marco, Silvia. 2012. *Naked to the flesh. Some notes on medical imaging, Modernism and Body Art*, in C. Azevedo Tavares (ed.), Imagens do Corpo na Ciência a na Arte, Lisbon: Fim de Século, pp. 35-48.

Di Marco, Silvia. 2015. *Bodies of knowledge – anatomy and transparency in contemporary art*. Journal of Science and Technology of the Arts, 7(2), 33-46. https://doi.org/10.7559/citarj.v7i2.157.

Duus, Rikke, Mike Cooray, and Nadine C. Page. 2018. *Exploring human-tech hybridity at the intersection of extended cognition and distributed agency: A focus on self-tracking devices*. Frontiers in psychology, 9, 1432.

Foucault, Michel.
1975. T*he birth of the clinic: An archaeology of medical perception*. New York: Vintage Books.

Gimbert, Carine, and François-Joseph Lapointe.
2015. *Self-tracking the microbiome: where do we go from here?* Microbiome, 3(1), 1-4.

Hatoum, Mona.
2002. *Centro Galego de Arte Contemporánea., & Centro de Arte de Salamanca*. Eds. Hatoum, M., Garb, T., Glencross, J., & Antoni, J..

Haraway, Donna.
2006. *A cyborg manifesto: Science, technology, and socialist-feminism in the late 20th century*. In The international handbook of virtual learning environments, pp. 117-158. Springer, Dordrecht.

Harris, Rebecca D.
Landscapes of our Lives. https://www.rebecca-harris.com/landscapes-of-our-lives/ (October 6, 2020; Retrieved April 5, 2021).

Hunter, WhiteFeather.
new: the witch in the lab coat. https://www.whitefeatherhunter.ca/new-research (Retrieved April 11, 2021).

Kemp, Martin.
2005. *Leonardo. Oxford*: Oxford University Press.

Kemp, Martin and Martina Wallace.
2000, *Spectacular Bodies: The Art and Science of the Human Body from Leonardo to Now, Exhibition catalogue,* Hayward Gallery London, Los Angeles: University of California Press.

Knowles, Bran, Alison Smith-Renner, Forough Poursabzi-Sangdeh, Di Lu, and Halimat Alabi.
2018. *Uncertainty in current and future health wearables*. Communications of the ACM, 61(12), 62-67.

Kolla, Bhanu Prakash, Subir Mansukhani, and Meghna P. Mansukhani.
2016. *Consumer sleep tracking devices: a review of mechanisms, validity and utility*. Expert review of medical devices, 13(5), 497-506.

Leiberich, Peter, Thomas Loew, Karin Tritt, Claas Lahmann, and Marius Nickel.
2006. *Body Worlds exhibition—Visitor attitudes and emotions. Annals of Anatomy*-Anatomischer Anzeiger, 188(6), 567-573.

Liang, Zilu, and Bernd Ploderer. 2016. *Sleep tracking in the real world: a qualitative study into barriers for improving sleep*. In Proceedings of the 28th Australian Conference on Computer-Human Interaction (pp. 537-541).

Liu, Wanyu, Bernd Ploderer, and Thuong Hoang.
2015. *In bed with technology: challenges and opportunities for sleep tracking*. In Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction (pp. 142-151).

Lupton, Deborah.
2016. T*he quantified self*. John Wiley & Sons.

Marino, Miguel, Yi Li, Michael N. Rueschman, John W. Winkelman, J. M. Ellenbogen, Jo M. Solet, Hilary Dulin,Lisa F. Berkman, and Orfeu M. Buxton.
2013. *Measuring sleep: accuracy, sensitivity, and specificity of wrist actigraphy compared to polysomnography*. Sleep, 36(11), 1747-1755.

Menezes, Marta de.
2004. *Functional portraits: Picturing the invisible body*. A Minima 7, 6, 17.

Meyer, Jochen, Judy Kay, Daniel A. Epstein, Parisa Eslambolchilar, and Lie Ming Tang.
2020. *A life of data: Characteristics and challenges of very long term self-tracking for health and wellness*. ACM Transactions on Computing for Healthcare, 1(2), 1-4.

Moore, Charleen M., and C. Mackenzie Brown.
2007. *Experiencing Body Worlds: voyeurism, education, or enlightenment?*. Journal of Medical Humanities, 28(4), 231-254.

Nafus, D., & Sherman, J.
2014. B*ig data, big questions| this one does not go up to 11: the quantified self movement as an alternative big data practice*. International journal of communication, 8, 11.

Nafus, Dawn, and Jamie Sherman.
2016. *Self-tracking*. MIT Press.

Orlan.
2021. *"The liberty flayed, 2013, La liberté en écorchée"*. Retrieved from http://www.orlan.eu/works/photo-2/ (February 14, 2021).

Purpura, Stephen, Victoria Schwanda, Kaiton Williams, William Stubler, and Phoebe Sengers.
2011, May. Fit4life: the design of a persuasive technology promoting healthy behavior and ideal weight. In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 423-432).

Pylypa Jen.
1998. *"Power and Bodily Practice: Applying the Work of Foucault to an Anthropology of the Body"*, Arizona Anthropologist 13.

Rifkin, Benjamin A., Michael J. Ackerman, and Judith Folkenberg.
2006. *Human Anatomy: depicting the body from Renaissance to today*. London, Thames and Hudson.

Sanders, Rachel.
2017. *Self-tracking in the digital era: Biopower, patriarchy, and the new biometric body projects*. Body & Society, 23(1), 36-63.

Šlesingerová, Eva.
2018. *Biopower imagined: Biotechnological art and life engineering*. Social Science Information, 57(1), pp. 59–76. doi: 10.1177/0539018417745164.

Splan, Laura.
2021a. "Embodied Objects". Retrieved from https://www.laurasplan.com/embodied-objects/ (February 14, 2021).

Splan, Laura.
2021b. "Manifest". Retrieved from https://www.laurasplan.com/manifest/ (Feb. 14, 2021)
The Philosophy behind BODY WORLDS: About the mission, concept & effects. 2021. Retrieved from https://bodyworlds.com/about/philosophy/ (February 2, 2021).

Van Dijck, José.
2005. *The Transparent Body*. A Cultural Analysis of Medical Imaging, Seattle: University of Washington Press.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Digital Doilies: Iterative Behavior as a Poetic Strategy

Keywords: Generative Art, Cellular Automata, Crochet Pattern, Poetics

André Silva
andrearqurb@outlook.com
Federal University of Minas Gerais, Belo Horizonte, Brazil

Marilia Lyra Bergamo
marilialb@ufmg.br
Federal University of Minas Gerais, Belo Horizonte, Brazil

Artists and researchers have widely explored the use of computational technology in artworks. This technology has shown the potential for aesthetic expansion when applied to other creative fields. For the perspective of computational creativity, the use of programming to explore traditional techniques within the craft practice appears to be enticing, due to its vast possibilities of exploration, which goes, for example, from woven fibers to sculpted artifacts. But in these practices the characteristic that stands out is the iterative process of craftsmanship. In this paper, we discuss the poetic practices that explore traditional techniques through computational approaches. Using a Cellular Automata algorithm that generates crochet lace patterns, we use the generative pattern and its materialization to illustrate and visualize the poetic practices that use repetition and reproduction as the base for their existence and survival.

1. Introduction

Most of the traditional techniques within the craft practice are based on iterative processes. Woven baskets, embroidery, pottery, and crochet, which is the case of study of this paper are a few examples to name. Originality and exclusivity were never a requirement regarding craftwork production. In their core reside a utilitarian function. But besides function, what differs craft from industrialization[1] is the capacity to combine beauty and purpose (Paz 1986). These artifacts represent local traditions, and they are incorporated into daily life. In general, the production comes from a family context or a small group of neighbors, which facilitates passing on knowledge, techniques, processes, and original designs. The importance and cultural value of these artifacts are related to the fact that they are the repository of the past, collectors of stories transmitted from generation to generation, and because they are an inseparable part of the community behaviors (Santana 2010). But beyond the reproduction and replication of existent patterns, which is a common characteristic among those techniques, they share an iterative process of craftsmanship intrinsic to their existence. In other words, the artifacts produced by iterative process of craftsmanship, have as their structure, reproduction, repetition, and replication values.

1. First Industrial Revolution.

These values are also to be found in computational processes, algorithm scripts, and so on and if both fields of knowledge share common characteristics, it seems reasonable to connect them. But this connection should be well-thought-out and not necessarily seek the total automation of the creative process, but its exploration through a method that allows participation and input from all the parts involved. In this paper, we present a Cellular Automata (CA) algorithm that generates crochet lace patterns. The CA as a mathematical approach uses the current result as a reference for the future generation of results, this characteristic is what makes it different from other traditional deterministic methods. Krawczyk points out that this recursive replacement method continues until some state is achieved (Krawczyk 2002). For the author, in parametric methods the results could be easily anticipated, which is not the case of recursive methods. This “out of control” behavior or algorithm creative autonomy opens up the possibilities for the crochet pattern exploration through an approach based on repetition, reproduction, and replication, which are values already consolidated in the traditional crochet practice. While the CA has some levels of creative autonomy, it is significant the participation from the other involved parties, such as, the lacemaker and artist. Those parties manipulate the CA logic inscribed in the algorithm, validate and select what is to be produced, and during the production phase, the lacemaker has the freedom to choose the best path to materialize the pattern, since the algorithm does not produce the rules of materialization.

2. Algorithmic perspective

In terms of pattern making, crochet lace patterns are developed through actions that inscribe the materialization of crochet pieces. These actions are rules that dictate how the thread is involved by the crochet needle, types of crochet stitches, pattern modules, and how the pattern is built. Crochet patterns are algorithmic because conceptually they exist as a group of defined processes (Kenning 2007). This group of processes is the actions needed to materialize a crochet pattern. Crochet lace patterns are also iterative. The same group of processes could be replicated from the beginning to the end. Another characteristic found in crochet patterns is their ability to be replicated into the digital environment since they exist not only as physical forms but as code. At the moment that the verbal instructions are shortened, a syntax that includes modules and feedback loops is created. This syntax is similar to code writing in computation. The crochet pattern instructions behave as code to be interpreted by the lacemaker (Kenning 2007).

Still, according to Kenning, the digital environment offers several opportunities for this format of making patterns. The development of the pattern can become a hybrid of human and technological influences. The pattern can be influenced not only by the subjective decisions of the lacemaker, but can also be exposed to technological inputs (mouse, keyboard, etc.), and/or be influenced by the flow of information from the programming scripts and operating systems in which the pattern is immersed. The digital environment can handle complex algorithms and allows larger iterative processes with numerous patterns emergences (Kenning 2007). The last characteristic to consider regarding the development of crochet lace patterns in the digital environment is the extent to which patterns can be recognized when they are translated and transformed. It may not be easy to recognize emerging patterns due to our lack of experience with the evolved pattern formed. Thus, such explorations require an open mind when evaluating the pieces created (Kenning 2007).

A couple of examples of this algorithmic perspective found in the craftwork can be noticed in the work developed by Gail Kenning (2007) whose efforts focused on understanding the exploration of crochet patterns through an approach the replicates its final physical form, and the work by Veronika Irvine (2014) who developed an algorithm that generates bobbin lace patterns. In their work, they designed algorithms that generate lace patterns ready for production. Even though Kenning focused on the digital development of patterns and not necessarily their materialization, the algorithm designed by her seems to produce "ready to go" patterns, which is the same case of Veronika's work, see figure 1. In our experiment, we use the cellular automata method that generates patterns with some level of abstraction that demand interpretation, validation, and some input from the lacemaker at the materialization phase. There are decision-making moments when the lacemaker is fabricating a pattern. For example, the lacemakers can choose how many stitches to connect to the previous row, they can choose to materialize each row from the start to the end or to see the rows as a unique spiral. The overall idea is to understand that what the algorithm produces is a suggestion and not a "ready to manufacture" pattern. Another difference in our experiment is the graphic pattern. We chose to work with symbols, because of that, it is only possible to see the translation of digital graphics to physical form if the pattern is materialized.

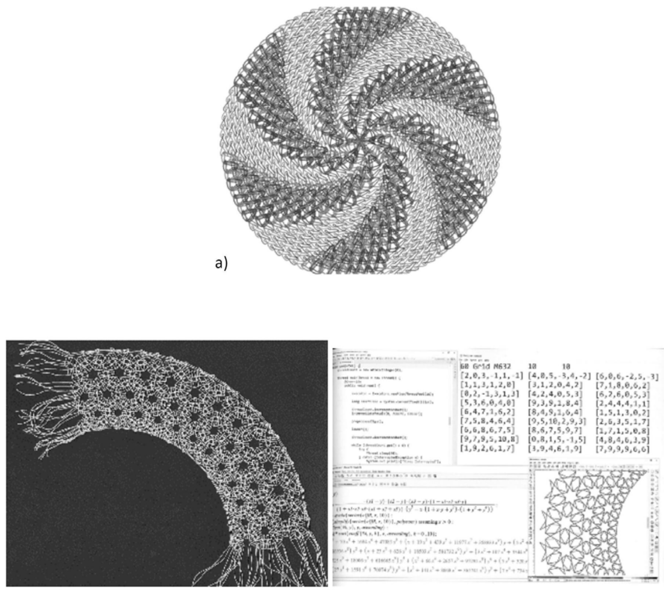


Fig. 1. a) Whirlpool design generated by an autonomous algorithm. Source: (Kenning 2007). b) Delle Caustiche work process by Veronika Irvine. Source: (Kanagy-Loux, Mills, and Neff 2019).

In figure 2.a., we can see a traditional pattern and instructions. In this scenario, any lacemaker who follows this material will materialize the same circular doily. In figure 2.b., we can see one graphic pattern generated by the CA and two different pieces. The first one (middle of figure 2.b.) is a materialization done to be close as possible to the algorithm stitches distribution (top of figure 2.b.), the second one (bottom of figure 2.b.) is a piece with few alterations from the lacemaker which decided to connect loose groups of stitches to the previous row. The lack of information generated by the image purposely instigates the lacemaker's creativity because there are creative decisions to be made by the lacemaker. In this production method, the lacemaker and artist decides the algorithm behavior logic, the algorithm gives back an output in form of images, and then, again, the lacemaker materializes the final piece following his/her personal understanding of the output image generated by the code.

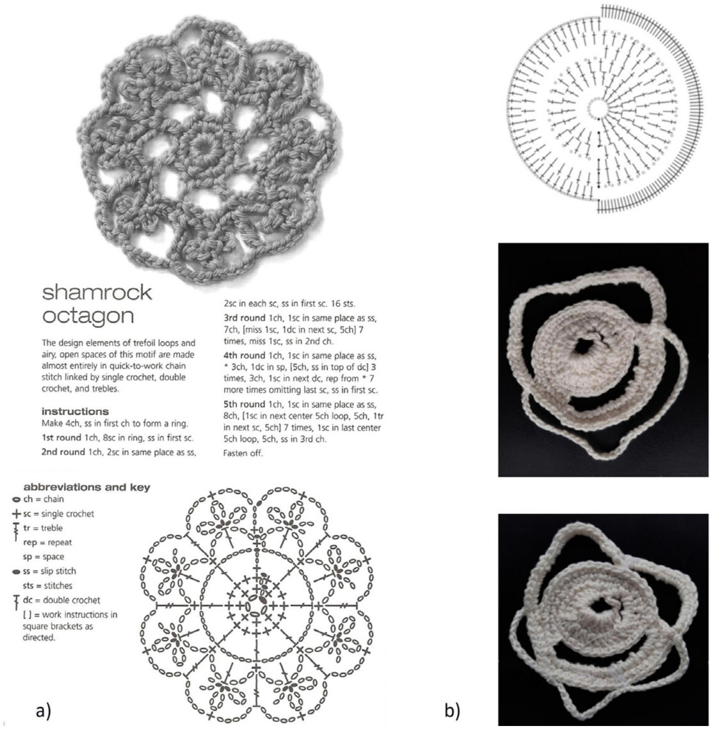


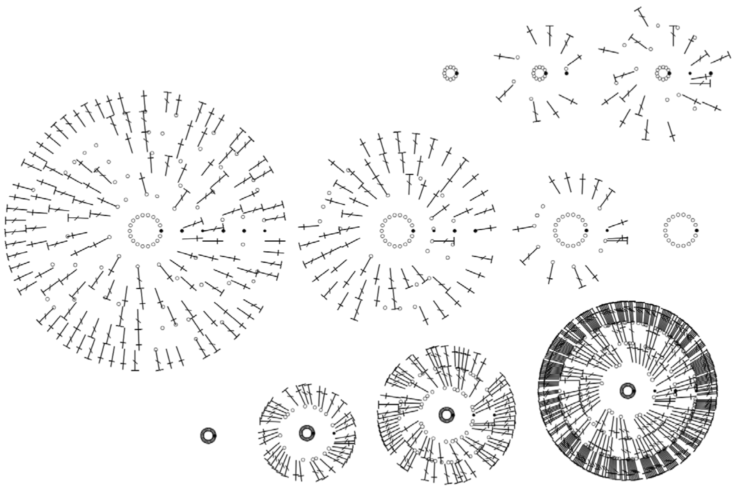
Fig. 2. a) Traditional pattern and instructions. Source: mimoedu.blogspot.
b) Pieces produced by computer and human influences. Source: The authors.

3. CA algorithm

The algorithm designed for this experiment works with four basic crochet stitches: Chain Stitch; a Slip Stitch to connect ends; Single Crochet and Double Crochet. In a physical crochet piece, the Chain Stitch is the base point to start a piece or change the direction of an existing one, and it can be used as an independent element. The Slip Stitch makes the needle advance without letting the fabric get too high, due to this property it is commonly used for finishing circles and for finishing rows in circular pieces. It is also possible to make an entire row with this stitch around an edge for finishing, but it can not be used as an independent element. The Single crochet has proportional height and width. A Double Crochet is high enough to go over a row made of Single Crochet and reach the previous row, or leave a larger space.

The initial design of the algorithm is based on random behavior, this first experiment was important in order to understand the intrinsic positions necessary for a doily form and the dynamic potentials of the code. We fixed the parameters of distance from the first row, then the distance between rows, and the number of stitches per row to be used. We then established the limit of seven rows for the study of the graphic qualities of the images. As observed in figure 3.

Fig. 3. Analysis of the random algorithm, in these images the central row was highlighted from the rest of the pieces for better visualization of the initial conditions of the system. Source: The authors.



Not all alternatives are likely to be physically implemented, but at this point of the work, there was a concern to investigate the potential of random values that could be altered for the generation of forms. Analyzing figure 3, it is possible to highlight one of the most basic characteristics of dynamic systems, the dependence on the initial conditions of the systems. If the system starts with a lot of amplitude between the stitches (at the top of the image) it becomes difficult to be produced, because the variation between the possible stitches and the distance between them creates many empty spaces. Likewise, when the distance between the stitches is very small (at the bottom of figure 3), the number of stitches can become very overloaded, and it is necessary to investigate the ability to physically create a piece like this. In the center of the image, we have a possible initial condition of the system, to create final pieces with six rows. However, the random algorithm due to the very random nature of the exchanges does not generate discernible patterns of composition.

This initial design of random code was the foundation for our Cellular Automata model. From here we will explain the code written on processing. In the void setup () function, the values for the doilies are defined, such as, the number of circles and neighborhoods. Some of these parameters can be manipulated according to the interest of the lacemaker and artist.

```
void setup() {
  size(1300, 800);
  background(255);
  //define values
  circles = 8; //Number of circles on a dily
  e_steps = 20; //Cannot be less than 19,
or you have to use less circles
  e_radius = 38; //Initial radius on center
  e_gauge = 50; //Must change according to the size of images
  neighborhoods = 4; //Number of neighborhoods
  e_counter = 0; //Helps to count circles
  frameRate (5); //Slow frame rate to see pattern feneration
  drawCircles ();
}
```

Void drawCircles () is responsible for drawing the initial row of chain stitches and predefining the remaining rows. In the circles tab, we can find the script section responsible for arranging the points in the rows. It contains the random and the generative logic. In this section the class Circle [] and some variables are defined.

```
void drawCircles() { // MADE UP FUNCTION
  for (int i =0; i < circles; i++) {
    if (e_counter == 0) {
      //Create a first circle of points that cannot be changed by
any logic
      Circle thisCirc = new Circle(e_steps, e_radius, true, neigh-
borhoods);
      thisCirc.drawMe();
      _circleArr= (Circle[])append(_circleArr, thisCirc);
    } else if (e_counter < circles) {
      // Create all the other circles
      Circle thisCirc = new Circle(e_steps, e_radius, false, neigh-
borhoods);
      thisCirc.drawMe();
      _circleArr= (Circle[])append(_circleArr, thisCirc);
      e_radius += e_gauge;
      b_radious = e_radius - e_gauge;
      e_steps-=3;
    }
    e_counter++;
  }
}

class Circle {
  int steps;
  float radius;
  boolean first;
  int numberOfNeighborhoods;
  Point[]_pointArr = {}; // Array of Cellular Automata
  Circle(int s, float r, boolean f, int n) {
    steps = s;
    radius = r;
    first = f;
    numberOfNeighborhoods = n;
  }
```

The void updateMe() function contains the generative logic of the Cellular Automata model. The algorithm makes a random arrangement of the stitches and afterward, this function reads these stitches and starts to produce results according to the generative logic. This logic can be changed in this section.

```
void UpdateMe()

// Count the type of neighbors
        int[] thisNeighborhood = _pointArr[count]._myNeighbours;
        for (int x = 0; x <  thisNeighborhood.length; x++) {
          if (thisNeighborhood[x] == 0) {
            numberOfChainstitch++;
          } else if (thisNeighborhood[x] == 1) {
            numberOfSingleCrochet++;
          } else if (thisNeighborhood[x] == 2) {
            numberOfDoubleCrochet++;
          }
        }
        //println("Chain Stitch:" + numberOfChainstitch);
        //println("Single Crochet:" + numberOfSingleCrochet);
        //println("Double Crochet:" + numberOfDoubleCrochet);
        //Apply logic
        if (numberOfSingleCrochet+numberOfDoubleCrochet > 3*(_
pointArr[count]._myNeighbours.length)/4) {
          _pointArr[count].drawMe(0); // becomes Chain Stitch
        } else if (numberOfChainstitch<2*_pointArr[count]._myNeigh-
bours.length/3) {
          _pointArr[count].drawMe(1); // becomes Single Crochet
        } else if (numberOfChainstitch+numberOfSingleCrochet>2*_
pointArr[count]._myNeighbours.length/3) {
          _pointArr[count].drawMe(2); // becomes DoubleCrochet
        } else {
          //_pointArr[count].drawMe(int(random(3)));
```

Figure 4 shows two pieces generated by the random logic. This logic works by arranging random stitches through the circular grid. The patterns generated by this algorithm are generally denser, due to the lack of chain stitches that do not allow empty spaces in the physical piece. However, it was noticed that the few empty spaces found in the pieces occurred in the presence of chain stitches. It was observed that isolated chain stitches do not represent any considerable space, but from the set of 3 stitches, it is possible to observe considerable empty spaces.

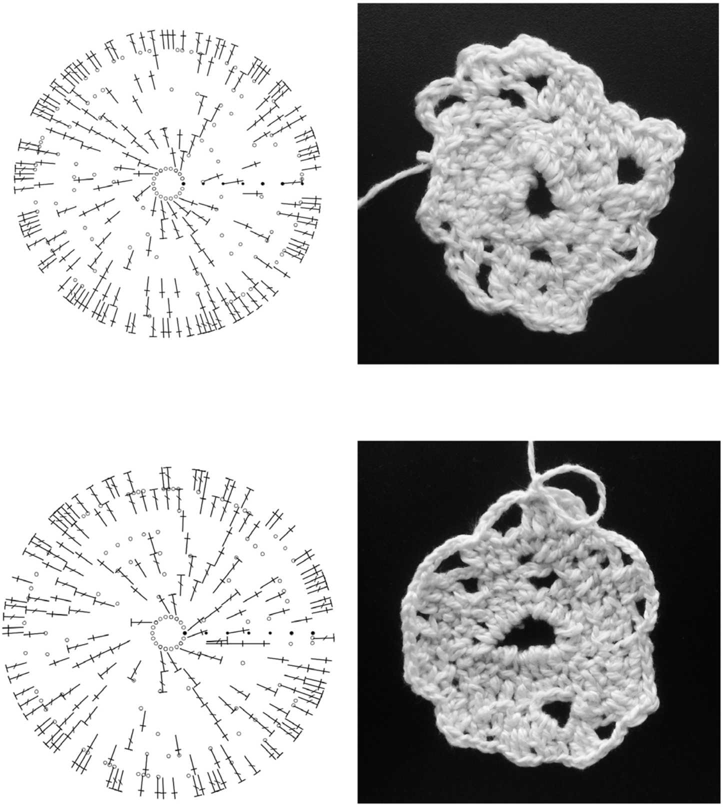
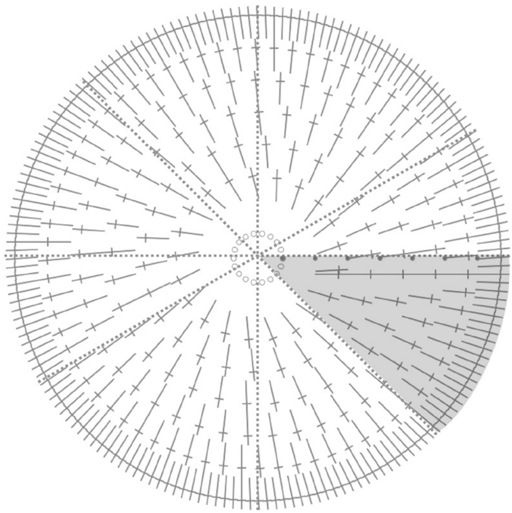


Fig. 4. Pieces generated by the random algorithm. Source: The authors.

For the second phase of the experiment, we worked with the CA method, which was explained previously. As the analysis of all stitches in the system requires a lot of computing resources, we established a logic that dialogs with the concept of the Game of Life by John Conway (Gardner 1970). We established a neighborhood where the stitch will observe the states of its neighbors and decide what it will become. This neighborhood can be parameterized by the code, and we can work with the entire piece as a single neighborhood, or by dividing the circular piece by the number of desired neighborhoods. Of course, there is a limit, a very high number of neighborhoods will not make sense for the division of parts of the doily. As in John Conway's Game of Life, stitches must choose one state, but we work with three states instead of two, a stitch can choose between being a chain stitch, single crochet, or double crochet, this decision depends on the logic below.

Fig. 5. Generative logic - Neighborhood concept. Source: The authors.



» Chain stitch: if the number of neighbors as Single Crochet or Double Crochet is greater than ¾ of the neighborhood;

» Single Crochet: if the number of Chain stitch is less than ⅓ of the neighborhood

» Double Crochet: if the sum of Chain stitch and Single Crochet is greater than ½ of the neighborhood;

The logic demonstrates the potential for generating patterns from the inclusion of computational creativity. In figure 6, the patterns generated for settings with one and two neighborhoods are shown. In the case of only one neighborhood (6a) the code always presents the same pattern for eight rows, which at the end of some life cycles always ends with the second row of double crochet, the third and the fourth of single crochet, and the fifth row of chain stitch, then again two rows of single crochet and one row of chain stitch. Still, in Figure 6, we have the generative behavior for two neighborhoods, this configuration always presented a total of four (6b, 6c, 6d, and 6e) patterns that alternated in the first neighborhood, while the second neighborhood was never changed. In figure 6 we present the result for the case of four neighborhoods, and again the last neighborhood remains unchanged, generating no pattern. In contrast, the first, second, and third quadrant showed different patterns than when there were only two neighborhoods (6f - first quadrant). But the first, second, and third quadrant also showed similar patterns to what happened with only two neighborhoods (6g - first quadrant).

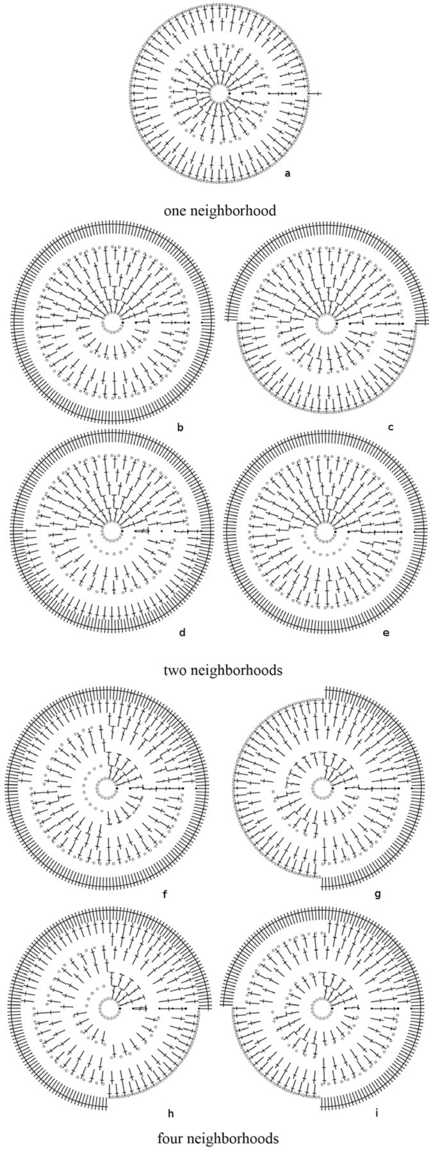


Fig. 6. Observed patterns for one, two and four neighborhoods. Source: The authors.

Despite the potential of the patterns found in figure 6, the purpose of this paper was not to create a series of observable patterns as in the case of the Game of Life but to validate the logic of the Cellular Automata as a potential for computational creativity and to visualize the poetics found in processes of repetition. Soon after this stage, instead of 1, 2, and 4 neighborhoods, it was decided to work with 2, 4, and 8. Some results can be seen in figure 7.

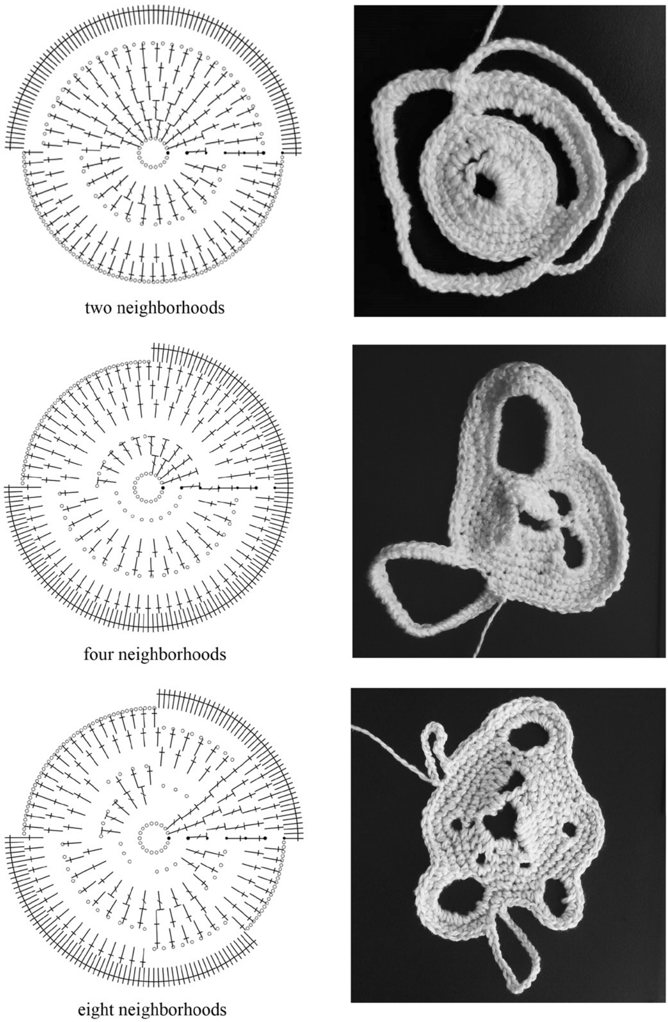


Fig. 7. Observed patterns for two, four, and eight neighborhoods. Source: The authors.

4. Poetics

Gilbert Simondon points out that it is the insertion that defines the aesthetic object and not the imitation (Simondon 2007). The philosopher makes this statement from the perspective of the industrial machine. However, craftsmanship precedes this industrial state and the massification of computing happens after it, and both use imitation, repetition, and reproduction as poetic values. The research object of this paper is inserted in a context in which the artisanal and computational technical objects use reproduction as a poetic and productive strategy. Both have functions whose understanding is necessary to comprehend completely their aesthetic value. Simondon points out that the discovery of the technical object's beauty cannot be left to perception alone. The function of the object must be understood and thought out. In other words, technical education is needed, so the beauty of technical objects can appear as the insertion of the technical schemes of a universe, at the key points of it. There is a lack of understanding of the object's function, which is necessary to correctly imagine and aesthetically perceive its structure and its relationship with the world (Simondon 2007).

The handicraft beauty is inseparable from function. Handicrafts are beautiful because they are useful, as they belong to a world before the separation between useful and beautiful (Paz 1986). The industrial object tends to disappear as a form, and become confused as a function. Its existence is its meaning, and its meaning is to be useful. Artworks are at the opposite side of industrial logic. Handicraft is a mediation, its forms are governed not only by the functionality but also by pleasure. The industrial object does not tolerate the superfluous, but the craftsmanship is satisfied in the adornments. Things are pleasant because they are useful and beautiful (Paz 1986).

The handmade object is not limited to its utilitarian function, it also reflects its decorative function. In the context of crochet, the decorative function prevails. Like a large part of craft production, the existence of crochet pieces occurs through the reproduction of existing patterns, which through small alterations from reproduction to reproduction, changes slowly. In addition to symmetry, shape, and color, we can see the poetics and beauty found in the detailed repetition, that within each reproduction, details are modified. This way the technique and the physical result can adapt to the needs and the environment where they are placed, guaranteeing survival and evolution of the technique, even in very small steps.

Understanding the crochet technique is crucial to comprehend its poetics. In addition to the pattern reproduction habit of the crochet practice, its materialization is an iterative process. The algorithm presented in this paper potentialized an intrinsic behavior of the crochet practice. The algorithm generates through repetition and similarity, but never identical patterns.

"Computational poetics take advantage of information compressed into small codes to generate otherness and beauty from generative processes" (Bergamo and Marinho 2019, 189). Crochet patterns behave this way in both physical and digital environments. The crochet piece is materialized through a group of processes, which are the necessary actions for the construction of a pattern, these processes are summarized in recipes that are interpreted by the lacemaker (Kenning 2007). In the digital environment, when translated into generative algorithms, these processes are even more compressed. The crochet practice has its iterative potential elevated when placed into a digital structure and poetics is found in that potential. Repetition and reproduction in biological systems guarantee the evolution of species, for the crochet technique, this potential grants the capacity of the emergence of novelty in processes that seem to never change or evolve.

5. Conclusion

The efforts of this paper were concentrated on explaining the algorithm designed to generate crochet lace patterns, the crochet technique, and the materialization of the patterns that emerged from the generative method. The understanding of these elements is necessary to perceive the poetics as we the authors see it. The constant and non-stop repetition allows for change and evolution, there is beauty and aesthetics in the subtle changes, and it is possible to get novelty from repetition. As highlighted in the previous sections, the crochet technique is an iterative process based on the repetition of actions and replication of existing patterns. The CA as a generative method potentialized the crochet iterative behavior. The CA works by repeating actions over and over. One cell needs to read its neighbors state to decide what it will become, this behavior is repeated until some desirable outcome is achieved. This behavior is analogous to the crochet technique because the lacemaker has to repeat modules of information to achieve a materialized piece. The generation of patterns by the CA simulated an evolutionary process based on repetition applied to crochet patterns. Even though the graphic patterns looked alike, when materialized, they presented unpredictable visuals. Simple stitches and behavior rules were enough to produce patterns that present a different aesthetic when compared to the traditional practice. The emergence of unexpected results is what instigates the artist who works with generative approaches. In addition to the emergence of unexplored structures, we could perceive the subtlety and poetics presented in the repetition not only of the algorithm, but also, the lacemaker, who from generation to generation materialized different, mutated, evolved, transformed, but similar results.

Acknowledgements. Acknowledgement to CAPES for the financial assistance used to carry out this research.

References

Bergamo, Marília L. and Francisco Marinho. 2016. *Tecnologia e Delicadeza: estratégias da simplicidade cotidiana na geração de resultados estéticos complexos*. In: #15.ART Encontro Internacional de Arte e Tecnologia, 2016, Brasília. 15° Encontro Internacional de Arte e Tecnologia (#15.ART): arte, ação e participação, p. no Prelo.

Irvine, Veronika, and Frank Ruskey. 2014. *Developing a mathematical model for bobbin lace*. Journal of Mathematics and the Arts, 8:3-4, pp 95-110. DOI:10.1080/17513472.2014.982938.

Gardner, Martin. 1970. *The Fantastic Combinations of John Conway's New Solitaire Game of "Life"*. Scientific American, 223, pp. 120-123.

Kanagy-Loux, Elena, Amy Mills, and Nancy Neff. 2019. *Lace, not Lace: Contemporary Fiber Art from Lacemaking Techniques*. Hunterdon Art Museum, Clinton, New Jersey.

Kenning, Gail Joy. 2007. *Pattern as Process: An aesthetic exploration of the digital possibilities for conventional physical lace patterns*. Tese (Doutorado em Artes). University of New South Wales, Australia.

Krawczyk, Robert J. 2002. *Architectural Interpretation of Cellular Automata*. Generative Art.

Paz, Ottavio. 1996. *O uso e a contemplação*. In : História geral da Arte.Artes decorativas I. Artes decorativas aplicadas a habitação: desde o mundo antigo até o barroco. Ediciones Del Prado.

Santana, Maíra F. 2013. *Design e artesanato: fragilidades de uma aproximação*. Cadernos Gestão Social, 3(2),103-115.

Simondon, Gilbert. 2007. *Relaciones entre el pensamiento técnico y otras*. In G. Simondon.El modo de existencia de los objetos técnicos. Prometeo Libros Editorial.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Brittle Opacity: Ambiguities of the Creative AI

Keywords: AI Art, Artificial Intelligence, Creative AI, Creativity, Deep Learning, Intelligence, Machine Learning

Dejan Grba
dejangrba@gmail.com
Interdisciplinary Graduate Centre, University of the Arts, Belgrade, Serbia

This paper outlines the ambiguities which influence AI science, manifest in the production of AI artists, and shape the representation of creative AI in the media and in popular culture. Looking at the interrelated conceptual, discursive, ethical and other aspects of the prevailing approaches towards AI, it discusses some of the factors which obscure or mystify the important features of AI technologies vis-à-vis human cognition and artistic expression. Through a combination of tendencies and circumstances, these misconceptions and fallacies both emerge from and exacerbate the current issues of AI, which calls for vigilance and critical consideration by the creative actors and by the public. With regards to the existing literature, which primarily addresses the creative AI issues from techno-scientific and historical perspectives, this study focuses on the ideas, methodologies, cultural contexts, and social impacts of AI art practices. It shows that current capabilities and transformative potentials of AI require artists—as well as scientists and entrepreneurs—to engage in a sharper critique of their motivations and goals, in a deeper creative investigation of their tools, and in a more nuanced scrutiny of their work. This will catalyze research in science, arts and humanities to define more robust concepts of creativity, to map its perspectives, and to inform our directives for further development and responsible application of AI.

1. Introduction

The research in artificial intelligence (AI) has been historically inspired by broadly defined concepts of intelligence found in living beings, branching out into various and sometimes conflicted neural models which can be highly abstract in their relation to cognitive and electrochemical models of the brain (Zheng and Sicker 2013; Sloss and Gustafson 2019). It has been targeting high-level cognitive functionality which includes the expressions of human intelligence in artistic creativity (Boden 1998; McCorduck 2004). Contemporary AI research centers around a machine learning (ML) paradigm called a neural network, which consists of parameter-processing units ("neurons"), input/output, and control modules. Such system can be programmed to refine the procedure for solving a particular problem by dynamically modifying parameters based on the referential data. Deep Learning (DL) is a subset of ML methods in which the optimization of network performance and accuracy relies on complex statistical rules applied to multiple layers of neurons (Bishop 2017; Nielsen 2019). The expanding research and implementation of ML have evolved into a range of creative disciplines that engage in the development, application or study of AI, and I use the term creative AI to address the field of these disciplines.[1] The increasing accessibility of DL since 2009 has enabled artists to start exploring the AI systems. Their work contributes in different ways to the creative AI, and shares both the advantages and shortcomings of the field.

1. This concept of the creative AI is distinct to and critical of the anthropomorphic notions which assign the autonomous creativity to AI systems, mystify their agency and fetishize their authorship, for example in articles by Marks (2019) and Newton-Rex (2019).

The existing literature has approached the ambiguities of the creative AI from several viewpoints. Melanie Mitchell in *Artificial Intelligence* (2019a), as well as Gary Marcus and Ernest Davis in *Rebooting AI* (2019) provide a conceptual, technological, and social critique of AI focusing on computer science and engineering, media and popular culture. In The *Ethical Algorithm* (2019), Michael Kearns and Aaron Roth address ethical and social consequences of the conceptual and technical issues in AI algorithm design. In *The Artist in the Machine* (2019), Arthur I. Miller discusses AI art within a study of creativity he had taken in earlier work (1996, 2014). In *AI Art* (2020), Joanna Żylińska provides a multifaceted theoretical discussion of the current AI debate and its reflections in AI-driven visual art. In *Understanding and Creating Art with AI* (2021), Eva Cetinić and James She present a comprehensive overview of AI research that takes art as a subject matter, and outline the practical and theoretical aspects of AI art production. With the aim to expand these and other authors' critical consideration, I address the ambiguities of creative AI from the interrelated perspectives of new media art, mainstream contemporary art and cultural sector, focusing on the poetic and expressive aspects of experimental AI art. This perspective is relevant to both artistic and scientific research in AI, and may contribute to its more appropriate handling by the cultural sector and to its more responsible representation in the media.

2. Concepts

Since its outset in the 1950s, AI science has been entangled with various epistemic uncertainties, conceptual challenges, and terminological issues. Most notably, the mutual non-exclusivity and the continuous range between the symbolic models of ML (based on logical rules) and the subsymbolic models (based on statistical methods) often prove difficult to control (Mitchell 2019a, 19-26, and passim). Looking for flexible hybrid solutions, recent AI research fluctuates the scope of these two models, but requires conceptual clarity to define the reliable methodologies for exploring such solutions.

This is compounded by the incoherent consideration of referential human cognitive abilities, for example in making the useful distinction between learned versus inherited elements of knowledge and skills. Human intelligence is not understood clearly enough in order to be captured with formally robust definitions and rules necessary for mathematical modelling and computer emulation. The ultimate emulation of human intelligence may even be unattainable with binary computer technology due to the undecidable problems in computability theory and the limits of mathematical formalization respectively established in Church-Turing Thesis and in Gödel's incompleteness theorems (Copeland 2020; Raatikainen 2021).

Intelligence is integral to human nature: a complex set of often conflicted cognitive faculties which have been evolving within the material, existential and social reality of our species (Pinker 2002, 217-304, 318, and passim). The idea that intelligence should be studied within the framework of human nature is controversial in the humanities, social sciences and other disciplines (Pinker 2002, 205-450; Buss 2015). It is also underappreciated in many domains of AI research, which affects both the cognitive scope of the systems modeled on human intelligence and their ethical applications. Mainstream AI protects its market incentives by being "politically correct," and by exploiting technologically feasible routes for the applicable narrow-focus platforms. However, without robust and flexible control algorithms analogous to human common sense, narrow AI systems struggle with accuracy and safety in handling statistically extreme (rare) but plausible scenarios (Mitchell 2019a, 84-95). As Marcus and Davis (2019, 20) summarize:

> Narrow AI alone is not enough. [Yet] we are ceding more and more authority to machines that are unreliable and, worse, lack any comprehension of human values. [...] For now, the vast majority of dollars invested in AI are going toward solutions that are brittle, cryptic, and too unreliable to be used in high-stakes problems.

Many notions about AI in the research community, as well as in popular culture, have been influenced by the narratives of science fiction literature and cinema. Science fiction may be inspirational, but it can also limit creative and critical thinking by canonizing certain ideas regardless of their validity, and by stimulating attractive aspirations that may ultimately prove to be meaningless or dangerous. In such context, one of the rational but potentially business-risky options for AI-related disciplines is the responsible acknowledgement of human nature informed by cognitive sciences. It could facilitate more rigorous research and more effective development by scrutinizing, deconstructing and reimagining the concepts, notions and claims about AI through a sharper, more sincere critical lens.

The conceptual issues of AI in popular culture, art and media, but also in science and in philosophical discourse, are additionally impeded by the unclear or arbitrary use of AI-related terms such as *Artificial Intelligence, Machine Intelligence, Machine Learning, Deep Learning*, and—most evidently—*Algorithm*. An algorithm can be formulated in different levels of semantic or mathematical abstraction with respect to its target system's executable code, so it has to be properly encoded in order to run successfully.[2] Therefore, the application of algorithms always involves a critical layer of translation which is often highly counterintuitive, cognitively costly and error-prone (Grba 2020, 76-77). Within a conceptual framework of computer science and technology, algorithm design involves defining a problem or task, finding its solution, creating and testing algorithms for this solution, translating the best algorithm candidate into software and (often custom-built) hardware systems, running, testing and debugging. Since the development of ALGOL programming language in 1958, this framework also includes the methodologies for designing high-level meta-algorithmic systems that learn how to write code from specifications expressed in natural language (Nye et al. 2019). Metaphorical use of the word algorithm which ignores these contextual basics, although colloquially economical, actually obscures both the intricacy and unpredictability of AI development and application.

2. Computer science informally views algorithms as tools for solving well defined computational problems. The statement of the problem specifies in general terms the desired input/output relationship, and the algorithm describes a specific computational procedure for achieving that input/output relationship (Cormen et al. 2001).

Another popular term whose uninformed use degrades the contextual milieu of the creative AI is *generative art* (GA). GA includes heterogeneous approaches (not necessarily involving AI) based upon consciously and intentionally interfacing the predefined systems with different factors of unpredictability in preparing, producing or presenting the artwork (Grba 2019, 4-5). Despite practical divergence and long history of GA (Boden and Edmonds 2019), the expression *generative art* has been often equated only with computational art practices or with AI art based on subsymbolic ML systems such as Generative Adversarial Networks (GAN) or Creative Adversarial Networks (CAN) (Chatel 2018).

AI art is an open-ended set of artistic practices based on the creative approach to different AI techniques and models, regardless of the degree of the artist's involvement with AI technology (McCormack et al. 2019, 39). Its conceptual scope derives from algorithmic art and GA, and is primarily (but not exclusively) informed by exploring and representing the phenomenology of subsymbolic ML systems. Contemporary AI art frequently thematizes human-centered notions of creative agency, authorship, and ownership of "creative property" in AI systems, for example in Huang Yi's choreographies with KUKA robots (Yi 2021) and Sougwen Chung's performances (Chung 2020).The AI artists which conceptualize the phenomena external to ML include Ben Bogart who analyzes the narrative and formal logic of popular cinema (*Watching and Dreaming* series, since 2014) (Bogart 2019), Benedikt Groß and Joey Lee who explore the semiotics of architectural shapes in satellite imagery (*The Aerial Bold*, 2016-), Ross Goodwin who uses language hacking to disrupt cinematic and literary stereotypes (*Sunspring* with Oscar Sharp, 2016 and *Automatic on the Road*, 2018), Libby Heaney who revisits the mediated pop-cultural and political conventions through deep fakes (*Euro(re)vision* and *Resurrection* (*TOTB*), both 2019), Nao Tokui (*Imaginary Landscape* and *Imaginary Soundwalk*, both 2018) and Shinseungback Kimyonghun (*Mind*, 2019) (Figure 1) who create conceptually strong and formally economical interactive installations based on various experiential topics.

Fig. 1. Shinseungback Kimyonghun, *Mind* (2019). Photo: National Taiwan Museum of Fine Arts.

3. Anthropomorphism

Anthropomorphism is perhaps the creative AI's most pronounced ambiguity. It is a tendency to fictionalize the existing narrow AI as the artificial general intelligence (AGI) charged with polar attributes (subjugation vs benevolence) rather than making better efforts to detect and correct in it a full spectrum of elusive human weaknesses, contradictions and biases that reflect in every technology (Winner 1980; Lee 2018).

In various modes, it influences the work in creative AI and its cultural representation (Mitchell 2019a, 227; Todorović and Grba 2019, 55-56). The epistemic uncertainties about human cognition, and prejudiced consideration of its contradictions, tend to obfuscate the real values, potentials, shortcomings and dangers of AI. Whenever an AI or any other artificial system outperforms some of our physical abilities, cognitive functions or manifestations of creativity by imitation, simulation or in some other way, we conclude that from now on humans will be (unsuccessfully) competing with technology in that domain (Pinker 2018). It is often difficult to evaluate, and easy to dismiss, the difference between the effectiveness of human intelligence and the efficiency of specialized artificial processes related to intelligence. As Nao Tokui remarked (2016-), AI should be not considered as the emulation of human intelligence but rather as an Alternative Intelligence with its specific range of functional logic.

Anthropomorphism also constrains AI research with regards to the alternative forms of creativity that automated systems could exhibit, which may include exploring their quirks and idiosyncrasies. This is partially a consequence of the pragmatic use of human features as references in mainstream AI, but maintaining human creativity as an exclusive paradigm signals either conceptual rigidity or intellectual inertia.

3.1. The Ever-Receding Artist

Popular interpretations of artistic creativity in relation to AI tend to exploit the ever "blurring line between artist and machine" (Elgammal 2018). They often unfold through naïvely polarizing comparisons of human and AI creations in order to consensually determine "who is the artist" and "what is real art" (Hong et al. 2019; Miller 2019, 289-295). Such comparisons are manipulative because they presume (and instruct the subjects) that their test material is art, so they usually content with determining weather and under which conditions humans can distinguish between human-made and machine-made art. They ignore two fundamental distinctions: *who* considers something as an artwork, and *why.*[3] Within the sociocultural and anthropological perspectives of making art, motivation, decision making, anticipative assessment and selection are crucial human-driven factors, regardless of the level of abstraction, complexity, technological entanglement or counter-intuitiveness of the tools used for effectuating these factors. Based on unfounded dualistic notions of creativity, and on the lack of appreciation that the arts are artificial by definition, these popular interpretations oversimplify the crucial artistic abilities such as cogency, economy, skill, style, analogizing, intuition, and anticipation. They also underappreciate the breadth of the constantly evolving impact of human physical, perceptual and cognitive features in making art.

3. While sociologists have argued that art appreciation is not innate but learned (Dimaggio and Useem 1978), modern cognitive science has been providing evidence that art appreciation is not exclusively learned or innate but features both aspects (Miller 2001; Davies 2013; Høgh-Olesen 2019).

The media and some art institutions try to sensationalize AI art by de-emphasizing human agency in the creative process,and by presenting the AI "algorithms" as artists (Schwab 2018; Browne 2020, 7-9). They disregard well-informed notions about the complexity of the relationship between authorship and technology (O'Hear 1995; Boden 2004; Boden 2010; McCormack et al. 2019, 42-43, 47; Grba 2020, 75-77). Computers, robots or algorithms are not artists because they do not embody human cognitive capabilities, skills and—most importantly—human motivations for making art (Hertzmann 2020). Namely, the poetic qualities of human-made artefacts are inherently instrumentalizable as virtue signaling means to impress, stand out, assert oneself, and move forward in sexual competition and social hierarchy. Among many other things, art is a socially-constructed system for displaying mating fitness (intelligence, protean-ism, creativity, sense of humor) and for exhibiting or gaining social status (Miller 2001; Høgh-Olesen 2019). So, by misidentifying AI systems as artists, the bio-dictated sociopolitical aspects of art are selectively masked in the popular domain because of the bio-dictated ambitions to gain an advantage in a broader sociopolitical context. Artists usually take a more interesting approach, as they consciously use AI systems to play with the variable abstraction of authorship vis-à-vis technology, to explore the notions of agency and learning in the creative process, or to accentuate the uncanny appearance of artificial entities.

3.2. The Uncanny Landscapes

Uncanniness is the occasional experience of perceiving a familiar object or event as unsettling, eerie, or taboo (Broad 2020, 36-37), and it can be triggered in close interaction with AI-driven imitations of human physical or behavioral patterns. Some AI artists approach it implicitly, for example by extracting human-like meaningfulness from machinic textual conversation in Jonas Eltes' *Lost in Computation* (2017) or by alluding the intimate familiarity of human body in Scott Eaton's *Entangled II* (2019) (Eaton 2020) which is comparable to earlier video works such as Gina Czarnecki's *Nascent* and *Spine* (both 2006), and Kurt Hentschläger's *CLUSTER* (2009-2012) and *HIVE* (2011). AI artworks based on deep fakes, such as Mario Klingemann's *Alternative Face* (2017) or *Libby Heaney's Resurrection* (TOTB) (2019), approach uncanniness explicitly by either disrupting or accentuating the formal persuasiveness of statistically rendered human visuals.

The artists' exploration of uncanniness is also related to hybrid artefactual or glitchy aesthetics that can be achieved by emphasizing the abstract visual representations of data in the inner neural layers of DL architectures. By relying on our pareidolic perception, these visuals play with "humanizing" the opacity of DL processes. This is a popular poetic line in AI art, with examples such as Memo Akten's *Learning to See* (2017), Mario Klingemann's *Neural Glitch / Mistaken Identity* (2018b), Weidi Zhang's *Lavin* (2018), Jukka Hautamäki's *New Parliament* (2019) (Figure 2), and many other.

Fig. 2. Jukka Hautamäki, *New Parliament* (2019). Detail. Image courtesy of the artist.

In *JFK Unsilenced* (*The Greatest Speech Never Made*), a project commissioned by the Times in 2018, Rothco agency took a reminiscent contemplative approach to uncanniness by exploiting the emotional impact of sound, and by referencing the romanticized image of the 35th president of the United States. Based upon the analysis of 831 speeches and interviews, John F. Kennedy's voice was simulated in a delivery of his address planned for the Dallas Trade Mart on 22 November 1963 (Rothco 2018). At the level of individual words and some short phrases, Kennedy's voice sounds familiar but overall tone is uneven, so the uncanny effect relies mainly on the context of the speech that young president never had a chance to give. However, even with perfect emulation of Kennedy's Boston accent, this machinic reincarnation could never come close to matching the eeriness of Kennedy's televised speech on 22 October 1962. It was contextualized by Cuban missile crisis in which sheer good luck prevented the multilateral confusion, incompetence, ignorance and ultimate insanity of principal human actors from pushing the world into nuclear disaster (Sherwin 2020).

4. Biases

Building the classification models for subsymbolic, big data-based ML systems require large training datasets of hand-annotated: texts, drawings, pictures, photographs, 3D models, music, videos, films, etc. (Khamis 2019). However, these systems often lack the objective reasoning criteria, which leads to the translation of sociopolitical biases, prejudices, and misconceptions from the human decisions used for model development into the machine-learned behavior (Kearns and Roth 2019, 32-48; Mitchell 2019a, 88-90).

These side-effects of AI design have been discovered by the AI scientists, but also by the artists. For example, Kate Crawford and Trevor Paglen's exhibition project *Training Humans* (2019-2020) (Crawford and Paglen 2019) exposed racial bias in the online image database ImageNet that has been widely used in ML since 2009. Consequently, ImageNet removed 600,000 images of people from its collection of more than 14 million images which have been downloaded from the Internet, and annotated by human workers of Amazon Mechanical Turk.

Biased AI design is sometimes intentional, for example in a disputed paper "Automated Inference on Criminality Using Face Images" whose authors Xiaolin Wu and Xi Zhang (full professors at a major university in China) claim that their supervised ML classifiers can predict with high accuracy weather a person is a convicted criminal based only on a driver's license-style face photo (Aguera y Arcas et al. 2017). Ironically — notwithstanding the issues of detecting, removing or preventing biases in AI systems — there is a deficit of individual biases and creative idiosyncrasies among the AI artists, which could spice up their projects into more provocative or inspiring experiences.

5. Ethics

Main principles for ethical AI comprise transparency/explainability, justice/fairness/equity, safety, responsibility, privacy, beneficence, freedom/autonomy, sustainability, and solidarity/social cohesion (Jobin et al. 2019). Disparate notions of these principles make it difficult to establish widely acceptable criteria and to implement them consistently as AI algorithms for evaluation, selection and decision making. That is because ethical principles are fuzzy categories which comply to generalized human interests in the form of Gaussian distribution whose long tails are problematic (Mitchell 2019a, 84-87), and throughout history they have been manipulated by ignorant or patronizing assumptions that human interests are compatible and homogenous.[4]

4. See Żylińska's critique (2020, 33) of Max Tegmark's discussion of AI ethics in his book *Life 3.0: Being Human in the Age of Artificial Intelligence (2017).*

For example, fairness is essentially defined by a set of rational or perceived interests, but these interests vary between individuals and groups, in different contexts and conditions. Individual self-interest—which can be pragmatically or unintentionally short-sighted, contradictory, self-deceptive, deceitful or inconsiderate—has a decisive impact on shaping our values, goals, and actions (Trivers 2011). Emotional immunity to most ethically relevant cognitive dissonances is an inherent feature of human mind. As John Hooker (2018) noted: *Ethical people can be worlds apart in their tastes, attitudes, ambitions, and achievements.*

In order to solve the problem of aligning values and goals between humans and AI systems we need to find the way to align values and interests between humans, which means that we will have to address our evolutionarily driven socio-sexual competitiveness. This requires reconsidering the roles of ambition, both on the individual and on the societal level, and its consequences as a major factor of human creativity. Critical understanding of ambition in economic enterprises will also be crucial for realigning the AI companies' values and corporate interests with the values and interests of end users.

6. Discourses

All branches of the creative AI face a temptation to exploit the ideological authority of digital paradigm and heightened socioeconomic attention to the field. It sometimes leads to overpromising or overstating in AI science and business (prompting hyperbolic media reports), to manipulative strategies in AI art, to dubious speculations about the AI's capabilities or consequences, and to extreme futuristic scenarios, either catastrophic or utopian (Marcus and Davis 2019, 30; McCormack et al. 2019, 11; Mitchell 2019b). In computer science, as Melanie Mitchel (2019a, 21) notes: [...] *many AI people joke that what approach to the AI they claim to take depends on where their funding currently comes from.*

Numerous studies which demonstrate and explain the conceptual specificity and functional limitations of AI systems fail to discourage popular beliefs that AI can, and ultimately will, acquire mental omnipotence and hyper-functionality that science fiction and singularity speculations ascribe to the AGI or to the artificial superintelligence. The examples include Ray Kurzweil (2005) in futurology, Nick Bostrom (2014) and Sam Harris (2019) in philosophy, and *Transcendence* (directed by Wally Pfister, 2014) in science fiction. The singularity speculations indicate their advocates' detachment from the inertias and materiality of everyday life (however computerized or networked it may be), and imply regressive infantile delusions of immortality and omnipotence. Mirroring failed Silicon Valley's prophecies of computer-human synergy in the 1960s (Curtis 2011), they indicate not only how unfounded and ultimately irresponsible our current hyperbolizing of AI could be, but also warn about our myopic retrospection and selective historical outlook (Barbrook 2007).

If absorbed without critical scrutiny, broad speculations about AI may divert our attention from many important but already misrepresented issues of the field. For example, Joscha Bach, a Vice President of Research at the AI Foundation, opens his online introduction to a series of talks at the Chaos Communication Congress with:

> Artificial Intelligence provides a conceptual framework to understand mind and universe in new ways, clearing the obstacles that hindered the progress of philosophy and psychology. Let us see how AI can help us to understand how our minds create the experience of a universe. (Bach 2016)

This assumes and presents AI as an idealized, coherent, clearly defined and fully understood framework which provides a reliable conceptual toolkit for understanding such complex systems as human mind and the universe. AI is neither conceptually coherent, nor clearly defined, nor fully understood. Many authors cited in this paper identify these deficiencies, and AIArtists website lists them on a dedicated page (Anonymous 2021a). Additionally, current AI's epistemological dynamics is in direct opposition to the claim that AI can clear the obstacles that hinder the progress of philosophy and psychology because it is the obstacles in philosophy, psychology, and other related sciences that, among other issues, hinder the progress of AI.

Following a long-established trend in contemporary art, AI artists are tempted to augment the impact of their works through manipulative representational discourse that usually features critical considerations or sophisticated theoretical models but suffers insufficient competence or sincerity (Stallabrass 2006; Żmijewski 2011). They sometimes saturate project descriptions with elaborate (metaphorical or literal) questions which do not necessarily match the experiential outcomes of the works. For example, these are some of the questions that Libby Heaney ascribes to her work *Resurrection (TOTB)* (2019):

> The work asks what it means to resurrect icons of western music and questions notions of truth and labour. Is technology the new religion? What does it mean to use artificial means to bring someone back form the dead? Is death just simply another marketing consideration? [...] (Heaney 2019b)

When overdone, introductory efforts can diminish the experience of an artwork by patronizing the audience as pupils rather than independent thinkers capable of appreciating art through their own feelings, knowledge and intelligence. Several AI artworks expose the side-effects of inflated art discourse,, for example Disnovation.org's *Predictive Art Bot* (since 2017) (Figure 3). It is a chatbot which generates concepts for art projects based on current art discourse, and occasionally prophesizes absurd future trajectories for art on its own website and on Twitter (Disnovation.org 2017). It would be instructive to feed Predictive Art Bot's proposals to OpenAI's DALL·E network which generates images from text input comprising a range of concepts expressed in natural language (Ramesh et al. 2021).

Fig. 3. Disnovation.org (Nicolas Maigret and Maria Roszkowska), *Predictive Art Bot V3* (2017). Installation view. Photo: Gabriel Asper, CC NC-SA 4.0.

7. Authenticity

Mainstream AI suffers inadequate sensibility or open-mindedness for investigating the quirks of existing AI technologies and discovering their authentic creative potentials. Its emphasis on mimicking or reverse-engineering human cognition in lieu of discovering new technical models of intelligence is chiefly influenced by the lack of exact knowledge about human cognition and by the commercial interests which tend to collapse promising research ideas into conventional business practices. This may be corrected through a range of

5. The Levin Lab at Tufts University analyzes morphogenetic systems as primitive cognitive agents that manipulate information about their shape and make decisions about pattern regulation.

directives for identifying the unexpected or surprising facets of emergent behavior, which can be explored further to expand the cognitive and poetic scope of AI, and to enhance the cooperation between human creators and automated systems. For example, the research of bioelectrical intercellular communication and decision-making during mitosis, which regulate cell behavior and gene expression for patterning and structural organization of tissues, offers new perspectives for computational modelling with possible applications in AI (Levin et al. 2021).[5]

Some existing AI algorithms involve, exhibit and implement the key features of creative processes: aspects of undirectedness, generation of variance, intentional incurrence of costs for gaining knowledge, and the part-is-sacrificed-for-the-whole principle. However, these algorithms are not part of the marketed AI which is dominated by objective-driven, narrowly defined utility functions. Also, the goals of creativity-enabled AI may be in a trade-off with explainability and accuracy (Loi et al. 2020, 3-4). How effectively the AI systems will enhance human creativity, and how they should be designed to attain the conceptual coherence, agency and reliability that we can accept as (ethical) creativity are two related but possibly conflicted questions (López de Mántaras 2016; Roudavski and McCormack 2016; Gobet and Giovanni 2019; Loi et al. 2020). Notwithstanding these drawbacks and concerns, AI development stimulates human creativity by challenging knowledge, procedural literacy, innovation, inventiveness, wit and artistic expression.

Compared to other areas of new media art, the poetic range of contemporary AI art is relatively modest (Browne 2020). Most notably, it is deficient in projects that use AI systems as means to actualize well-defined conceptual platforms that meaningfully and effectively address broader perspectives of human existence. AI art involves computer technologies which, regardless of their complexity and rigidity, offer a generous space for conceptual, formal, methodological and aesthetic experimentation that can transcend the technologically imposed limits of expression. But artists have varying degrees of technical knowledge and skills for working with ML—ranging from bricoleurs through artist-engineers to engineer- and scientist-artists—and relatively few of them design their own systems. They often use the same code (DeepDream, CycleGAN, SNGAN, Pix2Pix, etc.) and train it with same data sets available on the Internet, which quickly results in homogeneity.

Therefore, they engage in a race to access the emerging code architectures before they become aesthetically "exhausted" (Bailey 2018), or to build new training models by curating original data sets. For example, Anna Ridler uses her own drawings and photographs as training material for Conditional Adversarial Network's Image-to-Image Translation (Pix2Pix) to stress the conceptual and formal logic of the reliance of interpretation upon memory and experience in both AI and in humans (Figure 4).

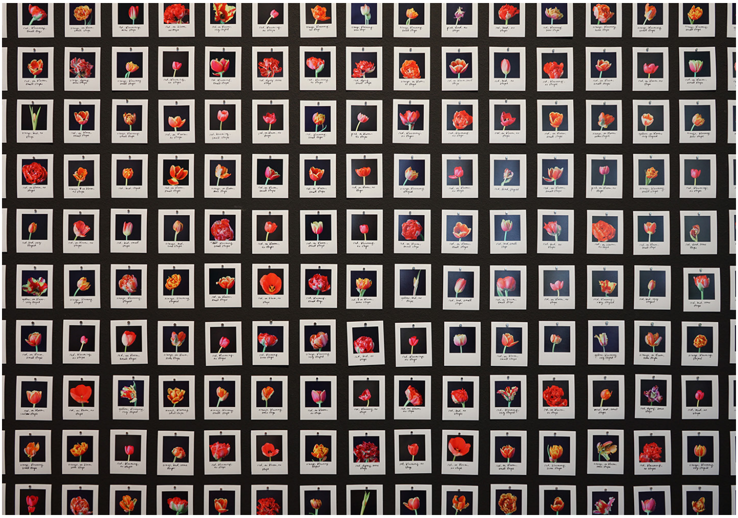


Fig. 4. Anna Ridler, *Myriad (Tulips)* (2018). Installation detail. Image courtesy of the artist.

Some AI artists push the pursuit of technical originality to the brink of obsession, in line with modernist myths of the heroic artist-conqueror (Miller 2019, 105, 127). Those who can afford it, seek originality in the spectacular by escalating formal richness and production/presentation values, for example Marco Brambilla (*Nude Descending a Staircase No. 3*, 2019) or Refik Anadol (*Melting Memories*, 2017; *Machine Hallucination*, 2019 and 2020; *Quantum Memories*, 2020). Such efforts are commendable, but may also indicate the lack of appreciation that originality can be misconceived or fetishized (Saltz 2019). Although it unavoidably reflects its technological reality, the poetics of AI art will remain constrained if the artists keep reducing their notions of authenticity and expressive cogency to prima facie relationship with technology. They may benefit by a more general recognition that, in principle, the improved functionality of AI systems emancipates human intelligence and creativity. In that sense, Man Ray's old critique of technically addicted artmaking applies:

> When my students present their wonderful [photographic] experiments [...] I have to tell them: this is your photograph, but it was not created by you. It was created by professor Carl Zeiss whom it took nine years to calculate the elements of the lens with which you can now capture even the slightest details of the face. (Bourgade 1972)

Additionally, high technical demands and fast competitive pace of producing AI art in current circumstances drain some of the artists' extra energy that comes from idleness and frivolity but often provides an invaluable touch of "dirt" which combines with experimentation, hard work, knowledge, idiosyncrasies, serendipity, luck and other decisive poetic factors.

8. The Art of AI

Its association with techniques and themes trending from AI science and technology exposes AI art to a critical consideration within the broader context of contemporary culture. AI art faces the intricacy, sophistication, and consequentiality of the creative work in computer science, robotics and other related fields. This techno-scientific work sometimes acquires artistic overtones notwithstanding the ambitions or the awareness of its practitioners. For example, tuning the hyperparameters[6] of the Convolutional Neural Networks (CNN) in supervised ML is highly experiential and intuitive, and AI scientists consider it as a kind of artistic process although it unfolds outside the art world (Mitchell 2019a, 82-83). Another example is a two-year experiment *Randomized Living* (2015-2017) in which former Google's employee Max Hawkins organized his life according to the dictate of recommendation algorithms (Hawkins 2021). He designed a series of apps that shaped his agenda by randomized suggestions based on the online data: a city where he would live for about a month and, once there, the places to go, people to meet, and things to do (Figure 5).

6. An umbrella term that refers to all the aspects of the CNN that need to be set up by humans to allow learning to even begin, such as the number of layers, the size of the units' "receptive fields" at each layer, the degree of change in each weight during learning, and many other (Mitchell 2019a, 82).

Fig. 5. Max Hawkins, *Randomized Living* (2015-2017): Random place in Tokyo, 14 July 2016. Image courtesy of the artist.

Randomized Living qualifies as a strong artwork of cybernetic-existentialism—the art of conceiving a responsive and evolving cybernetic system in order to express deep existential concerns (Dixon 2019). Instances like this suggest that artistic flavors of AI research could be arguably more interesting than current achievements of AI artists, but they also motivate the synergy of methodologies, skills and insights between various AI-related disciplines, which may be crucial for their advancement. As Vanessa Chang (2020) remarks:

> By extending humans' cognitive capacities, writing helped to sustain profound cultural transformations. AI may yet do the same. But as the uneven legacies of literacy suggest, the stories we tell with our writing tools are just as critical to cultural change as those tools themselves.

9. Entanglements

AI art requires technological infrastructures that are becoming ubiquitous and essential but remain largely elusive, exclusive, opaque and difficult to control. Artists build their projects upon multi-layered interconnections between programming languages, packages, libraries, APIs, software stacks and services that run on networked hardware with increasing complexity and pace of change. We generally consider these technical layers as guaranteed services of everyday life, but they are unstable and unreliable because they evolve according to capricious changes in business, technology and politics. Common technical functionality is predominantly aimed at satisfying the narrow windows of current procedural requirements, with reduced margins for backward or forward compatibility (Castells 2010).

The complex interrelatedness between artists' ideas, production techniques and presentational modes is inherent to artmaking, but the speed and volume of technological changes makes it difficult for AI artists to keep their projects running when the hardware/software systems they work with change significantly enough, usually in a time-span of several months. Furthermore, AI artworks are increasingly becoming time-based, continuous, interactive, relational, and dependent on various networked transactions during production or exhibiting (Grba 2021).

Similar to other media art practices, the technological entanglements and instabilities of the successful AI artworks are not mere byproducts or trade-offs, but are consciously integrated to serve as conceptual, tactical and existentially inherent expressive features of digital culture. Some artworks are created with exact intention to engage the sociopolitical consequences of ephemerality, and to address the fragility of information technologies by emphasizing their transitory character. The performative intricacies of technological entanglement are essential for experiencing the poetic identity of AI artworks, so it is difficult to preserve or recreate them without proper functionality of all their interdependent layers. However, their contingency and emergent character render the long-term preservation less relevant than timely and appropriate facilitation of these artworks within contemporary culture and education.

10. Dangerous Liaisons

Since the early computer art in the 1960s, experimental new media art has had an ambiguous relationship with MCA and, despite few intermittent hypes, remains both marginalized and occasionally exploited by it (Taylor 2014; Bishop 2012). Current surge of interest in AI- and crypto art has morphed from the MCA's association with post-digital art[7] throughout the 2010s. Post-digital artists thematize the affects of digital culture by using digital technologies as common utilities, and mainly produce their works in conventional materials and non-interactive media (Paul 2015). This approach conforms to the MCA's imperatives for tradeable materiality, but sacrifices the intricate tension between the artworks' conceptual, expressive or narrative layers and the contextual logic of the technologies in which they appear. With growing ideological authority and socioeconomic power of AI, MCA has been appropriating the AI phenomenology and, abiding by the post-digital formula, artists such as Hito Steyerl, Trevor Paglen, James Bridle, Gillian Wearing or Lucy McRae present their AI-derived works in marketable forms of installation, sculpture, video and photography.[8]

7. Sometimes also termed post-digital art, post-media art, and post-Internet art.

8. See for example Anonymous (2019).

The rising popularity of AI art in the past decade has allowed more artists to enjoy the patronage of large AI companies, and refreshed the supporting layers of digital culture such as virtual museums/galleries, online exhibitions, collections and marketplaces.[9] Notwithstanding their current momentum, it is uncertain how beneficial these platforms will be to experimental AI art because most of them were neither designed nor intended for such purposes. They have been increasingly incorporated into the MCA world whose selection criteria, operations and discourses are substantially market-driven (Stallabrass 2006; Shanken 2016, 465), so its interest in AI - and crypto art relates more to the commercial authorities of AI and blockchain than to problematizing and reimagining our relationship with digital technologies. For example, the AI and AI-related works that Ken Feingold (Figure 6), Louis Philippe-Demers, Patrick Tresset and other artists produced before the current AI spring remain largely overlooked by the MCA market although they explore the uncanny human-like behavior and question the meaning of technologically driven creativity.

9. Such as AIArtists.org, AI Art Gallery, Creative AI Lab, Nifty Gateway, OpenSea, Rarible, and others.

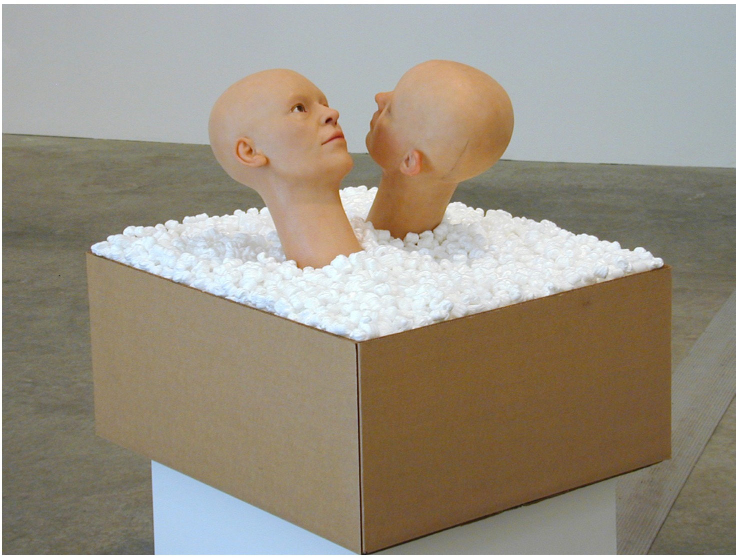


Fig. 6. Ken Feingold, *If, Then* (2001). Copyright 2001 Ken Feingold/Artists Rights Society, New York.

Seeking career advantages of institutional support, experimental AI artists are tempted to compromise some of the defining features of their artmaking in order to accommodate the MCA's requirements for scarcity, commercial viability, and ownership. Christie's sale of the French art collective Obvious' *Portrait of Edmond Belamy* in 2018 is a widely discussed example (Epstein et al. 2020). Competent AI artists are well-aware of the creative AI's subtleties and often explore them directly in their projects, so they should be expected not to accede to the MCA's "streamlining" of AI art. However, soon after Christie's AI artwork sale, Sotheby's chose Mario Klingemann's *Memories of Passersby I* (2018a) for their debut with AI art. Although technically and formally superior to *Portrait of Edmond Belamy*, Klingeman's work also conforms to the MCA's demands by imposing custom designed material components which are conceptually, technically and aesthetically redundant. Its limited-edition set is protected by Bitcoin-based certification of authenticity, which could be considered as a more suitable, although in principle no less objectionable, option for enforcing scarcity and ownership of digital artworks. Within that context, blockchain crypto products such as the NFT have been readily adopted and made profitable by the MCA market (Finzer 2020; Anonymous 2021b). Christie's sale of *Everydays: The First 5,000 Days* by Beeple (Mike Winkelmann) closed on 11 March with a bid for 69.4 million USD (Hertzmann 2021).

It seems that, up to this point, the interactions between AI art and the MCA world have been reinforcing conservative modes of expression, trivialized concepts and impoverished aesthetics rather than inciting new creative initiatives (Browne 2020; Żylińska 2020). Artists' endeavors for entering MCA by complying to its market-driven orthodoxies may bear a high cost to creativity and critical edge which distinguish most experimental art. Hopefully, their future poetic strategies for addressing the MCA's demands have not been outlined by the logic of *The Next Rembrandt* (2016), a collaborative project by ING bank, Microsoft, Technical University in Delft and Mauritshuis art collection (Anonymous 2016). The MCA's commodification of the potentially avant-garde practices such as AI art may be understood from the aspect of commercial interests, but its conservativism diminishes the value of (artistic) knowledge in its capacity for change. It degrades our mentality and deprives our cultural heritage by enforcing arbitrary disproportion of visibility and relevance on different artworks. In a wider perspective, the MCA's capitalization of our primitive notions of possession and ownership based on our pragmatically constrained perception of existence and time (Heller and Salzman 2021) is unethical because it nourishes false intuitions about our special place in the universe.

11. Deep Else

Current conceptual, technical and representational issues of the creative AI have a wide-ranging impact on science, technology, economy, politics and social relations. On the other hand, through dynamism and versatility, the field has been able to tackle many cognitive challenges, conceptual issues and technical obstacles, and to make continuous if not fully coherent improvements.

Together with computer scientists, artists are responsible for the discovery, development and application of authentically creative and valuable AI systems. The actual and the potential transformative capacities of AI require them to engage in a sharper critique of their motivations, in a deeper investigation of their expressive means, and in a more nuanced scrutiny of their work. The artists' opportunity to establish relevant poetic frameworks within such context depends on their ability to cultivate well-informed ethical attitudes toward their expressive practices and professional goals in order to overcome the frustration of being simultaneously marginalized and exploited by MCA. Their contributive range spans between two horizons. One is shaped by providing veneer and cultural legitimization to the big game AI. Another one involves taking genuine risks for the cutting edge inventiveness by asking not just what the world of AI can do for me but also how can I, as a thinking human, meaningfully relate my creativity with AI to incite new ideas in the intelligent world.

The responsibility toward creative AI is clearly not exclusive to immediate actors such as scientists, entrepreneurs, artists and cultural operators. Beyond consuming hype or indulging in complacency, general public and institutions need to engage in a difficult and uncertain work of demystification and reconceptualization in order to match the conceptual and technical intricacies of AI which has been increasingly intertwined and instrumental in defining the quality of our lives (Żylińska 2020, 33-34). In a broader prospect for versatile and acceptable AI, we need to empower our research, business enterprises and cultural incentives with a courageous and sincere look at ourselves. A constructive insight into the creative AI's ambiguities requires a profound understanding of the intrinsic contradictions and inconsistencies of human mind, including those "protected" by our ignorance, arrogance, hypocrisy, vanity and delusions of self-importance. We need to face—and transcend—the cynicism which comes with realization that many unfavorable traits shape our mentalities, direct our behavior and influence how we make and use our tools. This will catalyze science-technology, arts and humanities to define more robust concepts of creativity, to map its perspectives, and to inform our decisions for the future AI.

References

Aguera y Arcas, Blaise, Alexander Todorov, and Margaret Mitchell. 2017. "Physiognomy's New Clothes." Medium, 7 May. https://medium.com/@blaisea/physiognomys-new-clothes-f2d4b59fdd6a.

Akten, Memo. 2017. "Learning to See." Memo Akten's website. http://www.memo.tv/works/learning-to-see/.

Anadol, Refik. 2020. "All Works." Refik Anadol's website. https://refikanadol.com.

Anonymous. 2016. "Rembrandt Goes Digital." ING Next Rembrandt website. https://www.nextrembrandt.com.

Anonymous. 2019. "3 Things You Need to Know About AI-Powered 'Deep Fakes' in Art & Culture." Cuseum website. https://cuseum.com/blog/2019/12/17/3-things-you-need-to-know-about-ai-powered-deep-fakes-in-art-amp-culture.

Anonymous. 2021a. "Unanswered Questions About AI." AIArtists website. https://aiartists.org/unanswered-questions.

Anonymous. 2021b. "Beeple's Opus." Christie's website. https://www.christies.com/features/Monumental-collage-by-Beeple-is-first-purely-digital-artwork-NFT-to-come-to-auction-11510-7.aspx.

Bach, Joscha. 2016. "Machine Dreams - Dreaming Machines." Joscha Bach's website. December 28. http://bach.ai/machine-dreams.

Bailey, Jason. 2018. "Helena Sarin: Why Bigger Isn't Always Better with GANs and AI Art." Artnome, November 26. https://www.artnome.com/news/2018/11/14/helena-sarin-why-bigger-isnt-always-better-with-gans-and-ai-art.

Barbrook, Richard. 2007. *Imaginary Futures: From Thinking Machines to the Global Village*. London: Pluto Press.

Bishop, Chris. 2017. "Artificial Intelligence, the History and Future." The Royal Institution YouTube podcast. https://youtu.be/8FHBh_OmdsM.

Bishop, Claire. 2012. "Digital Divide: Contemporary Art and New Media." Artforum, 51, 1: 434–441.

Boden, Margaret A. 1998. "Creativity and Artificial Intelligence." Artificial Intelligence, 103: 347-356. http://citeseerx.ist.psu.edu/viewdoc/download?-doi=10.1.1.667.3710&rep%20=rep1&type=pdf.

Boden, Margaret A. 2004. *The Creative Mind, Myths and Mechanisms*. 2nd edition. London/New York: Routledge.

Boden, Margaret A. 2010. *Creativity and Art: Three Roads to Surprise*. Oxford: Oxford University Press.

Boden, Margaret A., and Ernest Edmonds. 2019. "A Taxonomy of Computer Art." In *From Fingers to Digits: An Artificial Aesthetic*, 23-59. Cambridge: The MIT Press.

Bogart, Ben. 2019. "Watching (2001: A Space Odyssey)." AI Art Gallery's website. http://www.aiartonline.com/community-2019/ben-bogart.

Bostrom, Nick. 2014. *Superintelligence: Paths, Dangers, Strategies*. Oxford: Oxford University Press Keith Mansfield.

Bourgade, Pierre. 1972. "Man Ray Talks with Pierre Bourgade." In *Bonsoire, Man Ray*. Paris: P. Belfond.

Brambilla, Marco. 2019. "Nude Descending a Staircase No. 3." Marco Brambilla's website. https://www.marcobrambilla.com/selected-works.

Broad, Terrence, Frederic Fol Leymarie, and Mick Grierson. 2020. "Amplifying the Uncanny." *xCoAx, 8th Conference on Computation, Communication, Aesthetics & X*: 33-42.

Browne, Kieran. 2020. "Who (or what) is an AI Artist?" Preprint. https://kieranbrowne.com/publications/who_or_what_is_an_ai_artist.pdf.

Buss, David M. 2015. *Evolutionary Psychology: The New Science of the Mind*, 5th edition, 9, 15-18. London/New York: Routledge.

Castells, Manuel. 2010. *The Information Age Vol. 1: The Rise of the Network Society*, 169-180. Chichester: Wiley-Blackwell.

Cetinić, Eva, and James She. 2021. "Understanding and Creating Art with Ai: Review and Outlook." Preprint (19 February). https://arxiv.org/pdf/2102.09109.

Chang, Vanessa.
2020. "Prosthetic Memories, Writing Machines." Noema website, December 3. https://www.noemamag.com.

Chatel, Marie.
2018. "In Focus: Mario Klingemann." Medium/Digital Art Weekly. https://medium.com/digital-art-weekly/in-focus-mario-klingemann-783533ec91fe.

Chung, Sougwen.
2020. "Selected Works by Sougwen Chung." Sougwen Chung's website. https://sougwen.com/artworks.

Copeland, B. Jack.
"The Church-Turing Thesis." In Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (Summer 2020 edition). https://plato.stanford.edu/archives/sum2020/entries/church-turing.

Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.
2001. *Introduction to Algorithms*, 5. Cambridge: The MIT Press.

Crawford, Kate, and Trevor Paglen. 2019. "Excavating AI: The Politics of Training Sets for Machine Learning." Excavating.ai website (published by The AI Now Institute, NYU). https://excavating.ai.

Curtis, Adam.
2011. "All Watched Over by Machines of Loving Grace, Part 2: The Use and Abuse of Vegetational Concepts." BBC TV Miniseries (directed by Adam Curtis).

Czarnecki, Gina.
2006. "Nascent." Gina Czarnecki's website. https://www.ginaczarnecki.com/nascent.

Czarnecki, Gina.
2006. "Spine." Gina Czarnecki's website. https://www.ginaczarnecki.com/spine.

Davies, Stephen.
2013. *The Artful Species: Aesthetics, Art, and Evolution*. Oxford: Oxford University Press.

Dimaggio, Paul, and Michael Useem.
1978. "Social Class and Arts Consumption: The Origins and Consequences of Class Differences in Exposure to the Arts in America." *Theory and Society*, 5, 2: 141–161.

Disnovation.org (Nicolas Maigret and Maria Roszkowska). 2017. "Predictive Art Bot V3." Nicolas Maigret's website: http://peripheriques.free.fr/blog/index.php?/works/2017-predictive-art-bot-v3. Project website: http://predictiveartbot.com. Artbot Space: http://artbot.space. Twitter: http://twitter.com/predartbot.

Dixon, Steve.
2019. *Cybernetic-Existentialism: Freedom, Systems, and Being-for-Others in Contemporary Arts and Performance*, 3. New York: Routledge.

Eaton, Scott.
2020. "Entangled II." Scott Eaton's website. http://www.scott-eaton.com/2020/entangled-ii.

Elgammal, Ahmed.
2018. "When the Line Between Machine and Artist Becomes Blurred." The Conversation website. https://theconversation.com/when-the-line-between-machine-and-artist-becomes-blurred-103149.

Eltes, Jonas.
2017. "Lost in Computation." Jonas Eltes' website. https://jonaselt.es/projects/lost-in-computation/.

Epstein, Ziv, Sydney Levine, David G. Rand, and Iyad Rahwan.
2020. "Who Gets Credit for AI-generated Art?" *Iscience*, 23, 9, 101515.

Finzer, Devin.
2020. "The Non-Fungible Token Bible: Everything You Need to Know About NFTs." OpenSea website. https://opensea.io/blog/guides/non-fungible-tokens.

Gobet, Fernand, and Sala Giovanni.
2019. "How Artificial Intelligence Can Help Us Understand Human Creativity." *Frontiers in Psychology*, Vol. 10. https://www.frontiersin.org/article/10.3389/fpsyg.2019.01401.

Goodwin, Ross.
2016. "Sunspring." YouTube website. https://youtu.be/LY7x2Ihqjmc.

Goodwin, Ross.
2018. "Automatic on the Road." YouTube website. https://youtu.be/TqsW0PM-d8R0.

Grba, Dejan.
2019. "Forensics of a Molten Crystal: Challenges of Archiving and Representing Contemporary Generative Art." *ISSUE Annual Art Journal*, 08, (Erase): 3-15.

Grba, Dejan.
2020. "Alpha Version, Delta Signature: Cognitive Aspects of Artefactual Creativity." *Journal of Science and Technology of the Arts*, 12 (3): 63-83.

Grba, Dejan.
2021. "Immaterial Desires: Cultural Integration of Experimental Digital Art." *The International Conference on Art, Museums and Digital Cultures*.

Groß, Benedikt, Joey Lee et al.
2016. "The Aerial Bold Project." The Aerial Bold Project website. http://type.aerial-bold.com/tw.

Harris, Sam.
2019. "Can We Avoid a Digital Apocalypse?" Edge.org, 14 June. https://www.edge.org/response-detail/26177.

Hautamäki, Jukka.
2019. "New Parliament." AI Art Gallery's website. http://www.aiartonline.com/community-2019/jukka-hautamaki.

Hawkins, Max.
2021. "Randomized Living." Max Hawkins' website. https://maxhawkins.me/work/randomized_living.

Heaney, Libby.
2019a. "Euro(re)vision." AI Art Gallery website. http://www.aiartonline.com/highlights/libby-heaney-2.

Heaney, Libby.
2019b. "Resurrection (TOTB)." Libby Heaney's website. http://libbyheaney.co.uk/resurrection-totb.

Heller, Michael, and James Salzman.
2021. *Mine!: How the Hidden Rules of Ownership Control Our Lives*, 14-18, and passim. New York: Doubleday/Penguin Random House.

Hentschläger, Kurt.
2009-2012. "CLUSTER." Kurt Hentschläger's website. http://www.kurthentschlager.com/portfolio/cluster/cluster.html.

Hentschläger, Kurt.
2011. "HIVE." Kurt Hentschläger's website. http://www.kurthentschlager.com/portfolio/hive/hive.html.

Hertzmann, Aaron.
2020. "Computers Do Not Make Art, People Do." *Communications of the ACM*, 63, 5: 45–48.

Hertzmann, Aaron.
2021. "Why Would Anyone Buy Crypto Art – Let Alone Spend Millions on What's Essentially a Link to a JPEG File?" The Conversation website, 15 March. https://theconversation.com/why-would-anyone-buy-crypto-art-let-alone-spend-millions-on-whats-essentially-a-link-to-a-jpeg-file-157115.

Høgh-Olesen, Henrik.
2019. *The Aesthetic Animal*. New York: Oxford University Press.

Hong, Joo-Wha, and Nathaniel Ming Curran.
2019. "Artificial Intelligence, Artists, and Art: Attitudes Toward Artwork Produced by Humans vs. Artificial Intelligence." *ACM Transactions on Multimedia Computing, Communications, and Applications*. 15, 2s, Article 58 (July).

Hooker, John.
2018. "Truly Autonomous Machines Are Ethical." Preprint. https://arxiv.org/pdf/1812.02217.

Jobin, Anna, Marcello Ienca, and Effy Vayena.
2019. "The Global Landscape of AI Ethics Guidelines." *Nature Machine Intelligence, 1* (9): 389–399.

Kearns, Michael, and Aaron Roth.
2019. *The Ethical Algorithm: The Science of Socially Aware Algorithm Design*. Oxford: Oxford University Press.

Khamis, Alaa.
2019. "The 7-Step Procedure of Machine Learning." Towards Data Science website. https://towardsdatascience.com/the-7-step-procedure-of-machine-learning-c15c922e7300.

Klingemann, Mario.
2017. "Alternative Face." Mario Klingemann's website. https://underdestruction.com/2017/02/04/alternative-face.

Klingemann, Mario.
2018a. "Memories of Passersby I." Mario Klingemann's website. https://underdestruction.com/2018/12/29/memories-of-passersby-i.

Klingemann, Mario.
2018b. "Neural Glitch / Mistaken Identity." Mario Klingemann's website. https://underdestruction.com/2018/10/28/neural-glitch.

Kurzweil, Ray.
2005. *The Singularity Is Near: When Humans Transcend Biology*. New York: Penguin.

Lee, Kai-Fu.
2018. *AI Superpowers: China, Silicon Valley, and the New World Order*, 126-129. Boston/New York: Houghton Mifflin Harcourt.

Levin, Michael.
2021. "Research: Lab's New Directions" The Levin Lab blog, https://ase.tufts.edu/biology/labs/levin/research/newDirections.htm.

Loi, Michele, Eleonora Viganò, and Lonneke Plas van Der.
2020. "The Societal and Ethical Relevance of Computational Creativity." Preprint. https://www.researchgate.net/publication/343179320.

López de Mántaras, Ramón.
2016. "Artificial Intelligence and the Arts: Toward Computational Creativity." *The Next Step. Exponential Life*. Madrid: BBVA. https://www.bbvaopenmind.com/en/articles/artificial-intelligence-and-the-arts-toward-computational-creativity.

Marcus, Gary F., and Ernest Davis.
2019. *Rebooting AI: Building Artificial Intelligence We Can Trust*. New York: Pantheon Books.

Marks, Anna.
2019. "How AI is Radically Changing Our Definition of Human Creativity." WIRED, 27 May. https://www.wired.co.uk/article/artificial-intelligence-creativity.

McCorduck, Pamela.
2004. *Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence*. Natick: A. K. Peters, Ltd.

McCormack, Jon, Toby Gifford, and Patrick Hutchings.
2019. "Autonomy, Authenticity, Authorship and Intention in Computer Generated Art." EvoMUSART: *8th International Conference on Computational Intelligence in Music, Sound, Art and Design*, vol 11453: 35-50.

Miller, Arthur I.
1996. *Insights of Genius: Imagery and Creativity in Science and Art*. New York: Copernicus/Springer-Verlag.

Miller, Arthur I.
2019. *The Artist in the Machine: The World of AI-Powered Creativity*, 289-295. Cambridge: The MIT Press.

Miller, Geoffrey.
2001. *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature*, 274-307, and passim. Anchor Books/Random House, Inc.

Mitchell, Melanie.
2019a. *Artificial Intelligence: A Guide for Thinking Humans*. Kindle edition. New York: Farrar, Straus and Giroux.

Mitchell, Melanie.
2019b. "We Shouldn't be Scared by 'Superintelligent A.I.'" The New York Times Opinion, 31 October. https://nyti.ms/3255pK2.

Newton-Rex, Ed.
2019. "Creative AI: A Reading List." Medium, 15 December. https://medium.com/creative-ai/creative-ai-a-reading-list-9a6d1d13563f.

Nielsen, Michael.
2019. "Neural Networks and Deep Learning." Online book. http://neuralnetworksanddeeplearning.com.

Nye, Maxwell, Luke Hewitt, Joshua Tenenbaum, and Armando Solar-Lezama.
2019. "Learning to Infer Program Sketches." https://arxiv.org/pdf/1902.06349.

O'Hear, Anthony.
1995. "Art and Technology: An Old Tension." *Royal Institute of Philosophy Supplement*, 38 (Philosophy and Technology): 143–158.

Paul, Christiane.
2015. "From Immateriality to Neomateriality: Art and the Conditions of Digital Materiality." *ISEA 2015 Proceedings*. https://isea2015.org/proceeding/submissions/ISEA2015_submission_154.pdf.

Pinker, Steven.
2002. *The Blank Slate: The Modern Denial of Human Nature*. New York: Penguin.

Pinker, Steven.
2018. *Enlightenment Now: The Case for Reason Science Humanism*, 323-327. New York: Viking.

Raatikainen, Panu.
2021. "Gödel's Incompleteness Theorems." In Edward N. Zalta (ed.), *The Stanford Encyclopedia of Philosophy* (Spring 2021 edition). https://plato.stanford.edu/archives/spr2021/entries/goedel-incompleteness.

Ramesh, Aditya, Mikhail Pavlov, Gabriel Goh, and Scott Gray.
2021. "DALL·E: Creating Images from Text." OpenAI blog. https://openai.com/blog/dall-e.

Rothco.
2018. "JFK Unsilenced." Rothco agency website. https://rothco.ie/work/jfk-unsilenced.

Ridler, Anna.
2018. "Myriad (Tulips)." Anna Ridler's website. http://annaridler.com/myriad-tulips.

Roudavski, Stanislav, and Jon McCormack.
2016. "Post-anthropocentric Creativity." *Digital Creativity*, 27: 1, 3-6.

Saltz, Jerry.
2019. "What the Hell Was Modernism?" New York Magazine, 30 September. https://www.vulture.com/2019/10/jerry-saltz-new-moma-modernism.html.

Schwab, Katharine.
2018. "An AI Learned to Make Fireworks, and They're Mesmerizing." Fact Company online article. https://www.fastcompany.com/90156087/an-ai-learned-to-make-fireworks-and-theyre-mesmerizing.

Shanken, Edward A.
2016. "Contemporary Art and New Media: Digital Divide or Hybrid Discourse?" In Christiane Paul (ed.), *A Companion to Digital Art*, 463–481. Chichester: John Wiley & Sons, Inc.

Sherwin, Martin J.
2020. *Gambling with Armageddon: Nuclear Roulette from Hiroshima to the Cuban Missile Crisis*, 15-16, 369-380, and passim. Kindle edition. New York: Knopf Doubleday Publishing Group.

Shinseungback Kimyonghun.
2019. "Mind." Shinseungback Kimyonghun's website. http://ssbkyh.com/works/mind.

Sloss, Andrew N., and Steven Gustafson.
2019. "Evolutionary Algorithms Review." https://arxiv.org/pdf/1906.08870.

Stallabrass, Julian.
2006. *Contemporary Art: A Very Short Introduction*. Oxford: Oxford University Press.

Taylor, Grant D.
2014. *When the Machine Made Art: The Troubled History of Computer Art*. New York and London: Bloomsbury Press.

Tegmark, Max.
2017. *Life 3.0: Being Human in the Age of Artificial Intelligence*. New York: Alfred A. Knopf.

Todorović, Vladimir, and Dejan Grba.
2019. "Wandering Machines: Narrativity in Generative Art." *CITAR Journal of Science and Technology of the Arts*, 11, 2: 50-58.

Tokui, Nao.
2016-. "AI DJ Project." Tokui Nao's website. http://naotokui.net/projects/ai-dj-project-2016.

Tokui, Nao.
2018a. "Imaginary Landscape." Nao Tokui's website. https://naotokui.net/projects/imaginary-landscape-2018.

Tokui, Nao.
2018b. "Imaginary Soundwalk." Nao Tokui's website. https://naotokui.net/projects/imaginary-soundwalk-2018.

Trivers, Robert L.
2011. *Deceit and Self-Deception: Fooling Yourself the Better to Fool Others*. New York: Penguin.

Winner, Langdon.
1980. "Do Artifacts Have Politics?" *Daedalus*, 109, 1: 121-136.

Yi, Huang.
2021. "Huang Yi & KUKA." Huang Yi's website. https://huangyistudio.com/huangyiandkuka.

Żmijewski, Artur.
2011. "Artists Are Just as Capable of Setting the Same Chain of Events as Politicians: Artur Żmijewski in conversation with Joanna Warsza." *Das Magazin der Kulturstiftung des Bundes*, 18.

Zhang, Weidi.
2018. "Lavin." Weidi Zhang's website. https://www.zhang-weidi.com/lavin.

Zheng, Chenyu, and Douglas C. Sicker.
2013. "A Survey on Biologically Inspired Algorithms for Computer Networking." *IEEE Communications Surveys & Tutorials*, 15, (3), 3rd Quarter: 1160-1191.

Żylińska, Joanna.
2020. *AI Art: Machine Visions and Warped Dreams*. London: Open Humanities Press.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Code, Poetry and Freedom

Keywords: Codeworks, Poetry, Livecoding, FLOSS, Hacktivism, Resistance, Abya Yala

Jorge Forero Rodríguez
jfforero@ldq.cl
FEUP/ITI-LARSyS
Porto, Portugal

Codework, also known as code-poetry, is a variant of digital poetry, in turn a subgenre of electronic literature. Codeworks are basically art that integrate computer code in its overall aesthetic. In its broadest sense, code-inspired visual art and livecoding could be categorized under this taxonomy. Livecoding is a creative technique by which it is possible to compose audiovisual works, interacting directly with the algorithms defined in a programming language, in order to obtain results "on the fly" (Wang 2008). Livecoding performance is permeated by FLOSS (Free / Libre / Open Source Software) culture, since by definition in this artistic format, the source codes of the programs are usually shared publicly with the audience. The research presented below seeks to compose a view around these topics, using Alan Sondheim's codeworks taxonomy in order to analyze them from a critical perspective. In particular, I seek to investigate the Latin American counterpart, where FLOSS and "art converge as an element of autonomy from the functional needs of the structure of code itself, while on the other hand, it attempt to historicize and politicize it by anchoring code in practices of Resistance'' (Ledesma 2015).

1. Introduction

Code-poetry (also known as codework), is a variant of digital poetry, in turn a sub-genre of electronic literature. Codeworks were for the first time described with that name in an article published in the American Book Review, by the artist and critic Alan Sondheim, in the year 2001. In this article the author introduces the concept as:

"The computer stirring into the text, and the text stirring the computer" (Sondheim 2001).

The researcher Rita Raley, refers to the concept as "the use of the contemporary idiolect of computers and computational processes in the form of experimental digital writing or net.writing" (Raley 2002). Sondheim's article proposes a first taxonomy, identifying several formulas by which it would be possible to merge poetry and code.

a. Works using the syntactical interplay of surface language, with reference to computer language and engagement.

This would be the case, as Sondheim describes, for poems inspired by the high-level ALGOL (algorithm-oriented languages) programming language. The idea of *ALGOL's poetry* stems from the first OULIPO (ouvroir de littérature potentielle) manifesto, published by François Le Lionnais in 1962, which proposes from experimental literature;

"other forays may be imagined, notably into the area of special vocabulary (crow, foxes, dolphins; Algol computer language, etc)" (Le Lionnais 1962).

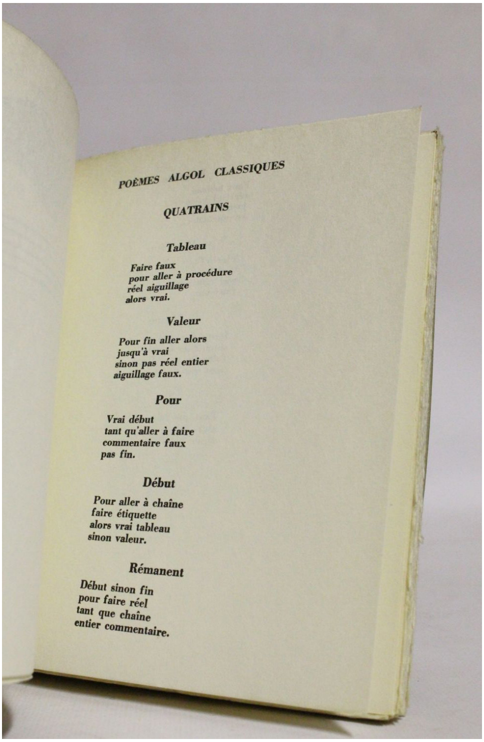


Fig. 1. Noël Arnaud ALGOL poetry book[1]

1. https://www.edition-originale.com/fr/litterature/editions-originales/arnaud-algol-1968-57350

As can be seen from this ALGOL poem (fig.1), written by the Oulipo Noël Arnaud, this approach suggests to use common expressions between natural language and high-level programming languages commands (BEGIN, For, Do, Else, etc.), as a fundamental part of the poems. It is important to mention that although those commands are originally created in English, Arnaud translated them in french. Another perspective in this category also suggests the inclusion of abstract symbolic elements of code in poetry. This is the case of the Mezangelle project by the Australian artist Mary-Anne Breeze. For Raley, *Mezangelle* (M[ez]ang.elle) is a "neologistic 'netwurked' language, which incorporates code snippets, as well as coding structures, such as indentations, parentheses, and other symbols to create new meanings'' (Raley 2002). It is important to mention that both AlGOL and Mezangelle poems are not functional languages by any computer and only refers to codes from its surface layers.

b. Works in which submerged code has modified the surface language—with the possible representation of the code as well.

In this category, codes are executable in the sense they can be compiled and translated into a functional machine language. *Poems By Nari*,[2] for example, are a series of visual poems produced by Ted Warnell, under the pseudonym of Nari in 1996. In this project, the text is deeply linked to the source code used to make the poem. In his poems, Warnell emphasizes this fusion between code and content, stating:

2. https://www.warnell.com/real/nari.htm

"**what i write:**

```
document.write( "static" );
```

what you read:

Static

what i write:

```
var x; var y = "dynamic";

for ( x = 0; x < y.length; x++ )

document.write( y.charAt( Math.floor( Math.random() * y.length ) ) );
```

what you read:

maddicn OR ynyadcm OR imdiyca ...

So there is what I write, and there is what I write writes (what you read) — two different texts: code, a text below and poetry, a text above — they are related and yet separate texts — separate, and inseparable!" *(*Warnell and Quimby 2012*).*

Fig. 2. Ted Warnell. Jack and Jill poem ByNari.[3]

3. https://elmcip.net node/7943

Poem by Nari

code.poetry::**executables**

000::take back your art

001::jack and jill

Date: Wed, 14 Feb 2001 23:44:12
To: webartery@yahoogroups.com
From: Ted Warnell <warnell@memlane.com>
Subject: Re: A conference I'm not going to...

```
<HTML>
  <HEAD>
    <SCRIPT language="JavaScript">
      var a0 = 'Jack and Jill';
      var a1 = new Array (
        'went up the hill', 'went to the beach', 'went by the way' );
      var a2 = new Array (
        'to fetch a pail', 'to catch the wave', 'to say to say' );
      var a3 = new Array (
        'of water.', 'of snails.', 'of men.' );
      var a4 = new Array (
        'Jack fell down', 'Jill jumped up', 'They fell apart' );
      var a5 = new Array (
        'and broke his crown', 'and teased her hair', 'and tore off a quickie' );
      var a6 = new Array (
        'and Jill came', 'and Jack came', 'and they both came' );
      var a7 = 'together, later.';
      var b = new Date();
      var c;
      function d() {
        return Math.floor( Math.random( b.getTime() ) * a1.length);
      }
    </SCRIPT>
  </HEAD>
  <BODY>
    <SCRIPT language="JavaScript">
                 document.write( "" + a0 + "<br>" );
      c = d(); document.write( "" + a1[c] + "<br>" );
      c = d(); document.write( "" + a2[c] + "<br>" );
      c = d(); document.write( "" + a3[c] + "<br>" );
      c = d(); document.write( "" + a4[c] + "<br>" );
      c = d(); document.write( "" + a5[c] + "<br>" );
      c = d(); document.write( "" + a6[c] + "<br>" );
                 document.write( "" + a7 + "<br>" );
    </SCRIPT>
  </BODY>
</HTML>
```

Jack and Jill
went to the beach
to catch the wave
of water.
They fell apart
and teased her hair
and they both came
together, later.

Pretty lite-duty machine, I know.
Apologies for the poetry.
Ted.

c. Projects in which the source code emerges as content; there is a deconstruction of superficial language and a dichotomy between the layers of languages.

In this category, Sondheim proposes the works of Netochka Nezvanova and JODI among other artists, alluding to their hybrid and rhizomatic characteristics in the use of languages (Sondheim 2001). Netochka Nezvanova N.N (Nameless Nobody), is one of the first fictional characters in art with multiple identities on the Internet. It has been present since 1995, under the pseudonyms of *anticorp, integer, m2zk! and =cw4t7abs*, among other names assigned to this identity. As with the Pythagoreans, it is difficult - if not impossible - to know the true authorship of the works presented under the various aliases that NN use, but for decades they have produced works ranging from open source audiovisual programming tools, to code-poetry. JODI, on the other hand, is an artistic duo made up of Joan Heemskerk and Dirk Paesmans. They were among the first artists to investigate and subvert conventions of internet and computer programs. Radically disrupting the language of these systems, including interfaces, commands, errors and code, JODI stages extreme digital interventions that destabilize the relationship between computer technology and its users.

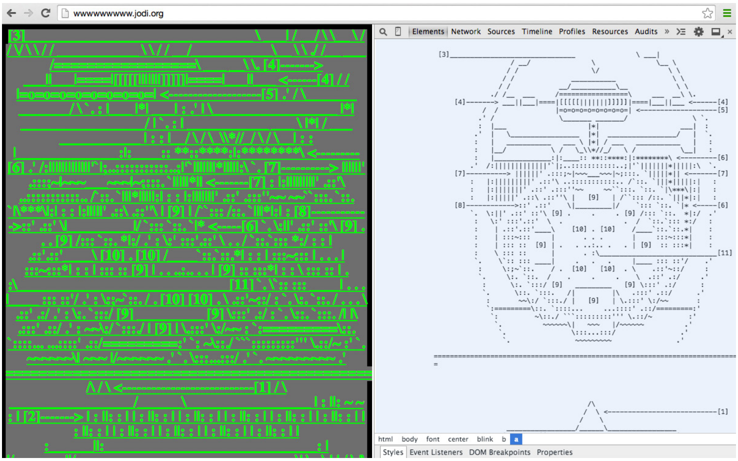


Fig. 3. Jodi Web page
http://wwwwwwwww.jodi.org

2. Livecoding and Freedom

In a broad sense, Livecoding (LC) performances can be considered in the third category in Sondheim's taxonomy, in which it is possible to identify at least three language layers. The idea has its antecedents in 1986 with the works of Ron Kuivila, who together with his experimental group The Hub, composed the piece *Watersurface*, done in a programming language called the Forth music language, developed by David Anderson and Kuivila (Anderso and Kuivila 1991). As described by the pioneers of the format, Alex McLean and his colleagues Adrian Ward and David Griffiths (who formed the Slub collective by the year 2000), "livecoding emerged at the beginning of the 20th century, to describe the activity of a group of practitioners and researchers who had begun developing new approaches to making computer music and video animation in real time" (McLean et al. 2010). It can be defined as the "interactive control of algorithmic processes through programming activity" (Ward et al. 2004). The style of music is not fixed, which suggests that livecoding is a performance method rather than a genre. A typical livecoding performance involves programmers writing/improvising code on stage, with their screens projected for the audience and their code dynamically interpreted to generate music and/or graphics (Collins et al. 2003).

2.1. FLOSS (Free/Libre/OpenSource Software)

Since the source codes that generate the audiovisual performances are usually projected publicly on a screen, livecoding format is closely linked to the FLOSS culture. Free / Libre / Open Source Software (FLOSS) are computer programs that can be used, copied, shared, modified and redistributed with little or no restrictions and that allow access to their source codes. The term FLOSS refers equally to the concepts Free and Open in order to unify both approaches. Free Software, defined by Richard Stallman and promoted by the Free Software Foundation, places its emphasis on the freedom that this concept brings to users (Stallman 2013). The 4 degrees of freedom in free software are:

» Freedom to use the program for any purpose.

» Freedom to study and modify the source code.

» Freedom to share and redistribute the program.

» Freedom to improve and release new versions.

On the other hand, open source software, in principle equivalent to free software, tries to evade the philosophical question and the political implications of the word freedom and place its emphasis on the peer-to-peer relationship of the model (Stallman 2007). As Martin Zelinger introduces in his article *Livecoding the Law: Improvisation, Code, and Copyright,* "in the field of copyright, livecoding practices can further highlight some of the inherent flaws in traditional intellectual property law" (Zeilinger 2014). Thus, he argues that livecoding has the possibility to radically destabilize intellectual property for two main reasons;

"first, the strong improvisational characteristics of the art form challenge the traditional definition of composer; second, his challenge of palimpsestic nature" (Zeilinger 2014).

The fertile field of studies on jazz improvisation, that offers us a relevant context for the present discussion, shows that improvised practices are recognized as powerful modes of political expression, useful to understand social changes and to break with structurally inscribed hegemonies in the music. Jazz and in particular free jazz, has often been associated with the insubordinate appropriation of cultural traditions by progressive artists, and with resistance and rejection of an established socio-political order (Stanbridge 2008).

2.2. Hacks, Hackers and Hackerspaces

Livecoding and the FLOSS philosophy are closely related to the D.I.Y (do it yourself) culture and in particular to the hacker world. "Typically, a hacker is a computer-minded technologist and a hack is a clever technical solution that is reached by non-obvious means" (Levy 1984). The term hacker was first used in 1960 among MIT technology developers, whose lives revolved around computer programming (Coleman 2014). The Researcher Steven Levy studied the undeclared ethical codes of hacker groups and conceptualized them under a hacker ethic. These ethical principles were constituted as an amalgam of aesthetic and pragmatic imperatives that included:

"Commitment to freedom of information, distrust of authority, greater dedication to meritocracy and the firm belief that computers can be the basis of beauty and a better world" (Levy 1984).

Hack spaces (also known as Hackerspaces or HackLabs) emerged from 1990, are basically public spaces that promote collaborative creation using technological means. They are usually linked to training proposals that promote the use of FLOSS resources into the DIY culture. Depending on their origin, these spaces are born or derived from cultural community centers (Schrock 2014).

Live coders have their own spaces and institutions. TOPLAP is an organization founded in 2004 to explore and promote livecoding. The activities that they organize are: workshops, talks, periodically livecoding sessions from scratch (improvisation from a blank page), meetings with the research community, as well as Algoraves (livecoding raves parties). They also advise on projects that use real-time code as a central element in the arts, digital humanities, and science. TOPLAP has a founding manifesto, initially focused on musical projects, however it has been expanded to various artistic genres. His manifesto clearly states the necessity of showing the screen as a philosophy against what they call a new digital obscurantism.[4]

4. https://toplap.org/wiki/ManifestoDraft

3. Critical Perspectives

Critical Theory refers to the ways of thinking associated with Frankfurt's Institute for Social Research. As Max Horkheimer described in his foundational essay, a theory is critical to the extent that it seeks human "emancipation from slavery", acts as a "liberating ... influence", and works "to create a world which satisfies the needs and powers of human beings" (Horkheimer 1972).

3.1. Critical Code Studies (CCS)

Critical Code Studies (CCS) are an emerging academic subfield linking socio-cultural studies with computer science, with a special emphasis on computational code. According to the theorist Mark C. Marino, "CCS can be defined as an approach that addresses critical hermeneutics, computer code, software architecture and all documentation from a socio-historical context" (Marino 2006). This perspective proposes that the lines of code do not have a neutral value and can be analyzed using theoretical tools common to any other semiotic system in addition to interpretive methods specially developed for the context. In the article Code as Language wrote by Loss Pequeño Glazier, the author argues that "if language is defined as written symbols organized in combinations and patterns to express and communicate thoughts and feelings - language that is executed - then the code is language" (Glazier 2006). Wendy Hui Kyong Chun's proposal goes further and argues that "software is ideology" (Chun 2004). In this sense, we could extend the argument proposing that computer code is ideology too, but an ideology that is doubly hidden by our illiteracy.

3.2. CCS for Multiples Code

In *A Box, Darkly: Obfuscation, Weird Languages, and Code Aesthetics*, Michael Mateas and Nick Montfort describe the concept of multiple coding as a practice by which it is possible to obtain different representations for each language layer (Mateas and Montfort 2005). A classic example of double coding in natural languages would be the sentence "Jean put dire comment on tap", which has grammatical sense in both French and English, but different meanings in each language. Thus, multiple coding becomes a way of describing the many meanings found in code, as in natural language, adding the computational field as another layer of meaning. So, we can think and argue that all programs have inherently multiple code and present the possibility for constructive interpretation. An extreme case of multiple coding could be found in esoterics programming languages. These kinds of expressions are created as an experiment or research where developers explore and extend the possibilities of code languages, sometimes even in an ironic and/or obfuscated way (Mateas and Montfort 2005). For example, Piet[5] is an esoteric programming language invented by David Morgan-Mar and named in relation to the artist Piet Mondrian, in which programs look like abstract paintings. Piet takes inputs like a picture instead of source code, and then it interprets the pixels in the picture as the code. So in this language we can clearly percibe at least three language layers (natural, machine and abstract language).

5. https://www.dangermouse.net/esoteric/piet.html

Fig. 4. Daniel Holden and Chris Kerr. Piet project.[6]

6. http://code-poetry.com/bark

3.3. Functional Language

The article *the Code is Not the Text (unless it is the text)*, published by the artist John Cayley, argues against the academic notion that computational code is itself the text we should study. According to Cayley, the figure of "code-as-text", or the interpretation of the code as the object of study "is more of a rhetorical form, of the baroque euphemism of the new media" (Caley 2002). His main argument is that many of the code-poetry studied by critics at the time, were analyzed just from the surface layer of the code. Thus, the analyzes do not delve into the functional part of the algorithms, in their interpretation as executable instructions and computable processes. Caley examines his poem Hypertalk written in a language that can be interpreted by humans and compiled by computers. From this perspective, this approach critiques proposals such as *Mezangelle* or *ALGOL* poetry, as examples of code-poetry. Although theorists such as Katherine Hayles refer to *Mezangelle* as a Creole composed of programming languages and natural languages (Hayles 2007), Caley claims that in this work the code presented is placed just as a decorative aesthetic, not making this Creole possible, since there is not really a computational language. However, the functionality of the code does not seem to be a requirement in a broad definition of the genre. In response, the article Interferences: [Net.Writing] and the Practice of Codework by Rita Raley, refutes these unnecessary limitations comparing Cayley's privilege of the code (on output) to Adorno's remarks on music as a mere consequence of the score. As she explains, codeworks do not suggest, nor don't need, that the code must itself be privileged. Therefore, Mez jobs are valid codeworks, because "they play with code structures at the display level of the text" (Raley 2002). Despite their disagreement over the functionality of code-poetry, both Raley and Cayley suggest that code is a special type of language that is worthy of the attention of scholars.

3.4. Critics to Code as Poetry

Geoff Cox, Alex McLean and Adrian Ward, in his essay *The Aesthetics of Generative Code*, compare code with poetry, while developing some techniques to interpret it. As they state, *"the code works like poetry in the sense that it plays with the structures of language itself, as well as with our corresponding perceptions"* (Cox, McLean, and Ward 2001). However, excluding some works for poetry and computer code in its broadest definition, most of the codes are far away from being considered literature. Unlike text, computer code does not usually appear to be written to be viewed by another human (however many times it is). Codes are the way we interact with computers, allowing us to convey thoughts, reasoning and choices that function as an extension of the creator's intentions. The written form is simply a logical notation that is computer-readable, and is a representation of this process. The code itself, therefore, is clearly not poetry. In addition, the artistic meaning of the code rests, as in poetry, in conjunction with its execution, not merely in its written form.

4. Codeworks from Latin Abya-Yala[7]

As with their Anglo-American counterpart, many Latin American artists have adopted a code-inspired aesthetic, creating projects that could be classified under Alan Sondheim's proposed taxonomies. In this sense we can find antecedents in some works of the Uruguayan artist Brian Mackern that fall into the first Sondheim's category. The project Wartime (2003) per example, is a codework that is situated on the invasion perpetrated by the United States and other countries to Iraq. As Mezangelle, Wartime does not use a functional programming language, but far away from mezangelle esthetical concerns, Wartime is situated in a notorious political context.

7. The ancient aboriginal civilizations that inhabited the land that Europe named America, had numerous denominations. The Aymara leader Takir Mamani invites us to revindicate the original name proposed by the Kuna culture for america; Abya Yala, which means land of blood.

Fig. 5. Brian Mackern WarTime poem.[8]

```
----- Original Message -----
From: "||| | ||||||| | ||| ||||" <vibri@internet.com.uy>
To: <wartime@area3.net>
Sent: Thursday, February 20, 2003 6:33 PM
Subject: >wartime< [ war_stmnt.txt ----->


> function setWar() {
> if (honored_Borders + power_Sickness + greed_Illness > 0) {
> for (i=1; i++) {
> death = death + i;
> poverty = poverty + i;
> misery = misery + i;
> starvation = starvation + i;
> disintigration = disintigration + i;
> local.Culture.close() ;
> }
> }
> // checked _overflow situation
> humanity.close();
> }
>
> // due to a bug of humanity object, variables can´t be reset to 0, unless
> // you make a restart of the system [kill earth object]
> // the problem with WAR is that we can´t do "CONTROL-Z"
> // the problem with PEACE is that we can´t make "SAVE AS..."
>
```

A relationship between codeworks and FLOSS in Latin America can be found in the poem *you CODE me*,[9] by the Mexican artist Laura Balboa. Balboa's poem may be in the line of not executable codes too, but it embodies the hacker's transgressive stance toward freedom of knowledge and dissemination of information through the deployment of codes and symbols. For instance, the poem highlights the concept of CopyLeft, using the expression "Viva la copyleft'' to expose the dominance of English-American culture by implicitly criticizing how English populated technological languages while "she ironically celebrates this linguistic hybridity" (Ledesma 2015). The techno-poetic works developed since 1999 by the Mexican artist and programmer Eugenio Tisselli, goes from net.art to the code-poetry. One of his first proposals entitled Midipoet[10] is a real-time image and sound manipulation computer program that allows to compose and interpret various types of works. According to the Argentine researcher Claudia Kozak, "the politicization in the practice of digital poetry has become very evident in Tisselli's works and latinamerican net-artists in general" (Kozak 2017). His codework project entitled *Degenerativa*,[11] meanwhile (2005), consists of a

8. http://netart.org.uy/wartime/

9. http://youcode.me/index.html

10. http://motorhueso.net/midipoet/

11. http://www.motorhueso.net/degenerativa/

web page that degrades the code as it is visited. This idea about the transitory and degradation is taken up in several of his proposals, particularly in his work *The27th.The27*,[12] where each time the New York Stock Exchange Composite Index closes with a positive percent variation, a fragment of the 27th article of the Mexican Constitution is automatically translated into English.

12. http://motorhueso.net/27/

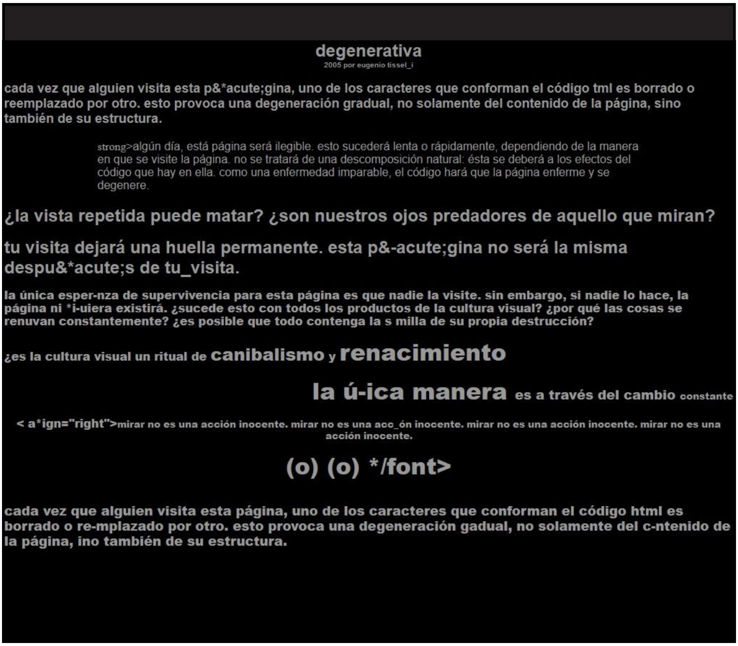


Fig. 6. Eugenio Tisselli *Degenerativa* poem.

4.1. Livecoding Yala (Livecoding land)

In the field of livecoding from Abya Yala, Hernani Villaseñor Ramírez register the first activities in Mexico, particularly since 2006, carried out by members of the Audio Workshop of the Multimedia Center (CMM), such as some concerts by the mU group, formed by Ernesto Romero, Eduardo Meléndez and Ezequiel Netri or in some concerts performed by Netri himself (Ramirez 2019). From 2009 to 2014, the aforementioned space also periodically organized livecoding concerts that were characterized by the writing of source code from scratch (a blank page), a duration of nine minutes per participation, the projection of the code to the public, participation of one live coder of sound and another of image in turn, and a predominant use of the SuperCollider and Fluxus softwares. Thus, in what griffiths entitled “the Mexican style” (Griffiths 2012), artists such as Alexandra

Cárdenas, Malitzin Cortés, Jaime Lobato or the RGGTRN group emerge, among many other artists and creatives who spread their concerns around Abya Yala.

4.2. My Abya (My blood)

My approach to the livecoding is related to a workshop that the Chilean artist Christian Oyarzún shared in the Faculty of Architecture of the University of Chile, at the beginning of year 2018. Christian, by the time, had just arrived from the International Live Coding Conference ICLC in Morelia Mexico,[13] where he was able to meet the Latin American coders. According to Oyarzún, in principle his codeworks were somewhat relegated in front of his audiovisual production. That is, although it was a livecoding proposal, the codes were just seen only by himself, while only the audiovisual results were shared. In such a meeting, the Colombian artist Alexandra Cárdenas proposes to Christian to incorporate that layer and show the process as part of the work. With that in mind, the workshop introduced us to tidalcycles software and discussed some interesting works that had been presented at the conference. In particular, he mentions the case of the Colombian artist Celeste Betancur who develops a proposal called CineVivo, with which it is possible to create livecoding using natural language (Rodríguez, Betancur, and Rodríguez 2019). That idea remained latent in me, so I initially sought to reconstruct an audiovisual work, called the transit of the Kloketen, from the poetics of Natural language coding. For this, I developed a patch in the open source language Pure Data, capable of reading from a text file, messages and arguments that would allow interacting with various pre-programmed audiovisual algorithms. My interest was to be able to point to the creative power of words, to build an identity from a decolonized language. The first live codework that I built by this way was entitled transit (it is worse than the flood),[14] was presented in the Selk'nam land Puerto Natales, a town wounded by the onslaught of colonization to the point of almost complete genocide.

13. https://iclc.toplap.org/2017/

14. Forero, Jorge (2018). El tránsito del Kloketen. Festival Internacional de Arte y Nuevos Medios LUMEN. https://forero.cl/transito/

4.3. Critical Studies from Abya Yala

While the code-poetry from the "northern hemisphere" has concentrated on aesthetic issues, in Latin Abya Yala seems it has been established from socio-political tension.

On the one hand Latin American works draw on an element of autonomy from the functional needs of the structure of code itself, while on the other, they attempt to historicize and politicize it by anchoring code in practices of Resistance (Ledesma 2015).

The presence of code in the artistic sphere, in addition to incorporating creative tools and techniques, reconfigures the notion of art itself and poses a challenge that encompasses its ontological and axiological meaning. This new writing responds to an integrating purpose of other discourses that "liberate literature from the tyranny of dogma, but it also aims to prevent it from being again engulfed by the system" (Vega 2016). Thus, and in accordance with their Latin American neo-avant-garde predecessors, these post-conceptual writings of software choose to "interrogate the political in art, in the mobile web of poetic strategies, rhetorical devices and forms of interpellation, through which the work projects and disputes its effects of meaning" (Davis 2011).

Latin American codeworks reveal its own uncertain position, making an ideological critique that bears traces of its historical context and its geographical ties with the Global South. It is, therefore, a commitment whose ethical scope entails an aesthetic response of rejection of the models legitimized by the institution. As Eduardo Ledesma argues, Latin Abya Yala presents code not as a mathematical certainty that, by its programmability, determines any outcome, but as indecisive in the, deconstructive sense of resistance to totalitarian and complete meaning or knowledge that resists the very ruthless application of codified rules or programs and casts doubt to the decision-making process, so that indecision becomes the origin of ethics and politics. Of course, for this to be possible it is necessary to intervene directly in the program, using computer code, a type of language that will always imply a degree of efficiency and usefulness even in uselessness. Tisselli reformulates this paradox by appealing to oulipian notions that you can only command language by obeying it.

5. Conclusion

As the expert in complexity Cesar Hidalgo tells us in his book *Why information grows*, although information arises naturally in systems out of equilibrium in the form of order and matter intrinsically has the ability to compute (Hidalgo 2015), communication supposes a first structure in common in the coding that structures a message. A message, as Claude Shannon states, certainly does not guarantee coherence or meaning, but rather it is constituted as a first form of information consensus.

Are we speaking the same language?

Codes and programs provide us new readings and tools with which we can critically analyze and construct cultural heritage, in a society mediated by information. For this reason, free access to source code seems to be so important by today. Knowledge cannot be privatized by and for a group. In this same sense, we must establish consensus to decode and share language. Otherwise, it will be the predominant hegemonies that will make a violent conquest of that territory (perhaps they longer do so). Livecoding and FLOSS in this sense naturally aligns themself with a critical and emancipatory perspective. Because the idea beyond proclaiming open and free access to software, warns that asymmetry in access to knowledge only promotes exploitation. In effect, it is about raising a writing that, following Eugenio Tisselli, "can break with the hegemony of economic behavior and its correlative technocracy, proposing, from language, other ways of understanding our way of existing" (Leonardo 2015).

I propose that Latin America seems to run with advantages, since we have had to survive hacking the foreign systems imposed. Hacks, for us, are a value and almost a duty. Thus, although Griffiths distinguishes a Mexican style that he proposes to build from the blank page, this proposal is far from just being aesthetic. The blank page is the possibility that we have from Abya Yala since we continually build ourselves in search of identity.

References

Anderso, David, and Ron Kuivila. 1991. "Formula: A Programming language for expressive computer music." *Computer* 24/7, 12-21.

Berelson, Bernard. 1959. "The State of Communication Research." *Public Opinion Quarterly 23* (1).

Berentsen, Mirthe. 2018. "How we became artists: Net Art duo JODI." Art|Basel. https://www.artbasel.com/stories/how-we-became-artists-jodi.

Caley, John. 2002. *The Code is not the Text (Unless It Is the Text)*. N.p.: Electronic Book Review. https://electronicbookreview.com/essay/the-code-is-not-the-text-unless-it-is-the-text/.

Chun, Wendy Hui Kyong. 2004. "On Software, or the Persistence of Visual Knowledge." *Grey Room* 18:26–51.

Coleman, Gabriella. 2014. "Hacker." The Johns Hopkins Encyclopedia of Digital Textuality. https://gabriellacoleman.org/wp-%20content/uploads/2013/04/Coleman-Hacker-John-Hopkins-2013-Final.pdf.

Collins, N., A. McLean, J. Rohrhuber, and A. Ward. 2003. "Live coding in laptop performance." *Organised Sound* 8(03) (Sound): 321–330.

Cox, Geoff, Alex McLean, and Adrian Ward. 2001. "The aesthetics of generative code." *In Proc. of Generative Art*, no. Art.

Dance, Frank, and Carl Larson. 1976. *The functions of human communication: A theoretical approach*. New York: Holt, Rinehart and Winston.

Davis, Fernando.
2011. “La invención de nuevos conceptos de vida. Estrategias poéticas y políticas en los conceptualismos en América Latina.” 143-155.

Glazier, Loss.
2006. “Code as Language.” *Leonardo Electronic Almanac* 14:5-6.

Griffiths, Dave.
2012. “Mexican livecoding style.” Dave’s blog of art and programming. http://www.pawfal.org/dave/blog/2012/11/mexican-livecoding-style/.

Hayles, Katherine.
2007. “Electronic Literature: What is it?” *The Electronic Literature Organization 1.0* (Literature).

Hidalgo, César.
2015. *Why information grows: the evolution of order, from atoms to economies*. N.p.: MIT.

Horkheimer, Max.
1972. *Critical theory*: selected essays. New York: Continuum Pub. Corp.

Kozak, Claudia.
2017. “Literatura expandida en el dominio digital.” *El Taco en la Brea*.

Ledesma, Eduardo.
2015. “The Poetics and Politics of Computer Code in Latin America: Codework, Code Art, and Live Coding.” *Revista De Estudios Hispánicos* 49.

Le Lionnais, François.
1962. “La LiPo.” First, no. Manifest (sep): 27.

Leonardo, Isaura.
2015. “Poéticas, lo humano a flote.” Entrevista a Eugenio Tisselli.

Levy, Steven.
1984. *Hackers: heroes of the computer revolution*. N.Y: Anchor Press/Doubleday.

Littlejohn, Stephen.
2002. *Theories of human communication*. Belmont, CA: Wadsworth/Thomson Learning.

Marino, Mark.
2006. *Critical Code Studies*. N.p.: Electronic Book Review.

Mateas, Michael, and Nick Montfort.
2005. “A Box, Darkly: Obfuscation, Weird Languages, and Code Aesthetics.” *Digital Arts and Culture*.

McLean, A., N. Collins, J. Rohrhuber, and A. Ward.
2003. “Live coding in laptop performance.” *Organised Sound 8*(03) (Computer Music): 321–330.

McLean, Alex, Dave Griffiths, Nick Collins, and Geraint Wiggins.
2010. “Visualisation of live code.” *Proceedings of the 2010 international conference on Electronic Visualisation and the Arts* (EVA’10), no. Electronic Visualisation and the Arts, 26-30.

Raley, Rita.
2002. *Interferences: Net. Writing and the Practice of Codework*. EEUU: Electronic Book Review.

Ramirez, Hernani.
2019. “Live coding en México: una revisión a partir del concierto “A la escucha del código fuente.”” La oreja culta. https://laorejainculta.net/2019/03/18/live-coding-en-mexico-una-revision-a-partir-del-concierto-a-la-escucha-del-codigo-fuente/.

Rodríguez, Jessica, Esteban Betancur, and Rolando Rodríguez.
2019. “CineVivo: a mini-language for live-visuals.” *ICLC 2019*.

Schrock, Andrew.
2014. ““Education in Disguise”: Culture of a Hacker and Maker Space.” Interactions: *UCLA Journal of Education and Information Studies 10* (Culture of a Hacker and Maker Space).

Sondheim, Alan.
2001. “Introduction: Codework.” In *American Book Review*, 4. Chicago: American Book Review.

Stallman, Richard.
2007. “Por qué el «código abierto» pierde de vista lo esencial del software libre.” GNU. https://www.gnu.org/philosophy/open-source-misses-the-point.es.html.

Stallman, Richard.
2013. “Philosophy of the GNU Project.” GNU. https://www.gnu.org/philosophy/philosophy.html.

Stanbridge, Alan.
2008. “From the Margins to the Mainstream: Jazz, Social Relations, and Discourses of Value.” *Critical Studies in Improvisation/ Études critiques en improvisation* Vol. 4 No.1 (Music).

Vega, Aparicio.
2016. *Software Allegorical Writings: Aesthetic Breakdown, Ethic Rearticulation, from Mexican Sphere*. Vol. 5#2. N.p.: Revista Caracteres.

Wang, Ge.
2008. *The ChucK Audio Programming Language: A Strongly-timed and On-the-fly Environ/mentality*. London: Princeton University.

Ward, A., J. Rohrhuber, F. Olofsson, A. McLean, D. Griffiths, N. Collin, and A. Alexander.
2004. *Live algorithm programming and a temporary organisation for its promotion*. London: Goriunova, O. and Shulgin, A.

Warnell, Ted, and Melton Quimby.
2012. “Code Poetry.” SCRIPTjr.nl. www.scriptjr.nl/texts/code/ted-warnell.

Zeilinger, Martin.
2014. “Live Coding the Law: Improvisation, Code, and Copyright.” *Computer Music Journal* 38 (Music): 78-89.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Art, Nature, and the Sublime in Virtual Reality

Keywords: VR, Philosophy, Aesthetics, Art, Metaphysics, Sublime

Julia Uhr
julia.uhr@colorado.edu
University of Colorado
Boulder, CO, United States

This paper addresses philosophical questions that are relevant to virtual reality (VR) developers, designers, and artists. It argues that some objects in VR really exist, and some of these virtual objects that exist are really what they appear to be. Digital art, like digital photography, 3D models, and interactive art installations in VR environments, are real art. Unlike art, nature in VR cannot be real nature, and experiences of nature in VR are illusory. However, VR nature can be real art, and VR art can elicit experiences of the sublime. This paper also offers suggestions of how to design sublime experiences in VR.

1. Introduction

When you look at art in virtual reality (VR), are you looking at genuine art or at a reproduction? When you stand on a VR beach watching the sunset, are you experiencing the beauty of nature? Are these even real experiences or just illusions? Answering these questions is important not only to philosophers but to VR developers and artists interested in creating authentic experiences in VR. This paper will draw on research from analytic philosophy, specifically in metaphysics and aesthetics, as well as research in human-computer interaction and game design to explore the questions of whether, and under what circumstances, aesthetic experiences in VR can be real. I will first address the underlying metaphysical question of whether virtual objects and events are real or illusory, concluding that they can be real and that art objects provide prime examples of real virtual things. Then I will contrast two types of aesthetic experience: first, the experience of looking at art in VR, and second, the experience of being in nature. I will argue that art can be real art in VR but nature cannot be real nature. Finally, I will examine the concept of the sublime and argue that, although art typically cannot be sublime, VR art has certain similarities to natural phenomena that make experiences of the sublime possible in VR.

2. What is Virtual Reality?

For this paper, I will use David Chalmers's definition of VR. Under this definition, VR is defined by three characteristics: It is immersive, interactive, and computer-generated. 'Immersive' means that the virtual environment "generates perceptual experience of the environment from a perspective within it, giving the user the sense of 'presence': that is, the sense of really being present at that perspective." 'Interactive' means the user's actions can affect the virtual world. And 'computer-generated' means the environment is "grounded in a computational process," (Chalmers, 2017). This definition is broad enough to encompass VR technology in its current state, including experiences available on consumer VR headsets like the Oculus Quest, as well as more speculative versions of VR in which VR becomes indistinguishable from the physical world.

3. Do Virtual Objects Exist?

To figure out whether art and nature are real in VR, we must first establish that things in VR exist, because if something does not exist, it cannot be art or nature. Views on the metaphysics of VR can be divided into two broad categories, realism and irrealism. Realist views hold that VR objects exist and events that take place in VR actually happen, while irrealist views hold that VR objects do not exist and events in VR do not really happen. Probably the most widely held irrealist view is fictionalism, which holds that VR objects and events are not real because they are fictional. The following sections will discuss David Chalmers's account of virtual realism and two counter-arguments to Chalmers's account from the perspective of virtual fictionalism.

3.1. Chalmers's Virtual Realism

In *The Virtual and the Real*, David Chalmers presents his realist account of VR. Loosely inspired by Heim (1998), the account starts by making the following claims:

1. Virtual objects really exist.

2. Events in VR really take place.

3. Experiences in VR are non-illusory.

4. Virtual experiences are as valuable as non-virtual experiences (Chalmers 2017).

To form his account, Chalmers builds on his previous paper *The Matrix as Metaphysics*, in which he argues that objects in a perfect, permanent VR (a virtual world that is indistinguishable from the physical world and persists over time) would be non-illusory, i.e., the things we call tables are actually tables; it just turns out that tables are not physical objects but virtual ones (Chalmers 2003). In his latest account, Chalmers expands this view to include imperfect and temporary forms of VR, including the types of VR experiences and games that are common today (Chalmers 2017).

Chalmers then goes on to further categorize virtual objects by distinguishing between things in VR that are what they appear to be and things in VR that are not what they appear to be. For example, a calculator in VR could be a real calculator, provided that it actually performs calculations. However, an object that appears to be a kitten in VR is not a real kitten, although it is a real virtual object (Chalmers 2017).

3.2. Counter-arguments from Virtual Fictionalists

Several counterarguments to Chalmers's realist view have been made by virtual fictionalists. Virtual fictionalists hold the view that virtual worlds are fictional worlds that do not really exist. Under fictionalism, virtual environments, like the continent of Skyrim in *Skyrim* VR (Bethesda Game Studios, 2018), are analogous to fictional environments, like Middle-earth in The *Lord of the Rings* novels. In both cases, according to fictionalists, the environment can be described, pictured, and imagined, but it does not actually exist.

Juul

In *Virtual Reality: Fictional all the Way Down (and that's OK)*, games researcher Jesper Juul argues that virtual objects cannot be real because they cannot fully replicate every aspect of the corresponding physical object in sufficient detail. For example, Juul addresses Chalmers's example of a VR calculator, arguing that to be a full-blown virtual counterpart of a calculator, "a virtual calculator would not only functionally be useable for everything a non-virtual calculator can be used for; in complexity it would not just simulate calculation, but also the electric circuits of a non-virtual calculator to a subatomic level" (Juul 2019). Essentially, Juul's argument is that because a virtual calculator cannot fully replicate the physical characteristics of a desktop calculator, it cannot be real. And by the same reasoning, no VR objects can be real because they are necessarily not identical to physical objects.

Response to Juul

The biggest problem with Juul's argument is its assumption that something must be identical to a specific, pre-existing physical object to exist. Juul is correct that VR objects must be limited or simplified in some way relative to their real-world counterparts. However, simplified things can still exist. For example, a stuffed animal shaped like a dog might be simplified and limited relative to a live dog, but it still exists. It is also possible for a simplified example of a thing to still be an instance of that thing. For example, six-sided dice are simplified relative to twenty-sided dice, but they are still dice. Even among desktop calculators, different brands and models have different circuitry. In fact, no two calculators are identical down to a subatomic level, so Juul's assumption that, to be a calculator, a thing must be identical to a specific desktop calculator, would rule out almost all of the things we usually consider to be calculators.

Moreover, Juul's requirement that, to be real, VR objects must accurately replicate physical objects seems to assume that only physical objects exist, which is clearly not true. From average rainfall to the number four to the Peloponnesian War, the world is full of things that exist without being physical objects. Most people would not argue that the calculator on their computer is a fictional calculator just because you cannot use it as a paper weight. Similarly, no one would argue that a digital clock is not a real clock just because you cannot rotate its hands like an analog clock, or that a digital photograph is not a real photograph just because you cannot rip it into pieces like a paper photo.

McDonnell and Wildman

In *Virtual Reality: Digital or Fictional?* Neil McDonnell and Nathan Wildman argue that VR worlds must be fictional because they have no causal power, and things cannot exist without causal power (Salmon 1998; Reichenbach 1958). In McDonnell and Wildman's account, things in VR are similar to things in traditional animation; they appear to cause events but do not actually.

McDonnell and Wildman illustrate their argument using the example of the cartoon characters Tom and Jerry: "Jerry strikes Tom on the head, and a lump emerges on Tom's head. We naturally describe this as a case where the strike caused the lump. Of course, there is no genuine causal relation between the frames of the animation." (McDonnell & Wildman 2019). Tom and Jerry do not really exist, as they are merely fictional characters. The real cause of the events in the cartoon is the animator drawing images and displaying them in a certain order to convey a story. Similarly, in VR, "the genuine causal interactions are between the execution of bits of code that decide which frames to render, not between the rendered frames themselves. VR and traditional animation are on a par in this respect," (McDonnall & Wildman 2019).

Response to McDonnell and Wildman

McDonnell and Wildman's argument is more convincing than Juul's, but their analogy between animation and VR applies best to objects, such as animals, that would be difficult or impossible to replicate digitally. In the example of Tom and Jerry, they are clearly not a real cat and mouse, and they are not actually moving or hitting each other; the animation merely creates a visual illusion that makes it appear as if they are physically causing things to happen. However, this paper is mainly concerned with aesthetic experiences, and there seems to be a relevant metaphysical difference between an animated mouse and an animated artwork.

Of course, it is possible for an artwork to be fictional. For example, the titular picture of Dorian Gray is not a real painting but a fictional one; although the novel that describes the painting is real art, the painting itself is not. On the other hand, some artworks depicted in fiction are real artworks. For example, the movie *Roman Holiday* was filmed in Rome, and the Trevi Fountain depicted in the movie is the actual Trevi Fountain, not a fictional fountain. Nevertheless, when people watch *Roman Holiday*, what they see is a video of the actual Trevi Fountain, not the fountain itself, but it seems possible that under some circumstances, the displayed artwork could really be the artwork itself, especially in the context of digital art. The next section will focus specifically on art and explore whether something that appears to be art in VR can really be art.

4. Virtual Art

Digital artwork exists in the world. Digital photography, video games, and streaming videos can all be art (Ang 1999; Melissinos 2012). If one digital artwork can contain another virtual artwork, it may be possible for a VR environment to contain genuine digital art. The following sections discuss digital art in VR, when it is genuine art, and when it is merely a reproduction.

4.1. Digital Art in VR

There are three ways in which digital art in VR can be real. First, a VR world can be a work of art itself. Second, traditional digital art can be displayed inside of a VR environment. Third, native VR artworks can be created specifically for display inside VR environments.

Perhaps the least metaphysically ambiguous way in which VR art is real is that a VR environment itself can be art. For example, *Eidolon360* is a VR film that places the user in the perspective of a resuscitation mannequin (Hood & Flint 2018). *Fool's Paradise* is a VR garden full of giant masks and musical compositions based on William Blake's *Proverbs of Hell* (Hertz & Dembski 2018). *Beyond the Canvas - Bliss* takes traditional oil paintings and transforms them into 3D interactive experiences in VR. Even some VR games, like Land's End (Us Two Games 2015), are stand-alone works of interactive art. All of the above examples are clearly works of art; they are analogous to digital videos or photographs displayed on a computer monitor or to video games. For the same reasons it is generally accepted that those digital artifacts can be real art, VR environments can also be real art.

More interesting are the ways in which artworks can exist when displayed inside of VR environments. This is possible when, for example, a VR art gallery displays digital photography on its walls or a 3D model is displayed in a VR sculpture garden, along the lines of Matias Brunacci's The Dome (Brunacci 2017), a virtual kinetic sculpture displayed in VRChat. In these examples, the gallery itself is not a real building, and it may or may not be a real gallery (determining the necessary and sufficient conditions of a gallery is beyond the scope of this paper), and the sculpture garden may not be a real garden. However, the digital photographs and 3D models are clearly real art.

Importantly, the above examples of art existing inside a VR environment are digital works of art. That is because all of the objects that exist in VR are virtual objects, so in order to be genuine art in VR, an artwork must be digital in its original form. Otherwise, it would be merely a virtual reproduction of a non-virtual artwork.

4.2. Digital Art Reproductions in VR

Virtual copies of physical artworks are not identical to the original artworks, and in some cases are not art at all. If we are all living in a simulation and always have been, then it seems the thing we have been calling the Sistine Chapel is the real Sistine Chapel; it just turns out to be a virtual rather than physical object (Chalmers 2003). However, if the regular world we are familiar with is not a simulation and the Sistine Chapel is, as it appears, a physical building in Rome, then a VR version of the Sistine Chapel, like *Il Divino: Michelangelo's Sistine Ceiling in VR* (Evans 2019), is clearly not the real Sistine Chapel. That is true even if the VR replica is a 3D scan of the Sistine Chapel, which, displayed in VR, is visually indistinguishable from the real thing. No VR reproduction of a physical artwork can be identical to the real artwork because it lacks the quality of being a physical object.

5. Virtual nature

A type of aesthetic experience that has recently received renewed attention in environmental ethics is experiencing the beauty of nature. However, in contrast to looking at VR art, the experience of being in VR nature is never genuine because real nature cannot exist in VR.

There are VR environments that attempt to accurately reproduce specific, pre-existing natural environments, like the Grand Canyon (Immersive Entertainment 2017). There are also VR experiences like *Nature Treks* (Greener Games 2017), which simulate natural environments that look similar to environments that really exist, with trees, mountains, deer, etc. And there are VR environments that depict completely fictional environments, like *No Man's Sky* (Hello Games 2016), which simulates the geography, flora, and fauna of alien planets. These examples may seem closer to or farther from actual nature, but they are all reproductions rather than genuine nature. That is because nature, by definition, is not made by humans or computers, while VR environments, per Chalmers's definition given at the beginning of this paper, are necessarily computer-generated, and usually designed by humans.

Although the things in VR that appear to be natural are not really nature, it is important to note that they can still be real art. However, to be art, a VR representation of nature must go beyond simply reproducing a pre-existing physical environment by applying curation or interpretation to it.

6. The Sublime

Most of us have, at some point, experienced the sublime. For example, staring up at the sky on a cloudless night and contemplating our own insignificance compared to the vastness of the universe stretches the bounds of our limited imagination and fills us with feelings ranging from helplessness to awe. Unlike experiencing beauty, which is a purely pleasurable aesthetic experience, the sublime is an aesthetic experience that mixes pleasure and displeasure. More specifically, sublime experiences may make us feel a sense of awe, danger, powerlessness, smallness, or being overwhelmed, while ultimately being a positive experience.

While the sublime has been studied deeply by continental philosophers like Lyotard, it has been out of fashion in analytic philosophy for over a hundred years and has only recently begun to receive renewed attention. Historically, the most influential account of the sublime in both the continental and analytic philosophical traditions comes from Kant. In *The Power of Judgment*, Kant distinguishes between two versions of the sublime. The mathematically sublime is characterized by vastness or infinity beyond what the human imagination can grasp (Kant 2000). Conversely, the dynamically sublime is characterized by extreme power, danger, or unpredictability, eliciting feelings of fear but also demonstrating the human intellect's superiority over nature (Kant 2000).

More recently, the sublime has experienced renewed popularity in the field of environmental philosophy. In *The Sublime in Modern Philosophy*, Emily Brady argues that the 18th century concept of the sublime is still relevant in analytic philosophy because it describes aesthetic experiences that are still valuable and important, and she offers a modern account of the sublime which is largely inspired by Kant.

6.1. The Sublime in Nature

The clearest examples of the sublime are found in nature. Paradigm cases of the mathematically sublime include mountains and the sea (Kant 2000). Paradigm cases of the dynamically sublime include overhanging cliffs, thunderstorms, volcanoes, and hurricanes (Kant 2000). All of these examples are overwhelming in size or power when compared to humans.

6.2 .The Sublime in Art

The vastness, formlessness, and wildness that characterize the sublime in nature are difficult to reproduce in art, because art objects are designed artifacts that are constrained by their media, and for that reason, many have concluded that art either cannot be sublime or can only be sublime through association (Zuckert 2012). More specifically, Brady argues that art lacks all of the following five characteristics, making it unlikely that art can be sublime (Brady 2013):

1. Vast scale

2. Formlessness and unbounded character

3. Wild and disordered character

4. Evoking feelings of physical vulnerability

5. Revealing your own interconnectedness with nature and making you see yourself as part of a larger whole

Not all five characteristics are necessary requirements for a sublime experience, according to Brady. For instance, 1 is specific to the mathematically sublime while 3 is specific to the dynamically sublime. However, things that lack all five characteristics are unlikely to be sublime (Brady 2013).

6.3. The Sublime in Virtual Reality

More than other media, VR is capable of overcoming the limitations standing in the way of sublime art, and I will argue that VR experiences can exemplify all five of Brady's characteristics of the sublime. Computer-generated environments can be infinitely large. Procedurally generated worlds can feel unbounded, disordered, and wild. VR is good at producing feelings of vulnerability by, for example, placing virtual objects around the user and restricting the user's field of view or by presenting steep drop offs. And finally, VR can reveal important aspects of humans' interconnectedness to the wider world.

Games like *Minecraft* (Mojang 2011) and *No Man's Sky* (Hello Games 2016) are set in procedurally generated worlds, meaning the environments are built by algorithms rather than being designed by people. The algorithms generate new planets, terrain, biomes, etc. as the player moves through the world, so theoretically, the player could move through the game world forever without seeing the same location twice. The vastness of these virtual worlds mirrors the vastness of the actual universe.

Similarly, VR worlds can have the "formlessness" and "unbounded character" that is lacking in other art forms. Paintings, for example, are usually small rectangular objects made of canvas and contained within frames. The boundaries of the painting are clearly defined, and to experience the painting, a viewer must stand near it and look. Paintings do not surround or engulf the viewer or contain the view within themselves, but VR environments can. From the inside, a VR world can appear boundless and unconstrained by the physical equipment producing it.

VR is also good at producing feelings of vulnerability in its users. Because the virtual world is displayed 360 degrees around the user, the user cannot see the whole world at once, which creates opportunities for things to sneak up behind the user. Unlike darkness displayed on a flat screen, which does not obscure users' view of their surroundings, darkness in a VR world is actually dark for the user. For those reasons, horror games are particularly effective in VR. Additionally, it is possible, using unconventional haptic feedback systems, to make VR interfaces genuinely dangerous, although ethical considerations weigh heavily against doing so.

It might at first seem like any computer-generated environment must lack the wild and disordered character of the natural sublime, because virtual worlds must either be designed by humans or created by algorithms, both of which tend to have more orderly and predictable results than natural phenomena. However, virtual worlds do not have to be orderly or predictable.

Finally, VR experiences may not be able to reveal much about humans' interconnectedness with nature, per Brady's fifth criteria, because real nature does not exist in VR. However, VR may be able to reveal other, equally important things about humans' interconnectedness with technology. The fact that computers can generate vast and unpredictable worlds, far beyond what we can hold in our imagination at one time, can evoke feelings of smallness and helplessness. At the same time, we can intellectually grasp the computational processes that are generating these vast worlds, and the realization that their enabling hardware and software was created by humans over many generations is simultaneously humbling and empowering. This realization amounts to an experience very much like the paradigm cases of the sublime discussed by Kant.

6.4. Design Suggestions

Artists wanting to create sublime VR experiences can start by incorporating random numbers into procedurally-generated worlds to get results that are unpredictable even to the artist. They may also want to disregard or subvert some widely-held design principles. For example, narratives in which the user is a hero whose actions determine the fate of the world are less likely to produce sublime experiences than narratives in which the user is a minor character with little power to affect the world. Similarly, clearly communicating rules and goals and nudging users towards those goals with rewards and feedback is less likely to produce sublime experiences than allowing users to wander aimlessly through an indifferent universe. In general, it will benefit artists of the sublime not to take a user-centered approach to designing VR experiences.

7. Conclusion

Some objects in VR really exist, and some are really what they appear to be. Digital art, like digital photography, 3D models, and interactive art installations in VR environments, are real art. Unlike art, nature in VR cannot be real nature, and experiences of nature in VR are fictional. However, VR nature can be real art, and VR art can elicit experiences of the sublime.

References

Ang, Tom.
The Art of Digital Photography. 1999. New York: Amphoto Books.

Bethesda Game Studios.
2018. Skyrim VR.

Brady, Emily.
The Sublime in Modern Philosophy: Aesthetics, Ethics, and Nature. 2013. New York: Cambridge University Press.

Brunacci, Matias.
The Dome. 2017.
https://www.matiasbrunacci.com/thedomevr.html.

Chalmers, David.
2017. "The Virtual and the Real". Disputatio 9 (46): 309-352.

Chalmers, David.
"The Matrix as Metaphysics". 2005. In Philosophers Explore the Matrix, ed. by C. Grau. Oxford University Press.

Evans, Christopher.
"Il divino: Michelangelo's Sistine ceiling in VR". 2019. ACM SIGGRAPH 2019: Virtual, Augmented, and Mixed Reality. Association for Computing Machinery, New York, NY, USA.

Greener Games.
Nature Treks. 2017.
https://naturetreksvr.com.

Hello Games.
No Man's Sky. 2016.
https://www.nomanssky.com.

Hertz, Paul and Stephen Dembski.
"Fools Paradise: Intermedia in VR". 2018. xCoAx 2018: Proceedings of the Sixth Conference on Computation, Communication, Aesthetics, and X. Porto: University of Porto.

Hood, Beverley and Tom Flint.
"Eidolon360 – A VR Experience". 2018. xCoAx 2018: Proceedings of the Eighth Conference on Computation, Communication, Aesthetics, and X. Porto: University of Porto.

Immersive Entertainment.
The Grand Canyon VR Experience. 2017.
https://store.steampowered.com/app/407710/The_Grand_Canyon_VR_Experience.

Juul, Jesper.
"Virtual Reality: Fictional all the Way Down (and that's OK)". 2019. Disputatio 11 (55):333-343.

Kant, Immanuel.
Critique of the Power of Judgment, ed. Paul Guyer, trans. Paul Guyer and Eric Matthews. 2000. Cambridge: Cambridge University Press.

Lyotard, Jean-François.
The Inhuman: Reflections on Time, trans. Geoffrey Bennington and Rachel Bowlby. 1991. Cambridge: Polity Press.

McDonnell, Neil and Nathan Wildman.
"Virtual Reality: Digital or Fictional?" 2019. Disputatio 11 (55):371-397.

Melissinos, Chris, Patrick O'Rourke, and Smithsonian American Art Museum.
The Art of Video Games: From Pac-Man to Mass Effect. 2012. New York: Welcome Books.

Mojang Studios.
Minecraft. 2011.
https://www.minecraft.net.

Mundry, Tonio.
"Beyond the Canvas/ Bliss". 2020. xCoAx, 2020: Proceedings of the Eighth Conference on Computation, Communication, Aesthetics, and X.

Reichenbach, Hans.
The Philosophy of Space & Time. 1958. New York: Dover Publications.

Salmon, Nathan.
"Nonexistence". 1998. Noûs 32, no. 3: 277-319.

Ustwo Games.
Land's End. 2015.
http://www.landsendgame.com.

Rachel E Zuckert.
"The Associative Sublime: Gerard, Kames, Alison and Stewart". 2012. In Timothy M. Costelloe, ed., The Sublime: From Antiquity to the Present. Cambridge: Cambridge University Press, 64–76.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Three Spaces

Keywords: Collaboration, Spatiality, Transversality, Un-synchronisation, Relaying

Hanns Holger Rutz
rutz@reagenz.at
University of Music and Performing Arts Graz. Institute of Electronic Music and Acoustics, Graz, AT

Nayarí Castillo
castillo-rutz@tugraz.at
Graz University of Technology. Institute of Spatial Design, Graz, AT

We register a need for novel ways of collaborative artistic work beyond solitary authorship or functional differentiation, on one hand, and unified, synchronised collective production, on the other hand. We propose that a transversal understanding of different kinds of spaces—spaces of thought, aesthetic spaces, and physical spaces—leads to a method for this envisioned new collaborative approach, and to include a horizontal nexus between spatial functions (workspace, exhibition space). We present three study cases and experiences that informed our approach, suggesting particular techniques that facilitated a "singular plural" perspective on artistic creation. We finally ask how this may help addressing the limitations of artistic online work.

1. Evacuation

One of the most pronounced transformations induced by the measures of controlling the pandemic was the way we could access and use spaces. Like many of the other effects, this transformation amplified differences between groups of people: Those that lived in nursing homes and those that did not, those that lived in houses and those that lived on the street, those that could move their work "home" and those that could not. Artists both in the performing arts and in the fine arts were affected by suddenly losing common spaces for showing their work such as concert venues, clubs, museums and galleries. There are different opinions on whether we will ever return to these spaces in the same way, or to what degree the transformation will create permanent change to art spaces. In many regards, the digital or virtual space of the Internet was used as a new "place" to which activities shifted. Although one may disagree to what extent this shift was rather a loss or a win, showing work online was certainly radically different from doing so in physical venues, and the same goes for the experience as a member of audience.

Taking a step back, many artists moved from the question of how to show their work to the question of how to make the work in the first place. The permeability between workspace and exhibition space was suspended. What was the purpose of building something if it would not be translated into an exhibition venue? And if everything was just virtualised, what use is a studio space other than a backdrop to video calls and providing a desk for a computer to sit on?[1]

1. The backdrop problem was conveniently solved in software so that you were soon conversing with people who presented themselves in front of imaginary beaches.

Some artists were literally evacuated from their studios, when that space was shared among different people who had to quarantine and could no longer enter their common spaces. The notable exception to isolation was the "common household". Another exception during lockdown was to be allowed outside to reach your workplace. We found ourselves in the luxury situation of both having a studio space separate from our apartment, and sharing it between us as members of a household. Being able every day to take the walk to the studio, and at overlapping times sharing that "same" space *for* work, even though not working *on* the same thing, amplified the defining qualities of spaces: a sociality that still permits everyone in the space to take a distance to one another.

2. Instantiating Spaces for Making-With

An unshared space is impoverished in terms of relationality, it can become solitary confinement or at best hermitage. As we are now plotting the strategies to return to prior spaces or to create new spaces, it is with regard to how it becomes possible to meet and cross paths. This awareness has the potential to alter the fabric of art-making itself, if we develop a deeper understanding how the different kinds of spaces and different functions of spaces are interconnected. While some policymakers, especially in the cultural sector, have welcomed the opportunity to raise the flag of regionalism against what they perceive as a dominance of globalism and disrooted global elites, such deepening of space/place understanding is not meant to attribute higher value to some types of space—local over global, physical over virtual—but to advocate for a transversal approach that addresses one of the most pressing issues: How to live and work together, despite an increasing societal fragmentation and segmentation.

Collaboration is driven by different objectives in different realms, for instance productivity in the economical sphere. Yet, across the board, a positive effect is usually acknowledged when collaborative practices are enabled—in research, for example, interdisciplinary collaboration is located at the heart of innovation (Löwy 1992). However, there is often a gap between ideal and practice, when facing failures of working together, stemming from difficulties to cross cultural and linguistic boundaries and from the resources needed (Nowotny 2017). In the arts, the challenging boundaries are between artists and audience—what has been attempted to cross in the form of “relational aesthetics” (Bourriaud 2002) or under the umbrella term of participatory art (Bishop 2012)—or among artists when it comes to authorship and control over aesthetic decisions. Traditionally, democratic principles such as finding compromise run against ideals of perfection, rigour, radicality and intransigence. The solutions to maintain uncompromising aesthetic command include taking complementary positions within an art project (e.g. composer vs. musician or choreographer, director vs. producer or writer), developing carefully balanced long-term relationships (often duos), or forming collectives that assemble under a common programme or manifesto.

The article proposes to develop artistic processes of collaboration that take a third position beyond constructing unified collective works of art or mimicking social interaction, on the one hand, and beyond returning to an evidently obsolete production by the isolated artist, on the other hand. How is it possible to allow mutual contaminations, without succumbing to the standard proceeding of collective action?

Space and spatiality can play a crucial role for such endeavour, both in terms how instantiating space and operating in spaces form a tacit experiential layer and knowledge that is already shared among us. This fundamental spatiality has been compellingly described by Jean-Luc Nancy using the preposition with (Nancy 2000). There is a genuinely "singularly plural coexistence" in which everything that matters happens in the between of beings that are incomparable or inassimilable, strange to each other, as a positive affirmation that does not attempt at undoing this incomparability. It is spatial because there is no individual or origin that could claim to be at a centre, instead the originary action is *distancing* in order to be-among. Nancy calls this distancing or spacing "curious", since the fundamental alterity around us is never obtainable. Violence begins with the attempt to appropriate the other origin (individual's position), and what must be imagined instead is a community "without common origin", instantiated by circulation which is the form of being-with (according to Nancy the *only* form of being itself, which would simply implode if it were not shared).[2] The important aspect of this conception is that the positions of the individuals never coincide, which is why it is immune to the totalisation usually implied by processes of collectivisation.

2. As noted by a reviewer, the idea of an originary being as being-with can already be found in Martin Heidegger's Being and Time (Heidegger 1967, §25–27). To be clear, Nancy develops his text, which was in response to the Bosnian War, partly in relation to Heidegger, but is often critical, for instance of the almost cultural pessimist undertones of the everyday distancing towards averageness without polymorphy and polyphony, where the "theme of existential 'distantiality' immediately reverts back to competition and domination, in order to open onto the indistinct domination of the 'one' ['Das Man']." (Nancy 2000, p. 82).

How would being-with be further specified and operationalised as a working-with? It seems one has to build on the element of curiosity without appropriation. One other thinker that develops a fitting concept of transformative practice is Isabelle Stengers. Also sceptical of consensus-forming, she borrows the term *relaying* from Deleuze and Guattari to describe a form of sharing that avoids appropriation and collapse of positions (Stengers 2017). More than simply passing on, relaying is understood as a practice that alters what is passed around. Similar to Donna Haraway's response-ability, it is never a "general" technique abstracted from what is handled, it is not a hollow container concept of communication channels, but the act of relaying is specific and bidirectional, indeed it poses more responsibility on the one who receives the offer than the one who offers. The one who offers must endow the offer merely with a concern which "must be such that it is liable to be shared with those who arouse it, liable to add new dimensions to the issue", whereas the receiver should "never idealize, … never demand or even hope that what one relays will be true to one's ideal". The receiver / relayer is not meant to be indifferent, they should be, to use Nancy's words, curious about what is received, and to stay faithful to the concern, it transforms to become a shared concern, it now must concern the relayer as well, they have to "inherit the trouble" (Haraway 2015).

In the following we will argue that the different kinds of spaces interacting in art-making practice form a suitable substrate for operations of relaying, and support the curious distancing more abstractly proposed by Nancy. This will be exemplified by multiple installations carried out using some of the ideas presented here.

3. Kinds of Spaces

Although it is of course possible to draw different categorisations or names, we want to focus on three kinds or principal modalities of space: Thought space, aesthetic space, physical space. They are spaces in the sense that despite their heterogeneity, they be defined through common descriptions such as boundaries, distances, and movement, and they can be researched based on distribution of different positions, isolation and boundary-drawing, and differentiation and intersection among them (Weinfurtner and Seidl 2019, 2).

Thought space captures the spatiality of developing, navigating, connecting thought, the movement between ideas, the circulation of "thinkables" (Frichot 2019, 174), a distribution of related things which one tries to tie together, but also the tension of isolation—the privacy of our thoughts, resistance to communication—and intersection, the thinking-with, embodiment and encounter that is needed to produce thoughts in the first place. With notation and utterance, it becomes a discursive space, a space that can be established ad hoc between humans as they act and speak, finding a "proper location almost any time and anywhere" (Arendt 1998, 198). It is not necessarily a verbalised space, but the play of various senses in our imagination, enactments and reenactments for our mind's eye and ear, the tentative space created by speculation—what if?

Aesthetic space refers to the spatialities composed and articulated through artworks or the non-functional surplus of design. These spatialities can be sensual or atmospheric as is almost the defining quality of installation art (Bishop 2005) and sound art (Ouzounian 2013), but also abstract as the poetic concept-space or the computational space of a new media art piece. It is the artist's positioning of elements relative to each other, it is opening the cleft *between* them, it is the play of foreground and background, opaque and transparent, what is said and what is not said. It is the offering of possible traversals for the audience. It is also the space created *by* the audiences as they allow themselves to get involved with a piece, it is the space opened between the artist and the audience.

Physical space may seem trivial. The space in which one works, the space in which one performs or exhibits. But physical spaces are of course always imbued with historical conditions and political implications, and the art history is ripe with disputes over the appropriateness of dedicated spaces for showing art and performing music. The same goes for the spaces in which art is produced or research is being conducted before it is shown or published. For example, in her look "behind" phenomenology, Sara Ahmed begins at the site of Edmund Husserl's elaborations—his own writing room that conditions the way he can even begin to formulate his philosophy (Ahmed 2006). Extending the ordinary notions of position and background, she notes the co-presence of another *type of background*, relegating the unheeded and familiar of Husserl's surroundings to the background while singling out elements that he orients his direction towards. Who cleared or prepared his working table? Something "must take place in order for something to appear". By turning the focus around from "bracketed" or pure foreground to facing the back, Ahmed proposes a meta- or ethno-phenomenology, including the historical trace of the body that eventually arrives at the table to begin the work of writing. We want to call the work that has been done to prepare and make actionable the artists' workspace an investment, following Hans-Jörg Rheinberger's observation that a lab or studio is also "an epistemic work-space with a lot of intellectual as well as material investment, an investment that tends to disappear in the product" (Rheinberger 2013, 217). We propose that studying the form of joint investments by multiple artists working together, and making the traces of these investments perceivable in the artistic "product", are critical components in the development of new ways of making-art-with.

4. Spatial Operations and Transversality

It should have become clear that there is inherent complexion when conceiving spaces. For analytical purposes, they can be separated by kind, but when beginning to describe what happens in these spaces, one quickly moves horizontally to include other criteria such as function—workspace, exhibition space, discursive space, refuge. In the examples of Husserl's writing table, or the artist's studio investments, spaces are not made by static positions insides containers, but dynamically created by traversals, arrivals, disappearances. The different kinds have affinities to one another. When you enter an art installation, do you not ask: How did all that you notice come here? Is there evidence of the space the artist worked in when making the piece? Were there several spaces and several artists involved? How can we understand prior doings and selections that gave importance to what is among the things to be found? What happened in the spaces of creation? The working space "figures" in the work itself, it con-figures the work. The notions of agency or the variable extent of "context and scope" could be used to describe this horizontal blurring (Gunnarsson 2021).

For the vertical movement between thoughts, aesthetics, and architecture, we propose spatial operations that aim not at treating these spaces as interchangeable, not at bringing them into congruence, but that can be applied transversally to them. In a similar scenario, describing the interlinkage of different kinds of ecologies, Félix Guattari called for a strategy of heterogenesis, which can be read as a sort of spatialisation in Nancy's terms of curious spacing, a "continuous resingularization" in which individuals "must become both more united and increasingly different" (Guattari 2000, 69). Spaces allow for the assembly of heterogeneous things (artists, tools, thoughts, artefacts) in no particular order, order is established by traversal, not once but again and again, constituting such continuous resingularisation, and by this ongoing traversals the spaces are made and remade.

We want to describe some examples of spatial operations. Coming from a background of architecture, and departing again from togetherness and being-with as the foundation of space, Franziska Hederer proposes an action of "enspacing" oneself, which presupposes continuously being within and beside oneself, an interplay of taking part and distancing. One works equally with what one encounters by chance and what is brought along, causing "unforeseen yet nonetheless intimate moments of varying density to arise. Those moments—in the form of objects, actions, images, installations, words or sentences and things, all capable of shifting, abolishing or newly constructing spatial borders in places one would not have expected them—put a new complexion upon the space itself" (Hederer 2010). Hederer is interested in how one inhabits a space, becomes familiar with it or questions its familiarity. She proposes to go beyond conventional codes and push oneself to the limits, moving to "the fringes of a system, towards its boundaries, where the inscribed ordering principles start to oscillate and threaten to slip into chaos; failing every-day rules, so to speak; moments of wonder, of uncertainty, exceptional situations." It is noteworthy that it is those marginal positions that she calls *neutral* and that set something new into motion without coming to a rest. What is set into motion includes *thought models*, and accordingly the neutral points can be understood as locations for moving transversally from architectural space to thought space, and this operation can be expanded, for example in the case of sound art, to perform the space looking for the neutral points that lead to aesthetic events and decisions.[3]

3. Alvin Lucier begins workshops searching with his students for particular points in space, a practice also used by other sound artists.

While the description of enspacing is implicit about the multiplicity of bodies, we want to focus more directly on what happens when artists share thought spaces, aesthetic spaces, and physical spaces. The terms that best describe how heterogenesis can be spatially supported, are *simultaneity* and *un-synchronisation*. By simultaneity, one usually understands the co-occurrence of elements at the same time—Latin *simul* means 'together, at the same time'—a togetherness but in independence from one another; not one has caused the other, not one is in a hierarchically distinguished position. If one removed the independence, elements would become temporally aligned or synchronised. Yuk Hui describes our general technological condition as increasingly synchronising towards a universal episteme, against which he posits a radical alterity (Hui 2016, p. 30). The active measures taken in this direction, we want to call un-synchronisation. It is somehow difficult to think un-synchronising in terms of digital objects, because the domain of the digital and computation is usually thought of in the regimes of connectedness, networking, interlocking. However, one can nevertheless create models of un-synchronisation or simultaneity *with* computational processes (approaching them in a different way), and the humans / artists irreducible from such models.

5. Method of Collaborative Work

Our work method proceeds through multiple phases, as depicted in Fig. 1. The group forms in a preparatory phase; heterogeneity among the artists with respect to their media and practices is advantageous, also the need to getting to know each other (there are always included constellations where artists have no ongoing long-term work relation, there is an intrinsic curiosity among them). They agree on the implementation of the method and a code of conduct to avoid conflict and misunderstanding on the intended process. Other than that, the process guarantees a high degree of independence, individual tempo and rhythm. For the principle work, physical exchange is essential, although the members of the group may work in separate studios or labs and only come together or visit each other in intervals. The different kinds of spaces are depicted as surfaces or boundaries, interpreting the overall situation as a sort of "cloud chamber" that makes the different artists' trajectories visible (audible, readable ...) through condensation on these surfaces. In the beginning, this surface is initially formed by the thought space, while the working spaces remain "open" and more distant in the background. The ideas developed are spun into threads that are negotiated, explicated and presented in gatherings. This is inverted in a subsequent intensive phase: The group installs itself in a particular architectural space; now the physical space, its particularity, and the coinstantaneous occupancy become the surface that structures and aligns the group's process, whereas conceptual constraints are lifted. After this intensive phase, the group members return to their respective labs and studios, enacting a form of distancing and decorrelation. Only after this movement away from each other, are the artistic products (exhibition, workshop, publication) brought together. Here, the different aesthetic spaces that were evolving over time in parallel now intersect in a public display. This display is not a "group exhibition" or show of "group residency artefacts", but makes visible what has been circulated and relayed in the process.

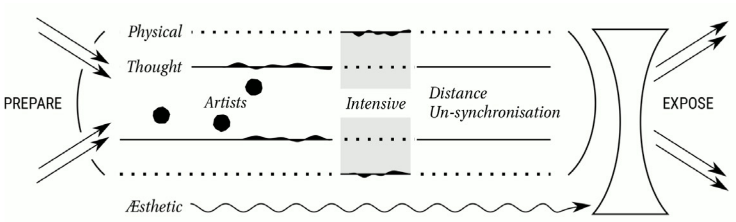


Fig. 1. Method for collaborative work through transversal spatial practice.

To structure the work, we have deployed and we are suggesting to deploy a variety of techniques, for example: *Framing the Inquiry*—elaborating questions that can be useful for others. *Circulation*—the capacity to come and react towards what others are doing, leaving behind a trace of the reaction, and giving the element reacted on possibilities for expansion, shaping the reaction so that it can eventually return to the others. *Continuous Notation*—the expedience of verbalisation methods (text production) differs largely across the individuals within a group process, so other forms of narration are mandatory. The "import" of each artist's form of notation can reorder the group process. Also collecting and prompting material among others is an important way to construct a significant analysis. *Temporary Bridging*—to come together and establish ephemeral bridges among artists. There are different scales of these rendezvous, some are mini-condensations, some more involved, creating a connection between different artefacts, e.g. exchanging data, sending pings, creating a physical contact between elements. *Distancing*—traces may develop in the form of "canopy shyness", a mutual distancing to produce gaps between the artists. It is also a common undertaking in most art media to repeatedly dissociate from the process and observe it from distance.

A certain fuzziness in the interpretation of these concepts is not disadvantageous, since rudimentary concepts can integrate heterogeneous actors and techniques, facilitate interactions and the circulation of thoughts among a group of people without threatening the individual identities, making them partially negotiable and "adaptable to local sites", improving communication and cooperation (Löwy 1992, 374f).

6. Study Cases

The work method is based on experiences from prior projects, a selection of which we briefly present here. To begin with, *Chain Reaction* (2016)[4] was a series of loosely connected interventions in the public space of a small Styrian town. The in-situ working phase of five artists produced something similar to the thought space condensation of Fig. 1, and is an early validation of the hypothesis that the working environment—here a small workshop studio / project space as "home base"—plays a crucial role in facilitating the circulation of materials and concepts without making "unified pieces". We were curious in what the others were doing, but there was no direct interference. An example of two elements created simultaneously were an analogue pinhole camera series and a digital exposure process using a peculiar "development" algorithm. Each existed in their own individuality, but they shared interest in a way of observing that was never verbally exchanged (Fig. 2).

4. https://www.sciss.de/texts/med_chainreaction.html (accessed 12-Apr-2021)

Fig. 2. *Chain Reaction*. Top: un-synchronously created artefacts, a digital long-term exposure process and analogue pin-hole photography. Bottom: work- and project space, sound installation in a cellar.

A differently constructed project was *Iterations* (2017–2020)[5], which attempted to understand moments of collaboration by enabling artists to come together in residency and exhibition processes in multiple countries, and focusing on digitally networked contexts to create speculative works around collective operation modes (Fig. 3). Open source methodologies originating from the digital realm were translated into analogue art-practices. Seeking a common production, the experiments demanded particular group dynamics hard to isolate. Each institution that was in charge of a residency imprinted particularities on the creation process, beginning with the institution's typical selection process for invited artists. The different spaces represented equally impacted the process of creation by articulating materialities, and ways of in-situ production and embedding in the local scenes and towns, resulting in variations from a large number of artists (around 40) engaged with theatre pieces and work in public space, to smaller groups (seven artists), engaged in a more intimate situation and strongly situated relation with the gallery space. This double agency of institutional strength and spatiality needs to be seen necessarily as a political influence over the artistic product—coming together by decision stipulates then a form of arrival with less freedom, at least than would be the case in the

5. https://iterations.space (accessed 12-Apr-2021) conditions of a self-directed collective formation. As Stavros Stavrides writes, common space "is both a concrete product of collectively developed institutions of sharing and one of the crucial means through which these institutions take shape and shape those who shape them" (Stavrides 2016, p. 7).

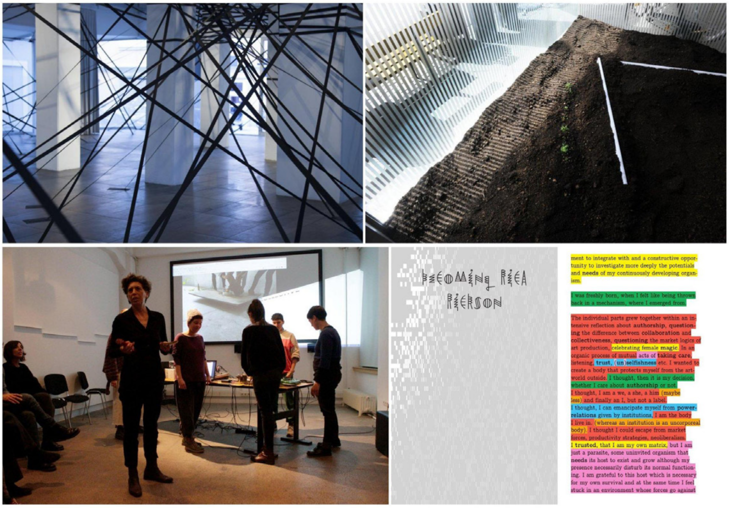


Fig. 3. *Iterations*. Top: Two collaborative installations *Net of Iterations* and *Collaboration Contamination*. Bottom: Handover event and collaborative publication.

During the different stages of *Iterations*, it was possible to distinguish some conditions of the collective process. The contact or synapsis is the first approach that occurs among the artists, getting to know each other through activities of leisure (cooking, eating, smoking), and it seems to be fundamental to establish a minimal base of trust to start the co-creation process. This process is not a complete dilution of one in another, it seems to happen as a sort of membrane by which information is being filtered. It was interesting to see the use of resources of communication, e.g. the "padding", the traces of which could be seen as a form of positive *contamination*. It requires the flexibility to understand the other and, at the same time, the strength to keep individuality, even if in the end we find a form that does not belong to one or another. A process that partly centred around dialogical argumentation proved contradictory to the collective process intended, which is not dual but multiple, and varies in intensity and form depending greatly on the group. As any experiment, *Iterations* revealed some problems, originating in this case in the group consolidation form. For each residency the group came together through an artificial situation, where the previous experience as a collective was inexistent. This lead to focus on daily subsistence and internal dynamics, rather than on the common production. The artificial dynamics also arose discomfort among some artists, who felt the incursion of a laboratory test. The tension between the common product, mostly in the realm of ideas, and the ownership opened a question that seems to be the initial preposition for the institutions—a common process will lead to a common produce. But there is really no unique product born out of the residencies, even if in some cases the artists became a unified acting group, a collective with new a body and the personality of "Rica Rickson", a fictive collective persona that represented the voice of the group. Despite placing the results under commons licenses, it still remains unclear how it is possible to distribute or further use this new compound work and the material at hand. A form of separation is needed, also to balance the dominance of strong personalities, common in a group of artists, that can override the experience of the quiet ones.

Fundamental to *Iterations* was the *handover*—a self-directed action to pass over some of the knowledge of the previous iteration. These actions were very different: The first handover was a song in Sicilian language, given to a group of the participants of the next iteration; the second handover took place in Vienna, with the re-enactment of a performance conceived in Barcelona. A physical and third handover in Brussels contained different elements of an installation in Graz. Each time, other materials were also passed from hand to hand (code, photographies, recordings). The gift exchange can be seen as an anarchist element that assumes "that it is not when a part of the self is inhibited and restrained, but when a part of the self is given away, that community appears" (Hyde 2007).

The third experience was *Through Segments* (2020), a collaborative sound installation among four artists, each developing their own real-time algorithms that listen into the storeys of a staircase space, taking an acoustical image of the visitors' movements, forming four individual reactions that intersect in the space (Fig. 4). It is a poetic attempt to think about the distributed, the fragmented, the parallel, thus reflecting within the work on ways of working together through transversal spatiality. The project was implemented during several months of documented online working sessions. The artists came together to think, sketch, code, compose independent layers of the installation.

The initial attempt to depart from a "common algorithm" which would be differently interpreted by each artist failed, because once someone suggested an algorithmic idea, it already reflected a bias by their personal investment in it, while an intrinsic motivation for the others was missing. We then reversed the motion, in a form of simultaneous arrival, heading for a *common* site not as a starting point but as the eventual conjunction of our trajectories, by bringing together our parallel work processes on the Research Catalogue online platform,[6] while the particular exhibition site remained a force of condensation that united the individual approaches. Actions included formulating questions for the others to reflect their own doing, developing log books next to each other, interlacing ideas and statements. It was important to be able to move between textual production and showing sound experiments and non-verbal sketches to the others. The movement between thought space, aesthetic space, and eventual physical space, could be read in the set of questions.

6. https://www.researchcatalogue.net/view/711706/711707 (accessed 12-Apr-2021)

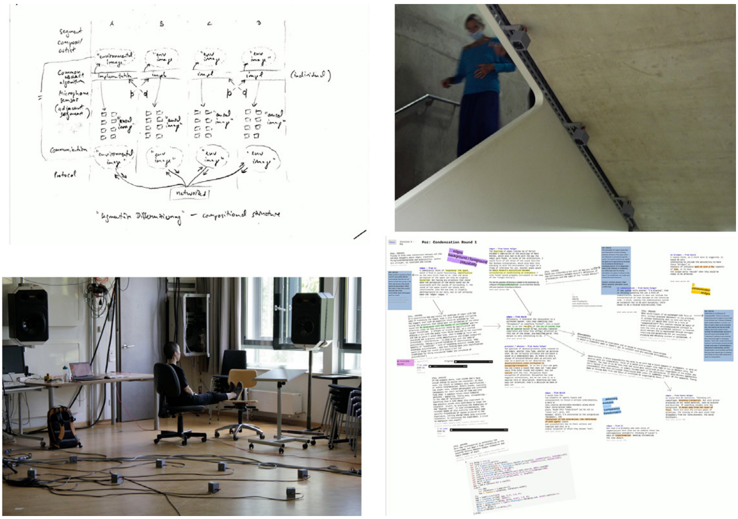


Fig. 4. *Through Segments*. Top left: Early sketch of the interleaving of the four artists / systems. Top right: Installation view. Bottom left: Meeting and prototyping in the lab (IEM CUBE). Bottom right: Research Catalogue page with one artist's (Daniele Pozzi) condensations from the first round of questions.

A condensed version of one example from the first iteration of each artist: *Reverberation*—what is the role of reverberation, its causality versus an inner movement (radiation, vibration) of things, people. Is it a volume, a form, accidental, reflection or complement? Does that become part of the piece? [7] *Deviation*—everything our works will inject into this space will change it, and cause the space's acoustic characteristics to deviate from their behaviour. Can these deviations be somehow subject to composition? How could it be possible to "compose" which "form" the deviations we will provoke have, and how big these are? *Edges*—the museum building has an outside media installation surface that is highly integrated into the architecture in a way that it does not feel like an addition, a separate entity, but rather a sort of skin that is part of the building itself. A text on the building talks about the absence of a recognisable boundary, and it could be interesting for us to include a similar reflection in our project. How can we create a situation where the environment and our work are perceived

7. This question was accompanied by two sound files.

as a single entity, rather than as two separate units (background / piece)? What would it mean for our installation to have (acoustic) "edges" that are not always perceptible? *Bridges*—can (a) bridge(s) be included in your segmentation networks? If so, do they have a direction? Are they (is it) supposed to be one directional, two, or more? If there are more than one bridge, do they look identical or not? Can they function to extend the whole network? Would they be recognisable, having their own duration and standing as a segment?

What is interesting is that this technique allows both very different ways of posing "questions" to appear, and at the same time one immediately senses points of contact between the different voices. The technique was elastic enough to allow a self-directed evolution, yielding for example a derived technique we called "pinning", selectively copying and pasting materials from the other collaborators' hyper-texts onto new personal subpages (pin boards). The necessity to meet physically in space was made possible during the summer of 2020 due to the short period of lockdown easing, and this allowed us to conduct sound experiments together in the same space, even though everyone was working in their own rhythm and focus most of the time. During setup of the installation in the exhibition space, the absence of one of the artists (Ji Youn Kang) due to new travel warnings was clearly felt, confirming the importance of the in-situ contact.

7. Irreducibility of the Spaces?

In the method described, and in the study cases presented, it is evident that the three spaces—of thoughts, of aesthetic propositions, and of physical work and exhibition—are indispensable. Each of them provides ways for moving into the other, and most importantly enables their own forms for curious spacing and enspacing of the artists, permitting a new type of collaborative work to emerge that is not subsumed in a unified collective work, but that preserves the individuality and otherness of all participants.

To return to the initial scenario, why is it not possible to satisfyingly contain these spaces "within" virtual and online, purely digital spaces? It is no coincidence that online platforms seem to work much better as workspaces than exhibition and performance spaces. The sketching and thinking, the thought space, has an affinity to the digital space whose evolution has optimised it for text and hypertext. To assume that it can convey the richness of modalities through audio-visual "windows" and rectangles, may be a similar fallacy as mistaking "the brain" for the entire human being and the omission of the "unthought" throughout periods of the history of cognition. We suspect, however, that the main reason for the frustration with art experiences online stems from the missing distance and detachment of the screen. This seems counter-intuitive, as spatio-temporal distances are at play between the art making and the audience—the artists have never been in your apartment—but the unconditionality of the way the screen-work requires attention could be seen as a particular form of synchronisation. "A barefoot hiker told me once that the reason we're drawn to screens is that we're looking for fire ..." (Braverman 2020) Unlike the real fire, the screen enforces a uniform technological regime which can result in disorientation (Hui 2019).

This is not to suggest that online spaces be written off, on the contrary, new strategies must be developed that address the lack of un-coupling and un-synchronisation with the screen. The digital online space in its affinity with text shares language's problem that it "does not easily lend itself to showing the 'with' as such, for it is itself the address [unconditional coupling] and not what must be addressed [the multiplicity of not assimilable individuals]" (Nancy 2000, p. xvi, our additions in brackets). Perhaps we can neutralise this address, provide the neutral points of the enspacement of the one who sits in front of the screen, by thinking this space more radiophonically, as the superimposition or simultaneity of the aesthetic and sensual space with the private space of the audience. Perhaps we need to develop new forms of "instructions" for an alternative address, for ways that the audience can perform its own incompatible traversal.

References

Ahmed, Sara
(2006). *Queer Phenomenology: Orientations, Objects, Others*. Durham and London: Duke University Press.

Arendt, Hannah
[1958] (1998). *The Human Condition*. 2nd edition. Chicago and London: University of Chicago Press.

Braverman, Blair
(2020). *Why We'll Always Be Drawn to Campfires*. Online: https://www.outsideonline.com/2413977/ode-to-campfires (accessed 12-Apr-2021).

Bishop, Claire
(2005). *Installation Art*. London: Tate Publishing.
(2012). *Artificial Hells: Participatory Art and the Politics of Spectatorship*. London: Verso.

Bourriaud, Nicolas
[1998] (2002). *Relational Aesthetics*. Trans. by Simon Pleasance and Fronza Woods. Dijon: Les presses du réel.

Frichot, Hélène
(2019). *Creative Ecologies: Theorizing the practice of architecture*. London: Bloomsbury Publishing.

Guattari, Félix
[1989] (2000). *The Three Ecologies*. Trans. by Ian Pindar and Paul Sutton. London: The Athlone Press.

Gunnarsson, Bjarni
(2021). *Context and Scope*. url: https://www.researchcatalogue.net/view/540350/540351 (visited on 12/02/2021).

Haraway, Donna J
2015. "A Curious Practice". In: *Angelaki* 20.2, pp. 5-14. doi: 10.1080/0969725X.1039817.

Hederer, Franziska
2010. "The Adventure of Arriving". In: *Upon Arrival*. Spatial Explorations. Ed. by Katharina Bantleon and Margit Neuhold. Graz: Centre for Intermediality Studies in Graz, pp. 15–20.

Heidegger, Martin
[1927] (1967). *Sein und Zeit*. Tübingen: Max Niemeyer Verlag.

Hui, Yuk
(2016). *The Question Concerning Technology in China: An Essay in Cosmotechnics*. Falmouth, UK: Urbanomic.
(2019). "What Begins After the End of the Enlightenment?" In: *e-flux journal* 96.

Hyde, Lewis
[1979] (2007). *The Gift: Creativity and the Artist in the Modern World*. New York: Vintage Books.

Löwy, Ilana
(1992). "The Strength of Loose Concepts—Boundary Concepts, Federative Experimental Strategies and Disciplinary Growth: The Case of Immunology". In: *History of Science* 30.4, pp. 371–396. doi: 10.1177/007327539203000402.

Nancy, Jean-Luc
(2000). *Being Singular Plural*. Trans. by Robert D. Richardson and Anne E. O'Byrne. Stanford: Stanford University Press.

Nowotny, Helga
(2017). "Prologue: The Messiness of Real-World Solutions". In: *Investigating Interdisciplinary Collaboration: Theory and Practice Across Disciplines*. Ed. by Scott Frickel, Mathieu Albert and Barbara Prainsack. New Brunswick, NJ: Rutgers University Press, pp. 1–4.

Ouzounian, Gascia
(2013). "Sound installation art: from spatial poetics to politics, aesthetics to ethics". In: *Music, Sound and Space: Transformations of Public and Private Experience*. Ed. by Georgina Born. Cambridge: Cambridge University Press, pp. 73–89. doi: 10.1017/CBO9780511675850.003 .

Rheinberger, Hans-Jörg
(2013). "Forming and Being Informed: Hans-Jörg Rheinberger in conversation with Michael Schwab". In: *Experimental Systems. Future Knowledge in Artistic Research*. Ed. by Michael Schwab. Leuven: Leuven University Press, pp. 198–219.

Stavrides, Stavros
(2016). *Common Space: The City as Commons*. London: Zed Books.

Stengers, Isabelle
(2017). "Autonomy and the Intrusion of Gaia". In: *South Atlantic Quarterly* 116.2, pp. 381–400. doi: 10.1215/00382876-3829467 .

Weinfurtner, Tania and David Seidl
(2019). "Towards a spatial perspective: An integrative review of research on organisational space". In: *Scandinavian Journal of Management* 35.2. doi: 10.1016/j.scaman.2018.02.003.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Sonic Imagination: Aural Environments as Speculative Artefacts

Keywords: Imagination, Multimodal Mental Imagery, Speculative Design, Artistic Research, Radio Play, Installation Art, Aural Environment, Binaural Audio

Ludwig Zeller
ludwig.zeller@fhnw.ch
Academy of Art and Design
FHNW, Basel, Switzerland

Martin Rumori
martin.rumori@fhnw.ch
Academy of Art and Design
FHNW, Basel, Switzerland

The human imagination received a discursive gain regarding its societal and economic importance as a cognitive resource in the course of the 20th and 21st century. This situation motivated the emergence of imagination techniques of which we discuss several briefly in this paper. The various formations of 'speculative' strategies within art and design can be seen as a recent extension to this tendency. While such strategies are usually predominantly visual, we suggested in our earlier research and practice ('The Institute of Sonic Epistemologies') that aural techniques might be equally suited to stimulate the human imagination, since such approaches leave the visual senses open for mental imagery in the human mind. We found these early explorations to be fruitful and decided to further our understanding of the aesthetic, fictional and medial factors being at work when aural environments trigger the human imagination. Against this backdrop, the present article is a working paper on 'aurally induced mental imagery' that covers a literature overview of the neuropsychology of the human imagination and discusses an eclectic corpus of sound work, which we query for the above-mentioned factors.

1. The Societal Rise of 'Applied Imagination'

According to the cultural scientist Jochen Schulte-Sasse, the human imagination was nearly always negatively charged in early philosophical theories for ontological, epistemological and moral reasons, and was fundamentally reassessed only in the course of the Enlightenment and especially in modernity (Schulte-Sasse 2001, 89). Human imagination, as a force that actively adds something to the existing and real, had been disciplined in the course of the modern era in the form of *design*, in the sense of a normative ability or cultural technique that was increasingly directed towards the improvement of our world condition (op. cit., 101). After the Second World War at the latest, the ability to imagine became a kind of cognitive resource of individual self-realisation, which gained importance in the creative industry of the emerging knowledge societies (cf. Reckwitz 2012). Imagination thus plays an important role today not only for the creativity of the design disciplines, but also for areas that depend on the speculative planning of not-yet-existing situations (Reuland 2010). Thus, also in the exact sciences, the ability to imagine and speculate is important for the development of new theories, as has been emphasised by various scholars (e.g. McLeish 2019 and Chico 2019). Among many other consequences, this societal and economic gain of importance of human imagination has led to the emergence of creativity and imagination techniques in the course of the 20th century, in particular after the Second World War (Mareis 2012 and Mareis 2016). Particular motors for this were the innovation-driven economy of modernity and the 'Cold War' between the USA and the Soviet Union, which lead military-industrial think tanks to develop 'imagination techniques', for example, to imagine the world after a thermonuclear war (cf. Erickson 2013). In the case of the forming creative industries, such 'techniques of the self' (cf. Möhring 2006) included morphological (Zwicky 1962) and bisociative (Koestler 1964, 663–666) synthesis methods, based on the systemic recombination of linguistic propositions in order to stimulate the imagination of the resulting entities. Additionally, communicative techniques such as 'DELPHI' (Dalkey 1969) or 'War Gaming' Kahn and Mann (1957) emerged from the context of military-industrial 'think tanks', which were intended to optimise interpersonal communication by means of behavioural rules and thus to promote the joint creation and synchronisation of imaginations.

Fig. 1. 'Three-Room Dwelling' (detail, about 1944–46), from the 'Nutshell Studies of Unexplained Death' by Frances Glessner Lee (Image: Collection of the Harvard Medical School, Harvard University, Cambridge, MA).

Even beyond capitalist value creation and military planning, remarkable methods for stimulating and training human imagination were developed throughout the 20th century. An example is the 'Nutshell Studies of Unexplained Death' – a series of twenty dioramas of murder scenes created by criminologist Frances Glessner Lee for educational purposes in the 1930s and 40s (see figure 1, cf. Lee 1952, Botz and Lee 2004 and Goldfarb and Melinek 2020). From 1945 onwards, these miniatures were analysed at Harvard University in seminars by trainees of criminology in order to discover clues about the course of past deaths and to derive explanations and motives from them (Uebel 2018, 125). However, according to Lee, these are "(...) not presented as crimes to be solved – they are, rather, designed as exercises in observing and evaluating indirect evidence" (Lee 2004, 24). Michael Uebel explains the continuing interest in such dioramas by the fact that the production of suspicious facts – in the sense of 'abductions', i.e. imaginations of plausible explanations – ultimately constitutes an essential aspect of human reason and is applied in a multitude of disciplines, from literary poetry and psychoanalysis to scientific theory formation (Uebel 2018, 125 in reference to Ginzburg 1989, Strowick 2005 and McKaughan 2008). Lee's dollhouses thus enable a 'feeling' for criminalistic situations through the intense imagining of sequences of events, since her models are constructed in a coherent and plausible way at the visual and material level, while nonetheless exhibiting a high degree of ambiguity at the narrative level. As 'atmospheres of imagination', such approaches show the potential of triggering and maintaining imaginations particularly well by offering ambiguous spaces of possibility.

As we can see, imagination is a foundation of all human cognitive activity that we think deserves to be inquired by foundational research from various disciplines. The recent interest in speculative strategies within art and design – probably most prominently so under the umbrella term of 'speculative design' (cf. Dunne and Raby 2013 and Zeller 2018) – can be seen as an exploration of new forms of engagement with 'possible worlds' by stimulating the human imagination through the creation of 'speculative artefacts'. While such artifacts usually are created as models, props, prototypes and various types of imagery, we experimented with expanding these speculative approaches into the aural domain, investigating what it means to stimulate the human imagination by the use of various forms of sonic media in the context of speculative thought experiments.

2. 'The Institute of Sonic Epistemologies'

As an experimental investigation within our earlier research, we inscribed the fictive 'Institute of Sonic Epistemologies' in a multi-functional event space in the basement of the House of Electronic Arts (HEK) in Basel, Switzerland in 2016 (see figure 2). The project used binaural techniques to create an augmented auditory space and aimed at exploring the fictional potential of aural environments as a new form of 'speculative design'. Generally speaking, a two-channel sound reproduction is considered binaural if there are so-called 'binaural cues' in both channels, which are related to the anatomical nature of the human skull and which, by differentiating between the left and right channels, allow us to hear in three dimensions (cf. Blauert 1997).

Fig. 2. 'The Institute of Sonic Epistemologies' (2016) by Ludwig Zeller and Martin Rumori, installation view at the House of Electronic Arts in Basel, Switzerland (Image: Ludwig Zeller).

Conceptually, the project departed from the thought experiment that our visual forms of knowledge production may have only acquired their dominance as a result of socialisation processes. The project thus explored the following speculative questions: What if visual strategies lost their dominance in scientific analytics? And what if visually impaired people were therefore in advantage to non-disabled people because of their more sophisticated perception of sound?

In this context, two notions of sonic epistemologies were elaborated: firstly, a utilitarian perspective on sound that is common in scientific data sonification and interaction design. In this regard, sound is valued for its specific ability to inform epistemic exploration and reasoning. And secondly, from a fictional perspective, sound is understood as a way to relate to and transcend existing life-world experiences through multisensory storytelling. In relation to the latter, the project aimed to explore ways in which a physical space can be seamlessly overlaid with a fictive one.

The production included a series of impulse response measurements at the venue, binaural recordings of sound elements common to workshop situations, as well as studio recordings of voice actors. The installation staged an educational workshop in statistical data analysis using sonification. The visitors were invited to enter the space and witness the lesson. However, the actual narration was only accessible through listening with headphones. These were installed at five locations in the space, each offering a different spatial perspective combined with a progressing narrative. Using binaural technology and individual acoustic measurements in the exhibition space, visual and auditory elements were related to each other, with the augmented and the real space providing a congruent acoustic impression. The aesthetic experience of this augmented environment was intended to allow both the participation of visitors in a 'radio play'-like narrative and a kind of otherworldly distancing through the uncanny presence of the imaginary workshop participants.

We discussed the narrativity and fictionality of augmented auditory spaces and binaural sound in an earlier research paper Zeller and Rumori (2019). Still, we had more questions and wanted to better our knowledge of what mechanisms are exactly at play within works such as our 'Institute of Sonic Epistemology'. Therefore, the goals of our currently running project are (1) to broaden our understanding of the aesthetic, fictional and medial factors involved and (2) to conduct further lab and field experiments that take the notion of 'augmented auditory spaces' into urban open-air spaces by combining headphone-tracking with ambisonics-based binaural spatialisation. In the second half of this paper, we will focus on goal (1) by (a) offering a brief literature overview in order to see what neuropsychology has found out about the stimulation of imagination through multimodal cues, and (b) a comparative discussion of three pieces by other authors and artists that make use of aural techniques to a varying degree. Our research aims at contributing to the expanding field of speculative strategies within art and design in specific, and the epistemology and aesthetics of aural environments in general.

3. The Neuropsychology of Imagination

Today's neuroscience and psychology regards imagination as a central aspect of human cognition and information processing (Singer 2011, 19). Through the power of imagination, human beings are able to remember past events (cf. Garry and Polaschek 2000), to anticipate or plan future events (cf. Moulton and Kosslyn 2009 and Gilbert and Wilson 2007), as well as to create entirely fictive worlds (cf. Taylor 2013, 792). According to Buckner et al. (2007, 50), the human imagination of future and counterfactual situations has been increasingly investigated at the intersection of psychology and neuroscience, where it is discussed using terms such as 'episodic future thinking' (Atance and O'Neill 2001), 'memory for the future' (Ingvar 1985), 'pre-experiencing' (D'Argembeau and Van der Linden 2004), 'mental time travel' (Wheeler et al. 1997) or 'simulation' (Decety and Grézes 2006). Wilson & Gilbert (2005) proof that imagining non-existent states can have direct effects in the now, since, for example, moral decisions depend to a large extent on envisioning their consequences in the sense of an 'affective forecasting' (Gaesser and Schacter 2014 and Amit and Greene 2012).

A recurring theme of such research is that imagination in general seems to be highly dependent on prior experience (Byrne et al. 2007) and is sometimes even negotiated as a kind of attenuated form of perception, since imagined entities are represented in brain areas of the early visual cortex (Pearson et al. 2015). Even as early as 1940 Jean-Paul Sartre (2004, 8ff) described imaginations as "quasi-observations" and discussed their similarities and differences to sensory perception in the here and now. Such findings support sensualist theories in the sense of a 'grounded cognition', which regard sensory experience as a prerequisite for any cognition (Barsalou 2010).

Furthermore, the ability to imagine varies from person to person (D'Argembeau and Van der Linden 2006), is generally subject to many different cognitive limits (Beardsmore 1980) and therefore cannot be regarded as completely 'free'. Memories may not be accessible in equal measures and can change or fade over time while the synthesis of fictive entities regularly eludes our imagination. It is therefore a topical question of neuropsychology to what extent these limitations are also caused, for example, by the circumstance that imagination and vision partly take place in the same brain areas and thus compete for the same cognitive capacities on one hand and underly similar mental limitations on the other (Keogh and Pearson 2018). In a similar vein, phenomenological considerations concluded that seeing and imagining one and the same object are not possible at the same time (Casey 1976: 146). Additionally, the term 'aphantasia' has been introduced by Zeman et al. (2015) in order to discuss the phenomenon of having a poor or completely lacking ability of creating voluntary mental imagery in front of one's 'inner eye', whereas 'hyperphantasia' oppositely describes the dominance of highly vivid visual imagery in some people (cf. Pearson 2019).

Lastly–and for our interest in aurally induced imagination most relevantly–, the concept of 'multimodal mental imagery' in neuropsychology and empirical philosophy describes mental imagery "that is not triggered by corresponding sensory stimulation in a given sense modality" (Nanay 2018, 127). This applies to all kinds of sensory combinations, including for instance *smelling* something with your 'inner nose', when you merely *see* something, or–and this is the central interest of this paper–*seeing* something in front of your 'inner eye', when you only *hear* something. Bence Nanay gives the example of hearing somebody walking up a staircase, which can trigger olfactory or visual mental imagery depending on which person we identify or expect to approach us, e.g., a "stinky friend" would tend to provoke olfactory mental imagery (op. cit., 129). According to Nanay, multimodal mental imagery differs from 'synaesthesia' mostly in regards of the much higher "idiosyncrasy" of the latter: "In the case of synaesthesia, in contrast, the 'correspondence' is not based on repeated exposure of any kind of multisensory event (...). We do not encounter, let alone repeatedly encounter colours that have a certain specific pitch (and the same pitch in all contexts). So, synaesthesia is multimodal mental imagery where 'correspondence' is unusual" (op. cit., 130f), i.e. while synaesthetic couplings seem statistically odd and somewhat arbitrary, multimodal mental imagery in general activates associations that have been learned and memorised from repeated sensory experiences in the past. In this respect, Nanay appears to account for the currently predominant meaning of 'synaesthesia' as a phenomenon of neurodiversity, whereas the phenomenologist Maurice Merleau-Ponty used the term in a broader sense, closer to what Nanay calls multimodal mental imagery.

Nanay proposes that the induction of multimodal mental imagery can be used in certain psychotherapeutic treatments that rely on "imagery rescripting", i.e. the positive revaluation of traumatic memories and associated imageries. But while evoking such imagery *voluntarily* can be difficult for many, inducing "multimodal mental imagery, on the other hand, could bypass these blocks and it could provide a more efficient way of interfering with the patients' mental imagery, which is easier to control and to maintain" (op. cit., 131). In a way, we are trying to pursue a similar strategy in the context of speculative design and art, i.e. finding alternative ways to immerse oneself in thought experiments and their respective scenarios that are usually hard to grasp or to imagine and that could therefore benefit from rich, multi-sensory offerings.

4. Aurally Induced Mental Imagery in the Arts

Generally speaking, audio technology enables us to hear sounds that point to places different from the one we are located at or that make the given place appear different. Both effects can be productive to aurally induce mental imagery, but surprisingly this specific combination of sound and imagination has not received a lot of attention so far. A large part of the existing research on imagination in the field of sound concerns 'listening before the inner ear', i.e. the imagining of sounds themselves, initially related primarily to musical contexts (Copland 1952, Cook 1990) and closely linked to creativity research (Hargreaves, Miell, and MacDonald 2011). The broader understanding of sound beyond its musical manifestations is ultimately also carried out in this thematic area (see Grimshaw-Aagaard et al. 2019; Street 2019). Nonetheless, the notion of sound as a stimulant of imagination has been given attention in studies on radio plays and cinematic movies (Chion 1994; Verma 2012; Kane 2014; Chattopadhyay 2017) and occasionally in marketing studies regarding the creation of 'brand imagination' (Gustafsson 2019). In order to exemplify and clarify our notion of aurally induced mental imagery, we are going to discuss such effects in three works of art and fiction.

Fig. 3. Orson Welles directing a crew performing his radio adaptation of H.G. Wells's novel 'War of the Worlds' at a CBS studio in October 1938, New York City (Image: Bettmann/Corbis).

4.1. 'War of the Worlds'

A famous example of a radio play that is legendarily known for the imaginative effect it had on its audience is Orson Welles's radio adaptation of H.G. Wells's 'War of the Worlds'. The piece had to be performed live at CBS radio in October 1938 (see figure 3), which was common in the early days of popular radio broadcast due to the lack of magnetic tape recording. The roughly one-hour long radio broadcast created the impression that invaders from Mars are launching an actual attack on the United States of America and thus left many of its audience dazed in horror. Therefore, this is an early example for the extraordinary stimulative potential that sonic media can have on the human imagination. The play not only achieved this, because it abused the social institution of live radio news broadcasts that were still relatively new at that time and effectively became a sort of 'fake news' avant la lettre, or because radio was a wondrous new medium in general that the audience had not cultivated a lot of listening experience with yet. Instead, a central reason for its imaginative appeal – that by the way can still be intriguing to listeners today – lies in the use of sound in the absence of visual cues. Like any (fictional) medium, radio plays are co-constructed by their audience. But radio plays make use of sound not only for verbally communicating narrative expressions as it is the case with 'audiobooks' – instead radio plays use tonal qualities and atmospherical, spatial renditions in order to create immersive, auditory spaces that are highly stimulative to the human imagination. As can be seen in the image, the live performance of 'War of the Worlds' actually resembled a theatre play, acoustically presented in front of the audience through the available technology of the 1930s, bridging the aural environment of the audience with both the studio space of CBS and the fictionalised places of the Martians' attacks. Therefore, the imaginative power of radio plays cannot be fully understood by fictional and narrative studies alone but has to be queried from the perspective of sonic epistemologies and soundscape studies as well.

In contrast to our 'Institute of Sonic Epistemologies' project, where we placed an emphasis on approaches of 'in-situ binaural audio' that augment the auditory space of a given place by the use of spatial sound techniques, the 'War of the Worlds' was a one-channel, monaural production that obviously did not make use of multichannel or even binaural production techniques (although stereophonic and dummy head techniques were subject of vivid research at that time, regular mainstream stereophonic broadcast only started in the 1950s). While the horrifying alien sounds of the play for sure did 'fill up' the sitting rooms of the 1940s US-Americans, it did not do so in an encompassing, 360-degree sense of aural environment. We conclude that while technologically more advanced renditions of sound can often be beneficial for fostering immersive intensity, the aesthetic and narrative fictionality of the presented scene is just as important for creating a sense of immersive engagement.

Fig. 4. 'Touched Echo' by Markus Kison, Dresden, 2007 (Image: Unknown).

4.2. 'Touched Echo'

Our second example is another one-channel, monophonic audio production that immerses its audience without relying on binaural spatiality: the public space installation 'Touched Echo' by Markus Kison that confronted pedestrians in Dresden, Germany, with the horrors of the airstrikes in that city towards the end of the Second World War in 1945 (see figure 4). Using bone conduction – a way of feeding sonic vibrations directly into the inner ear that is also used for some hearing aid devices – the trespassers of a balustrade were able to listen to the piece simply by resting their elbows while firmly closing their ears, effectively creating a mechanical link between their skull and the electro-magnetic actuators that had been installed on the metal. Because of this acoustic principle the installation is only audible if the mentioned mechanical connection is established, effectively allowing to instantly switch between the actual acoustic environment of the listener standing at the balustrade in the here and now, and a sonic interpretation of the devastating air raid bombings that happened decades ago. Furthermore, the sounds are not rendered in high fidelity, but instead appear muffled and highly resonating because of the acoustical properties of the metal balustrade and the human body. Therefore, the overall impression is highly diffuse and appears as if being carried from a distant past. Sounds of plane motors and exploding bombs are smeared up to the point of being almost incomprehensible, creating an uncanny, dream-like listening situation.

Similar to the above-mentioned 'War of the Worlds', this epistemic ambiguity actually increases the imaginative atmosphere of the piece, allowing to feel empathy with the inhabitants of Dresden who must have been frightened by sounds that appeared just as haunting while bracing in their shelters. Since the audience of the sound installation has to take in a similarly protective posture, it could be argued that they become at the same time protagonists of a historical re-enactment of the Dresden bombings to the surrounding spectators, further increasing the intensity and immersivity of the piece.

But unlike 'War of the Worlds' – where the audience's environment was only augmented emotionally and semantically, but not immediately sensorially – this project is transforming the environment of the visitor in several ways: by covering the ears, the visitor swaps their actual sonic environment against a virtual one. In this context, the sounds of plane motors and exploding bombs can trigger visual mental imagery of military aircrafts, falling bombshells, burning houses and frightened people in shelters. In some cases, this does not only conjure up sensations before the 'inner eye', but might even transform the visual perception of the physical surrounding, i.e. through embeddings of visual mental imagery within the environment of the listener. Presumably, most members of the audience have learned these images from repeated presentations in factual and fictional media such as documentaries and movies, while others might have experienced similar horrors in person and thus will be triggered to relive complex patterns of such experiences. Just as in the case of the 'War of the Worlds' this could also raise ethical questions in some situations. And finally, it could be explored in further research whether the specific, protective posture, which the audience has to take in, is eventually yet another multimodal driving factor of mental imagery by offering a mix of tactile (touch), vestibular (sense of balance) and proprioceptive (body perception) stimuli – something that could be studied in further research, since our current project focuses on aurally induced imaginations.

Fig. 5. 'The Paradise Institute' by Janet Cardiff & George Bures Miller, 2001 (Image: Markus Tretter).

4.3. 'The Paradise Institute'

Our last example is 'The Paradise Institute' by Janet Cardiff and George Bures Miller, a mixed media installation conceived for the Canadian pavilion at the Venice Biennale in 2001 (see figure 5). The visitors entered the reconstruction of a common cinema situation with rows of red velvet seats to sit on. In front of these seats the visitors saw the miniature reconstruction of a cinema hall in an exaggerated perspective as it is common in dioramas, the seats in front of them being sized smaller the further away they are in order to fake the appearance of distance. The miniature cinema screen showed a short film produced by the artists that could be listened to via headphones that were provided for each seat. Unlike commonly expected from situations where movies are watched with headphones on, the headphones used in the installation were not playing the direct audio track of the film, but instead a reproduction of that soundtrack that had been re-recorded in an actual movie theatre using binaural microphones. As a consequence of its binaural encoding and reproduction, the movie appeared to be embedded within a spatial reverberation that sounded correctly like a front seated situation in a cinema, including peripheral sound events that belong to the specific soundscapes of movie theatres, such as people flitting along the aisles, whispering to each or hastingly trying to mute ringing cell phones. As a consequence, the visitors might feel the social presence of these invisible people, forcing many of them to adjust their sonic emissions as well. Similar to how restaurants are positive feedback systems that tend to get louder the more people are already talking (Blesser and Salter 2009, 10ff), cinema halls can be seen as negative feedback systems: the members of the audience are actively observing and regulating the sounds they emit, in order to obey a social etiquette that they mutually enforce upon each other. This created a fourfold intersection between the soundscape of the simulated cinema hall, the fictive space of the 'film noir' movie that is displayed within it, the physical cinema mock-up – and the actual gallery space of the Venice Biennale.

We used a similar effect for our 'Institute of Sonic Epistemologies', where a simulated lecture situation afforded an implicit collective constraint of not breaking the silence. The intensity of this situation was further amplified by having the fictive director of the institute stand close to the side of the visitor, whispering quietly in intimate proximity into their ear in order to not disturb the social code of the situation. Generally speaking, such affective impacts can clearly benefit from the presence and immersive intensity that binaural techniques offer in specific circumstances, which are taken to an extreme recently in so-called 'ASMR performances' (autonomous sensory meridian response).

5. Conclusion

We discussed a series of findings from philosophy and neuropsychology that present human imagination as a central faculty of human intelligence. Many of these positions see imagination closely connected to its temporal aspect, as attributions like episodic future thinking, mental time travel, pre-experiencing, or affective forecasting suggest. Another important point is the relation between imagination and sensory perception: both show activations in the same brain areas, imagination is understood as being based on prior empiric knowledge gained by repeated experience and mental imagery can be induced in multi-modal ways through the various senses. Consequently, human imagination (and cognition in general) is highly constructivist and relativist in nature.

We elaborated that radio plays are rich in imaginative stimuli, since they present their fictive worlds without using visual cues such as images and instead make use of sonic cues that go far beyond the narrative speech known from audio-books and fictional literature in general. We stressed the sensory asymmetry that radio plays carry by providing stimuli in mostly one domain, namely the auditory, and by making indexical use of sound while leaving the other senses to the recipient's current surroundings. We propose that addressing the multi-modal nature of human perception in such asymmetrical ways may help inform imagery in the minds of an audience.

We expanded this idea to include works that conceptually draw from the artistic form of the environment, mainly installations, and we introduced examples of such 'radio play'-like installative work. Subsequent to our previously made claim we argued that the presence of invisible entities through sonic cues in emphatically spatial, multimodal arrangements has a highly stimulating effect on the human imagination. To conclude our argument, we focussed on the use of binaural audio in these works, a reproduction technique that can match the acoustic properties of the presentation environment, rendering sounds to appear to be 'in-situ' (cf. Barton and Windeyer 2012 and Eckel and Rumori 2014) of the spatial context of the listener. This technique allows to establish auditory spatial entities and phenomena that are plausibly congruent with the recipient's perceived surrounding but at the same time are only incompletely confirmed in the visual and other domains. We hypothesize that experiencing such conflicts in multimodal perception can enhance the human imagination in a special way, up to an almost uncanny sense of presence, immersion and hyper-realism within an augmented auditory space.

Our research aims at contributing to the expanding field of speculative strategies within art and design in specific by offering both new perspectives for further foundational research into the epistemology and aesthetics of speculating by the means of aurally induced mental imagery as well as exciting possibilities for new artistic work. In extension to Bence Nanay's proposal of using multimodally induced mental imagery in therapeutic contexts, we assume that the kind of design work that we outline in our research could potentially also contribute to the field of psychotherapy, if conducted in interdisciplinary settings.

6. Outlook

This paper summarizes some initial research efforts of our current research project, currently carried out at the Academy of Art and Design FHNW in Basel. One of our next steps will put above-mentioned neuroscientific concepts of imagination in a relation with contemporary discourses in aesthetics, namely those on aesthetic experience and atmosphere. Common theories of aesthetic experience (cf. Shusterman 1997) pursue the re-grounding of contemporary aesthetics on sensory perception rather than focussing on ever new theories of art or even callistic aesthetics centering questionable ideals such as 'beauty' or 'truth'. After having been introduced by John Dewey (1934/1980), major motors for the continued discourse about aesthetic experience in the second half of the 20th century are the emergence of conceptual art that cannot be explained by then prevalent art theories, and the observed increasing aestheticisation of everyday life. To us, both appear to be fruitful grounds for further investigating imagination in both applied and artistic contexts. Based on the same driving forces as for debates on aesthetic experience, Böhme (1993) proposed the term atmosphere as a basis for theories of a so-called 'new aesthetics' (not to be confused with James Bridle's 'The New Aesthetic'). Further understanding 'atmospheres of imagination' can be seen as a major goal of our research project. Additionally, we are currently preparing practical field experiments based on binaural auditory environments in order to gain empiric insights into the conditions, catalysts and obstructors of the human faculty of imagination in public urban spaces.

Acknowledgements. Our research is funded by the Swiss National Science Funds (SNSF 195868).

References

Amit, Emit, and Joshua Greene. 2012. "You see, the ends don't justify the means: visual imagery and moral judgment." *Psychological Science 23* (8): 861–868.

Atance, Cristina, and Daniela O'Neill. 2001. "Episodic future thinking." *Trends in Cognitive Sciences 5* (12): 533–539.

Barsalou, Lawrence. 2010. "Grounded cognition: past, present, and future." *Topics in Cognitive Science 2* (4): 716–724.

Barton, Bruce, and Richard Windeyer. 2012. Immersive Negotiations: Binaural Perspectives on Site-Specific Sound. In: Birch, Anna, and Joanne Tompkins (Eds). *Performance Site-Specific Theatre. Politics, Place, Practice*. New York: Palgrave MacMillan, 182–199.

Beardsmore, Richard. 1980. "The Limits of Imagination." *The British Journal of Aesthetics* 20 (2): 99–114.

Blauert, Jens. 1997. *Spatial Hearing. The Psychophysics of Human Sound Localization*. Cambridge: MIT Press.

Blesser, Barry, and Linda-Ruth Salter. 2009. ''The Other Half of the Soundscape: Aural Architecture''. *World Federation Acoustic Ecology*, Nr. March 2009: 1–15.

Botz, Corinne May, and Frances Glessner Lee. 2004. *The nutshell studies of unexplained death*. New York: Monacelli Press.

Buckner, Randy L., and Daniel C. Carroll. 2007. "Self-Projection and the Brain." *Trends in Cognitive Sciences 11* (2): 49–57.

Byrne, Patrick, Suzanna Becker, and Neil Burgess. 2007. "Remembering the past and imagining the future: A neural model of spatial memory and imagery." *Psychological Review* 114 (2): 340–375.

Böhme, Gernot. 1993. "Atmosphere as the Fundamental Concept of a New Aesthetics." *Thesis Eleven 36* (1): 113–126.

Casey, Edward S. 1976. *Imagining: A Phenomenological Study*. Bloomington: Indiana University Press.

Chattopadhyay, Budhaditya. 2017. "Reconstructing atmospheres: Ambient sound in film and media production." *Communication and the Public* 2(4): 352-364.

Chico, Tita. 2018. *The Experimental Imagination: Literary Knowledge and Science in the British Enlightenment*. Stanford: Stanford University Press.

Chion, Michel. 1994. *Audio-Vision. Sound on Screen*. Columbia: Columbia University Press.

Cook, Nicholas. 1990. *Music, Imagination, and Culture*. Oxford: Clarendon Press.

Copland, Aaron. 1952. *Music and Imagination.* Cambridge: Harvard University Press.

Dalkey, Norman C. 1969. *The Delphi method: An experimental study of group opinion*. No. RM-5888-PR. Santa Monica: RAND Corporation.

Decety, Jean, and Julie Grézes. 2006. "The power of simulation: imagining one's own and other's behavior". *Brain Research* 1079, 4–14.

Dewey, John. 2005. *Art as experience*. New York City: Penguin.

D'Argembeau, Arnaud, and Martial Van der Linden. 2004. "Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: influence of valence and temporal distance." *Consciousness and cognition* 13(4): 844–858.

D'Argembeau, Arnaud, and Martial Van der Linden. 2006. "Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies." *Consciousness and Cognition* 15(2): 342–350.

Dunne, Anthony, and Fiona Raby. 2013. *Speculative everything: design, fiction, and social dreaming*. MIT Press.

Eckel, Gerhard, and Martin Rumori. 2014. "StiffNeck: The Electroacoustic Music Performance Venue in a Box." In *Proceedings of the International Computer Music Conference*.

Erickson, Paul, Judy L. Klein, Lorraine Daston, Rebecca Lemov, Thomas Sturm, and Michael D. Gording. 2013. *How Reason Almost Lost Its Mind. The Strange Career of Cold War Rationality*. Chicago and London: University of Chicago Press.

Gaesser, Brendan, and Daniel L. Schacter. 2014.. “Episodic simulation and episodic memory can increase intentions to help others.” *Proceedings of the National Academy of Sciences of the United States of America* 111(12): 4415–4420.

Garry, Marianne, and Devon Polaschek. 2000. *Imagination and memory. Current directions in psychological science* 9(1): 6–10.

Gilbert, Daniel T., and Timothy D. Wilson. 2007. “Prospection: experiencing the future.” *Science* 317(5843): 1351–1354.

Ginzburg, Carlo. 1989. “Clues: roots of an evidential paradigm”. In *Clues, Myths, and the Historical Method*, 96–125. Johns Hopkins University Press: Baltimore.

Goldfarb, Bruce, and Judy Melinek. 2020. *18 tiny deaths: the untold story of Frances Glessner Lee and the invention of modern forensics*. Endeavour.

Grimshaw-Aagaard, Mark, Mads Walther-Hansen, and Martin Knakkergaard (eds.). 2019. *The Oxford Handbook of Sound and Imagination, Volume 1*. New York: Oxford University Press.

Gustafsson, Clara. 2019. “Sonic Branding: From Brand Image to Brand Imagination.” In The *Oxford Handbook of Sound and Imagination*, Volume 1 edited by Mark Grimshaw-Aagaard, Mads Walther-Hansen, and Martin Knakkergaard. 359–376. Oxford: Oxford Handbooks.

Hargreaves, David, Dorothy Miell, and Raymond MacDonald (eds.). 2012. Musical imaginations: *Multidisciplinary perspectives on creativity, performance and perception*. Oxford: Oxford University Press.

Ingvar, David H. 1985. “Memory of the future: an essay on the temporal organization of conscious awareness.” *Human Neurobiology* 4: 127–136.

Kahn, Herman, and Irwin Mann. 1957. *War gaming*. No. P-1167. Santa Monica: RAND Corporation.

Kane, Brian. 2014. *Sound unseen: Acousmatic Sound in Theory and Practice*. New York: Oxford University Press.

Keogh, Rebecca, and Joel Pearson. 2018. “The perceptual and phenomenal capacity of mental imagery.” *Cognition* 162: 124–132.

Koestler, Arthur. 1964. *The Act of Creation*. London 1964.

Lee, Frances Glessner. 2004. “Foreword to the Investigator.” In *The Nutshell Studies of Unexplained Death* edited by Corrine May Botz, 47. New York: Monacelli Press.

Lee, Frances Glessner. 1952. “Legal Medicine at Harvard University.” *The Journal of Criminal Law, Criminology, and Police Science* 42: 674–678.

Mareis, Claudia. 2016. “Angewandte Imagination und Kreativität um 1960. Eine Einführung.” In *Designing Thinking. Angewandte Imagination und Kreativität* um 1960 edited by Claudia Mareis. 9–38. Paderborn: Wilhelm Fink.

Mareis, Claudia. 2012. “Methodische Imagination. Kreativitätstechniken, Geschichte und Künstlerische Forschung.” In *Kunstforschung als Ästhetische Wissenschaft. Beiträge zur Transdisziplinären Hybridisierung von Wissenschaft und Kunst* edited by Martin Tröndle and Julia Warmers. 203–241 Bielefeld: Transcript.

McKaughan, Daniel J. 2008. “From ugly duckling to swan: Charles S. Peirce, abduction, and the pursuit of scientific theories.” *Transactions of the Charles S. Peirce Society: A Quarterly Journal in American Philosophy* 44: 446–468.

McLeish, Tom. 2019. *The poetry and music of science: comparing creativity in science and art*. Oxford: Oxford University Press.

Möhring, Maren. 2006. “Die Regierung der Körper. «Gouvernementalität» und «Techniken des Selbst»” In *Zeithistorische Forschungen* 3(2): 284-290.

Moulton, Samuel T. and Stephen M. Kosslyn. 2009. “Imagining predictions: mental imagery as mental emulation”. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1521): 1273–1280.

Nanay, Bence. 2018. ‘‘Multimodal mental imagery’’. *Cortex 105*. Elsevier Ltd: 125–34.

Pearson, Joel. 2019. ‘‘The human imagination: the cognitive neuroscience of visual mental imagery’’. *Nature Reviews Neuroscience 20* (10). Springer US: 624–34.

Pearson, Joel, Thomas Naselaris, Emily A. Holmes, and Stephen M. Kosslyn.
2015. “Mental Imagery: Functional Mechanisms and Clinical Applications.” *Trends in Cognitive Sciences* 19(10), 590–602.

Reckwitz, Andreas.
2012. D*ie Erfindung der Kreativität: Zum Prozess gesellschaftlicher Ästhetisierung.* Berlin: Suhrkamp.

Reuland, Eric.
2010. “Imagination, Planning, and Working Memory: The Emergence of Language.” *Current Anthropology* 51(1): 99–110.

Sartre, Jean-Paul.
1940/2004. *The Imaginary: A Phenomenological Psychology of the Imagination*. New York: Routledge.

Schulte-Sasse, Jochen.
2001. “Einbildungskraft/Imagination.” In *Ästhetische Grundbegriffe* edited by Karlheinz Barck, Martin Fontius, Dieter Schlenstedt, Burkhart Steinwachs, and Friedrich Wolfzettel. 88–120. Stuttgart: Metzler.

Shusterman, Richard.
1997. “The End of Aesthetic Experience.” *The Journal of Aesthetics and Art Criticism* 55 (1): 29–41.

Singer, Jerome L.
2011. “Imagination.” In *Encyclopedia of Creativity* edited by Mark Runco and Steven Pritzker. 13–25. Amsterdam, Boston: Academic Press / Elsevier.

Street, Sean.
2019. *The Sound inside the Silence. Travels in the Sonic Imagination*. London: Palgrave Macmillan.

Strowick, Elisabeth.
2005. “Comparative epistemology of suspicion: psychoanalysis, literature, and the human sciences.” *Science in Context* 18: 649–669.

Taylor, Marjorie.
2013. “Imagination.” In *The Oxford Handbook of Developmental Psychology*, Volume 1: Body and Mind edited by P. D. Zelazo, 791–830. New York: Oxford University Press.

Uebel, Michael.
2018. “Corpus Delicti: Frances Glessner Lee and the art of suspicion.” *Epidemiology and psychiatric sciences* 27(2): 124-126.

Verma, Neil.
2012. *Theater of the Mind: Imagination, Aesthetics and American Radio Drama.* Chicago: University of Chicago Press.

Wheeler, Mark A. et al.
1997. “Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness.” *Psychological Bulletin* 121(3): 331–354.

Wilson, Timothy D., and Daniel T. Gilbert.
2005. “Affective forecasting: knowing what to want.” *Current directions in psychological science* 14(3): 131-134.

Zeman, Adam, Michala Dewar, and Sergio Della Sala.
(2015). Lives without imagery – Congenital aphantasia. Cortex, 73, 378–380.

Zwicky, Fritz.
1962. *Morphology of propulsive power.* Pasadena: Society for Morphological Research.

Zeller, Ludwig.
2018. ‘‘The B1/B2 Manifesto: Refining Dichotomies in Post-utopian Design Research’’. In *Unfrozen – a Design Research Reader by the Swiss Design Network*, edited by the Swiss Design Network, 37–62. Zürich: Triest Verlag.

Zeller, Ludwig, and Martin Rumori.
2019. „The Institute of Sonic Epistemologies. Life-world Fiction within Augmented Auditory Space“. In: *Acoustic Space Journal 17 - Virtualities and Realities – New Experiences, Art and Ecologies in Immersive Environments*, edited by Rasa Smite and Raitis Smits, 103–120. Riga: RIXC.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Off the Digital: Neo-analogue Hybrids

Keywords: Audiovisuals, Aesthetics, Neo-analogue, Hybridity, Materiality, Media Archaeology, Post-digital

Pedro Ferreira
ferreirapedro@pm.me
Universidade de Lisboa, Faculdade de Belas-Artes, Centro de Investigação e de Estudos em Belas-Artes (CIEBA), Portugal

Luísa Ribas
l.ribas@belasartes.ulisboa.pt
Universidade de Lisboa, Faculdade de Belas-Artes, Centro de Investigação e de Estudos em Belas-Artes (CIEBA), Portugal

This paper examines recent artistic engagements with analogue media in audiovisual art practices, commonly known as neo-analogue media practices. These practices and cultures of creative production often revive and repurpose older media technologies as well as devise analogue-digital media hybrids. These hybrid forms are commonly affiliated with a post-digital aesthetic, prone to blur established dichotomies between old and new media, as well as digital and non-digital realms. Neo-analogue hybrids can then be understood as a reaction to the post-digital condition by taking a critical stance towards common connotations of the term digital and engaging media hybridisation as a form of resistance against the hegemony of digital technologies.

1. An Aesthetics of Repurposing

There has been a growing interest in analogue media in the past two decades by a generation of artists, hobbyists and enthusiasts in diverse areas of artistic practice that are often labelled as neo-analogue. These practices commonly reuse, recycle and repurpose analogue media through do-it-yourself (DIY) or do-it-with-others (DIWO) creative strategies. These strategies are commonly developed as offline modes of creative production and distribution, by engaging materials and methods that are not mediated through computational networks or the Internet, such as crafting, handmade and artisanal modes of production. As such, these practices adhere to a DIY culture of creative production that "stands for anti-institutionalism, outside either white cubes or creative industries," and also implies "anti-aestheticism wherever it frames itself as technical practices that can be picked up by everyone" (Cramer 2019, 68).

Neo-analogue practitioners follow a bottom-up social dynamics[1] and position themselves critically against "a completely digital life" while also resisting "the ubiquitous and non-stop surveillance of the Internet" (Ludovico 2012, 154-155). Thus, neo-analogue artworks often result in media forms that, ultimately, can no longer be categorised as analogue or digital media but as hybrids. But rather than devising a "new hybrid visual language of moving images" (Manovich 2013, 254) converged through software and distributed digitally, tied to what scholar Lev Manovich describes as an aesthetics of hybridity, this kind of neo-analogue hybridity[2] is more closely related to what researcher Alessandro Ludovico describes in his book *Post-digital Print* (2012). Within the context of "post-digital publishing" Ludovico addresses these modes of cultural production in which:

> [a new generation of artists is] able to make use of various new and old media without the burden of ideological affiliation to any particular one of them, [they] will surely be in a position to develop new and truly hybrid publications, by creatively combining the best standards and interfaces of both digital and print. (Ludovico 2012, 156)

The merging of features and processes of different media results in "new and truly hybrid" forms (ibid.) which broadly correspond to a post-digital aesthetics. According to the scholar Florian Cramer, the term post-digital "describes a perspective on digital information technology which no longer focuses on technical innovation or improvement" and consequently eradicates the "distinction between 'old' and 'new' media, in theory as well as in practice" (Cramer 2014, 18).

1. Neo-analogue practitioners create offline networks for production and distribution that evoke a "bottom-up structure and peer-to-peer ethic" that resemble Internet communities but, at the same time, oppose a "'go all digital' philosophy which advocates a completely digital life" (Ludovico 2012, 154). As scholar Florian Cramer writes, the World Wide Web "had been a DIY publishing medium in the 1990s, [but] digital DIY has become difficult in a medium defined by only four corporate players (Google, Apple, Amazon, Facebook)" (Cramer 2012).

2. These forms of hybridity should not be confused with Lev Manovich's "aesthetics of hybridity" (2013) that reflects a shift in the visual language of moving images, from mid-1990s and early 2000s, categorised by software-based modes of production and a combination of techniques emulated and brought about by software, such as the combination and remixing of multiple imagery layers (Manovich 2013, 254–77).

This stance towards digital technologies can be seen in neo-analogue hybrids that combine and remix analogue and digital media resulting in non-traditional art forms which are no longer reducible to the specificity of a single medium. Namely, neo-analogue practices combine and experiment with a diverse range of media in order to create idiosyncratic relations between sound and image, which not only include the reuse of analogue media[3], but also electronics, custom-made software, hardware and a wider range of digital media technologies. In short, neo-analogue media hybrids not only highlight the materiality of (audiovisual)[4] media through their hybridisation but also reject the media-based categorisation of artistic forms.

This kind of resurrection of analogue media becomes possible due to the ever-increasing discarding media technologies, given the surplus of media brought about by the accelerated consumption and wide diffusion of digital media since the 1990s. Examples of this are artist-run film labs[5] and their networks, which could only be established when the film "industry started dropping small format equipment in the 1990s" (Rey 2018, 66), such as the discontinuation of the film format super 8mm. More recently, the artist-run film labs have expanded with the discontinuation of industrial analogue film production.[6] In this way, artist-run film labs and collectives recover and acquire the surplus of the photo-chemical cinema industry and its discarded machinery allowing a "younger generation [of] media-critical artists [to] rediscover analog information technology" (Cramer 2012).

Consequently, artists have been reusing and repurposing these technologies in neo-analogue creative practices that emphasis cooperation, community and sharing of knowledge around nearly forgotten media devices, as a retrospective creative engagement with analogue technologies. But rather than mere nostalgic revivalism of older or obsolete media technologies, "such practices can only be meaningfully called 'post-digital'" when they "functionally repurpose them in relation to digital media technologies" (Cramer 2014, 18).

Following this idea, neo-analogue media practices correspond to an aesthetics of repurposing since they functionally revive obsolete media into new hybrid forms. Discarded media are repurposed and "recycled into new assemblies", which can be characterised as "Zombie Media" that are resurrected "to new uses, contexts and adaptations"[7] (Hertz and Parikka 2012, 429). By doing so, they also highlight that "media never die but remain as toxic waste residue" (Parikka 2015, 48). In this sense, the neo-analogue can also be understood as a form of media archaeology, as media excavations wherein the "past is brought to the present, and the present to the past; both inform and explain each other, raising questions and pointing to futures that may or may not be" (Huhtamo and Parikka 2011, 15).

3. This can include discarded analogue media such as film, slides and overhead projectors, modular synthesisers, tape recorders, cassette tapes, vinyl records, analogue video, CRT televisions, VHS, miniDV, obsolete electronics as well as light bulbs and many other physical objects.

4. As media theorist Marshall McLuhan has pointed out, hybrids are "the meeting of two media" where "a new form is born" (McLuhan 1964, 62). In this sense, audiovisual art has always been a hybrid art form that intersects both sound and image in many different ways, be it in simulated, representative, figurative or abstract forms. However, audiovisuals have always been tied to their medium, the carrier of information, for example a film reel, a DVD, software or the Internet.

5. Artist-run film labs are collectively organised spaces for filmmakers and artists who work with analogue film (see http://www.filmlabs.org).

6. As the artist Nicolas Rey explains, this was only possible "in the period from 2012-2015, when the switch to digital film exhibition led to the disappearance of many commercial film laboratories around the world" (Rey 2018, 68).

These creative practices thus devise idiosyncratic audiovisual artworks that ultimately reject the market-driven narratives of technical progress, opposing ideas that equate the "digital" to high resolution, innovation and other hypes of consumer digital media technologies. Neo-analogue hybrids become offline provocations[8] and counter-reactions to "the messy state of media, arts and design *after* their digitisation" (Cramer 2014, 17). They react critically to the post-digital condition, as a result of the current ubiquity of digital computational technologies as they permeate all aspects of daily life and become interwoven within the physical world.

2. Digital, Analogue and the Neo-analogue

The word "digital" was popularised during the 1990s following the marketisation of digital media together with the writings on digital technology by scholar Nicholas Negroponte in his *Wired Magazine* column and his book *Being Digital* (1995). Negroponte proclaimed "four very powerful qualities" of the digital age, or digitality, as being "decentralizing, globalizing, harmonizing, and empowering" and posited that "digital technology can be a natural force drawing people into greater world harmony" (Negroponte 1995, 229-230). However, this sort of advocacy of digital technologies is at odds with the current post-digital age, wherein their "powerful" socio-cultural effects translate into the centralisation in one proprietary platform/software, global mass internet surveillance, electronic waste and environment devastation as well as the widespread of conspiracy theories, fake news and misinformation on social media. Scholars Hertz and Parikka write that:

> Chronologically, digital media have moved from a speculative opportunity in the 1990s to become widely adopted as a consumer commodity in the 2000s and have now become archaeological. As a result, studying topics like reuse, remixing, and sampling has become more important than discussions of technical potentials. (Hertz and Parikka 2015, 152)

Reacting to this cultural phenomenon of digital media commodification, neo-analogue media practices emerged at a time when the term "digital" also lost significance as a qualifying feature of media technologies and, in turn, "has become a meaningless attribute because almost all media are electronic and based on digital information processing" (Cramer 2012).

This loss of significance is due not only to the ubiquity of "digitality" and "computation" but also to their banalisation. As Florian Cramer clarifies, the meaning of "digital" does not necessarily signify digital computation, as is often misunderstood in an artistic context. The technical meaning of digital "simply means

7. Hertz and Parikka distinguish *dead media* from *zombie media*: the first as obsolete and inert dead media that "creeps back as dangerous toxins into the soil" and the latter as "media that is not only out of use, but resurrected to new uses, contexts and adaptations" (Hertz and Parikka 2012, 429).

8. As stated by Andersen et al. these are offline reactions and withdrawals from the "computer, which was originally developed as a military technology but redefined as emancipatory and revolutionary by Apple and others, [but which] is now back again where it began: as a military intelligence technology" (Andersen, Pold, and Riis 2014, 164).

that something is divided into discrete, countable units" (Cramer 2014, 15).[9] Similarly, the term "analogue" is often misunderstood and regarded as something non-computational, but there are analogue forms of computing.[10] Cramer also clarifies that the term "analogue" simply "means that information has not been chopped up into discrete, countable units, but instead consists of one or more signals which vary on a continuous scale, such as a sound wave, a light wave, a magnetic field" as well as "the flow of electricity in any circuit including a computer chip" (ibid., 16). According to this view, what is often called analogue cinema has technically always been a digital-analogue hybrid technology:

> [...] the film emulsion is analog, since its particles are undifferentiated blobs ordered organically and chaotically, and thus not reliably countable in the way that pixels are. The combined frames of the film strip, however, are digital since they are discrete, chopped up and unambiguously countable. (Cramer 2014, 16)

Reacting to common misconceptions of the digital and analogue, neo-analogue media hybrids express a desire to eradicate such binary distinctions as analogue/digital and old/new media as well as the way these binaries are influenced by modernist medium-based conceptions of the arts.[11] Thus, they engage in an aesthetics of hybridisation without ideological affiliation to any particular medium.

Therefore, discussing the meanings of "digital" and "analogue" is useful to clear up misapprehensions of their associations to artistic works, given that their common understanding relies heavily on ideas that are "mainly cultivated by product marketing and advertising," and which have "been unquestioningly adopted by the 'digital humanities'" (Cramer 2014, 20). In this sense, curator Christiane Paul, writer of the book *Digital Art* (2003), describes "digital art" as interchangeable with "new media art," defined as a broader range of artistic works and practices that are not described by one unified aesthetics, as a hybrid field that can be loosely divided into two broad categories:

> [...] art that uses digital technologies as a tool for the creation of more traditional art objects – such as a photograph, print, or sculpture – and digital-born, computable art that is created, stored, and distributed via digital technologies and employs their features as its very own medium. The latter is commonly understood as 'new media art'. (Paul 2003, 12–13)

9. The binary system of zeros and ones to sample information is one form of dividing things up. One example that Cramer suggests is "the floor mosaics made of monochrome tiles" (Cramer 2014, 15). The tiles are divided into discrete samples to compose images, a digital system which does not necessarily involve digital computers.

10. As Cramer explains, one form of analogue computing is to use "water and two measuring cups to compute additions and subtractions—of quantities that can't be counted exactly" (ibid.). This is a form of computing that does not use digital computation. An example of this is the artwork *Fluid Memory. Fluidic Computer* (2019-20) by Ioana Vreme Moser that explores computing using water.

11. Digital art or new media art are persistently defined by media specificity or as "an autonomous genre by virtue of its technical medium," which is tied to the use of digital technologies, or software, as an artistic medium. This view follows a modernist rhetoric of "medium specificity" in the visual arts according to Clement Greenberg's conception "driven by the paradigm of a self-referentiality immanent to the artistic medium," together with Marshall McLuhan's view that "the medium itself–or the »

» choice of a medium–carries one, if not the central message" (Daniels 2016, 51).

However, the combination of analogue and digital technologies, as devised by neo-analogue practices, does not seem to fit into those categories because these hybrids do not merely use digital technologies as a tool neither are they, exclusively, "digital-born, computable art" (ibid.). It also seems problematic to define digital art by its tools, or software, given that this view often ignores the hardware aspect as an integral part of digital technologies. The scholar and media theorist Friedrich Kittler goes further to claim that "there is no software" because "all code operations [...] come down to absolutely local string manipulations [...], to signifiers of voltage differences. [...] software does not exist as a machine-independent faculty" (Kittler 1995). Software instructions and processes run as analogue voltage differences at the machine level. The shrink-wrapped software marketisation, be it in a physical package or somewhere in the cloud, is a business that does not exist separately from hardware. In the words of scholar Wendy Hui Kyong Chun, both "software and hardware (like genes and DNA) cannot be physically separated" (Chun 2005, 28).

Adding to this emphasis of the materiality of software, as embodied in hardware, Cramer writes that "media, in the technical sense of storage, transmission, computation and display devices, are always analogue" (Cramer 2014, 20). In short, what Cramer argues is that "our senses can only perceive information in the form of non-discrete signals such as sound or light waves. Therefore, anything aesthetic (in the literal sense of *aisthesis*, perception) is, by strict technical definition, analog" (ibid.).

This focus on the materiality of media technologies and on the analogue nature of their tangible and sensorial aesthetic manifestations is also at stake in neo-analogue hybrids. As the scholar Joseph Hyde acknowledges, neo-analogue practices seem to stress physicality and emphasise primarily "sound and light as physical materials as opposed to electronic signals or media" (Hyde 2020, 198).[12]

12. Hyde explains further that the physicality aspect is emergent in contemporary "sound art which explores physical space and acoustic phenomena" (Hyde 2020, 198).

As a form of media archaeology, neo-analogue practices engage not only in repurposing discarded analogue media but also in creating a clash of temporalities through hybridisation— one that disrupts the notion of the old and the new within digital media ideologies and imaginaries. They excavate the past as "an attempt to challenge the techno-social constructions of contemporary interface culture" (Andersen, Pold, and Riis 2014, 157).

Ultimately, creative practices that devise neo-analogue hybrids also question whether in the post-digital era—in times when digital computational technologies permeate all aspects of daily life, and where there is no apparent difference between being online or offline—it is still relevant to categorise something as *being digital*.[13]

13. In the words of scholars Berry and Dieter, "the term 'digital' describes a historical world of discrete moments of the computational" (Berry and Dieter 2015, 3).

3. Neo-analogue Creative Practices

Neo-analogue practices often reclaim hybridisation of analogue and digital media, be it through the exploration of analogue media such as film, electronic video or through analogue-digital media assemblages. Some of these practices include a mesh of handmade film and expanded cinema as well as audiovisual installation or performance. These practices reuse and repurpose analogue media as a reaction to the supremacy of digital video through a media archaeological approach that often follows a DIY methodology.

As the artist and scholar Philip Hoffman explains, "experimental filmmakers bring back to life analog technologies and repurpose them for the present" as a means of sharing "past knowledge for future development" (Hoffman 2018, 39). This is an example of a wide diversity of neo-analogue creative practices that reuse and revive analogue media and fabricate analogue-digital hybrids as an artistic move away from the hype of digital technology.

3.1. Materiality and Tangibility

Neo-analogue practices explore handmade cinema by experimenting with film as a material, through a hands-on approach. In analogy to a metalworkers' "intense intimacy with their material", this attitude expresses the "desire of the craftsperson to see what a metal can *do*, rather than the desire of the scientist to know what a metal *is*" (Bennett 2010, 60). Adding to this idea, scholar Jussi Parikka writes that a photo-chemical "film artist with a media archaeological bent knows the amount of combination needed in testing and experimenting with chemicals or materials" (Parikka 2015, 55). Therefore, instead of employing mechanical film processing, artists have been hand-processing their films and sometimes creating their own emulsions. This attitude shows "a move from machine-built control to the circuitous processes of serendipity" (Hoffman 2018, 43). In other words, a move from industrial cinematic modes of production to a post-digital craft and handmade way of filmmaking

This artistic move not only shows the "reconfiguration of film from industrial to artisanal – a quality closely tied to authenticity in its emphasis on craft and rejection of the division of labour" – but is also a statement on "the work and care of the hand, an investment in palpable materiality that recruits the power of anachronism to debunk the false promises of progress and innovation" (Balsom 2018, 76).

This haptic and often intimate relationship to film and its palpable materiality can be seen, for example, in the black and white 16mm film *All That Is Solid* (2014), by the artist Eva Kolcze, that explores "utopian visions that inspired the Brutalist movement and the material and aesthetic connection between concrete and celluloid" (Kolcze 2014). The work stresses hands-on manipulation and materiality by using travelling shots of brutalist architecture that face the surface of the film, as a material substance manipulated by hand using chemicals and physical processes.[14]

14. Moving images of Brutalist buildings disintegrate in molecular artefacts of matter, reminding us that all matter turns to dust. The 16mm film was further transferred to digital video and is also accessible online: https://www.evakolcze.com/new-page.

Another intimate approach to the materiality of film is seen in the work *Ways + Means* (2015), by the artist Leslie Supnet, a city symphony of Toronto shot with a Bolex 16mm film camera and edited in-camera using several multiple exposures and pixilation techniques.[15] The film, which is a goodbye letter to the city and portrays hectic city life as well as daily life, was first presented as a 16mm loop on a pedal-powered hand-built artisan projector, created by Martin Heath and Petra Chevrier. The "film's projection speed is dependent on how fast or slow the user is peddling" (Supnet 2015), thus, if the audience-collaborator stopped peddling the film projection would fade to black. The work delegates control to the audience as an alternative way of powering the projector and of raising awareness on the functioning of the cinematic apparatus. This process subverts traditional modes of cinematic presentation in order to create coexistence, cooperation and exchange among audiences, the artwork and the artist. The choice to use a hand-cranked Bolex camera for its production and a pedal-powered projector for its presentation demonstrates a post-digital move to an offline, neo-analogue media attitude.

15. The film exists in both 16mm and as digital video and is accessible online: https://lesliesupnet.ca/films/ways-means-16mm-11-minutes-colour-digital-sound-2016.

Figs. 1 and 2. Ways + Means (2015) by the artist Leslie Supnet, Art Spin/Pleasure Dome event, 2015. Photo by Priam Thomas.

The performance *Second Star* (2015) by Scott Fitzpatrick, which combines film loops, similarly deconstructs and expands traditional modes of cinematic presentation. During the performance, the abstract film loops run through the optical sound reader of the projector, creating rhythms that are manipulated in real-time using a looper effect pedal. The classic technique of direct translation of light-to-sound through the optical sound reader in combination with the looper effect pedal enables further sound manipulations in real-time. In this way, the optical sound is highlighted as a second cinematic "star" or as a fundamental element of the cinematic experience that is often overshadowed by the moving images.

These works foreground the haptic manipulations of film, as a material medium that can be directly intervened, be it through the filmstrip surface, projection speed or loops running on projectors. They also emphasise hybridity by combining analogue media and offline modes of production with digitalisation and online distribution.

3.2. Repurposed and Resurrected Media


Figs. 3 and 4. Electrostatic Bell Choir (2012-13) by Darsha Hewitt, Blackwood Gallery, 2013. Photo by Toni Hafkenscheid.

Other neo-analogue practices may explore the appropriation and reuse of discarded video technologies and the manipulation of electronic video signals in engagements with hardware hacking, cracking, modifying or bending. This repurposing of discarded analogue devices can be defined as Zombie media, resurrected into new forms and contexts.

For example, the installation *Electrostatic Bell Choir* (2012-13) by the artist Darsha Hewitt, uses the static electricity emitted from discarded CRT televisions to make several electrostatic bells ring that stand in front of the CRT televisions. The TVs are programmed using a microcontroller to switch on and off in order to compose different sequences of light and sound, triggering subtle bell ringing sounds that reverberate through the dark space. In this manner, the compositions materialise electrostatic energy while, at the same time, foreground that all media devices are dependent on electricity as a "stream of electrons moving in a current" (Bennett 2010, 26) that becomes a "choir" of nonhuman agents defining the flow of the work.

Fig. 5. Föhnseher (2011) by Julian Oliver.

Another example is the modification of discarded or obsolete devices as is the work *Föhnseher* (2011) by artist Julian Oliver, a modified analogue TV converted into a new device, the *Föhnseher*, a wordplay on the German words *Fernseher* (television) and *Föhn* (warm wind). The Föhnseher resurrects an analogue TV modified into a media device that "captures and displays images downloaded by people on surrounding local wireless networks" (Oliver 2013). This media device thus reveals the illusion of online privacy and security, while giving a tangible expression to wireless networks as electromagnetic waves travelling through the air.

These examples resurrect analogue devices with custom-made software into new media assemblies and seek to make tangible their invisible driving forces, such as electrostatics, electricity, electromagnetic waves or wireless networks. As such, they make tangible what is often described as immaterial in analogue electronic or computational media.

3.3. Analogue-digital assemblages

Neo-analogue hybrids are also explored in analogue-digital media assemblages that, rather than disrupting or resurrecting existing media technologies or devices, suggest a media ecology of balance and entanglements across several media technologies.

More concretely, the audiovisual performance *10,000 Peacock Feathers in Foaming Acid* (2007) by Evelina Domnitch and Dmitry Gelfand explores the generative structures of soap bubbles, together with a laser light beam that is controlled by custom software. This process generates visuals of "large-scale projection of molecular interactions as well as mind-boggling phenomena of non-linear optics" (Domnitch and Gelfand 2007). This performance defies the common expectation of computational generative visuals through an analogue-digital assemblage for generating abstract visuals.

A similar combination of analogue media and custom software is explored by artist Sally Golding in the performance *Light Begets Sound* (2016). The work captures the flickering projected light of a film projector and translates it to sound as an integrated feedback loop through an audiovisual assemblage that results in a hallucinogenic experience. The performance combines analogue film projectors with LED lights, camera flashes, custom software and light-reactive DIY instruments, as separate but interconnected elements that create a balanced media ecology.

Like the previous DIY approaches, *Bulbble* (2019) by the artist Viola Yip, is an electronic self-built instrument that deviates from standardised media technologies. It has a variable configuration and assembles 4-12 channels of incandescent light bulbs and produces a "pulse-timbre continuum of acoustic sounds that are generated from relays" (Yip 2019). Its electronic circuit was built as a score but the score became entangled with the instrument, together with unexpected elements such as switches' interferences or electricity. The instrument itself becomes the composition, unfolding in time as a network of complex relations between the relay's buzzing sounds and lights bulbs flickering, together with performative gestures and unexpected behaviours as well as the artist's animated shadow.

Fig. 6. Bulbble (2019) by the artist Viola Yip. Photo by Youi Shih.

3.4. Neo-analogue Post-digital Hybridisation

With their different approaches, comprising hands-on manipulation of media materiality, the computational resurrection of obsolete devices or devising customised analogue-digital assemblages and ecologies, neo-analogue creative practices also move between offline modes of creative production and distribution. They rely on hybridisation as a means to reject the rhetoric of the digital, with a critical view on media digitisation and online surveillance, withdrawing from the computer as the sole means of creative production and reacting to the dominance of our current online mode of cultural consumption.

DIY approaches to the reappropriation, resurrection and repurposing of analogue and digital technologies also seek to defy the notion of media standardisation. Assemblies of analogue devices and custom software, analogue electronics and computational processes create media ecosystems that challenge traditional artistic conceptions of medium specificity as well as common screen-based forms of media consumption. Through direct manipulation of light and sound as media materials, neo-analogue practitioners also emphasise haptic engagement with media materiality. They turn into “vital materialists” who are aware of media material capacities and its limitations (Bennett 2010, 111) and thus strategically engage in devising post-digital hybrid forms.

4. Conclusion: Off the Digital Grid

Neo-analogue practices suggest that analogue vs. digital, or old vs. new media, are just two sides of the same coin. Rather than taking analogue or digital media as extremes of “how individuals relate to the techno-political and economic realities of our time,” either through “over-identification with systems, or rejection of these same systems” (Cramer 2014, 22), neo-analogue practitioners engage in post-digital hybridisation. Consequently, in neo-analogue practices, there is an implicit sense of agency over the medium that, as Cramer argues, is inherent to post-digital subcultures as an “illusion of more control over the medium” just like digital cultures “are driven by similar illusions of free will and individual empowerment” (ibid.).

Accordingly, the engagement of the neo-analogue practitioner, artist or enthusiast with the self-made is characterised by a dedication to material experimentation, sometimes delegating control to chance processes, as opposed to the granular control enabled by digital technologies. The sense of agency inherent to the DIY attitude is also combined with community building and peer cooperation, knowledge sharing and learning by doing, as key aspects of these cultures of creative production.

By relying on a DIY methodology, with a focus on handmade and artisanal modes of production, these practices also emphasise media materiality infused with computation as well as online and offline networking. However, these forms of tinkering and craftsmanship should not be seen as mere nostalgic revivalism, neither as a search for technical innovation. Rather, they seek to remix and combine characteristics and qualities of both analogue and digital media into neo-analogue hybrids that take a critical stance towards the post-digital condition, or the fact that the digital and computational have become hegemonic – “a condition in which digital disruption is not transcended as such, but becomes routine or business as usual” (Berry and Dieter 2015, 6).

Artists choose to reinvent their own tools by both reviving media technologies through electronic and computational customisation and by exploring diverse tangible manifestations of the computational as something “experiential, spatial and materialized in its implementation, embedded within the environment and embodied”, as something that is “touched and touchable, manipulated and manipulable and interactive and operable through a number of entry-points, surfaces and veneers” (Berry and Dieter 2015, 3).

Through assemblages of analogue and digital technologies, neo-analogue practices devise hybrid forms that are no longer defined by their tools or media formats but by their concepts, contexts and ideology. They do so by emphasising media mutation and diversification instead of normalisation and standardisation, as a reaction to, and rejection of, an inevitable entanglement in *the digital* media grid. They stage the possibility of being *off the digital* media grid by incorporating digital technologies and defying medium specificity, thus rejecting the techno-positivist ideologies of *being digital*.

Acknowledgements. This paper was funded by national funds through the FCT – Foundation for Science and Technology, I.P., in the context of the project SFRH/BD/143713/2019 and UIDB/04042/2020.

References

Andersen, Christian, Søren Pold, and Morten Riis. 2014. "A Dialogue on Cassette Tapes and Their Memories." *A Peer-Reviewed Journal About 3* (1): 156–67. Accessed April 10, 2021 https://aprja.net//article/view/116095 .

Balsom, Erika. 2018. "The Ambivalence of Authenticity." *Film in the Present Tense*, 75–77. Archive Books.

Bennett, Jane. 2010. *Vibrant Matter: A Political Ecology of Things*. Duke University Press Durham and London.

Berry, David M. and Michael Dieter. 2015. "Thinking Postdigital Aesthetics: Art, Computation and Design." *Postdigital Aesthetics: Art, Computation and Design*. Berry, David M. and Michael Dieter (eds.), pp. 1-11. Hampshire, New York: Palgrave Macmillan.

Chun, Wendy Hui Kyong. 2005. "On Software, or the Persistence of Visual Knowledge." *Grey Room* 18: 26–51.

Cramer, Florian. 2012. "Post-Digital Writing." *Electronic Book Review*, December 12. Accessed April 10, 2021. https://electronicbookreview.com/essay/post-digital-writing/.

Cramer, Florian. 2014. "What Is 'Post-Digital'?" *A Peer-Reviewed Journal About* 3 (1): 10–24. Accessed April 10, 2021. https://doi.org/10.7146/aprja.v3i1.116068.

Cramer, Florian. 2019. "Does DIY mean anything? - a DIY attempt (= essay)." *Anrikningsverket Journal*. 1: Convulsion, Jul 2019, 52-72. Accessed April 10, 2021. https://files.cargocollective.com/667217/Anrikningsverket_Journal_1_2019.pdf#page=52.

Daniels, Dieter.
2016. “What Happened to Media Art? A Summary and Outlook.” *Across and Beyond: Post-Digital Practices, Concepts, and Institutions*. Bishop, Ryan, & Gansing, Kristoffer, & Parikka, Jussi (eds.), pp. 44–62. Germany, Berlin: transmediale e.V. and Sternberg Press.

Domnitch, Evelina, and Dmitry Gelfand.
2007. “10000 Peacock Feathers In Foaming Acid.” Accessed April 10, 2021. http://portablepalace.com/10000feathers.html.

Hertz, Garnet, and Jussi Parikka.
2012. “Zombie Media: Circuit bending media archaeology into an art method. *Leonardo* 45 (October).

Hertz, Garnet, and Jussi Parikka.
2015. “Zombie Media: Circuit bending media archaeology into an art method.” In *A Geology of Media*. University of Minnesota Press.

Hoffman, Philip.
2018. “Vulture Aesthetics: Process Cinema at the Film Farm.” Film in the *Present Tense*, 37–45. Archive Books.

Huhtamo, Erkki (Ed.), and Jussi (Ed.) Parikka.
2011. *Media Archaeology: Approaches, Applications, and Implications*. University of California Press.

Hyde, Joseph.
2020. “The New Analogue Media Archaeology as Creative Practice in 21st-Century Audiovisual Art.” *Sound & Image: Aesthetics and Practices*, 188–205. Routledge.

Kittler, Friedrich.
1995. “There Is No Software.” *Ctheory*. Accessed April 10, 2021. https://web.stanford.edu/class/history34q/readings/Kittler/There_is_No_Software.html.

Kolcze, Eva.
2014. “All that is solid.” Accessed April 10, 2021. http://www.evakolcze.com/new-page.

Ludovico, Alessandro.
2012. *Post-Digital Print: The Mutation of Publishing since 1894*. Onomatopee 77. Eindhoven: Onomatopee.

Manovich, Lev.
2013. *Software Takes Command: Extending the Language of New Media*. New York: Bloomsbury Academic.

McLuhan, Marshall.
1964. *Understanding Media: The Extensions of Man*. Signet Books. Canada: The New American Library of Canada Limited.

Negroponte, Nicholas.
1995. *Being Digital*. Alfred A. Knopf, Inc.

Oliver, Julian.
2013. “Föhnseher.” Accessed April 10, 2021. https://julianoliver.com/output/foehnseher.html.

Parikka, Jussi.
2015. A *Geology of Media*. University of Minnesota Press.

Paul, Christiane.
2003. *Digital Art*. 3rd ed. Thames & Hudson.

Rey, Nicolas.
2018. “Contemporary Issues of Artist-Run Film Lab Practices.” *Film in the Present Tense*, 63–71. Archive Books.

Supnet, Leslie.
2015. “Interview with Leslie Supnet.” Interview by Christina Battle. *INCITE* Journal. Accessed April 10, 2021. http://incite-online.net/lesliesupnet.html.

Yip, Viola.
2019. *Bulbble*. Accessed April 10, 2021. https://www.violayip.com/bulbble.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

New Eyes: Probing the Visual Cultures of the Technosphere

Keywords: Environment, Technosphere, Architecture, Computation, Digital, Media, Visual Culture

Corneel Cannaerts
corneel.cannaerts@kuleuven.be
KU Leuven, Ghent, Belgium

Michiel Helbig
Michiel.helbig@kuleuven.be
KU Leuven, Ghent, Belgium

The emergence of the technosphere, a planetary accidental megastructure comprised of networked emerging technologies, leads to novel ways of seeing and understanding our environments. The paper questions the impact of these new visual cultures on architecture and urban design, practices that rely heavily on visual media. The research is contextualised and framed in contemporary design and artistic practices engaging with digital technologies as means of understanding the complexities of our technologically saturated environments, The paper looks into a series of case studies that probe the visual cultures of the technosphere, looks at emerging technologies as a lens for mapping environments and discuss the medial practices and strategies developed in the work.

1. Introduction

The environments in which we operate as architects are increasingly saturated with digital technologies, resulting in a technological layer spanning the globe which has been described as the technosphere[1], in addition to the geosphere, biosphere, hydrosphere and atmosphere. Emerging technologies impact how we see ourselves and understand our environment, they produce a constantly updating plethora of images, maps an representations of our world. The visual cultures these technologies give rise to are not just representing but actually *producing* the environment in which we operate, i.e. our world is increasingly experienced and made through digital media. This paper questions how architecture, a discipline whose practice relies heavily on the visual media responds to these novel ways of seeing and the visual cultures it produces? Can we develop new ways of understanding and practicing architecture through the novel ways of mapping our world and the visual cultures afforded by digital technologies? The paper addresses these questions by situating the work in the context of the ongoing practice and research projects of fieldstation studio, relating the work to state of the art practices and research, setting up a framework of notions and concepts and demonstrate them through projects. The research is based on a number of case studies consisting of projects, mappings, videos and speculative software developed by fieldstation studio.

2. Context

Fieldstation studio was initiated by Michiel Helbig and Corneel Cannaerts in response to the challenges to architectural practice and culture posed by the emergence of the technosphere, an accidental planetary megastructure of digital technologies. Fieldstation studio was set up as a learning environment confronting research, education and practice with real-world challenges through collaboration with external partners. Fieldstation studio is a node in the international Fieldstations eV[2] network of architects, artists, scientist and activists exploring new models for architecture in relation to the Anthropocene and the technosphere. The network consists of a growing number of local nodes, collectively it organizes workshops, exhibitions and summer schools[3] and lectures.[4] We approach the built reality and architecture as only one of the layers that make up the environments we inhabit, it is embedded within other material and immaterial layers, and it contributes to larger economic, political, material, environmental, technological and infrastructural systems. Within the design studio, this expanded field, this constantly changing, layered and hybrid environment is seen as the context architecture operates in.

1. Peter Half coined the term Technosphere in 2014, referring to all man-made structures, we use a more concise definition of the technosphere as the global infrastructure resulting from digital networked technologies, similar to the accidental megastructure described in Benjamin Bratton's *The Stack.*

2. The Fieldstation network initially had its headquarters at Teufelsberg , an artificial hill constructed from the rubble of Berlin after the second world war, on the site of the Nazi military-technical school designed by Albert.

3. Several workshops and summerschools were organised: Sense, Adapt, Create http://fieldstations.net/sense-adapt-create/, If This(), Then(Keephouse); http://fieldstations.net/wekeephouse/

4. Fieldstation Berlin organises a lecture series at the Deutsches Architektur Zentrum, Michiel Helbig and Corneel Cannaerts, gave a performance lecture in this series on June 29 2019.

Fieldstation studio engages with the complex reality described above by rethinking our modes of operation, the toolbox we use and our position as architects designing embedded in this layered and hybrid environment. The studio investigates the potential of architecture as a medium to explore disrupt and raise questions rather than solving them. We proclaim that architects should proactively engage the complex reality of today rather than passively waiting for design briefs and projects. Students are trained in taking positions within contemporary fields and are the studio provides them with a platform for developing their future practice. Additional elective courses provide students with the necessary critical tools, skills and design media. The tools of choice are design fiction, spatial narratives, speculative media, imagineering, hacking and critical making. The studio operates as a collective practice, students are encouraged to actively participate in the organization and content of the studio, breaking out of the confines of academic architectural education. We undertake fieldwork and actively seeks encounters with practitioners, thinkers, makers, hackers, architects and artists operating in similar fields, to exchange alternative practices, to share experiences and ideas.

3. State of the Art

Architects, both in practice and in academia have generally approached digital technologies as an extension of their toolbox, developing digital means for drawing, modeling, calculating and communicating architectural ideas. Research into the digitalisation of architecture, in the fields of computer aided design, building information modelling, virtual and augmented reality, digital and robotic fabrication… tends to look inward into how technologies impact the use of design media in architecture[5]. Related fields of research look at how digital technologies manifest themselves in the built environment, most of the research into smart cities, smart homes and internet of things pushes a positivists technological agenda and mostly lacks the criticality to assess the spatial impact of these technologies. A relatively small number of practitioners and researchers within architecture and related disciplines critically engage with the emergence of the technosphere, the increasing digitalisation of our environment, beyond the instrumentality of design media and the uncritical pragmatics of all things 'smart'.[6]

Unknown Fields Division,[7] a design studio and research practice run by Liam Young and Kate Davies, undertakes fieldtrips to what they call the 'dark site of the city', the mines, factories, waste dumps, logistics and infrastructures that enable our technologically saturated lifestyles. They use their skills in data

5. An online compilation of paper presented at key CAD conferences in those fields is hosted at CUMINCAD, see http://papers.cumincad.org/

6. See Shannon Mattern, *A City Is Not a Computer*, Places Journal November 2017, see https://placesjournal.org/article/a-city-is-not-a-computer/

7. See http://www.unknownfieldsdivision.com/ consulted on 25/02/2020.

mining, surveying, modelling, storytelling, image production and cinematography, to tell tales from what they call *city everywhere*, and compile these into videos, performances[8] and publications[9]. *Scanlab Projects*[10] is an architectural practice that uses digital scanning, modelling and cinematography to represent environments, landscapes and events into compelling visualisations. *Landskip lab*,[11] a research laboratory and landscape architecture practices specialised in understanding our environment through innovative and traditional surveying technologies, develops tools for collecting, navigating and visualising large data sets and integrating them in urban and landscape design practice. *Territorial Agency*,[12] develops research into territorial and spatial transformation, for example in the Oceans in Transformation, using earth observation, data visualisation to visualise, map and understand the complex layered territories. *Forensic Architecture*[13] uses architecture as a device to undertake investigations into human rights violations, collaborating with activist groups, NGO's and international organisations. Using remote sensing, cross referencing media, material analysis, interviewing and crowdsourcing they construct spatiotemporal forensic models of how events unfolded, exposing state violence and secrecy.[14]

Artistic practices related to architecture deal more directly with the media ecology or new forms of visibility and opaqueness brought forth by the technosphere. In his book the *New Dark Age: Technology and the End of the Future*,[15] James Bridle argues against the belief that increasing computational power and availability of data leads to clearer understanding of the world. Metahaven voices similar concerns focussing on opaqueness and transparency related to surveillance in *Black Transparency: The Right to Know in the Age of Mass Surveillance*.[16] *Vertical Atlas* a project by Digital Earth and Het Nieuwe Instituut,[17] works with over 50 artists, designers and scholars in compiling an atlas of the technosphere, including mappings and narratives from all continents. Trevor Paglen[18] worked on exposing landscapes of surveillance using photography and camera technologies borrowed from disciplines like geography to explore the limits of visibility. Recently he has been looking into imagery produced for machines instead of humans in the development of machine learning and artificial intelligence. In the work From '*Apple*' to '*Anomaly*',[19] he presented a mural consisting of a selection of 30.000 images from imageNet, a data set used to train machine learning models, revealing peculiar associations and biases.

These state of the art examples demonstrate how architects and artists respectively engage with the complexities of the technosphere and approach technologies not as neutral or transparent means for seeing and mapping our world, but as highly politicised infrastructures and territories that hide as much as

8. Liam Young, City Everywhere (https://www.youtube.com/watch?v=rE_c0hmx9Fg)
Hello City (https://www.youtube.com/watch?v=Nx9ydyQsSSk)
performances, consulted on 25/02/2020.

9. See Young, Liam & Unknown Fields Division, eds. *Tales from the Dark Side of the City*, AA Publications 2016.

10. See https://scanlabprojects.co.uk/, consulted on 25/02/2020 .

11. See https://www.landskip.ch/, consulted on 25/02/2020.

12. See https://www.territorialagency.com/, consulted on 25/02/2020.

13. See https://forensic-architecture.org/ consulted on 25/02/2020.

14. Weizman, Eyal. *Forensic Architecture: Violence at the Threshold of Detectability*. Brooklyn, NY: Zone Books, 2017.

15. Bridle, James. *New Dark Age: Technology, Knowledge and the End of the Future*. London ; Brooklyn, NY: Verso, 2018.

16. Kruk, Vinca, Daniel van der Velden, and Metahaven, eds. *Black Transparency: The Right to Know in the Age of Mass Surveillance*. Berlin: Sternberg Pr, 2015. »

they reveal. In the architectural examples emerging technologies are used to extend the architectural toolbox to reveal the complexities of our interconnected and mediated world. In other words technology expands not only the architectural design media but also the subject matter and content addressed within these creative practices. Similarly, the projects presented in this paper look at emerging technologies as architectural media and how they enable us to critically engage with the media-ecologies of our technologically saturated world.

4. Probing the Technosphere

> *"The shift in meaning could not be greater: once a reference to an ideal geometric figure of Euclidean space, a harmonic surface spanned by the same distance to a central point – today a functional description of a complex and integrated metabolic system, an endless circulation of energy and matter through shapeless domains, or spheres. Moreover, every one of these messy spheres intermingles with every other. Where does the gaseous atmosphere end? Where is the hydrosphere absent? Where is the planet uninfluenced by the biosphere? Where is the technosphere not at work? How do we approach, let alone construct, this paradoxical notion of a shapeless sphere, not to mention the idea of many spheres blending into one?"*[20]

The technosphere, as coined by Peter Half in 2014[21] encompassing all of humanity and human made artefacts, and thus intersecting the geosphere, biosphere, atmosphere and other spheres as defined in geology. The technosphere intermingles and interacts with other spheres, it cannot be seen in isolation but is entangled with other material and immaterial spheres or layers, which interactions are in constant flux. We use the notion of technosphere in a much narrower sense as the recent global spatial structure emerging through digital technologies, encompassing of its material infrastructures, the data and information that flows through it as well as the cultures it harbours. Notions of the Anthropocene and the technosphere operate on timeframes and scales beyond the disciplinary focus of architecture. One approach to overcoming this might be working transdisciplinary, collaborating with scientific and artistic practices more attuned to handling these issues. Another approach might be looking where these scales and timeframes intersect with the spatial understanding, the vocabulary and toolset of architectural practice and culture. Focussing on the habitual scale and timeframe of an architectural object we might be blind for its entanglements with certain phenomena and fields, while looking on the largest scale, i.e. all of mankind, the planet as a whole, risk depoliticizing and deterritorializing the consequences of the Anthropocene and technosphere. Within

17. See https://verticalatlas.hetnieuweinstituut.nl/en, consulted on 25/02/2020.

18. See Thompson, Nato, Jeffrey Kastner, and Trevor Paglen. Experimental Geography. Brooklyn, N.Y. : New York: Melville House ; Independent Curators International, 2008. and http://www.paglen.com/, consulted on 25/02/2020.

19. Cook, Sarah, Alona Pardo, Trevor Paglen, and Barbican Art Gallery. Trevor Paglen: *From "Apple" to 'Anomaly' : Selections from the ImageNet Database for Object Recognition*, 2019.

20. Orit Halpern, Spheres, See https://archive.anthropocene-curriculum.org/pages/root/resources/spheres/, consulted on 25/02/2020.

21. Haff, Peter. K. Technology as a Geological Phenomenon: Implications for Human Well-Being. Geological Society, London, Special Publications, vol. 395, nr. 1, 2014, pp. 301–09.

fieldstation studio we aim to work on multiple scales simultaneously, we aim to use the spatial understanding present within architecture and related spatial disciplines to unravel complex contemporary phenomena through modelling, mapping and visualising.

The Fifth Tower is a video that found its origin in the increasing digital mapping of our environment, it looks at a technological glitch as an architectural object indicating the emergence of the technosphere and how it reorders powers. More specifically it looks at how towers in the city of Ghent represent various forms of power: from religious and political power represented by the three historical towers to Vande Velde's University Library tower representing the power of science and knowledge.[22] The fifth tower is a glitch in google maps, an accidental architectural volume floating in the skyline of this particular digital representation of the city. The fifth tower represents a shift in economic, political and technological power, the introduction of platform economies, a map owned by google a private tech company, based on military satellite and lidar technology. The University Library consist of a painstakingly and carefully\collected, peer reviewed and debated body of knowledge, which at the moment of making this video was being scanned and digitised as part of the google library project. In contrast, google maps is the result of a technological data capturing and automated mapping process, a kind of blind scanning of our world. This indicates a shift in how we model and map our world, from a scientific model that represents our understanding of the world, to one were we capture enough data to simulate and reliably predict certain phenomena without the need for a human understanding of how that prediction works. Taking this glitch serious as a tower, through its verticalness it indicates centrality and a concentration of power, in the periphery of the city of Ghent the same mapping introduces an new border where the 3D model abruptly becomes a flatland of 2D satellite imagery.[23]

22. Interestingly all three historic towers of Ghent and the University Library of Ghent have a website, indicating their centrality and position within the digital domain: https://www.belfortgent.be/, https://www.sintniklaaskerk.be/de-kerk/, https://sintbaafskathedraal.be/ and https://boekentoren.gent, consulted on 25/02/02.

23. Ian and Erin Besler developed this idea in a project called Resolution Frontiers, see https://www.ianbesler.com/frontiers/, consulted on 25/02/2020.

Fig. 1. The Fifth Tower, video loop.

Stijn Colon's project titled *Fieldstation Google Earth* explored the relationship between the physical earth and google earth as its digital counterpart. Google earth is updated through lidar scans, satellite images and google street view cars, while lagging behind physical earth the refresh rate of the digital counterpart is increasing. Currently Google Earth operates as a memory for earth, but in response to the increased refresh rate, Stijn speculated on what might happen if google earth would catch up, becoming real-time, or even evolve faster than the physical earth, running simulations of various potential versions of the earth simultaneously. The project resulted in the design of a house that incorporates and materialises various conflicting simulations. Google earth becomes a place for imagination, a place to be colonised, a battle ground for a multitude of ideas that might or might not manifest themselves physically.

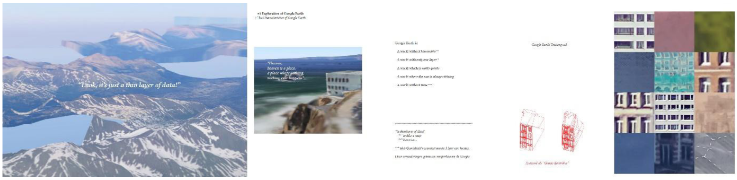


Fig. 2. Stijn Colon, Fieldstation Google Earth.

In the paper *Fieldnotes from the Technosphere*[24] we published a first attempt of modelling the structure of the technosphere and how it consists of a stack of interacting layers in the vertical, and a set of dynamically shifting territories and borders in the horizontal. Architectural objects, whether in the form of materialised constructs or buildings, or existing within mediated environments as imagery, as discussed in the examples below, can be seen as probes that interact with and reveal parts of the horizontal a vertical complexities of the technosphere. They reveal the politicised and contested nature of the technological layer and how this interacts with and reorganises existing societal structures.

24. Cannaerts, Corneel and Helbig, Michiel, (2019). *Fieldnotes from the Technosphere*. In: Proceedings of CA²RE Conference for Artistic And Architectural Research. Presented at the CA²RE Conference for Artistic And Architectural Research, Ghent, 04 Oct 2019-06 Oct 2019.

5. Technological Eyes

> *At planetary scale, we see the formation of a vast geocinematic apparatus built from roving satellites, surveillance cameras, geosensing arrays, billions of cell phones etc, producing not one master image but multiple possible composites each of which overflows frames of perception. We have yet to really discover what kinds of cinema we can compose with this already existing apparatus - what durations, what perspectives, what contortions of narrative, what distribution of 'screens' - but the answers will define visual culture: an archive of/for an uncertain future-present.*[25]

25. Bratton, Benjamin H. "Further Trace Effects of the Post-Anthropocene." Architectural Design 89, no. 1 (January 2019): 14–21. https://onlinelibrary.wiley.com/doi/abs/10.1002/ad.2382

The Earthrise (1968) and *Blue Marble* (1972) photographs, taken from Apollo 8 and 17 respectively, coincided with the emergence of the environmental movement and a more widespread ecological awareness.[26] The photographs demonstrate that our collective imagination can be drastically altered through visual media and points of view afforded by technology. Contemporary digital technologies similarly impact how we see ourselves, and understand our environment: Satellite imagery, laser scanning, the plethora of cell phone and other cameras, surveillance systems, sensor arrays, data logging... produce a constantly updating plethora of maps and images of our world.

26. See amongst others: Buckminster Fuller, R. *Operating manual for spaceship Earth* (Clarion books). New York: Simon and Schuster, 1970, and Brand, S. *The last whole earth catalog* (Penguin books 3544). Harmondsworth: Penguin books, 1971.

In addition to the cold war military apparatus that produced the first images of the planet as a whole, image production and sharing has become accessible to a larger part of the population, its aggregation and propagations is still tied up in political, technological and economic structures. Many of these data streams are not necessarily visual in nature, they are rendered visual through screens targeting our eyes with specific imagery tailored to our personal histories and preferences. The digital nature of these technologies makes them interactive, it is not just our eyes that are looking at the imagery, increasingly technology is looking back, providing novel ways of seeing our world.

The *Prometheus* video is a zoom through the various scales of the technologically saturated environments. The video is reminiscent of the *Powers of Ten*,[27] the film produced by Ray and Charles Eames in 1977, it traverses various scales over a number of sequences: i*nto the screen, extended bodies, augmented interiors, mediated building and numb city*. It was produced during the four day workshop with 90 bachelor students from the Faculty of Architecture KU Leuven. The video is an experiment in how digital media afford collaboration, rather than story boarding and carefully setting up scenes and shots, the video resulted from a collective and blind data logging, scanning our environments through screenshots, smart phone apps and photogrammetry. The final video is compiled and rendered on screen as a camera travels through the collected point clouds.

27. See https://www.youtube.com/watch?v=0fKBhvDjuy0, consulted on 20/08/2019.

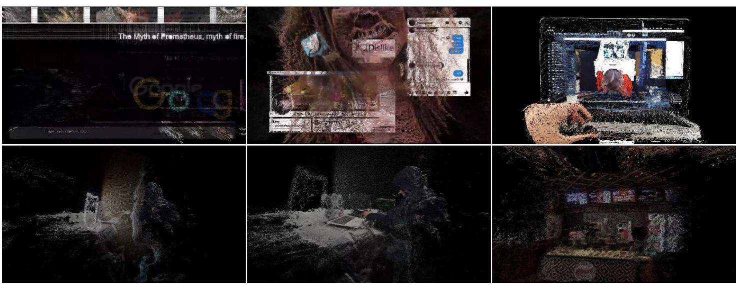


Fig. 3. Prometheus, collaborative video based on photogrammetry.

The *Artificial Landscapes* project explores the blurring between the natural and the artificial, resulting from the technosphere, the contemporary world that is increasingly saturated with digital technologies, running on data and computation. The videos are a result of an elective course introducing architecture students in programming as a visual medium to engage notion of artificial landscapes: Landscapes of Exploitation models resource extraction through the interaction between terrains, agents and environmental simulations. Machine Vision uses found footage and computer vision to render the vision of a machine navigating a terrain. [E]SC is an android app that uses the smartphones sensors to generate and navigate into an abstract landscape. Tiny Planet renders interaction between several layers of a tiny planet.

Fig. 4. Artificial Landscapes: Machine Vision project tracking motion through computer vision.

Deep Dream of a Self-Driving Car is a video and installation that consist of a surround video projected onto four screens. The video is recorded entirely in google earth, four cameras slowly moving through the familiar but strange landscape, through a process called data-moshing the footage increasingly bleeds and fades into itself, further alienating the landscape. In contrast to conventional cinematography, where scenes are carefully story-boarded and shots framed, google earth is the result of a blind capturing, an automated scanning of the world, providing a seemingly unbiased gaze that records everything with the same resolution. For now the mediality of the technology reveals itself as low-res and full of glitches, this is further emphasised through the use of data-moshing, a manipulation not on the visual content of the video, but on the data structure of the digital file itself.

Fig. 5. Laura Beccu & Batmagnai Altansukh, Deep Dream of a Self-Driving Car, installation.

The technologies for capturing, processing and composing imagery used in the examples descried above – screenshots, photogrammetry, pointclouds, computer vision, video, 360° projections, data moshing – demonstrate digital technologies as specific lens for seeing and visualising our world. A lens that is not neutral or passive, but a medium that actively influences how and what is being seen. Digital media rely on data, which are essentially discrete and finite, in order to capture continuous phenomena, which can be spatial, material or experiential, they are sampled at discrete intervals, digital data always has a resolution: dots per inch, bit depth, sample rate, frame rate... As the Chrono Drawings and *Deep Dream* of a *Self-Driving* Car demonstrates the discrete nature and resolution of digital media is not merely a technicality, it introduces its own qualities that can become part of the design process. The photogrammetry experiments, the use of google earth and the custom computer vision algorithms suggest novel ways of collaborating for producing time-based mappings of our world. There is a clear dissociation between data collection and making it visible through rendering or drawing it on screen, which is demonstrated by the two cameras used in the examples described above, one for capturing and one for rendering. Both cameras work as lenses that introduce their own qualities and forms of estrangement into the mapping of our world.

6. Into the Medium

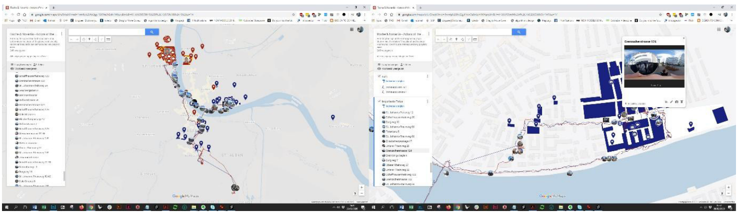
Architecture as a discipline and a profession has identified itself largely through the tools and media architects use to design, from the start of the profession with the inception of orthographic drawing and the ruler and compass, over the blueprints, sketches and collages to 3D modelling, rendering and image editing. There is an interesting lineage of specific instances of the relationship between architecture and media,[28] from the medial practices of architects, to media as architectural production, to architecture as medium, and the mediation of architecture in other artistic disciplines.

28. See Rattenbury, Kester, ed. *This Is Not Architecture: Media Constructions*. London ; New York: Routledge, 2002.

The increasing digitalisation of the practices of architecture and the environments in which we operate, and the emerging ways of seeing and mapping our world as outlined above, urges us to reconsider the habitual distinction between architecture and media, between represented and representation: through the advent of 3D scanning and surveying technologies, building information modelling, parametric modelling and environmental simulations, digital and robotic fabrication, virtual and augmented reality, to the consumption of architectural imagery through blogs and social media. These technological evolutions seem to forge novel pathways of exchange between, or even a reversal or collapse of the dichotomy between architecture and media.

We position the work of fieldstation studio explicitly in the lineage of using media in architectural culture by providing students with references of exemplary medial practices and encourage them to experiment with contemporary design media and visual culture developing a language suitable for the project they are working on. In elective courses we go a step further and directly engage the question of what contemporary design media afford for design practice: In the Cinematic Architecture elective, next to an introduction of time based media such as film and animation, students focus on questions of technologically mediated vision, further developing scenarios resulting from the Fieldstation studio. In the Computation and Materiality elective students are introduced into coding as a design medium, developing their own design tools for mapping, modelling and visualising architecture's entanglement.

Fig. 6. IFTTT collaborative mapping workshop.



If This Then That was a four days intensive data collecting and mapping workshop organised at the HyperWerk in Basel. For four days participants used their smartphones and laptops to investigate the impact of two of the largest pharmaceutical companies, La Roche and Novartis on the city of Basel. Through scraping data from websites, social media profiles, online videos and walking photographing and filming with sensor logging and gps-tracking enabled smartphones, we looked into the online and physical presence and visibility of these companies. All the gathered data was collected in google maps, using google maps to draw properties and sites of the companies throughout the city, collecting walking tracks through gps and geotagging photos. The walk concentrated on the periphery of the closed of campuses, and the various borders, threshold's and points of entry provided, in the digital map the gathered data was geo-fenced within the boundaries of these campuses.

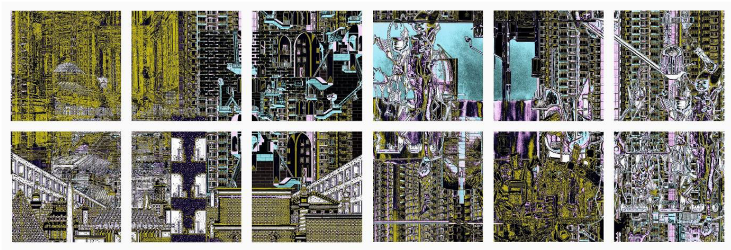


Fig. 7. Catherine Caglan, Compressed City, screenshots of Instagram page.

The project *Compressed City* by Catherine Caglan reflects on compression as a contemporary technological and architectural notion. Compression was approached as a technological concept, the balance between the information and the size of data, and compression as an economic and cultural value, measuring lifestyles in access to data bandwidth. We can also think of compression in an architectural, urban or even environmental sense as the compressing of spaces, functions and experiences. The design exploration looked into the increasing importance of interfaces in our environments as connections between the material and the digital, and speculated on manifestations of compression across various scales, from private, over shared to public and infrastructural spaces. The final work was collected in an Instagram account where several posts made up one large section drawing, a mash-up or collage that samples from historical architectural imagery estranged while familiar. In addition to the large drawing more information and small narratives were revealed using stories. Instagram is both medium and message, as it was used as a convenient medium for compiling and collecting and sharing the work, but also functions as a commentary on the content.

The examples outlined above demonstrate the strategies we use in the studio of working into or against the medium: using or abusing contemporary interfaces, platforms or technologies that form the content of the work as an inspiration for how the work is developed, borrowing or hijacking their visual languages. In the work we can identify several medial strategies: from surrendering to a certain medium and embracing its mediality, over abusing a medium for different use then intended, to subverting a medium by revealing it internal workings. We are interested in how contemporary media allow us to publish and share the work beyond known professional and academic audiences, and take a more provocative, proactive position within the world. Likewise the studio explores how digital media enable novel ways of collaborating and producing work as a collective. The synergetic relationship between content and media can also be found in the topics addressed and the operation of the studio. While exploring automation and platforms as topics of the studio we also looked into setting up a platform for sharing the work and finding automated ways of collaborating, compiling and discussing the work.

7. Discussion

As our world becomes increasingly digitised resulting in the emergence of the technosphere, a planetary accidental megastructure, that impacts and reorganises the spatial layout of our planet, both vertically by interactions between a stack of various layers or horizontally by forging new territories. The digital technologies that span our planet introduce novel ways of perceiving our environments, particular regimes of visibility and opaqueness, the resulting visual cultures are not neutral but highly politicized and contested. As the examples in the paper demonstrate the emergence of the technosphere urges us as architects to rethink both our medial practices, i.e. the media we use for designing and making architecture, as well as how architecture interfaces with other disciplines and expand the content or subject matter of architectural practice. The paper looked at the body of work produced within Fieldstation Studio and selected a number of projects that demonstrate the potential of emerging technologies to reconsider our position as architects, to see the world through new eyes. The paper demonstrates how architectural projects can be seen as probes revealing or rendering visible some of the complexities of our technology saturated world, how specific technological eyes introduce their own visual languages and showed examples of how architectural practice can interface with the world by working within the medium. The projects presented are work in progress, and the focus on the visual cultures of the technosphere emerged only through developing the work, we hope that the paper and discussion will help us developing a research agenda and conduct further experimentation as the digitalisation of our world unfolds.

References

Bratton, Benjamin H.
The stack: on software and sovereignty. MIT Press, 2015.

Bridle, James.
New Dark Age: Technology, Knowledge and the End of the Future. London ; Brooklyn, NY: Verso, 2018.

Haff, Peter. K.
Technology as a Geological Phenomenon: Implications for Human Well-Being. Geological Society, London, Special Publications, vol. 395, nr. 1, 2014, pp. 301–09.

Kruk, Vinca, Daniel van der Velden, and Metahaven, eds.
Black Transparency: The Right to Know in the Age of Mass Surveillance. Berlin: Sternberg Press, 2015.

Mattern, Shannon.
Code and Clay, Data and Dirt: Five Thousand Years of Urban Media. University of Minnesota Press, 2017.

Mattern, Shanon.
Cloud and Field, On the resurgence of "field guides" in a networked age. Places journal, August 2016

Oosterman, Arjen, Lilet Breddels, and
Leaonardo Dellanoce, eds. Volume 51 - Augmented Technology. Archis, 2017.

Runting, Helen, Frederik Torrison and Erik Siege, eds.
Lo-Res: Architectural Theory, Politics, and Criticism, ISSN 2002-0260, Vol. 1: High-Rise, 2015.

Turpin, Etienne, ed.
Architecture in the Anthropocene: Encounters among Design, Deep Time, Science and Philosophy. Open Humanities Press, 2013.

Weizman, Eyal.
Forensic Architecture: Violence at the Threshold of Detectability. Brooklyn, NY: Zone Books, 2017.

Young, Liam & Unknown Fields Division, eds.
Tales from the Dark Side of the City, AA Publications 2016.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

A Taxonomy of the Simulation of the Depth of Field Effect in Videogames

Keywords: Depth of Field, Videogames, Mediated Space Design, Cinematography

João P. Ribeiro
up201601392@edu.fba.up.pt
Faculty of Engineering of the University of Porto, Portugal

Miguel Carvalhais
mcarvalhais@fba.up.pt
Faculty of Fine Arts of the University of Porto, Portugal

Pedro Cardoso
pedroccardoso@ua.pt
University of Aveiro, Portugal

This essay focuses on the simulation of the depth of field effect in the design of videogames. As a visual aesthetic element in videogames, knowing and mastering the depth of field effect can be crucial for designers to project systems that stimulate players' emotions. However, there are no guidelines for designers to use. With that in mind, this paper proposes a taxonomy for analysing depth of field in games. This taxonomy stems from the notions of depth of field in film, a very influential medium on the design of videogames. We implemented a methodology consisting of the models of research in Art and Design defined by Christopher Frayling and research in videogames by Ashley Brown along with a combination of three reference books as the foundation of our case study selection. We examined the classifications present in film and subsequently explored their presence in videogames. As a result, we found a single category exclusive to videogames and another to film, having discovered six categories: No Depth, Standard Depth, Shallow Focus, Soft-Focus, Rack Focus, and Tilt-Shift.

1. Introduction and Methodology

The present article focuses on a specific element of the aesthetic output and design of videogames: the *depth of field*. When dealing with elements regarding the aesthetics of videogames, designers project the mechanics they believe will elicit certain feelings in players, as they interface with the game and the structures that support play (Hunicke et al. 2004, 2). Play is supported by and manifests through many game spaces. We considered Michael Nitsche's five planes thesis for the study of videogame spaces (2008). Since we focused on the depth of field, which typically manifests through computer monitors and TVs, we have taken into special consideration what Nitsche calls the mediated space. Sercan Sengün has interpreted and described the *mediated space* as consisting "of the visual outlet of the game and mostly breeds cinematic and visual studies" (2015, 186-7).

We review the concept of depth of field, its use in media that preceded videogames, and the current literature on the concept within game studies and culture. Afterwards, we present a taxonomy that is canonical for analysing the depth of field in film and describe its various categories. Alongside such a description, we provide some examples and analysis of its use. This analysis is especially crucial since our taxonomy derives from film's notions on the implementation of depth of field. We chose film as our comparison point since the mediated space of videogames has many elements that are analogous to film. Videogames and film are both audiovisual media with the "potential for experimental, documentary, and narrative-based forms" (Clearwater 2011, 38). Likewise, they share likenesses concerning how they often come to be related to the development of fandoms[1] with specific values and traditions. We can also see comparable interactions connecting creators and the public in both media (ibid.).

1. "Subculture composed of fans characterized by a feeling of empathy and camaraderie with others who share a common interest, usually a media franchise of some sort" (Yeromin & Charskykh 2018, 82).

After describing the effect in film, we provide a similar description for videogames. We observed the categories present in film and investigated whether they are present in the mediated space of videogames. While establishing a comparison to film is our starting point, we acknowledge that videogames are idiosyncratic and videogame designers often use some tools that are different to communicate with players. As such, our taxonomy needed to adapt such categories to fit the specificities of videogames better. We also found one new category that is exclusive to videogames, and one category that exists in film but not in the videogame medium.

Our methodology is based on Christopher Frayling's (1993) and Ashley Brown's (2015) research. Frayling contends that there are three categories of research in Art and Design, of which we position ourselves into the "research into art and design" category (1993). Our study fits in this category because we conducted a study that relies on aesthetic perception. This methodology describes in what manner aesthetics is embodied in the field of videogames, coupled with in what way a particular aspect of a videogame might suggest the corresponding reactions through perception (Xenakis & Arnellos 2014, 1).

Brown argues that descriptive anthropology allows us to be aware of culture through experience. She states that instead of observing other players, ethnographers need to gain context by experiencing the artefacts themselves and interacting with the computational systems that support them. This methodology recognises biases as elements "of the human experience of doing research – even in virtual worlds." Autoethnography exists as a form of descriptive anthropology focused upon oneself, and we can use case studies "to make generalisations about (...) games" (2015, 77-87). We have a collective experience of playing hundreds of videogames from various decades. Intrinsically, we found this methodology particularly suitable for the analysis of the depth of field in videogames and, therefore, we employed it to construct our arguments.

To choose our case studies, we reflected upon the many videogames we have played and how they would support our thesis. To make sure we are making use of case studies of historical and cultural relevance, we used the 3rd edition of Rusel DeMaria's *High Score! Expanded: The Illustrated History of Electronic Games* (2019), Brian Wardyga's *The Video Games Textbook: History, Business, Technology* (2019), as well as Klaus Sachs-Hombach and Jan-Noël Thon's *Game Studies: Aktuelle Ansätze der Computerspielforschung* (2015) as references. Combined, these books cover the history of videogames and videogame technologies up until 2019. We consider that such a combination provides a wide and varied sample of adequate case studies. Additionally, our range of examples symbolises an archetypal combination of distinctive types of videogames, including platforming, action, adventure, shooter, racing, puzzle, survival, and role-playing games, from diverse periods of the history of the medium.

2. Use of Depth of Field: From Photography and Film to Videogames

2.1. Photography

A lens can focus only on a single target at a distance at any given time. Technically, the forefront and background elements of the span of the target in which the lens is centred on would never appear sharp in an image. In reality, an acceptable sharp target is rarely restricted to only one plane. Instead, surfaces near our target can turn up sharp and in focus. The *depth of field* represents the spectrum of target ranges within which subjects are seen with appropriate sharpness. The depth of field is not restricted to the zone centred on, since the human visual system has restricted processing capacity, such that a circular area up to a determined proportion looks like a dot. The largest possible area which still looks like a dot is entitled the "permissible circle of confusion" (Salvaggio 2009, 110).

Depth of field changes according to many variables, including aperture size, the distance separating the sensor or film and the target, as well as the focal length of the lens. *Depth of field* can be exploited for artistic effect and helps the artist adjust the region of emphasis in a photo to a tiny region of limited focus, a broad region of general sharpness, and other options located in-between those two poles (Warren 2005, 383).

Depth-from-focus approaches are premised on a reality where, through an image created by an optical device like a convex lens, artefacts at a specific range from the lens should be centred. At the same time, objects at any other location are distorted or blurry at different degrees based on position.

In Fig. 1 we can observe the same objects photographed at the same focal length f as well as the same distance between camera v, with variations only on the aperture diameter d. We can see that focus position u is affected by the d, which results in images with different *depth of field* values.

Fig. 1a and 1b. On the right, an image with a *shallow* depth of field, taken with a low *f-number*. On the left, the same objects, with a wide depth of field. They were shot with a high *f-number*.

The front and the back of view cameras "have four possible basic movements in addition to focusing — tilt, swing, vertical shift, and lateral shift — for a total of eight movements" (Stroebel 1999, 266). Similar movements can also be achieved in other camera formats by using tilt-shift lenses. Adjusting these movements can increase or decrease the *depth of field*.

We believe that *depth of field* is a crucial component the photographer must consider when producing their work. The iconic photographs by Ansel Adams were not exact representations of the reality beyond his lens. Instead, they were perceptions of the subject associated with his intense feelings. His artistic motivation was a genuine vision. Ansel accomplished his vision by incorporating an elevated perspective, a flattening of the picture, depth of field, sophisticated composition and exhaustive detail. His photos display an extraordinary virtuosity, especially in mastering the *depth of field* (Alinder 2014, 327). By observing Adams' *Mt. Williamson, Sierra Nevada, from Manzanar, California* (1944), one can find such evidence in the near-infinite depth of field. To the human eye, it allows one to perceive that focus seems to be equally present in all objects within the frame.

We find that the mastery of the *depth of field* was also an essential element of composition for other authors such as William Christenberry, Gregory Crewdson, Jack Delano, and George Hurrell, among others.

2.2. Film

In film, *depth of field* is especially important for the concept of suture. Suture was initially presented as a psychoanalysis principle in an essay by Jacques-Alain Miller, followed by a transformation into film studies by Jean-Pierre Oudart (Heath 1981, 76). Oudart tells us that "suture represents the closure of the cinematic *énoncé* in line with its relationship with its subject (...), which is recognised, and then put in its place as the spectator" (1977, 35). The concept of suture sought to assess how to transcend the division between the different framed sections of a film in order to convey a cohesive, united cinematic language (Branigan 2013, 133-4).

Like Jean-Luc Godard, Robert Bresson placed the recorded subject back where it belongs as a symbolising entity. Nevertheless, he places the recorded subject inside the context and in the conceptual position of film itself. Suture is better grasped when understanding what we are speaking about in the practice of film reading. To grasp it, it is essential to interpret the picture to its detriment, a reading of which modern film has often caused us to lose our understanding. Such loss happened because the use of imagery without depth conceals what the depth-of-field in film has always shown, Oudart writes. Both the cinematic areas tracked by the lens and all entities shown via the depth of the field are replicated. They are replicated by yet another field, the fourth wall, as well as the omission it originates. Such factors indicate that a picture on its design approaches the signifier's function (Oudart 1977, 35-6).

A missing area mirrors each cinematic area, the location of a person positioned there by an imagined audience, and whom Oudart calls the Absent One. At some period of the interpretation, all the items in the *mise-en-scène* join together to produce the signifier of its absence. At such crucial times, the picture reaches the "order of the signifiers, and the undefined strip of film the realm of the discontinuous, the 'discrete'" (Oudart 1977, 36).

Theatrical stages, before film, expose little of its essence, but this demonstrates that it is only the cinematic space, "only the depth of its field", that is "echoed by the other field, the side of the camera" (Oudart 1977, 41). Film can be distinguished by the incompatibility of interpretation and enjoyment, since space in turn often revokes the object. The depth of the field allows the entities depicted inside it to disappear (Oudart 1977, 42-3).

To illustrate how suture works, Branigan describes what he believes to be the nine phases of Oudart's explanation of the viewer's shifting focus throughout a shot in *The General* (1926) (Branigan 2013, 135-6):

1. The audience "experiences an animated photograph", leading up to the film, not a proper filmic area.

2. The audience learns that they are in the movie theatre when confederates abruptly spring up from the bottom picture rows.

3. "The spectator experiences a "vertiginous delight" in an "unreal" filmic space and its depth of field."

4. "The spectator discovers the "framing" when he or she suddenly understands that an unseen space has been "hidden" by the camera."

5. "The spectator experiences (imagines) an Absent One located "in place of the camera" in the unseen, hidden space."

6. "The spectator discovers a "signifying Sum," the meaning(s) of the filmed event; he or she discovers that cinema is a closed discourse."

7. "The spectator experiences the "haunting presence" of the Absent One within the unseen, hidden space in relation to the image."

8. "The spectator discovers the Absent One in the next shot (a reverse field showing the previously unseen space)."

9. In a new picture, the viewer encounters what was predicted in the original picture. At the same time, he or she recalls what was once seen in the original picture.

Aside from describing how suture works, Branigan identifies another aspect through which *depth of field* is critical in cinematic design. He tells us that for André Bazin, the lens, "acted upon by reality", should respond in the position of the missing viewer, but mostly in forms which follow the rules of human senses. Two of the filmmaking strategies advocated by Bazin were "deep focus" in onscreen space and "lateral depth of field" in the activation of offscreen space." Both strategies support each other and help to merge the two critical pillars of Bazin's pieces dealing with "profilmic and postfilmic realities beyond the image" (Branigan 2013, 78). When describing his major conceptions of the camera, Branigan sees the "camera as agent for a postfilmic viewing situation." As a theory of narrative, the "perceiver sees A as he or she would see B." This conception of the camera only works with the lateral depth of field. Its most crucial storytelling quality is that it acts as a "reproduction of human perception" (2013, 95).

2.3. Depth of Field in Videogame Environments

Game consoles and computers employ embedded three-dimensional special effects boards – commonly known as video or graphics cards - and can use external 3D equipment – like VR headsets – to improve depth of field across game spaces (Wolf 2012, 642). 3D game spaces typically work with a cartesian coordinate system with three axes (*x*, *y*, and *z*). The z-axis represents depth. If we follow the examples of photography and film, we cannot represent the lack of *depth of field* effect in the x and y axes, as those are always in focus. However, the presence of this effect in games is a reproduction which tries to mimic what we see in optics and is not native to videogames. We can observe this simulation occur differently from how it does in the physical world.

Throughout their formative days, game environments were mostly portrayed from either a side or top point of view. This absence of z-axis complexity was primarily due to technical limitations. The introduction of greater-resolution raster graphics made it possible to depict entities from different perspectives, giving more scale to the sequences. For instance, *Zaxxon* (1982) presents items "in the world from an isometric perspective." This form of isometric drawing point view denotes a three-dimensional space without any "vanishing points, giving all three dimensions equal importance." To express the illusion of depth, "video games made use of most of the types of perspective typically seen in technical drawings" (Wolf 2012, 270).

2.4. Depth of Field Across Multiple Videogame Spaces

Egenfeldt-Nielsen et al. (2015) argue that formal elements like depth of field are as essential as gameplay. They are not just “mere window dressing, eye candy providing an enticing way of interacting with the actual game beneath” (129). How a game environment is set out is connected to its appearance. “Geography, representation, and gameplay are interrelated” (ibid.). In *Moon Patrol* (1982), the player explores the planetary terrain for extraterrestrials as space-age structures are scrolling along. Those constructions do not possess a clear in-game impact; for example, they do not obstruct a player’s progress nor give them shielding. In reality, formal and aesthetical elements often specify the mechanics. The visual design should usually be selected for its capacity to facilitate the gameplay mechanics (Egenfeldt-Nielsen et al. 2015, 129). Depth of field mainly contributes to the mood of the game, offers the feeling of filmic framing, and lets the game’s world feel realistic.

Spacewar! (1962) is a multiplayer game in which opponents (usually) view the game world through the same display. Events occur on a basic *xy*-axes system. That is in contrast with 3D representations, that often have depth, just like actual life. Player warships can travel in either of the cartesian coordinates. Still, they cannot travel downward or upward “away from the plane, in a two-dimensional space battle, which is equivalent to a space battle carried out on a game board, but not realistic in any way” (Egenfeldt-Nielsen et al. 2015, 130). The ships in *Spacewar!* do not scroll, and players are continuously in the same position on the display. Therefore, the viewpoint can neither shift nor pursue either of the ships. The games that scroll have traditionally included multiplayer action titles like *Golden Axe* (1989), *Gauntlet* (1985), and *Double Dragon* (1987). In those games, it is beneficial for players to travel in unison (Egenfeldt-Nielsen et al. 2015, 130).

It should be noted that sometimes the *mediated space* lacks depth in some objects and locations due to a limitation known as *draw distance*. In three-dimensional gameplay, entire objects often unexpectedly appear in the frame. It happens because of the inadequate configuration of the drawing regions. It can also happen due to a lack of processing capacity, which does not allow the machine to show some elements unless they are near and essential to play (Imagine Media 1996, 32). Draw distance should not be confused with the *depth of field* effect.

We also note that, like many games from the 20th century, some modern games do not take advantage of state-of-the-art visual assets and effects, like *depth of field*. Often, the lack of advanced graphics is not owed to the absence of expertise or designer abilities but due to artistic intentions.

3. Results of the Analysis

3.1. Depth of Field in Film

As reviewed, the lack of depth in a field, which manifests through blur, is not native to videogames. It imitates film and photography. As such, we looked at the different types of usage of the depth of field effect in film in order to verify if its analogue counterparts — simulations of the effect with comparable results — are used in videogames. It also allowed us to demonstrate the presence of types of depth of field that are exclusive to the videogame medium, or the lack of that presence.

In film there are six categories of usage of depth of field for artistic effect: *Deep Focus, Shallow Focus, Soft Focus, Rack Focus, Split Diopter, and Tilt-Shift* (Dunham 2020). The *Deep* focus technique leads to images that have a vast depth of field. When this happens, none or almost none of the framed objects are blurred or out of focus, regardless of their distance to the camera. Examples of notable films that make extensive use of *deep focus* are *Nosferatu, Eine Symphonie des Grauens* (1922) and *Suspiria* (2018). Deep focus images give greater depth perception to a spectator, enabling complex activities to be displayed on several planes.

Shallow focus is a practice that leads to a minimal depth of field. When a shot has a *shallow focus*, one of its planes is focused whereas the remainder planes are blurred. Shallow focus is usually employed to accentuate a specific aspect of a scene above others. Filmmakers often reference a blurred segment's stylistic appearance as bokeh (Mamer 2013, 19-20). Instances of notable movies that make extensive use of shallow focus are *La Règle du Jeu* (1939) and *Polytechnique* (2009).

Soft focus often occurs due to a defect in lenses, culminating in hazy pictures. In pictures with a *soft focus*, the outlines of surfaces are not precise nor plain, and objects appear as if they are shining. It leads to pictures with an otherworldly style. Examples of notable films that make extensive use of soft focus are *The Sound of Music* (1965) and *The Saddest Music in the World* (2003).

The *rack focus* relates to a moment in which a lens' focal point is adjusted while shooting a scene. This change might expose a vital detail or signify a significant shift in the story. It helps the filmmaker place significant importance towards one point and then shift the focus to some other. The British anthology film *Aria* (1987) contains various short films that make extensive use of *rack focus*. Among them, we highlight *Un ballo in maschera by Nicolas Roeg and Rigoletto* by Julien Temple.

The *tilt-shift* technique is based on the application of camera motions that adjust the direction or location of lenses regarding the photographic film or camera sensor. Its usage makes humans, vehicles, and structures appear as if they are dioramas. It is also used to adjust the perspective of tall structures such as skyscrapers. Examples of notable films that make use of tilt-shift are *Shadowboxer* (2005) and *A Serious Man* (2009).

With the *split diopter* method, one can get a field focused in two different portions of the image, with only a slight blur between them. Such a result is suitable, e.g. for the full height anamorphic aspect ratio, that typically allows for less depth of field. Another reason most filmmakers do this is to make a scene slightly more suspenseful or obscure. Instances of notable movies that make extensive use of split diopter are *Reservoir Dogs* (1992) and *Passion* (2012).

3.2. Taxonomy of the Simulation of the Depth of Field Effect in Videogames

Given that most early videogames' presentation relied solely on two axes, they did not present any depth. In games with no depth, players can read the environment on a horizontal and vertical alignment. As there is no sensation of depth, all elements are typically in focus as there is only one practical plane. Some games made use of the parallax effect to simulate the presence of different planes. A plane in the distance might be blurred to simulate photography's lack of depth of field effect. This false sense of depth is typically referred to as occlusion. However, players cannot move towards the occluded planes, and the foreground and background planes are not connected. As such, we consider that there is no depth. Instances of videogames that exhibit no depth are *Super Mario Bros* (1985) and *Mega Man Zero* (2002).

We might think of *deep focus* as the default mode of presentation of the depth of field in three-dimensional games. Such happens because the blurring of a scene to emulate *shallow focus* only appeared much after the inception of 3D games as a post-processing effect. Nevertheless, the concept's description is the same – a scene in which all elements in all planes are focused. However, we believe that a distinct terminology should be used for videogames, as this is the de *facto* depiction of depth. As such, we propose the term *standard depth*. This term designates a videogame scene in which there are no post-processing effects emulating film's effects of depth of field. It should be a clear-cut scene in which everything has the same depth of detail. Exceptions are made for elements that lack detail due to *draw distance*. Examples of videogames which vastly present *standard depth* are *Half-Life* (1998) and *Halo*: *Combat Evolved* (2001). Like film's *deep focus*, videogames' *standard depth* allows players to read all elements and planes. Its use can be attributed to artistic intention or lack of need or thought of the *depth of field* effect.

Like films, videogames also make use of the *shallow focus* aesthetic. The effect is simulated as a post-processing effect in three-dimensional game engines. Its result is analogous to what we see in film – a scene with a too narrow depth of field – and we believe that the nomenclature can be the same. The effect is easily observed when a scene presents planes that are blurred. Videogame designers can use this as a mechanic that invites players to focus their attention on specific elements on the screen, as is done in film. This option can be made due to those elements' importance to the diegetic narrative or impact on players' actions. In some videogames, the *shallow focus* effect can be manually activated by players in a game's menu. This activation can be useful to some players of first-person games. It allows them to focus on specific elements while ignoring everything else. Instances of videogames that exhibit *shallow focus* are *Ridge Racer V* (2000) and *Titanfall 2* (2016).

Videogames also make use of *soft-focus* as an effect for visual impact. Like in film, it can give a scene a dreamlike aesthetic to a scene or highlight a character. However, in videogames, the *soft-focus* effect is also frequently used to highlight or obscure certain graphical qualities in a scene. For instance, some developers apply the effect to scenes when they make use of new graphical technologies, to highlight their achievement. In the opposite direction, some designers use it to cover characters that they might consider having a low polygon count. Some videogames which vastly present *soft-focus* are *The Legend of Zelda*: *Breath of the Wild* (2017) and *Shadow of the Colossus* (2005).

The presence of an effect analogous to film's *rack focus* can be found in videogames quite frequently as well. It is mainly observable in cinematic cutscenes. Nevertheless, some videogames also use it during gameplay. Its primary use is for changing the focus from the elements in one plane to the ones in another. It is also used when videogame designers intend to make their work appear more comparable to film's traditional cinematography methods. Most players' cultural backgrounds usually include high familiarity with cinematic artefacts, especially Hollywood's filmmaking style. As such, this effect seems natural to them, thus helping them navigate and read a scene. Instances of videogames that exhibit *rack focus* are *Alien: Isolation* (2014) and *Death Stranding* (2019).

In opposition to film, the simulation of the *tilt-shift* technique's appearance has been widely adopted in videogames. Its inclusion can be found equally during gameplay and cutscenes. The most frequent use of this effect in videogames is either to make a scene seem like part of a diorama or to portray delusion or delirium. It is also used for conveying information on the player character's status. Regarding the latter use, it can be exploited to indicate that the character is low on health, is inflicted with physical or mental ailments, or is using special powers. Examples of videogames which vastly present a *tilt-shift* effect are *3D Dot Game Heroes* (2009) and *The Witcher 3: Wild Hunt* (2015).

At the date of writing, we could not find any cases of videogames that make use of a technique analogous to film's *split diopter*. We believe that such is the case because the technique is used to circumvent lenses' physical limitations in film. Such limitations do not exist in virtual cameras. Since its use in film is contained, video game designers have likely not attempted to emulate its aesthetic appearance. As the effect is little sought-after, individual players can be unfamiliar with it. However, this is a hypothesis that we were not able to test. In a bibliographical search, we also found no information regarding this result.

In preparing the present article, we evaluated the various case studies we have played in recent years. Our heuristic argument results in the belief that there are no other simulations of the depth of field effect observable in the videogame medium. One can argue for a different taxonomy if one analyses videogames that make use of technologies such as 3D displays, dome-based video projection environments, head-mounted displays, holography, or augmented reality. However, we believe that the effect must be studied independently with those technologies. This analysis must be taken into account in future studies. In consideration of the preceding, in Table 1, we summarise our results.

Table 1. Taxonomy of the various types of simulation of the Depth of Field effect in videogames.

Classification	Principles	Comparable to Depth of Field in Film
No Depth	» No sensation of depth. » All elements are in focus. » Prevalent in 2D games.	None
Standart Depth	» The default mode of presentation in 3d games. » All elements in all planes are focused. » No post-processing effects emulating a lack of DoF	Deep Focus
Shallow Focus	» Narrow depth of field. » Most planes are blurred. » Allows players to focus on specific elements.	Shallow Focus

Soft-Focus	» Hazy image quality. » Gives a scene a dreamlike aesthetic. » Outlines of surface are not precise.	Soft-Focus
Rack Focus	» Change of focus between planes. » Helps players navigate and read the environment. » Observable during cutscenes and gameplay.	Rack Focus
Tilt-Shift	» Makes artefacts look like dioramas. » Blurs the borders of the screen. » Useful for conveying information to the player.	Tilt-Shift

4. Conclusions

In this paper, we adopted an approach comprised of the models of research in art and design established by Christopher Frayling (1993) and research in videogames by Ashley Brown (2015). We found these methodologies to be particularly relevant for studying the depth of field in videogames since several video games from different generations have been played by us. We contemplated a combination of three reference books as the basis for our case study selection. This combination supplied us with a broad and diverse sample of suitable videogames to be studied in our essay. We used the texts of Rusel DeMaria (2019), Brian Wardyga (2019), and Klaus Sachs-Hombach and Jan-Noël Thon (2015).

In film there are six categories of usage of depth of field for artistic effect: *Deep Focus, Shallow Focus, Soft Focus, Rack Focus, Split Diopter,* and *Tilt-Shift*. We studied the categories present in film and then examined whether they remain present in videogames. We discovered one category unique to videogames – *No Depth* – and one unique to film – *Split Diopter*. We identified six categories in video games: *No Depth, Standard Depth, Shallow Focus, Soft-Focus, Rack Focus,* and *Tilt-Shift*.

With *No Depth*, a ubiquitous category in 2D videogames, the traversable environments lack depth as only one plane is navigable. *Standard Depth* is the standard way of displaying graphics in 3D games, and each plane is well-defined. There is depth but no emulation of photography's lack of field effect. When the *Shallow Focus* effect is used, scenes have a limited depth of field. Nearly all planes stand obscured, which lets players concentrate on aspects of the focused plane. With *Soft-Focus*, environments typically have a fuzzy picture quality. The contours of surfaces are not detailed, which provides them with an otherworldly visual experience. *Rack Focus* is an effect that is discernible through cutscenes and gameplay. It allows for a shift of players' attention between different planes, helping them traverse and understand the environment. With the *Tilt-Shift* effect, environments resemble dioramas. The effect distorts the screen's boundaries, allowing developers to communicate crucial information in the screen's centre.

We believe our results summarise all the categories of the simulation of the depth of field effect present in video games that use conventional display devices. Such devices consist of two-dimensional TVs and monitors. However, we acknowledge that future studies must analyse the effect in different display technologies. Such technologies include 3D displays, dome-based video projection environments, head-mounted displays, holography, and augmented reality. Such an analysis might lead to a different taxonomy.

References

Alinder, Mary Street.
2014. *Ansel Adams*: *A Biography*. New York, USA: Bloomsbury Publishing Ple.

Branigan, Edward.
2013. Projecting a Camera: *Language-Games in Film Theory*. Taylor & Francis.

Brown, Ashley.
2015. "Awkward: The Importance of Reflexivity in Using Ethnographic Methods." In *Game Research Methods*, 77–92.

Clearwater, David A.
2011. "What Defines Video Game Genre? Thinking about Genre Study after the Great Divide." *Loading... The Journal of the Canadian Game Studies Association* 5 (8): 29–49.

DeMaria, Rusel.
2019. *High Score! Expanded: The Illustrated History of Electronic Games*. 3rd ed. CRC Press.

Dunham, Brent.
2020. "Ultimate Guide to Camera Focus: Understanding Depth of Field." StudioBinder. July 27, 2020. https://www.studiobinder.com/blog/types-of-camera-focus-in-film/.

Egenfeldt-Nielsen, Simon, Jonas Heide Smith, and Susana Pajares Tosca.
2015. *Understanding Video Games*: *The Essential Introduction*. Taylor & Francis.

Frayling, Christopher.
1993. *Research in Art and Design*. Royal College of Art.

Heath, Stephen.
1981. "On Suture." In *Questions of Cinema*, 76–112. London: Macmillan Education UK. https://doi.org/10.1007/978-1-349-16579-7_3.

Hunicke, Robin, Marc LeBlanc, and Robert Zubek.
2004. "MDA: A Formal Approach to Game Design and Game Research." *Workshop on Challenges in Game* AI, 1–4.

Imagine Media.
1996. "Draw In." *NEXT Generation,* 1996.

Mamer, Bruce.
2013. *Film Production Technique: Creating the Accomplished Image*. Cengage Learning.

Nitsche, Michael.
2008. *Video Game Spaces: Image, Play, and Structure in 3D Game Worlds*. MIT Press.

Oudart, Jean-Pierre.
1977. "Cinema and Suture." *Screen* 18 (4): 35–47.

Sachs-Hombach, Klaus, and Jan-Noël Thon.
2015. G*ame Studies: Aktuelle Ansätze Der Computerspielforschung*. Herbert von Halem Verlag.

Salvaggio, Nanette.
2009. *Basic Photographic Materials and Processes*. Focal Press/Elsevier.

Sengün, Sercan.
2015. "Why Do i Fall for the Elf, When I Am No Orc Myself? The Implıcatıons of Vırtual Avatars In Dıgıtal Communıcatıon." *Comunicação e Sociedade* 27 (0): 181.https://doi.org/10.17231/comsoc.27(2015).2096.

Stroebel, Leslie.
1999. *View Camera Technique*. Focal Press.

Wardyga, Brian J.
2019. The Video Games Textbook: *History • Business • Technology*. CRC Press.https://doi.org/10.1201/9781351172363.

Warren, Lynne.
2005. *Encyclopedia of Twentieth-Century Photography*. Taylor & Francis.

Wolf, Mark J. P.
2012. *Encyclopedia of Video Games: The Culture, Technology, and Art of Gaming*. Greenwood.

Xenakis, Ioannis, and Argyris Arnellos.
2014. "Aesthetic Perception and Its Minimal Content: A Naturalistic Perspective." *Frontiers in Psychology* 5 (September): 1038. https://doi.org/10.3389/fpsyg.2014.01038.

Yeromin, Mykola, and Igor Charskykh.
2018. "Universal and Specific Codes of Cultural Context in Audio-Visual Media: Collision and Mutual Enrichment in International Technology-Enhanced Language Learning." In *Cross-Cultural Perspectives on Technology-Enhanced Language Learning*, edited by Dara Tafazoli, M. Elena Gomez Parra, and Cristina A. Huertas-Abril, 68–82. IGI Global.https://doi.org/10.4018/978-1-5225-5463-9.

Works Cited

Adams, Ansel.
1944. *Mount Williamson, Sierra Nevada, from Manzanar, California*. United States: The Ansel Adams Publishing Rights Trust.

Altman, Robert, Bruce Beresford, Bill Bryden, Jean-Luc Godard, Derek Jarman, Franc Roddam, Nicolas Roeg, Ken Russell, Charles Sturridge, and Julien Temple.
1987. *Aria*. United Kingdom: Miramax Films.

Atari Games.
1985. *Gauntlet.*
United States: Atari Games.

Bruckman, Clyde, and Buster Keaton.
1926. *The General*.
United States: United Artists.

Bungie.
2001. *Halo: Combat Evolved*.
United States: Microsoft Game Studios.

CD Projekt Red.
2015. *The Witcher 3: Wild Hunt*.
Poland: CD Projekt.

Coen, Joel, and Ethan Coen.
2009. *A Serious Man*.
United States; United Kingdom; France: Focus Features.

Creative Assembly.
2014. *Alien: Isolation*.
United Kingdom: Sega.

Daniels, Lee.
2005. *Shadowboxer*.
United States: Teton Films.

De Palma, Brian.
2012. *Passion*.
France; Germany: Ascot Elite Entertainment Group.

Guadagnino, Luca.
2018. *Suspiria*. United States; Italy: Amazon Studios.

Inti Creates.
2002. *Mega Man Zero*.
Japan: Capcom.

Irem.
1982.
Moon Patrol.
Japan: Irem.

Kojima Productions, and Guerrilla Games.
2019. *Death Stranding*.
Japan; Netherlands: Sony Interactive Entertainment.

Maddin, Guy.
2003. *The Saddest Music in the World*. Canada: Metro-Goldwyn-Mayer.

Murnau, F. W.
1922. *Nosferatu, Eine Symphonie des Grauens*. Germany: Film Arts Guild.

Namco.
2000. *Ridge Racer V.*
Japan: Namco.

Nintendo EAD.
1985. *Super Mario Bros*.
Japan: Nintendo.

Nintendo EPD, and Monolith Soft.
2017. *The Legend of Zelda: Breath of the Wild*.
Japan: Nintendo.

Renoir, Jean.
1939. *La Règle Du Jeu*.
France: The Gaumont Film Company.

Respawn Entertainment.
2016. *Titanfall 2*.
United States: Electronic Arts.

Russell, Steve.
1962. *Spacewar!*
United States: Steve Russell.

SCE Japan Studio, and Team Ico.
2005. *Shadow of the Colossus*.
Japan: Sony Computer Entertainment.

Sega.
1982. *Zaxxon*. Japan: Sega.

Sega.
1989. *Golden Axe*.
Japan: Sega.

Silicon Studio.
2009. *3D Dot Game Heroes*.
Japan: FromSoftware.

Tarantino, Quentin.
1992. *Reservoir Dogs*.
United States: Miramax Films.

Technōs Japan.
1987. *Double Dragon*.
Japan: Taito.

Valve.
1998. *Half-Life*.
United States: Sierra Studios.

Villeneuve, Denis.
2009. *Polytechnique*.
Canada: Alliance Films; Remstar.

Wise, Robert.
1965. *The Sound of Music*.
United States: 20th Century Fox.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Personal Instants

Keywords: Data Aesthetics, Personal Data, User Profiling

Pedro Silva
pedros@dei.uc.pt
University of Coimbra, CISUC, DEI, Coimbra, Portugal

Pedro Martins
pjmm@dei.uc.pt
University of Coimbra, CISUC, DEI, Coimbra, Portugal

Penousal Machado
machado@dei.uc.pt
University of Coimbra, CISUC, DEI, Coimbra, Portugal

We live in a society governed by information, much of which is produced by us through the most diverse ubiquitous computing devices. Every day more people are connected to the Internet and more information is produced. In large part, this increase in online production is due to social networks and the content we produce and share on them. *Instagram* alone has more than one billion users. As almost all activities on social networks, many of our activities on Instagram are performed in a few seconds and quickly become part of the past and are forever forgotten. In this paper, we present *Personal Instants*, a web-based tool to visualize the entire activity data of an *Instagram* user. By using the users own personal data to compose the visualization, the tool aims to portray the amount of data that we produce on the social network Instagram. Withal, we intend to profile our online social behavior through our usage patterns and types of actions performed, thus visually perpetuating our ephemeral online social activity. The work was subsequently evaluated with the creation of a form where the participants responded to both analytical and aesthetic aspects of our approach to visualization.

1. Introduction

For some years now, we have been living in a recognized information society where the use, creation, distribution, manipulation and integration of information is a deep-rooted and almost unconscious activity of our daily lives (Manovich 2005). The Internet is a central pillar of this society, where the latter depends heavily on the former. The proof of this is the fact that until 2013, about 90% of the Internet content has been produced in the two previous years only (Max Roser and Ortiz-Ospina 2015). This phenomenon may be explained by the increasing number of mechanisms for capturing and registering the most diverse daily activities and the increasing size of the stored data. Also, it may be caused by the increasing number of Internet users. For instance, every hour, 27.000 users access the Internet for the first time (Max Roser and Ortiz-Ospina 2015) — the more users, the more the data. Nowadays, the number of Internet users surpasses 3,5 billion, almost half of the world population, and social network platforms are used by two-thirds of all Internet users, representing a considerable portion of our virtual activity (Max Roser and Ortiz-Ospina 2015). More than ever, we are constantly producing and storing data on the Internet and much of these contents are images, videos and other documents shared through social networking, which together form a virtual universe of digital organisms.

Instagram, launched about 10 years ago, is a social network that quickly stood out, currently being in the top 3 behind *Facebook* and *Youtube* with about one billion users (Max Roser and Ortiz-Ospina 2015). Like almost all social network activities, much of our activities on *Instagram* are considered and executed within a few seconds, which, at the distance of a button or a swipe gesture, is part of the past and becomes forever forgotten in an infinite scrollable virtual space (the feed). All of these actions shape our virtual persona, which in turn affects the environment for our personal benefit (the feed adapts to our interests and likes). At the same time, through our online attitude, a persona is drawn for us, bringing us closer or farther away from people that are similar or behaviorally distinct from us.

From this reflection comes *Personal Instants*, a visual representation of our spontaneous activity on the *Instagram* social network that aims to reveal the huge amount of data and content produced by us in this virtual universe and, at the same time, reveal our type of virtual persona, our online social stance, in a perpetual manner. The tool presents itself as a resource for users to explore all their activity in an overview mode so that they could discover unknown activity patterns and understand a little better the type of behavior they have on the social network. In addition, the tool provides the possibility to generate a personal artifact using the users' data, representing their type of persona on the social network. The choice of perpetuating the user's activity in this type of profiling seeks to attain the purpose of self-portraits static on canvas, for future contemplations (Sampaio and Ribas 2019). The work resorts to the users' own downloadable data about their *Instagram* activity which is then used to define the visualization elements and their disposition.

2. Related Work

Nowadays, an increasing number of visualizations of personal data are being produced by new casual creators with the intent of exploring novel visual concepts and materializations to depict their data, either to transmit new sensations and tell a story in a more humane way and/or to produce artifacts of artistic nature. These recent practices originated a thriving sub-domain of Information Visualization: Casual Information Visualization. This sub-domain can be separated from traditional Information Visualization systems by following main factors: the target user population; the usage context of the developed works; the type of data used, generally more personally interesting and relevant to target users; the types of insights they intend to foster Pousman, Stasko, and Mateas (2007).

LastHistory (Baur et al. 2010) visualizes digital music consumption based on the user's personal data from a social network, the music-recommendation service *Last.fm*. *LastHistory* has been implemented for Mac OS only, making it impossible to use with other operating systems. The data is retrieved with *Last.fm* API, from where every listened song is represented by a circle (colored by genre and sized by relevance) in a simple timeline. The authors also add personal calendar events and photos to further trigger active memories.

Embroidered Ephemera (Sullivan 2020) explores the huddled data creation on the social network *Twitter*. The work deals with something that can take just a few seconds to create and share, and just as quickly disappear — the tweet. Nevertheless, the authors make perpetuate it in "embroidery", which conversely, takes a long time to create as well as to disappear. The work results in an online tool that allows users to enter a *Twitter* user or hashtag and then generate an embroidery sample design according to the tweets retrieved by the system.

Sampaio and Ribas's work addresses the new paradigm of personal data collection, where they are particularly interested in the application of pleasant visualizations to represent digital self-portraits. Their *Data Self-Portraits* (Sampaio and Ribas 2019) work series makes use of information about the environment, physical aspects of the users (heart rate and energy spent) and some of their everyday activities such as online searches or distance traveled away from home. The system consists of a web-based program to generate abstract visualizations, comprising static images and dynamic outputs that can be interactively explored through a polar coordinate system and a timeline approach. This work series establishes a close connection to the type of visualization that we aim to create since their main focus resides on user profiling. The authors deepen their research in a later article (Sampaio and Ribas 2020) where other works with similar objectives are reviewed. From these, we highlight *Poisonous Antidote* (Farid 2016), and *Spigot* (Oracle's Reflection) (Salavon 2009). *Poisonous Antidote* resulted in a website where everyone can consult the author's e-mails, messages, phone calls, browsing history, location coordinates, social network posts, as well as any photographs or videos on his phone. All of this data was sent to a 3D printer to create abstract sculptures, each one representing a day of the artist's "digital life". This work represents personal information in unlikely ways in order to achieve different purposes, which demonstrates the high range of possibilities for the representation and materialization of the same data.

Spigot is a real-time public investigation of Salavon's personal Internet search history. The work gathered over 12.000 searches that are visually translated into two modes. In one, the literal text and time of a search are displayed, giving a deeply personal voyeuristic view into the artist's private search habits. The second mode presents the same type of data as endless concentric, psychedelic data-streams, as a mostly aesthetic-driven composition translating his entire activity.

Artificial Senses (Albrecht, n.d.) visualizes sensor data retrieved from the ubiquitous devices that surround us to promote an understanding of how they experience the world. Through the machine perspective, this work gives us an even more raw view of our data patterns and their storage resulting "shapes".

The Sixth Sense from Clever Franke Barros et al. (2018) is another interesting application of real-time sensory data visualization, this time applied in a club. The authors collected activity data from the guests through hybrid bracelets that were provided to them. They captured data such as guests' movements and room temperature, which was then used to create personalized real-time data visualizations that were being projected during the club event. At the end of the event, all guests received a unique and personalized artifact, a data visualization summarizing their own activity. This work manages to reveal, in real-time, albeit on a smaller scale, the amount of data that are possible to collect about our activity and, at the same time, how data-driven artistic artifacts can be generated, disclosing new aesthetic possibilities to be explored with data visualization.

Lupi and Posavec are quintessential examples of those who practice this new data exploration paradigm. They use data from personal experiences (our activities, thoughts, behaviors, relationships) and seeks to grasp our human nature and every aspect of our society through engaging visual narratives. Moreover, they often take into consideration visualization field literacy, hence exploring friendly approaches to communicate the data so that it could be appropriated to all ages and audiences. One seminal work in this subject is *Dear Data* (Lupi and Posavec 2016), which returns to the initial practices of data collection by producing entirely hand-drawn data visualization shared between the two of them, exploring the overlooked aspects of our everyday routines through data. Lupi further developed other works on the same topic such as Data Portraits at *TED* (Lupi 2017) and *What Counts* (Lupi 2019) of which she also generates physical artifacts, as a result of user inputs and interactions with the works.

After reviewing the previous works, an important aspect to take into account when implementing our work was its accessibility to the users. Developing work for the web environment, such as the works of Sullivan or Sampaio and Ribas, is an asset since it allows more comfortable dissemination of the work and its easier access for many more users since generally it does not require anything else but the browser to be experienced. *LastHistory* fails in this regard as it was developed as a desktop application and only for Mac OS, limiting its use only to users who have access to such an operating system. The question of personal data disclosure is increasingly relevant and, as such, more attractive for ordinary users to perceive and visualize this same data about themselves. Casual Visualization operates here as a valid way to reveal the size and composition of that data itself so that the user can have greater transparency of what he is providing to third parties. *Spigot* and *Poisonous Antidote* are examples of works that use the personal data of their authors and make them public, accessible to the public audience, even if in more artistic and abstract ways. These two works present another aspect that we intend to explore in our work. Both use personal data to make a more artistic exploration, with a high aesthetic component consideration. Furthermore, *Sixth Sense* is another example of work that shows how these types of personal data, more or less intimate, which are often collected and produced effortless, present themselves as possible sources to generate visual artifacts for the most diverse ends, namely of artistic nature. In our case, we wanted to produce static pieces that can work as a unique souvenir/artifact for each user.

3. The Tool

Personal Instants is a web-based tool that displays a visual mesh made up of the entire activity data of an Instagram user. Each one of its modules represents a single action/event. This activity is obtained through the data that Instagram allows its users to download. The data downloaded divides the user activity into a set of *JSON* files from which we choose to use the following files:

1. Connections: When the user started following other *Instagram* users. When other Instagram users started following the user and *Instagram* users defined as close friends by the user.

2. Media: All photos, stories and videos uploaded by the user and direct content sent to other Instagram users.

3. Seen Content: All photos, videos, ads and chain content seen by the user.

4. Likes: Likes the user gave to other users' contents such as posts and comments.

5. Comments: Comments made to friends' posts or replies to other comments.

6. Saved: All content that the user archived.

The tool was designed for the web, using JavaScript and using the *P5.js* library, so it is accessible and easy to use for anyone who wishes to consult their own *Personal Instants* artifact. Among the downloaded files, there are other more intimate files, such as direct messages, which for that same reason were not used as they also were not relevant to the purpose of our work. The objective of our work is to reveal the immensity of media content produced, shared and stored by us in social environments, namely, on *Instagram*. Furthermore, it intends to communicate information about the users' social posture online, that is, to reveal what kind of user they are, with a more aesthetically driven approach. As such, there has been a central consideration not only in the data structure but more importantly, in its visual materialization, to create an aesthetic artifact, that could behave and stand as a self-portrait alone. An approach in this sense is made by translating all the user data into an abstract visualization representing the user's virtual persona.

3.1. Visualization Organisms

Taking the metaphor of the universe of virtual organisms aforementioned, we wanted to represent each type of action/event through a distinct organism. Generally, when we talk about organisms from invisible universes, we are often talking about microscopic organisms, as if they were the unitary modules of something bigger. For that reason, we chose a pixel-based approach to create the organisms, since the pixel is the module of the virtual universe when made visible (Graf 1999).

The type of action/event of the organism is indicated by its main color. The remaining parts of the organism were designed to visibly resemble the icons that are generally used to represent the respective object or action. Active actions/events such as media production and sharing, giving likes and making comments take on more vivid colors in order to stand out more while passive activity. This does not involve the creation of new data, such as visualizing other users' content or making new connections to acquire less vivid colors (see Figure 1).

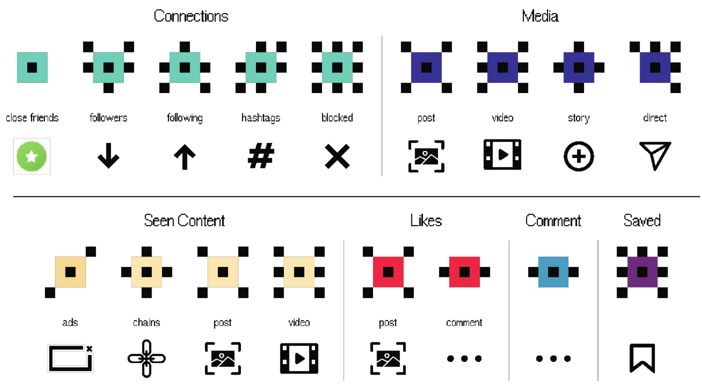


Fig. 1. Type of action/events and corresponding organisms.

3.2. Grid Visualization

As said before, our activity data is distributed across multiple files, where each event is labeled with a time of occurrence (timestamp). However, since our activity is recorded in a linear manner throughout our *Instagram* usage, one prior processing of the data was done so that the information was grouped into a single structure containing the user's activity temporally ordered and separated by days. After obtaining the now ordered structure of the entire data, the visual mapping process also took into account this linear process of registration, and as such it was designed through a continuous thread (just like the feed is presented on *Instagram*). Here it is constructed from left to right and from top to bottom, generating a visual mesh to be read in a familiar and natural process for the users. The horizontal dimension of the mesh will always take the entire horizontal dimension of the screen where it is being displayed, always creating a mesh as compact as possible and avoiding the creation of empty spaces.

To more easily locate the represented organisms in time and also to have a better perception of the user's daily activity dimension, a tag containing the corresponding date was added to the beginning of each day's activity. Another temporal variable that was taken into account was the user inactivity interval, that is, the gap of days without any type of activity associated with the user account. To represent this interval, and to emphasize this personal behavior which in our opinion is distinctive information in the user profile characterization, a visual interval was added to the mesh with the number of modules equal to the gap of inactivity days (see Figure 2).

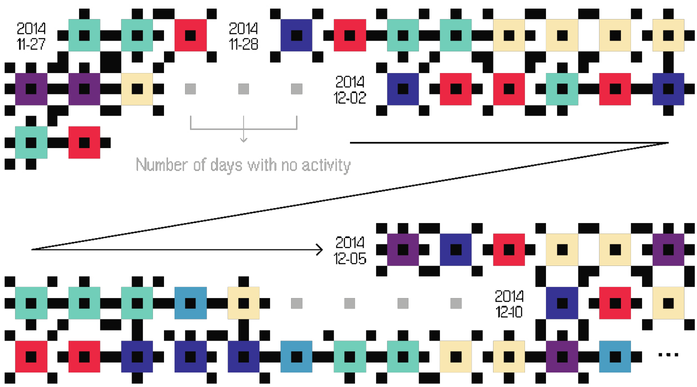


Fig. 2. Activity mesh mapping process, starting on the canvas top-left corner and taking a direction from left to right and from top to bottom.

Since very long outputs can be generated, the user was allowed to interact with the visualization, being able to define the time interval he/she wants to view or highlight the types of activities he/she wants to consult. To see a specific activity, the user can click on the corresponding organism to access all its information.

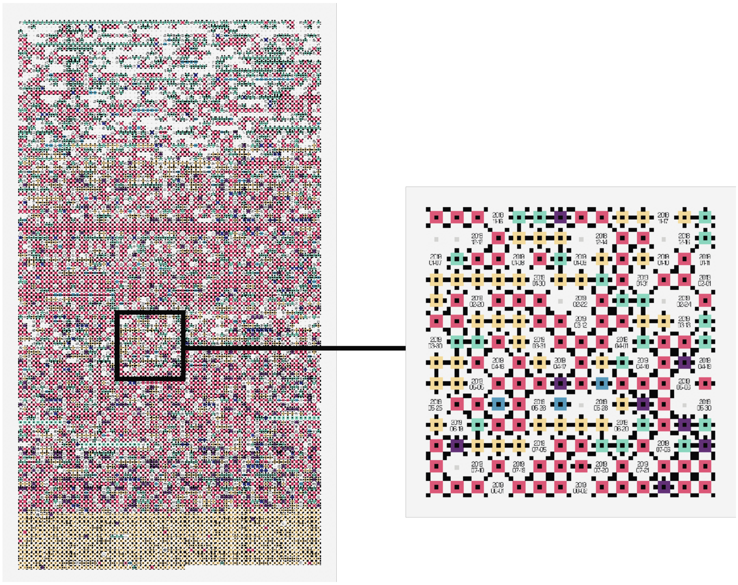
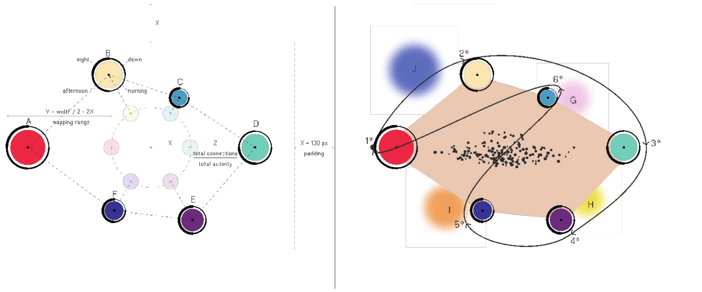


Fig. 3. Grid visualization of one user data. On the right, can be seen a zoomed excerpt of the visualization

3.3. Virtual Persona

In addition to the grid visualization, where all actions that constitute the user's activity are broken down to a single organism, we also intended to represent that same activity in a more abstract and condensed way that could allow the profiling of the user's online behavior, as a self-portrait of the user activity. To be able to represent any size of data, a mapping process of the element's dimensions and positions had to be carried out. The data mapping process was based primarily on a polar coordinate system (see Figure 4).

Fig. 4. Virtual Persona mapping process.



The six main types of activity (*comments, connections, likes, media, saved, seen content*) are represented in six points equally distanced, along a circumference, from the center of the canvas. Each type of activity is represented by a circle filled with the corresponding color, activity centroid (AC), marked from A to F in figure 4, left. The diameter of the circle is a mapped value representing the ratio of the total events of that type of activity divided by the entire user activity. At the same time, the bigger the diameter, the further away from the center the AC will be. From this choice of design, the user can quickly and easily perceive a relationship between the amount of each type of activity.

Another visual element associated with each type of activity is the division of that same activity into four parts of the day: *dawn, morning, afternoon and night*. These parts of the day are divided between 0h – 6h, 6h – 12h, 12h – 18h, 18h – 24h, respectively. Each part is represented by a 90° arc around the activity circle. Starting from the top, the arcs are drawn clockwise. The stroke weight represents the relative amount of corresponding activity that occurred within that time period (see Figure 4, left).

In order to provide also a global idea of the entire activity distribution throughout the day, the activity is distributed over the same four parts of the day and mapped into four circles, marked from G to J in figure 4, right, where the diameter and distance to the center are calculated with the same formula applied to the circles that represent the different types of activity. To further distinguish types of personas among the users' data, we use the AC points, in decreasing order of events, to draw a polygon through vertex curves. This gives origin to similar forms for similar types of behavior. In a very similar way, another polygon was created using the same AC points. This polygon is colored with an average color, obtained with the average calculation of the RGB channels of the activity colors over the entire activity, thus obtaining a chromatic approximation to the user's predominant type of activity/activities.

The set of black circles within the area formed by the AC points represent the user activity days, each day is represented by a single circle. The circle diameter corresponds to the activities carried out on that given day. The circle position is, once more, obtained with an average calculation, using the AC points of the types of activities performed within that day. Figure 5 shows an example of a day were performed 10 events — 6 connections and 4 likes. The position of the circle corresponding to that day is obtained using the points associated with these types of activity.

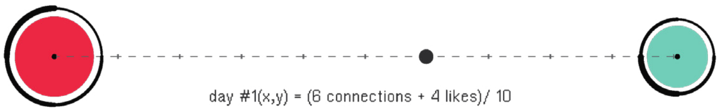


Fig. 5. The mapping process for each black circle that represents a day's activity.

Below, in figure 6, are presented the virtual personas resulting from the data of six users, three males and three females. They quickly reveal three distinct types of personas due to the predominant color of the polygon, further emphasized with the AC circles position and dimension. Personas #2 and #5 are *hard likers* given that the vast majority of their activity falls into the likes AC. Persona #4 is a *content collector* since it has a lot of saved content while personas #1, #3 and #6 present a more distributed activity. This evidence is quickly provided by. We can also infer that users tend to be more active during the night, between 16h and midnight. The virtual personas presented here are the result of users' entire activity. The online tool also allows seeing the evolution of this representation over the days, helping to understand the changes in the user's behavior throughout time.[1]

1. The 6 virtual personas and their time lapse animations can be consulted at: https://2021.xcoax.org/files/070-Personas

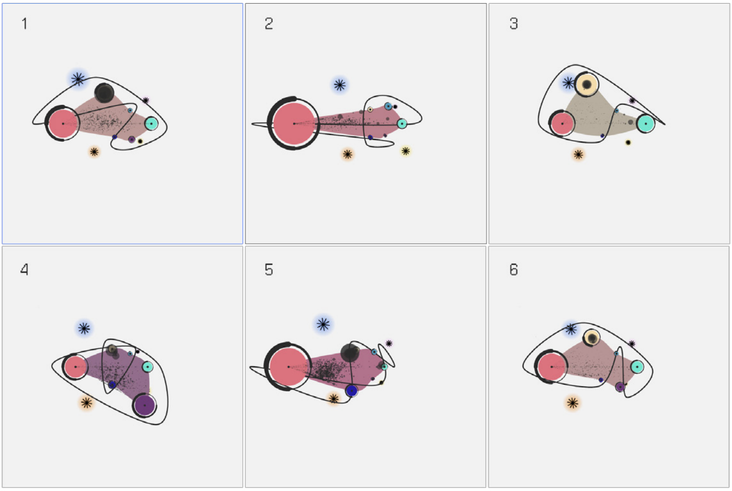


Fig. 6. Virtual Personas resulting from six different Instagram users' data.

4. Tool Evaluation

Since the work was conceived with the intent of perceiving the different types of *Instagram* users' profiles, namely through their behaviors, we requested the activity data from ten users, of which the results of three are presented in figure 7[2]. As the visual approach was designed with a strong aesthetic consideration, we also wanted to see if the compositions obtained could elicit different types of insights than when looking at the same data in more traditional and analytical ways.

2. The 3 user activities can be consulted in further detail (PDF format) at: https://2021.xcoax.org/files/070-Activities

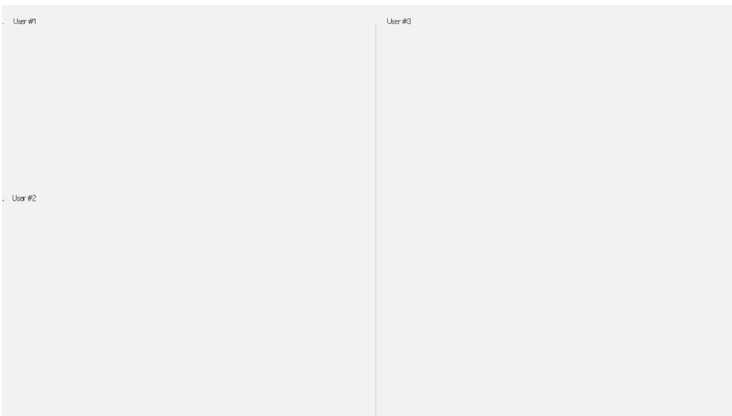


Fig. 7. Activity data from three Instagram users portrayed by *Personal Instants* Tool.

4.1. Methodology

We composed an online form and made it available to a computer science research lab at our university., An initial introduction section covered the context and objective of the developed work. This background was followed by an instruction phase, in which participants were introduced to each of the visualization elements (with figure 1) and the visual mapping approach briefly explained (with figure 2).

To begin, participants were asked to rank their knowledge on Data Visualization using a 5-point Likert scale (1 = None, 5 = Expert), so we could access whether or not such background could influence the interpretation of the work. Then, the three users' activities were provided in PDF format to be consulted in more detail.

We asked to the participants to provide the insights/differences they could retrieve about the activity of the three users with our visual representation (see Figure 4). Finally, participants were asked how they consider the composition approach in aesthetic terms, using a 5-point Likert scale (1 = Not aesthetically pleasant, 5 = Very aesthetically pleasing).

4.2. Results

Fourteen participants answered the form, five females and nine males. Nine participants listed their experience with Data Visualization as high (4 or 5), four as moderated (2 or 3) and the remaining participant as low (1). Next, the insights provided by the participants to the user profiling and the visual approach are presented. The number of times a given insight has been provided is shown within parentheses.

User Profiling

Regarding the profiling of user behavior, the participants provided the following statements about each one of the users:

User #1

» The user who uses *Instagram* less the *Instagram* because the pattern is less filled (inactivity gaps).
» The usage evolution of the app is visible, using more now (x2).
» Observer user, sometimes leaves some likes, sometimes makes posts.
In summary, makes a little of everything. More balanced behavior as it seems to go through all activities (x4).
» Passive-active user (x2).
» Gives many likes/comments.
» Makes connections and sees contents.
» “Normal” user (x2).
» Has defined close friends.

User #2

» Seems to focus more on one type of activity (like and comment).
» The usage evolution of the app is visible, using more now (x2).
» Saves much more posts (x6).
»VHard poster and liker. (mistaken the media and saved colors).
» Very active-active user.
» Gives fewer likes (than remaining users) (x2).
» Performs a little bit of all types of activities.
» Seen less content (than remaining users) (x2).
» Seems a collector of content (x3).
» Has defined close friends.

User #3

» Seems to focus more on one type of activity (like and comment) (x7).
» Focuses its activity on giving likes, watching stories and sending directs (x2).
» Very active-active user (x6).
» A great number of connections in the beginning.
» The user that posts more (x4).
» Has not defined close friends.

About all users

» The users do the same activity in a row several times (modules of the same color/ shape).
» The three users established connections, although User #3 did it mostly at the beginning of his activity. The others more throughout their activity.
» All users see more content at the end of their activity (x4).

Visual Approach

Regarding the tool's visual approach, twelve of the fourteen participants rated it with a major high appreciation (4 or 5) and the remaining two participants gave it a satisfactory appreciation (3). Regarding the idea itself, two participants considered it very interesting, stating also that it could be further explored with the integration of animation to represent the activity evolution or apply different visual aggregations in scenarios, for example, where there are several action/ events of the same type in a row.

Another participant said that "the white spaces in the composition aid in the distinction between activities" and that an interesting characteristic of the visualization mapping approach is that "it works both in close up and in general overview analysis". Even so, the participant pointed out that the analysis of User #3 activity was particularly difficult, as "it is vertically longer than the other two representations of activity". Despite being a valid observation, it would be easily answered if the user's activities were viewed through the tool itself, where the visualization would occupy the entire screen, but in order to provide access to several examples of activity under the same conditions for all participants, we decided to provide identical static versions instead.

Four participants found the different types of activity to be easily comparable mainly through color, but more difficult to distinguish the subcategories. This difficulty is due to the modules connected layout originating a visual aggregation of its external elements, thus making it more difficult to associate the elements belonging to the respective module. In addition, given the multiple subcategories, at least in a more initial phase, some participants mentioned the need to consult the explanatory image.

Although no information is given to the participants about our intent to make our work available under the format of a free, web-based tool so that any user could generate their pattern, several participants suggested precisely the evolution of the work in this way. Furthermore, they referred to the possibility of existing business investment on demand, where users could acquire their representation in different physical formats (posters, clothing, tile murals, etc).

5. Discussion and Future Work

The difference in the amount of activity between the three users was evident to the participants, having quickly noticed the different sizes of the three users. The participants were able to easily distinguish the different types of categories, mainly through the color, from where they were able to classify the three profiles as being three different types of users. However, there are some problems with the colorization of the modules to be improved, evidenced by the misinterpretation of a participant who read the saved content (purple) as media content (blue). Moreover, the visual mapping approach also needs to be improved taking into account that some users reported difficulty in reading the sub-categories when displaying the modules so close together. Still concerning the user behavior analysis, two participants noticed an increase in the frequency of use of the application for the first 2 users. At the beginning of the account creation, they presented many inactivity gaps of several days, reaching in some cases 2 weeks without activity and afterward took a more frequent, almost daily activity. These comments show that the intent of our inactivity gap visual variable was successful and was in fact able to reveal distinctive behaviors in the activity between users.

In general classification of the user profile, our visual approach proved to be able to categorize the three users as different types of users, where many participants considered the first user as passive, “normal” user, covering the different types of action/events in a moderated way, the second user as being more active and a collector, saving a lot of content, and the third user as the most active, producing a lot of content. In a more local analysis, participants also evidenced typical behaviors across all users as well as behaviors that distinguish them. A punctual action for User #1 and User #2 that generated a prominent pattern in their activity mesh was the definition of close friends. User #3 did not perform this activity. Performing the same activity on a row, especially giving likes and comments, is another very common pattern pointed out by the participants. One last comment that raised many questions to several participants was the high amount of activity in the Seen Content category (yellow category) at the end of the activity mesh of all users. It seems that this type of information has only recently started to be collected (It is worth mentioning that this same information has recently become possible to consult in the application itself).

Taking into account the different levels of knowledge and the feedback provided by the participants, the visualization approach seems to have managed to communicate several insights without the requirement of prior advanced or moderate knowledge in the field of data visualization, revealing its accessibility to the general public. The qualitative appraisals of the visual approach were well-received, exposing a strong possibility of artistic exploration such as the materialization of the outputs in exhibitions or physical artifacts to provide to users. After all, taking into account the participants' feedback we can say that, although there are clear visual refinements and more explorations to be made, our tool has promising capabilities to perform user profiling analysis and, at the same time, generate visual artifacts with a good aesthetic appraisal.

In future work, we intend to improve the tool by adding more interaction functionalities. We plan to address the visual issues/suggestions to improve our tool. We will continue to experiment with distinct forms to represent the different organisms and explore more dynamic ways of mapping them in the canvas to achieve more diversified results structure-wise. In a more conceptual and artistic way, we also intend to explore the application of sound, namely in the creation of musical compositions obtained through the mesh of generated organisms.

6. Conclusion

In this paper, we presented *Personal Instants*, a web-based tool for visualizing Instagram users' activity data. The tool was developed in order to expose the dimension of the content produced by us and reveal information about what kind of user we are.

In our visualization approach, the data takes the form of a mesh that fits the screen where it is being displayed. The mesh consists of a set of modules that represent each type of action/event performed by the user. More specifically, the design of a glyph takes a pixel-based form, where the color and structure composition are the main attributes to distinguish the types of actions/events. In what concerns the layout, we choose a matrix placement, with a linear, familiar reading to the users, depicting the temporal dimension from left to right and from top to bottom. We applied the proposed method on the dataset from multiple *Instagram* users to assess the tool capability to distinguish different types of user behavior.

To further validate the quality of the visual and mapping approaches in both analytical and aesthetics terms we analyzed the testimonials obtained through the form made available. In that form, the participants provided information about the types of insights they were able to derive from our tool outputs as well as their opinion regarding the aesthetics of the visual approach. With this information we could retrieve valuable suggestions to improve our work in the future, both at the organisms' level (such as their color and exterior structure) as well as the level of disposition and animation of the entire structure as a whole.

Acknowledgements. The first author is funded by the Fundação para a Ciência e Tecnologia (FCT), Portugal under the grant SFRH/BD/144283/2019. This work was partially supported by the LEXIA Project (POCI-01-0247-FEDER-038420) and by national funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project CISUC - UID/CEC/00326/2020 and by European Social Fund, through the Regional Operational Program Centro 2020.

References

Albrecht, Kim.
n.d. “Artificial Senses by Kim Albrecht.” https://artificial-senses.kimalbrecht.com/.

Barros, Sergio, Jack Jansen, Pablo Cesar, Thomas Röggla, and David A Shamma.
2018.“Designing the Club of the Future with Data: A Case Study on Collaboration of Creative Industries.” In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–9.

Baur, Dominikus, Frederik Seiffert, Michael Sedlmair, and Sebastian Boring.
2010. “The Streams of Our Lives: Visualizing Listening Histories in Context.” *IEEE Transactions on Visualization and Computer Graphics* 16 (6): 1119–28.

Catarina Sampaio, Luísa Ribas, Pedro Ângelo.
2019. “Data (Self) Portraits: An Approach to the Visualization of Personal Data from an Autoethnographic Perspective.” In *XCoAx 2019: Proceedings of the Seventh Conference on Computation, Communication, Aesthetics & X*.

Farid, Mark.
2016. “No Title.” *Poisonous Antidote*. http://www.poisonous-antidote.com/.

Graf, Rudolf F.
1999. *Modern Dictionary of Electronics*. Oxford: Newnes.

Lupi, Giorgia.
2017. “Data Portraits at TED.” http://giorgialupi.com/data-portraits-at-ted2017/.

Lupi, Giorgia.
2019. “What Counts.” http://giorgialupi.com/whatcounts.

Lupi, Giorgia, and Stefanie Posavec.
2016. *Dear Data*. Chronicle books.

Manovich, Lev.
2005. “The Shape of Information.” *Retrieved March* 5: 2012.

Max Roser, Hannah Ritchie, and Esteban Ortiz-Ospina.
2015. “Internet.” *Our World in Data*.

Pousman, Zachary, John T. Stasko, and Michael Mateas. 2007. “Casual Information Visualization: Depictions of Data in Everyday Life.” *IEEE Transactions on Visualization and Computer Graphics* 13 (6): 1145–52. https://doi.org/10.1109/TVCG.2007.70541.

Salavon, Jason.
2009. “No Title.” http://salavon.com/work/SpigotOraclesReflection/.

Sampaio, Catarina, and Luísa Ribas.
2020. “On Data Portraits: An Analysis of Creative Approaches to the Visualisation of Personal Data.” *Proceedings of EVA London* 2020 30, 255–62.

Sullivan, Anne.
2020. “Embroidered Ephemera: Crafting Qualitative Data Physicalization Designs from Twitter Data.” In *Joint Proceedings of the ICCC 2020 Workshops (WS 2020)*, edited by Max Kreminski, Viktor Eisenstadt, Sofia Pinto, and Oliver Kutz.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Of Sparkle-Vomit and Base Materialism: Field Notes on Blingee GIFs

Keywords: Bataille, Cute, Cyberfeminism, Formless, Kawaii, Pretty, Postdigital, Produsage

Ana Matilde Sousa
ana.matilde.sousa@gmail.com
CIEBA - Centro de Investigação e de Estudos em Belas-Artes

This article focuses on the website Blingee, a popular online GIF generator, founded in 2006, whose mode of operation is based on user-made "stamps" and other ornamentations. Originally designed for teens to decorate their personal Myspace accounts, Blingee has inspired a cult following for its kitsch "sparkle-vomit" Internet aesthetic, that is, excessive cuteness and prettiness, often including profuse amounts of digital glitter. While the site almost closed in 2015, it was brought back by public outcry and even has a community of specialized "amateur" artists that spend endless hours working on their GIFs. In the first part of the article, I contextualize Blingee in terms of its development and background — e.g., its filiation in the tradition of Japanese purikura photography—and describe its primary uses and material-semiotic characteristics. In the second part, I explore a possible connection between Blingee GIFs and the Bataillean concepts of "base materialism" and the "formless," exuding from the poetic valences of and the specific ways in which these GIFs use the stamps and the glitter. I argue that Blingee, as poisonous "sentimental rubbish," has the potential to affect, destabilize, and disrupt the contemporary cyborgian imagination by creating sites of "parapolitical" resilience.

1. Introduction

Cute. Forever Friends. Best Friends. Love. Sweet. It's a Girl's World. Good Morning. Happy Birthday. Adorable. 100% Me. Thank you! Princess. Cutie. Emo. The Cutest Girl in the World!

Add to that layers of sparkling glitter, kittens, puppies, babies, hearts, stars, ribbons, fairies, unicorns, rainbows, flowers, anime chibi, and big-eyed cute girls (Fig. 1). Ah, did I mention sparkling glitter? Lots, lots of sparkling, maniacally sparkling glitter, corroding the images away like the uric acid in Andy Warhol's *Oxidations* (or, more colloquially, piss) paintings from the 1970s, made by having his friends urinate on copper panels as a homage to Pollock (Fig. 2). This is the material-semiotic substance of Blingee, a website founded in 2006 by German multimedia conglomerate Bauer Media Group. Blingee is one of the most popular online GIF generators that allows users to create animated pictures using photographs and artwork, combined with user-generated ornamentation called "stamps." Once created, a stamp is made available to all other Blingee users, and one cannot delete the stamp once used in a GIF (some stamps become extremely popular and widely used). Blingee GIFs are an embodiment of the cuteness and prettiness that have become deeply embedded elements of contemporary digital matters and Internet aesthetics (Wittkower 2012). Their stubborn adherence to kitsch aesthetics forefronts the workings of unruly cybercultures, betraying the high expectations of transhumanist enhancement promised by the digital revolution—a betrayal that happens at the level of the pixel. Or, as media scholar Ethan Zuckerman once eloquently put it, "Web 1.0 was invented to allow physicists to share research papers. Web 2.0 was created to allow people to share pictures of cute cats" (Zuckerman 2008). That and porn, of course: a lot of it (Kleinman 2017, para. 1).

Fig. 1. Example of Blingee GIF using multiple stamps on a drawing of a cute anime girl. Source: shorturl.at/eovzR

Fig. 2. Example of an *Oxidation* painting by Andy Warhol.

Before going any further, it is necessary to briefly address what one means by "cute." Cuteness can be understood on two different, if necessarily interconnected, levels. On the one hand, cuteness is an "affective response — a feeling one can refer to as the 'Aww' factor" (Dale 2016, 5), serving as an evolutionarily advantageous trait. This "natural" cuteness, understood as a primal, protective instinct towards neonates, is not exclusive to humans, intertwining with the broader evolution of animals on Earth. In the 1940s, Austrian ethologist Konrad Lorenz was the first to describe what he called *kinderschema*, or "baby schema," a set of features and behaviors found in animals, including humans, indexing youthfulness and vulnerability that trigger our nurturing instinct. Nevertheless, many scientists today argue that "instead of stemming solely from helplessness and dependence, cuteness is... intimately linked to companionship, cooperation, play, and emotional reactivity" (Dale 2016, 50 - 51), suggesting it plays a role in motivating prosocial behavior, empathy, and disarming aggression (Dale 2016, 46 - 51). This prosocial aspect is particularly significant when it comes to the role that cuteness plays in creating communities, including online communities.

This brings us to cuteness as a socio-cultural concept and, by extension, as an aesthetic category. This "second nature" of cuteness is relatively recent in human history, relating to the word's emergence at the dawn of the twentieth century, although its roots can be traced back further, for instance, to Rococo's fascination with the small and playful against Baroque's grandeur, encapsulated in works such as Jean-Honoré Fragonard's *L'Escarpolette*, or some Edo period paintings and prints in Japan (Dale et al. 2016, 2). However, in essence, the cute is a modern category, whose growth to enormous proportions in the twenty-first century has led some to speak of a "cuteness-industrial complex" (Ehrlich 2015, para. 2). The iconic Crying Boys painting series by Italian painter Giovanni Bragolin, an icon of kitsch mass-market art, epitomizes the intimate relation of cuteness to manipulative and profit-oriented consumer culture and sentimentality. But one could also refer to Margaret Keane's paintings of big-eyed women and children or the kitty and puppy calendars hanging in homes all over the world. These associations have put cute aesthetics squarely on the "dumb" side of what art and literary critic Andreas Huyssen famously called "the Great Divide" (Huyssen 1987, viii) between high art and lowly mass culture. Likewise, the pretty is a "desintensification" or domestication of the beautiful, something which is appealing in a delicate and graceful way but removed from the solemnity of beauty as a central category in classical art; one could argue that the pretty is a "cutefication" of the beautiful.

Disconnected from the biodeterminism of Lorenz's *kinderschema*, cuteness becomes contingent and relational. This is not to say that everything is (or can be) cute. Cuteness does evoke a specific word cloud or arena of attributes ranging from "small," "weak," "helpless," or "manipulative" to "young," "pretty," "quaint," "playful," "adorable," and so on. However, in the artistic and pop-cultural realms, cuteness often reflects the fact that "social and subcultural groups have their own (rather specific) criteria for what sorts of manners and attitudes constitute 'cute'" (Shiokawa 1999, 120). Even the ugly can be cute, to some extent: take, for instance, the World's Ugliest Dog Contest as an example of such concoction of cuteness and ugliness, or the blobfish, voted the world's ugliest animal in 2013 by the Ugly Animal Preservation Society (Schultz 2013), or even the cutefication of disability in Internet celebrity cats like Lil Bub (Laforteza 2014). In many respects, Japanese cute aesthetics, a.k.a. the kawaii, are a remarkably elastic and fertile ground for investigating how cuteness often combines with "antagonistic" elements—what Joshua Dale calls the "dark side of cute" (Dale 2016, 39), epitomized by trends like ugly-cute, grotesque-cute, and disgusting-cute (*buso, guro, and kimo or yami-kawaii*).

Since my article is a collection of "field notes" or preliminary observations about Blingee and the GIFs produced by its user base, it focuses on a particular intersection of cute aesthetics and "digital folklore," a term coined by Internet artists and theorists Olia Lialina and Dragan Espenschied to describe both "the customs, traditions and elements of visual, textual and audio culture that emerged from users' engagement with personal computer applications during the last decade of the 20th and the first decade of the 21st century" (Espenschied and Lialina 2009, 9–10) and the artifacts resulting from such "a distinct user culture developed inside user-oriented applications and services despite their low social status" (Espenschied and Lialina 2009, 11). Of the article, I contextualize this phenomenon in terms of its development and background and describe its primary uses and material and semiotic characteristics. In the second part, I take a poetic leap, speculating upon a connection between Blingee and the Bataillean concepts of base materialism and the formless. In the end, I hope to contribute, however modestly, to broaden our collective understanding of the poetic valences of such user and female-led digital environments that, despite their omnipresence and relevance to contemporary cyborgian imaginations, are not widely regarded as worthy of close observation and serious study.

2. What Blingee is and does

Initially, Blingee was created to help teens and young adults easily craft animated content to decorate their personal accounts on platforms that were then (i.e., by the mid to late 2000s) at their peak, like Myspace, the precursor of Facebook and the first social network with a global audience en *masse* (Goodings 2012, 485 - 86). In 2015, the site was about to be shut down, but due to massive outcry from fans and specialized media, it managed to secure funds to continue its operation to this day—although the end of Adobe Flash Player, by January of 2021, now threatens to take down the website for good if the Blingee team fails to convert it to HTML5. However, it is not too hard to understand why the company, perhaps not quite aware of the website's cult status, decided to shut down Blingee. After all, by the mid-2010s, the "Myspace era" already seemed like a long-buried layer of Internet stratigraphy. What is more, one can argue that Blingee's nostalgic appeal goes back to an even earlier Internet—one would not say prehistoric, but a period in the late 90s, when GeoCities reigned over the Earth.

Thus, even at its birth in 2006, Blingee already felt like an atavistic remainder of a vanishing aesthetic. The aesthetics of the World Wide Web's age of innocence, of cheesy personal websites and fan pages, *Tenshi Muyu* and *Sailor Moon* tributes, and primitively animated cute emoticon mascots. The Internet Archive did a favor to humanity by preserving over 4.500.000 GeoCities-era animated GIFs through their special project GifCities: The GeoCities Animated Gif Search Engine, available online at gifcities.org. Similarly, Lialina and Espenschied created a Tumblr-based project called "One Terabyte of Kilobyte Age" to collect screenshots from defunct GeoCities homepages. Their "treasure trove of outdated aesthetics, web design tropes, and apologies for not posting more or not having the site cleaned up" (Chayka 2013, para. 2) is an ode and eulogy to early www aesthetics.

Blingee's continued popularity is a noteworthy phenomenon, resulting from the interweaving fibers of authentic tween "sparkle-vomit" (Wilson 2015, para.1) and an adult "tongue-in-cheek, retro take on remix culture" (McHugh 2015, para.1). Like other obsolete technologies, revived by the love of devoted fan communities, their appeal is ultimately nostalgic — consider, for instance, Polaroid and its rescue (and eventual merge in 2020) with The Impossible Project, or the current popularity enjoyed by risograph printing at the hands of graphic artists. Here, I use the word "nostalgic," not necessarily in the syrupy acceptation of "sentimental rubbish," as Adorno (2013, 340) put it; although, in what Blingee is concerned, this is *exactly* right. Instead, in the sense of being attracted to outdated things that lay "outside of the modern framework" (Natali 2004, 11) of emancipatory progress. In other words, although Blingee was rescued from the digital oblivion and resurrected, it was also "zombified" in the process: leaving one with the impression of an artifact of the past without a future proper, one which has overstayed its welcome in the teleological march of history. Such resistance to futurity becomes embedded in Blingee GIFs as an integral part of their materiality, like a clot blocking futuristic visions of the Internet's information highways.

Fig. 3. *Purikura* machines in Japan.

Fig. 4. Example of *purikura* taken by a group of friends in cosplay.

It is worth mentioning that there are non-Internet-based antecedents to Blingee, which follows in the tradition of Japanese *purikura* (from the English, "print club"). Purikura is a form of photography taken in specialized coin-operated photo booths, available in malls or on the streets, in neighborhoods like the fashionable Harajuku in Tokyo. It allows one to add stamps and manipulate the image digitally according to a set of options, for instance, "backdrops, borders, insertable decorations, icons, and text writing" (Miller 2017, loc 2464) as well as "hair extensions or twinkling diamond tiaras" and, notably, eye-enlargement and "tenderized light effects" (Pan 2015, 107) (Figs. 3 & 4). The underlying idea is to beautify, or rather, "kawaiify" the photo — *kawaii*, as I mentioned before, is the Japanese word for "cute." Mostly devoted to female group selfies, purikura became popular in the second half of the 90s, intersecting with the evolution of coeval street fashion subcultures, like *gyaru* or decora. Indeed, both styles imported purikura into real life by gluing glitter and stickers on the face and other areas of the body and clothes (Figs. 5 & 6). Although Blingee is an animated version, many of its primary features of cute stamps and glitter galore adhere to the aesthetics of the older Japanese *purikura*. Conversely, the smartphone camera lens filters and stickers (e.g., on Snapchat, Instagram, TikTok, etc.) whose usage has become, nowadays, a widespread cross-age cultural technique, can be considered the successors of Blingee GIFs.

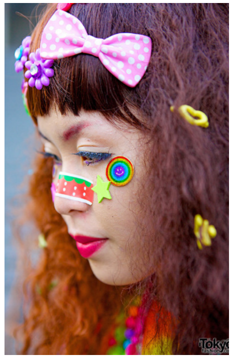


Fig. 5. Examples of gyaru models with cute face stickers.

Fig. 6. Example of a decora practitioner with stickers on her face.

Besides stamps, texture (instead of opticality) is arguably the primary aesthetic feature for which Blingee is known, namely, its heavy use of glitter, affectionately nicknamed "sparkle-vomit." In Blingee GIFs, sparkles can be superimposed on the entire image or restricted to parts of it, using masks. For instance, one can add glitter of various shapes and colors to the clothes of pop celebrities like Drake or Avril Lavigne (Fig. 7),or the hair of a beloved anime character. An important point to emphasize is that in many Blingee GIFs, the only movement in the animated clip (i.e., that which moves from frame to frame) is the "movement" of the glitter. Or, when there are stamps, of the stamps. In other words, even though they are GIFs, the base picture does not move, only the ornaments applied over it.

Fig. 7. Celebrity rapper Drake "glitterfied" using Blingee. Source: shorturl.at/fuGY3

Additionally, like in *purikura*, cuteness and prettiness become all-absorbing (although not exclusive) forces indexed by the medium, to the point that gothic and grotesque darkness themselves can be rendered rather cute and cuddly. Color combinations like black, white, purple, and red are popular choices in such cases. Users combine these with stamps of bat and spiky angel wings, black hearts and butterflies, sparkling skulls and spider webs, and attempts at "dark" or "depressive" text (e.g., "gothic love," "100% crazy" or "emo girl") (Fig. 8).

Fig. 8. Example of Blingee GIF with an emo "dark" aesthetic. Source: shorturl.at/ikDH6

On occasion, as can be seen in Figure 9, Blingee is also used for political activism, for example, to undermine the image of macho figures like Donald Trump. Another form of Blingee "activism" is actually not politics but a kind of "para-politics" (Ivy 2010), related to what writing duo Alicia Eler and Kate Durbin have termed The Teen-Girl Tumblr Aesthetic. The Teen-Girl Tumblr Aesthetic combines dreamy adolescent girl sensibilities with "immediate, hyper-embodied, raw and vulnerable" (Eler and Durbin 2013, para. 14) expressions, as a strategy for feminist reclaiming of the "minor and generally unprestigious feelings" (Ngai 2007, 6) and aesthetics associated with femininity. One could think of it as a fourth-wave version of the 1990s kinderwhore or Riot Grrrl movements. *Au point*, Eler and Durbin begin their article with a Blingee GIF of artist Frida Kahlo with a glittering unibrow, beautifully encapsulating the mix of Blingee's sparkling cuteness and prettiness with an icon of visceral female strength against physical and psychological pain (Fig. 10).

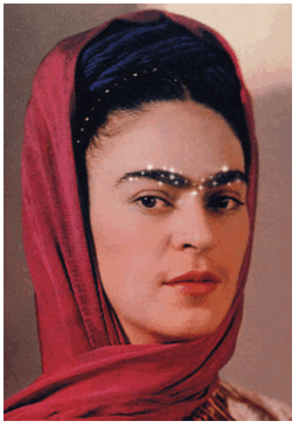


Fig. 9. A Blingee GIF with a cute aesthetic mocks Donald Trump, using the phrase "Putin's Little Bitch." Source: shorturl.at/adkvE

Fig. 10. The Frida Kahlo GIF in Eler and Durbin's article "The Teen-Girl Tumblr Aesthetic." Source: shorturl.at/diT03

Generally speaking, in Blingee GIFs, puppies, kittens, and babies rule. Fantasy figures, too: fairies with sparkling wings, diaphanous elves, beautiful princesses, and enchanted princes (Fig. 11). The probability of finding an anime character with big dewy eyes is equally great, as this kind of character has become a "go-to" to create fluff on the Internet. Add a few hearts, ribbons, and some sparkles, and one gets to have a perfect Blingee. There is, however, yet another common kind of "cutefication" in Blingee, namely, when male characters from Japanese animation (or other media), popular among female fans—often, characters with "masculinized" traits of aggressiveness or emotional uptightness—are "cutefied" with glitter and other kinds of pretty embellishments and ornamentations. Here, we enter a terrain, if not of deliberate irony, of subversion of masculinity by feminized, and therefore abject, digital matters. There are countless examples of this kind of intervention on Blingee, such as Figure 12, featuring a popular *tsundere* character (who is generally cold or disagreeable to others), Uchiha Sasuke, from the action manga and anime series Naruto.

Fig. 11. Example of a Blingee GIF with a fairy tale aesthetic. Source: shorturl.at/egD57

Fig. 12. Uchiha Sasuke, a popular tsundere character from Naruto, "cutefied" with Blingee stamps. Source: shorturl.at/oszAG

3. Blingee and/as Base Materialism

In its undermining of the aesthetic integrity of images, Blingee's sparkle-vomit may establish a surprising relationship with concepts such as Georges Bataille's "base materialism." As Benjamin Noys puts it, "base materialism" as defined by the French philosopher, is an "active base matter that disrupts the opposition of high and low and destabilizes all foundations," and that, in doing so, "destroys the promise of liberated spaces and offers a more radical disorienting freedom" (Noys 1998, 499), unreducible to politics. While sparkle-vomit (in Internet lingo) means an excess of cuteness or prettiness which becomes too much to handle by the standards of decorum and good taste, the term already encodes a destabilizing contradiction: “sparkle” denotes an idea of light, purity, and idealization, while “vomit” is its dialectical opposite, i.e., the unclean and debased substances one expels to the ground below. One finds a similar contradiction on the Internet and pop culture meme “puking rainbows,” meaning “To vomit rainbows at the sight of something amazing on the Internet,” or “To be so overwhelmed with cuteness that you puke rainbows” (MPVTOX 2012). Unicorns are a common subject of the “puking rainbows” variety of illustrations, signaling that they are so magical that even their lowest excretion is made of sugar, spice, and everything nice (Fig. 13). The notion of “sparkle-vomit” may not fit into what is usually understood as the “dark side of cute” but constitutes an integral part of it.

Fig. 13.

Borrowing from Adorno’s expression in his *Aesthetic Theory*, Blingee’s “poison” is that of kitsch and other axes traditionally “low” in the hierarchy of artistic production and reception for their abundance of “sentimental rubbish” (again, Adorno). These include fandoms of various culture-industrial products and, in my view, particularly Western fandoms of mainstream manga and anime, which, due to their internalization of *kawaii* aesthetics, and despite the massive Japanization of global pop culture in the twenty-first century, still tend to be frowned upon as an improper form of cultural impurity (the birth and spread of Internet slurs like “wapanese,” from “wannabe Japanese,” “weeaboo” or “weeb” attest to the enduring suspicion towards such fandoms). In any case, one of the more striking aspects of Blingee GIFs is that despite (or precisely because of) all their brilliance, they exude a material decomposition. Or, rather, they seem to be in the process of decomposing or being decomposed, in the biological sense of decay but also in the *sensu stricto* of being "de - + composed." Undone, split, or fragmented into pieces. Specifically, it seems to me that the clouds of diamond-shaped sparkles add an unsettling dimension to the images they intend to "beautify." The use of sparkles to represent an aura of "preciousness" has a long tradition; for instance, in the iconography of shoujo manga (Japanese girl-oriented comics), they convey hazy sentiments or beauty (Fig. 14). But Blingee sparkles are not delicate — they are aggro. White or brightly colored and often used in large quantities to give the images a glittery effect. Thus, they tear up the fabric of the images, gnawing at their surface, piercing them with tiny voids that compromise their material integrity (Fig. 15).

Fig. 14. Example of "shoujo sparkles" in a screentone used in manga.

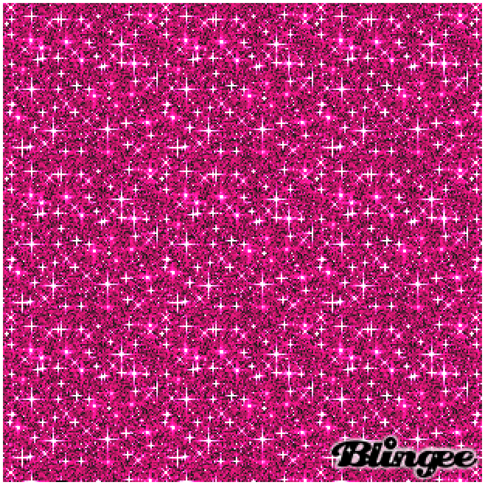


Fig. 15. Example of Blingee glitter. Source: shorturl.at/bksA5

Returning to the comparison that I drew earlier in this article between Blingee GIFs and Warhol's *Oxidations*, these sparkles are like urine on copper. Of course, one should note that the context surrounding the production of these two types of artifacts is undoubtedly different, even contradictory, considering the latter's phallocentric dimension. However, for the sake of argument, I would like to dispense with such contextual differences and focus on one aspect they have in common despite any apparent differences: their baseness and lowness. Just like Warhol's Oxidations destabilize the spiritual and philosophical sacredness of art by literally pissing on it, so do GIFs in "pretty pink princess" (Moskowitz 2011) style made by the prototypical Blingee user, i.e., the teen girl, engage in a transgression of taste that, in its own way, also fits into the category of "excremental" aesthetics. While one suspects that, in most cases, such programmatic transgressiveness is all but removed from authorial intent, one could go so far as to argue that (following Bataille's theory of transgression) Blingee GIFs capture the fracturing, "unacknowledged excess" (Buchanan 2010) produced by such stereotypical visual culture associated with girlhood, especially within a misogynistic "culture that celebrates youth and beauty above all else while simultaneously denigrating the bearers—young women, overwhelmingly" (Power 2013, para. 2).

Another connection between Blingee GIFs and the *Oxidations* happens on a "purely" formal level, in the process mentioned earlier of de-composition. Both these types of artifacts are *corps morcelé* (Lacan), whose fragmented surfaces, eaten up from the inside (in the case of Blingee GIFs, not by piss but by vomit—sparkle vomit), threaten to "shatter the illusion of wholeness" (Buchanan 2010) underlying our fantasies of ageless perfection. Considering that Blingee GIFs typically evoke a neotenic aesthetic of perpetual adolescence, this shattering of fantasies becomes even more striking and the contrast (of life and decay, Eros and Thanatos), more glaring. Here, Blingee GIFs enter squarely into the territory of post-digital aesthetics, which oppose "digital high-tech and high-fidelity cleanness," as well as any notions of "teleological movement towards "perfect" representation" (Berry and Dieter 2015, 16), in favor of wallowing in the "messy state of media, arts and design after their digitization" (Berry and Dieter 2015, 19). The fact that, in a way, Blingee GIFs already seem damaged or fragmented ties in with their anti-futurity (i.e., against the grand narratives of digital progress) and even the current interest in them, of which this article is a manifestation, has something retro about it. Indeed, it is not hard to imagine a digital archaeologist of the future lovingly digging up glitchy traces of Blingee GIFs, like fragments of vases from excavations into millenary ruins, for there is something about them that gives one the impression that they would be entirely at home in a ruined environment. It is as if these images are ready to unravel into pixelated muck, despite their aspirations to the stratosphere of sparkling optimism. Moreover, because, in Blingee, the worse taste, the better, the damage is not "just" material (assuming that anything can ever "just" happen on a material or formal plane, divorced from their content), but also culturally catastrophic. Poisonous—in the Adornian sense, which is thoroughly conducive to Bataillian baseness.

The name of the website itself, Blingee, comes from “bling,” an onomatopoeic jargon indicative of ostentatious clothing and gaudy jewelry as well as of the materialistic attitudes that are associated with them — explaining why some of the more popular Blingee stamps are gold gangsta chains, a symbol of status and wealth in hip-hop culture (Fig. 16). Following Bataille, the idea of excess and, therefore, expenditure is thus inscribed in the very etymology of Blingee. An expenditure, a loss of energy, time, and resources also visible, for instance, in the works of competition-winning Blingee artists like Irina Kuleshova, a 50-something-year-old Russian divorcee who has, by her own admission, “married Blingee.” As she puts it in her interview with Olia Lialina, “All my free time I make blingees or I think about a new trick that would make my pictures more alive” (Kuleshova 2015, “You are the author of 263,207 stamps...”). Kuleshova’s epic Blingee GIFs epitomize the act of “designing for abundance, joy or delight” (Kendall 2019, 90), which is the substance of Bataillean luxury as meaningless dissipation of surplus energy (Kendall 2019, 74) (Fig. 17).

Fig. 16. Example of a gangsta chain stamp used on puppies in a Blingee GIF. Source: shorturl.at/fsBH0

Fig. 17. Example of a Blingee GIF created by Irina Kuleshova, a "queen of Blingee." Source: shorturl.at/bsPQ9

The excesses of kitsch beautification have become the hallmark of the contradictory aesthetics of subcultures that stem from poverty, including trailer trash, gangsta culture, or Zef in South Africa. Thus, while apparently contradictory, the fact that a significant part of Blingee GIFs are permeated with cute aesthetics establishes a link with this "culture of the gutter, of trash, [which] is itself scatological" (Krauss and Bois 1997, 120) in its nouveau riche fixation on superficial displays of wealth. This superficiality—both literal and figurative—is encapsulated in the idea of the "stamp" as a decorative unit that exists over the image, a sticker repeated ad nauseum and whose relationship with the image beneath is inevitably shallow. (Fig. 18) As I mentioned before, the same shallowness applies to the very "movement" of these GIFs, as the only thing that actually moves in the short clips are the stamps or the glitter, not the picture at the base. This, in itself, is one of the aspects that "lowers" the aesthetics of Blingee GIFs. It is a cheap trick of amateur and, importantly, girls' crafts, that goes against the tenets of "proper" composition in the fine arts (associated, in the modernist tradition, with masculinized precision and restraint). In other words, glitter, kittens, cute anime characters, and other "sentimental rubbish" like motivational phrases are scatological insofar as, excreted from any aesthetic or intellectual deepness, they naturally occur on the surface.

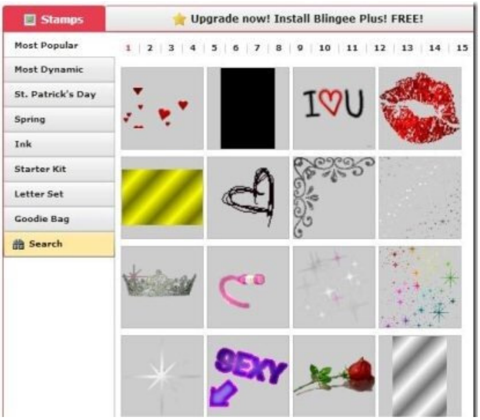


Fig. 18. Stamps can be searched on the Blingee website using keywords and hashtags.

The use of texture (e.g., glitter) and stamps, superimposed on the images in Blingee, attempts to create a sense of integration that is ultimately futile due to the superficiality embedded in the website's mechanics. This observation brings me to yet another Bataillean category, the formless. Far from being "informal" (as in the abstract and gestural qualities of *arte informale*), Blingee GIFs, in their maniac operations, attack the formal qualities valued by modernist taste. In particular, Blingee stamps, compulsively repeated and opened up to amateurism (remember that these are all user-generated!), create a paradox, as their customization eventually results in absolute redundancy and visual standardization. Which is to say that, after a few Google searches, all Blingee GIFs blur into each other. Regardless of their authors' intentions, these GIFs magnificently fail to reach the heights of beauty and imagination promised by their most recurring motives, whether cute or fantastic, pointing to a phenomenological "toxicity" lurking from within the layers of kittens and sparkle-vomit. If anything, Blingee GIFs may strike one as resolutely anti-lyrical in their baseness. They enact a dismemberment of lyricism itself, as the expression of deep feelings or emotions in art, which comes neither from the straight path of modernist medium-specificity nor from the emphasis on disgust-inducing (bodily) scatology in abject art. It is a curveball from somewhere unexpected. A catastrophe of this kind can, if not be redeemed, at least translate into a radical and exciting (perhaps, to some point, even liberating) material experience.

3. Conclusion

I intended this article as a collection of thoughts and notes taken during my field research on the website Blingee, where users create animated GIFs in the aesthetic of Internet sparkle-vomit, i.e., excessive cuteness and prettiness. Since these were primarily meant to meet my own research interests for an art project, it was not my intention to be exhaustive or final, and my mindset was speculative and exploratory. Nevertheless, the fact that sparkle-vomit aesthetics have achieved considerable relevancy within the contemporary psyche is undeniable. It is manifested, for example, in the fact that Lisa Frank — author of colorful illustrations of puppies, unicorns, dolphins, stars, hearts, rainbows, cute patterns, and whatnot — has been selected to represent the United States at the 2021 Venice Biennale; this, although her company primarily produces stationery and stickers (Vartanian 2019, para. 1).

I think that further exploration on the topic of Blingee GIFs and sparkle-vomit will connect to the postdigital aesthetics of cyberfeminism and glitch feminism, currently enjoying renewed interest. How might these "girly" techno-environments spark and destabilize the contemporary cyborgian imagination? Can there be a value to their "parapolitical" actions, for instance, in reclaiming and rerouting "Internet Ugly"(Douglas 2014) aesthetics and meme culture towards a "consciously posthumanist and ecologically invested postmodernism" (Chaudhuri 2016, 70)? Whatever the answer to these questions, I hope, more generally, that my brief "field notes" are evocative to those interested in the elusive and ever-broadening scope of digital and Internet trends, and the relations that these can establish with the realm of philosophy and aesthetics.

Acknowledgments. I thank the anonymous xCoAx reviewers for their careful reading of my article and insightful comments and suggestions. This work was supported by the Foundation for Science and Technology (FCT) under Grant SFRH / BD / 89695 / 2012.

References

Adorno, Theodor.
2013. *Aesthetic Theory*. London: Berg Pub Ltd.

Berry, David, and Michael Dieter, eds.
2015. *Postdigital Aesthetics: Art, Computation and Design.* Houndmills, Basingstoke, Hampshire ; New York, NY: Palgrave Macmillan.

Buchanan, Ian.
2010. *A Dictionary of Critical Theory*. Oxford: Oxford University Press

Chaudhuri, Una.
2016. *The Stage Lives of Animals: Zooesis and Performance*. Milton Park, Abingdon, Oxon ; New York: Routledge.

Chayka, Kyle.
2013. "An Introduction to the Early Web Aesthetics of Geocities." *Hyperallergic*. February 14, 2013. https://hyperallergic.com/65108/an-introduction-to-the-early-web-aesthetics-of-geocities/.

Douglas, Nick.
2014. "It's Supposed to Look Like Shit: The Internet Ugly Aesthetic." *Journal of Visual Culture* 13 (3): 314–39. https://doi.org/10.1177/1470412914544516.

Ehrlich, David.
2015. "From Kewpies to Minions: A Brief History of Pop Culture Cuteness - Rolling Stone." Rolling Stone. July 21, 2015. http://www.rollingstone.com/movies/news/from-kewpies-to-minions-a-brief-history-of-pop-culture-cuteness-20150721

Eler, Alicia, and Kate Durbin.
2013. "The Teen-Girl Tumblr Aesthetic." *Hyperallergic*. March 1, 2013. https://web.archive.org/web/20180124083049/https://hyperallergic.com/66038/the-teen-girl-tumblr-aesthetic/.

Espenschied, Dragan, and Olia Lialina.
2009. *Digital Folklore*. Merz & Solitude.

Goodings, Lewis.
2012. "Understanding Social Network Sites: Lessons from MySpace." *Visual Communication* 11 (4): 485–510. https://doi org/10.1177/1470357212454098.

Huyssen, Andreas.
1987. *After the Great Divide: Modernism, Mass Culture, Postmodernism*. Bloomington: Indiana University Press.

Ivy, Marilyn.
2010. "The Art of Cute Little Things: Nara Yoshitomo's Parapolitics." *Mechademia* 5 (1): 3–29.

Kendall, Stuart.
2019. "Making More (of Waste)." In *Georges Bataille and Contemporary Thought*, edited by Will Stronge, 73–94. Bloomsbury Academic.

Kleinman, Alexis.
2017. "Porn Sites Get More Visitors Each Month Than Netflix, Amazon And Twitter Combined." *HuffPost*, December 6, 2017. https://www.huffpost.com/entry/internet-porn-stats_n_3187682.

Krauss, Rosalind, and Yve-Alain Bois.
1997. Formless: *A User's Guide by Yve-Alain Bois*. New York: Zone Books.

Kuleshova, Irina.
2015. "I am a free woman now, I married Blingee" Interview by Olia Lialina. One Terabyte of Kilobyte Age. https://blog.geocities.institute/archives/5348.

Laforteza, Elaine M.
2014. "Cute-Ifying Disability: Lil Bub, the Celebrity Cat." *M/C Journal* 17 (2). http://journal.media-culture.org.au/index.php/mcjournal/article/view/784.

McHugh, Molly.
2015. "Blingee Is Dead, Long Live Blingee." *WIRED*. August 14, 2015. https://www.wired.com/2015/08/rip-blingee/.

Miller, Laura.
2017. "Expressive Energy in Female Self-Photography." In *Introducing Japanese Popular Culture*, edited by Alisa Freedman and Toby Slade, Kindle edition. Abingdon, Oxon ; New York, NY: Routledge.

Moskowitz, Clara.
2011. "The Destructive Culture of Pretty Pink Princesses." *LiveScience*. January 24, 2011. https://www.livescience.com/11625-destructive-culture-pretty-pink-princesses.html.

MPVTOX.
2012. "Puking Rainbows." Urban Dictionary. January 13, 2012. https://www.urbandictionary.com/define.php?term=Puking%20rainbows.

Natali, Marcos.
2004. "History and the Politics of Nostalgia." *Iowa Journal of Cultural Studies* 5 (1): 10–25.

Ngai, Sianne.
2007. *Ugly Feelings*. Harvard University Press.

Noys, Benjamin.
1998. "Georges Bataille's Base Materialism." *Cultural Values* 2 (4): 499–517. https://doi.org/10.1080/14797589809359312.

Pan, Lu.
2015. *Aestheticizing Public Space: Street Visual Politics in East Asian Cities*. Bristol: Intellect. http://public.ebookcentral.proquest.com/choice/publicfullrecord.aspx?p=2091495.

Power, Nina.
2013. "She's Just Not That into You." *Radical Philosophy*. 2013. https://www.radicalphilosophy.com/reviews/individual-reviews/rp177-shes-just-not-that-into-you.

Schultz, Colin.
2013. "In Defense of the Blobfish: Why the 'World's Ugliest Animal' Isn't as Ugly as You Think It Is." *Smithsonian*. September 13, 2013. https://www.smithsonianmag.com/smart-news/in-defense-of-the-blobfish-why-the-worlds-ugliest-animal-isnt-as-ugly-as-you-think-it-is-6676336/.

Shiokawa, Kanako.
1999. "Cute but Deadly: Women and Violence in Japanese Comics." In Themes and Issues in Asian Cartooning: Cute, Cheap, Mad, and Sexy, edited by John A. Lent, 93–126. Bowling Green, OH: Popular Press 1.

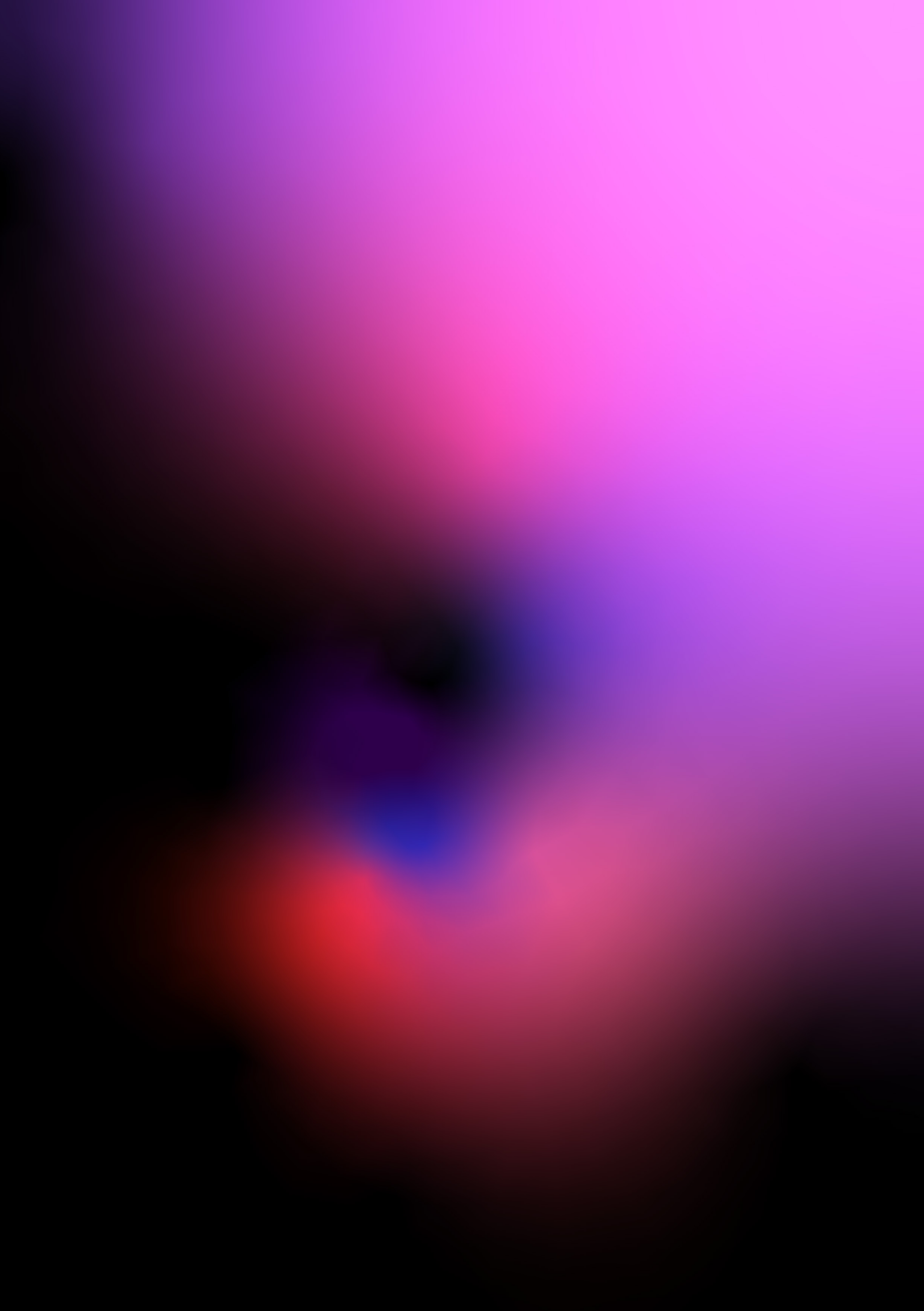
Vartanian, Hrag.
2019. "A Startling Choice, Lisa Frank Is Selected for the US Pavilion at the 2021 Venice Biennale." Hyperallergic. April 1, 2019. https://hyperallergic.com/492709/lisa-frank-2021-venice-biennale/.

Wilson, Mark.
2015. "RIP Blingee: Here Are The Best, Worst Blingees of All Time." *Fast Company*. August 19, 2015. https://www.fastcompany.com/3050036/rip-blingee-here-are-the-best-worst-blingees-of-all-time.

Wittkower, D. E.
2012. "On The Origins of The Cute as a Dominant Aesthetic Category in Digital Culture." In *Putting Knowledge to Work and Letting Information Play*, edited by Timothy W. Luke and Jeremy Hunsinger, 167–75. Transdisciplinary Studies 4. SensePublishers. https://doi.org/10.1007/978-94-6091-728-8_13.

Zuckerman, Ethan.
2008. "The Cute Cat Theory Talk at ETech." *Ethan Zuckerman*. March 8, 2008. https://ethanzuckerman.com/2008/03/08/the-cute-cat-theory-talk-at-etech/.

Artworks



xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

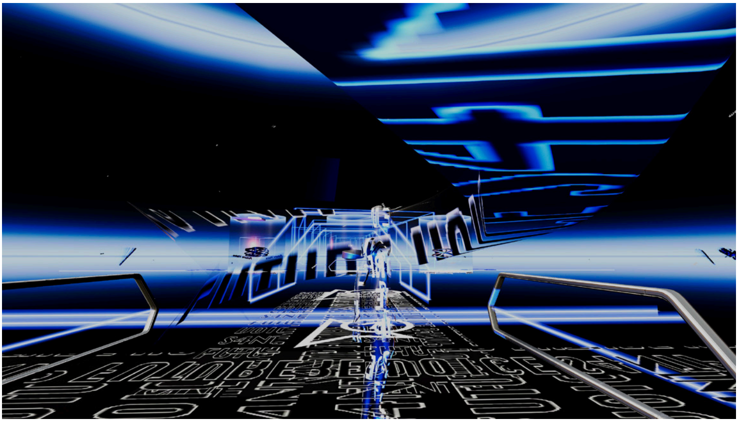
2021.xCoAx.org

Alberto de Campo
adcxyz@pm.me

Hannes Hoelzl
hannes@earweego.net

S4NTP[1]

UdK Berlin & Society for Nontrivial Pursuits, Berlin, Germany



Future Voices / Zukunftsmusik

Keywords: Future, Participative Art, Generative Art, Radio Art, Generative Composition, Long Duration

1. Please see credits section for the S4NTP members list for this project.

Future Voices / Zukunftsmusik invites people from all over the world to give voice to what they expect, hope, fear, plan or propose for the future. Their contributions flow into a generative sound stream composed from these individual "Future Voices"; voices that would otherwise remain unheard within an attention economy that favours loudness, provocation, and conspiracy theories. We, the Society for Non-Trivial Pursuits (S4NTP), believe these voices have constructive things to say, and through our project we try to channel the power of a collective and diverse sonic stream of consciousness.

Future Voices was created and is being continuously expanded by The Society for Non-Trivial Pursuits (S4NTP), a group of students, alumni and teachers of the Class for Generative Arts / Computational Art at Berlin University of the Arts (UdK).

https://2021.xcoax.org/adc/

Description

Future Voices/Zukunftsmusik invites people from all over the world to give voice to what they expect, hope, fear, plan or propose for the future (https://futurevoices.radio).

Background & Idea

When radio was invented, it was imagined as two-way communication; then it quickly became a one-way mass medium that played a central role in 20th century dictators grabbing power. The internet started with high hopes of giving everyone a voice; now it drifts toward hyper-monetization, citizen surveillance, and extremism. These factors are helping a new wave of emerging dictators to grab power by subverting democracies from within. The attention economy embodied in the rating mechanisms of most social media favours loud provocations and conspiracy theories, creating filter bubbles which divide humanity into digital tribes who consider everyone outside their respective bubble an enemy.

A multitude of less spectacular individual voices tends to get lost in this flood. We believe these voices can have constructive things to say about the future and its potentials, and can form a conversation that engages with the current overlap of crises which causes widespread concern about the future.

We, a group of students, teachers and associates of the class Generative Art / Computational Art at UdK Berlin – The Society for Nontrivial Pursuits (S4NTP) – propose to develop a project that invites a diversity of voices to contribute their ideas, expectations, fears, hopes and strategies for the future to a sonic collective stream of consciousness.

Anyone interested is welcome to access the *Future Voices* web page, speak a few sentences in a language of their choice (or make other sonic or musical statements), and upload the recording. After a review (annotation for language and keywords, and necessary filtering for infringements against our code of conduct), these recordings flow into a generative composition that explores the continuum between intelligible multi-lingual spoken text and abstract musical textures, varying in density from single-voice focus to rich polyphony. Over the one-year timespan that the project is running (from 17/01/20201 to 16/01/2022), this database will grow organically. Concurrently, our team keeps adapting and expanding the compositional modules based on the scope, meaning and intention of the contributions, creating a supportive context for them like a rhythm section for a soloist.

In order to value the contributions with responsibility and artistic integrity, the conversation with the contributors continue on a second layer: we make the database of annotated sound files accessible via a web interface, so listeners can look up what they heard, read on, find related statements, links to related resources, and thus engage more deeply with the flow of ideas expressed in the *Zukunftsmusik* stream.

Communication & Engagement

After a round of invitations in our own networks, we hope our commissioning partners will be interested to spread the invitation to contribute to *Future Voices / Zukunftsmusik* through their worldwide channels: the network of advanced art/music festivals that CTM has been co-building over the years, and the DLF's art-radio network that e.g. co-created the *Savvy Funk* program for Documenta 2017. Through these channels, we believe we can reach many people that might be interested in sharing their thoughts and sounds.

As the stream becomes available online and in radio programs, we assume that listeners will begin to contribute as well, supported by appropriate communication by the radio programs, grassroots radio initiatives and any other networks that find the idea of open exchange of future voices worth supporting and spreading. For engaging with communities at an international scale, we have set up a multilingual editorial team that solicits new contributors through local networks and reviews incoming contributions. This way, we can support a global multitude of voices and native languages. The international members of S4NTP already cover many widely spoken languages, and we are inviting more students of UdK and other Berlin universities to join as editors.

The core team of S4NTP is available throughout the year to supervise and evolve the running project; parts of it can also be integrated in course activities of the GenComp class.

Technical Realisation

In the recent summer term at GenComp, we have been exploring a technically similar approach in the ongoing project *Just A Moment of Patience* (JaMoP). It focuses on a single aspect of the current pandemic situation: indeterminate waiting until some unknown condition may be fulfilled. For this project we implemented most of the technical infrastructure required for *Future Voices / Zukunftsmusik* on a high level of usability and reliability.

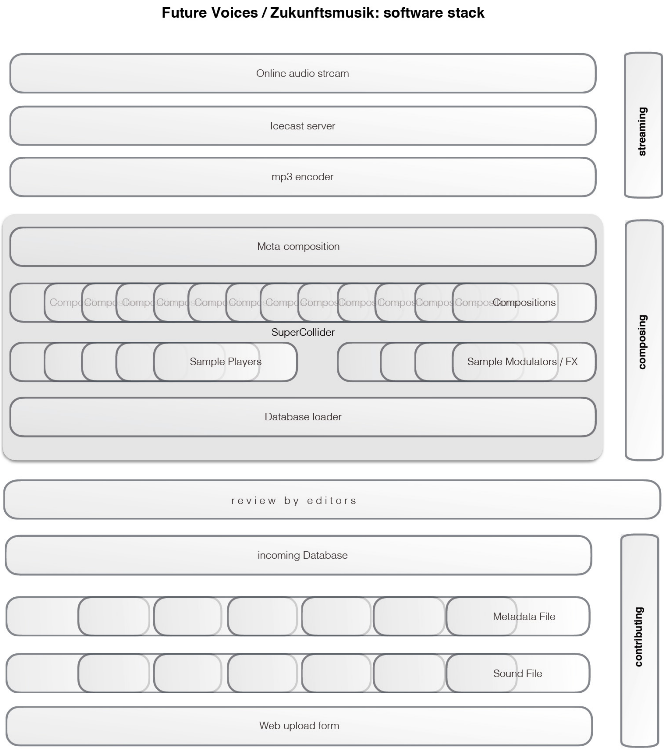


Fig. 1. *Future Voices* Software stack; it implements the whole cycle of Future Voices in technical layers.

A person listens to the stream on the web or on the radio; in the composed stream, she hears statements talking about topics such as schools, ecology, racism, and many others; she might explore the database via its web interface to find the contributions she heard and related ones. Thinking about these, she hopefully decides to contribute her own notions about the future by going to the contribute page; once this new contribution has been approved by a member of the review team that speaks that language, it becomes available to the composition algorithms and will appear in the continuous composition.

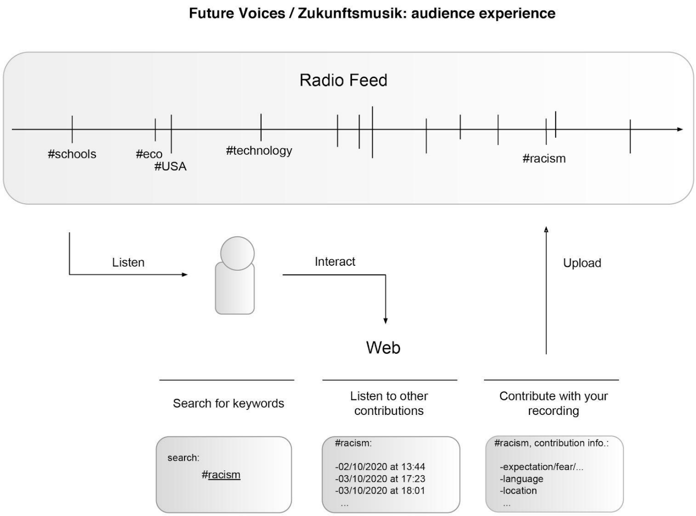


Fig. 2. *Future Voices* audience / participants experience flow diagram; it shows the audience experience the software stack supports.

When designing these access options, we are careful to avoid the common pitfalls of social media (attention economic patterns, filter bubbles, etc); the original wiki concept seems a good reference point: collecting and organising a body of information by calm forms of collaborative interaction. *Zukunftsmusik* is an attempt to come back to the initial promise of radio and the internet: the possibility of democratic, symmetrical, cooperative exchange of ideas without any attention-economic rewards for spectacularity and provocation.

Algorithmic Composition

Our piece is based on a collection of generative composition algorithms and the expectation that the amount of sound files contributed will be growing over time. The algorithms work on different time scales to create the individual episodes that form the generative composition. Some might leave the recordings provided by participants instantly audible and recognizable, while others process them heavily, turning them into abstract musical material. A meta-composition program decides when to activate which algorithms to create the evolving composition. This open structure allows for adding and dynamically including new modules to the process, in co-evolution (or maybe conversation) with the growing number of contributions in the contributions database.

Change and variation are composed at multiple time scales: from single sentences, over sonic textures in the minutes range to modulations in hourly, circadian, and weekly cycles, spiced with special editions for particular days in the year, such as anniversaries of liberation days, Martin Luther King Day, and many others, informed by suggestions from our contributors.

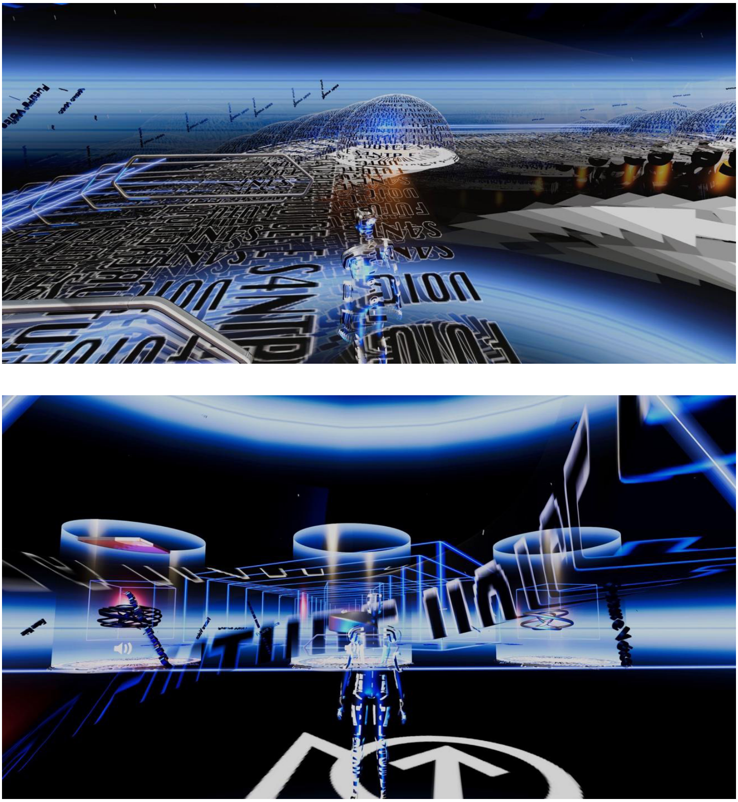


Fig. 3. Screenshots of the VR portal.

Credits & Acknowledgements: *Future Voices* was created and is being continuously expanded by The Society For Non-Trivial Pursuits (S4NTP), which is affiliated to the Class for Generative Arts / Computational Art at Berlin University of the Arts (UdK).

S4NTP members for this project include: Adel Akram Alameddine, Vinzenz Aubry, Valentina Berthelon, Alberto de Campo, Özcan Ertek, Pedro Ferreira, Juan Pablo Gaviria Bedoya, Bruno Gola, Isak Han, Hannes Hoelzl, HyungJoong Kim, Yun Chu Liang, André Martins, Sujay Mukherjee, Sangwon Nam, Carlos Andres Ortega, Cagil Ozdemir, Marcel Schwittlick, Ilija Šorševiç, Lisa Maria Steppacher, MengXuan Sun, Fang Tsai, Hana Yoo, ChunLi Wang, Anne Wellmer, Tsingyun Zhang.

The *Future Voices* Unity Portal at:
https://www.ctm-festival.de/festival-2021/programme/exhibition/ctm-cyberia/future-voices-zukunftsmusik-by-society-for-nontrivial-pursuits-s4ntp
Was created by: MengXuan Sun, Hana Yoo, Marcel Schwittlick

FutureVoices/Zukunftsmusik was commissioned by Deutschlandfunk Kultur / Klangkunst, ORF Kunstradio, and CTM Festival, as the winner of the Kontinuum Call.

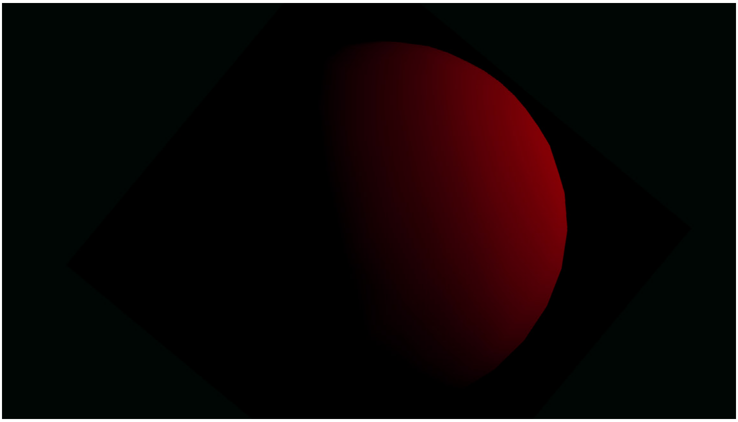
All SuperCollider composition code is available at:
https://github.com/adcxyz/futurevoices/

All website code is available at: https://github.com/futurevoices/FV_web/

A radio piece by Anne Wellmer about Future Voices (in German) is available at:
https://www.deutschlandfunkkultur.de/generative-musik-wie-klingt-die-zukunft-kontinuum.3685.de.html?dram:article_id=488388

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Stephen Roddy
roddyst@tcd.ie
Music & Media Technologies, Dept. of Electronic and Electrical Engineering, Trinity College Dublin, Ireland

The Body in the Machine: Indices Online

Keywords: Online Installation, Sound Art, Machine Learning, Music, Indices on the Body, AMAE, DePinto, Jean-Luc Nancy

This piece is an online audio-visual installation that uses machine-learning techniques to reflect on the interplay of the artist and the artifact in the context of technologically mediated arts collaborations. This project grew in dialogue with another ongoing project titled 58+1/63 *Indices on the Body*. That project is a collaboration between the artistic collective AMAE and the artist Pier Giorgio De Pinto and philosopher Jean-Luc Nancy to which the author has also contributed. Adopting Nancy's view of the body as extended in the work of AMAE/DePinto and the author, the piece asks what happens to the body when we begin to rely heavily on translations across disembodied technologies to mediate our communication and art-making. It reflects on how meaning mutates and transforms as the work is translated across various technologies and media.

https://2021.xcoax.org/sro/

Inspiration and Early Developments

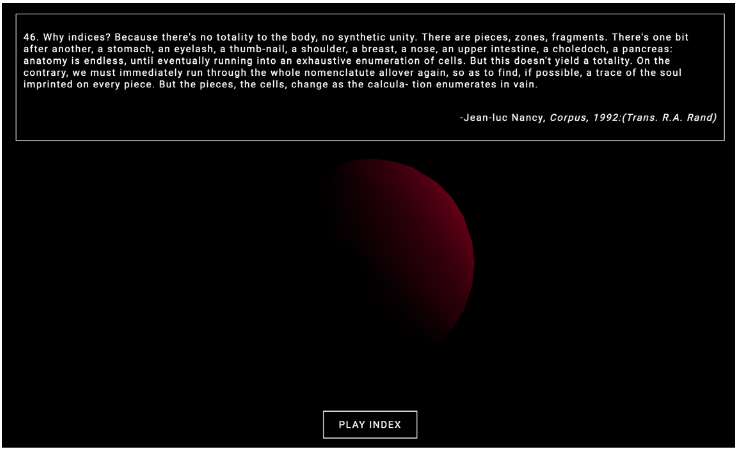


Fig. 1. *The Body in the Machine: Indices Online.*

This project grew in dialogue with another ongoing project titled 58(+1)/63 Indices on the Body. That project is a collaboration between the artistic collective AMAE and the artist Pier Giorgio De Pinto and philosopher Jean-Luc Nancy. This project focuses on Nancy's 58 indices on the body, written in 2006 by Jean-Luc Nancy and presented, alongside 4 additional new compositions, in the 2008 translation (by Richard A. Rand) of his 1992 book *Corpus* (Nancy 1992, Nancy 2008). Throughout this project, Nancy has produced 5 additional indices. The project combines performances, videos, interactive installations and collaborations with a large and varied group of artists.

As part of this project Jean Luc Nancy recorded himself reading his 58 indices on the body, he also wrote an additional index specifically for the project in 2013. The project presented here grew out of a collaboration with AMAE, Pier Giorgio De Pinto and Jean Luc Nancy in which I originally set some of these indices to music in 2015. The result was a piece that we were invited to perform during the *Helicotrema festival* at the Francois Pinault Foundation in Venice, alongside La Biennale events taking place throughout the city (see fig. 2).

This original piece entitled *21,7 & 3* (feat. Jean-Luc Nancy, Amae & DePinto) represented a sonic reflection on the materials presented in indices 21, 7 and 3 of Nancy's *Corpus*. The piece was informed by the content of the indices as translated to English by Richard A. Rand and also by Nancy's own rendering of the indices in his native French. This second rendering of the material is interwoven through the original composition. As a result, the composition can be heard at times to respond to the intonation and rich prosody of Nancy's vocal performance and at other times it operates in references to the translated text.

Later, in 2016/2017, I recorded additional sound works and musical pieces incorporating Nancy's indexes, a portion of which will be set to performances and recorded by video artists as part of the 63 Videos on the *Body* project. Those pieces were released independently in the collection "Le Son Du Corps Et Un Corps de Sons". Each of these pieces was assembled similarly. They each respond to the English translations of the text, but they are guided by the ebb and flow of Nancy's voice as he reads the pieces. The prosody in his voice, the vocal patterns of stress and release convey much new information and modulate the meanings of the words as they were written on the page. The original composition *21, 7 & 3* (feat. Jean-Luc Nancy, Amae & DePinto), was realized as a harmonic piece that had obvious points of reference to Western art music. The 14 new compositions created for this phase of the project were diverse in their texture and instrumentation, as was demanded by the introduction of 15 new indices. They follow where lead by Nancy's vocal performance and Rand's translations to explore sound-worlds with which listeners of electroacoustic music, soundscape composition, glitch and microsound might feel comfortable while wondering back from time to time to the familiar sounds of the Western tradition

Fig. 2. *21, 7 & 3* for Helicotrema 2015. Credit: Pier Giorgio De Pinto.

The pieces composed for this project were originally interesting to me for their translations across domains. Nancy distills bodily experience into language in Corpus. Then at the end of the book he presents some core ideas further transformed into small little packages of meaning he calls indices. When AMAE & DePinto started their work with Nancy they originally re-interpreted and re-presented that work through the medium of performance art. They then involved Nancy in another translation of the work when he performed and recorded his indices. My contributions contained yet another layer of translation as I engaged with Rand's translations of Nancy's work alongside Nancy's performances. I then re-presented that performance in a series of musical and sonic contexts. In these works I had hoped to reveal the soundworlds suggested by the interplay of these layers of translation, and find within them something which still held its link back to the bodily experience which was Nancy's original subject matter. As the work progressed, I found that the process of translation through technology provided that link as at each step the work was filtered through human bodies but also through technology. Nancy's original exposition and later recording of the indices are of course technologically mediated. In 2013 AMAE/DePinto performed 58 (+1) indices on the body, Index *N.17_Proximity* and *Distance* at the *Spuren 2.0 symposium* at E-WERK in Freiburg. This multimedia performance drew from Index 17 and integrated the body with technology in contemporary performance involving both live performers and digitally manipulated video projection. In 2014 AMAE, DePinto & Nancy performed *Indices 60_61*. A Living Archive at the *INACT Festival* in Strasbourg. This another multimedia performance in which the first performer's body had been tattooed with the numbers of the 58 original indexes and 2 new indexes created for the project. The piece involved an augmented reality (AR) implementation for mobile tablet devices. The system recognized each tattoo and presented the corresponding text of the index mapped to the tattoo's location on-screen. A second performer used the AR implementation to scan the performer's tattoos allowing the author to read his own writing from the tablet. A feed from the tablet was also projected live to a screen allowing the audiences to experience the AR performance from the perspective of the author and second performer. You can see a recording of the piece in figure 3.

Building on this theme of the index as mediated through the body and technology, I began to work on an installation that would re-present the musical pieces I had created and translate them through a critical engagement with technology. In 2019/2020 I began work on an installation to be delivered via a web application. Early iterations of this work were installed at the 2020 edition of NIME: The International Conference on New Interfaces for Musical Expression[1] and

1. NIME 2020: The International Conference on New Interfaces for Musical Expression 2020

the 2019 edition of the Irish Sound Science and Technology Event at the Cork School of Music[2] and built conceptually around the representation of physical sound waves as amplitude values over time as demonstrated in figure 4. The current installation is a further iteration on those earlier works. This iteration collects together and iterates upon my sonic/musical work for the project to date introducing rudimentary 3D primitives and exploring AI/ML techniques. The audience is invited to listen to the pieces, experience their visual expression and reflect on the indices, which have been translated into English from Nancy's native French by Richard A. Rand for the English translation of Nancy's *Corpus for the Perspectives in Continental Philosophy Series*.

2. Irish Sound Science and Technology Event at the Cork School of Music: https://drive.google.com/file/d/1W_np9Jb-QEeny_Hd4wzR12Zvv-CdpXFr/view

Implementation

The current installation is a further iteration on those 2 previous installations. This iteration collects together and iterates upon all of my sonic/musical work for the project to date. The audience is invited to listen to the pieces, and reflect on the indices, which have been translated into English from Nancy's native French by Richard A. Rand for the English translation of Nancy's *Corpus for the Perspectives in Continental Philosophy Series*. It then introduces a new element a machine learning model for sentiment analysis. Sentiment analysis is an emotional AI approach that applies NLP (natural language processing) techniques to systematically quantify affective states as represented in written or spoken text.

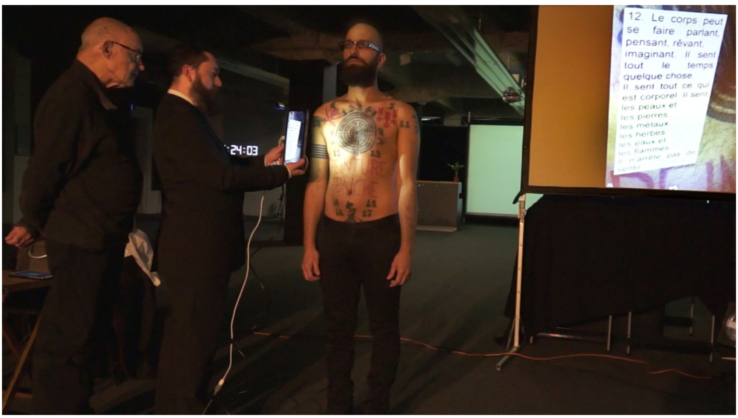


Fig. 3. *Indices 60_61*. A Living Archive (https://vimeo.com/102234129). Credit: Pier Giorgio De Pinto.

3. https://www.javascript.com/
4. https://p5js.org/
5. https://ml5js.org/
6. https://www.tensorflow.org/js
7. https://learn.ml5js.org/#/reference/sentiment

This installation, being web-based and written in Javascript[3] with the p5.js[4] library, uses a machine learning model for in-browser sentiment analysis implemented in ml5.js[5]: an open-source, friendly high-level interface to TensorFlow.js[6] that brings machine learning and deep learning functionality to the web. The reference[7] files describe the model as follows:

> Sentiment is a model trained to predict the sentiment of any given text. The default model, currently 'moviereviews', is trained using IMDB reviews that have been truncated to a maximum of 200 words, only the 20000 most used words in the reviews are used. (ml5.js 2021)

8. https://p5js.org/reference/#/p5.FFT

The sentiment model is used to analyze Rand's translation of Nancy's indices. These translations are presented on screen alongside the soundworks composed around Nancy's reading of the given index. In the center of the screen underneath the translated indices is a sphere rendered on a WebGL canvas object via p5.js. It is illuminated by a colored light source. Sentiment returns a value on a scale of 0 (negative) to 1 (positive). A sentiment score below .4 (neutral) will result in a light with red/purple color space and rightwards rotation while a sentiment score above .4 will result in a light with blue/green color space and leftward rotation. The audio, both Nancy's speech and the music, is analyzed for frequency content (using the p5.js FFT implementation)[8] and the frequencies present determine the color space for the light is traversed as well as its overall intensity. Thematically, the abstract 3D primitive, the spherical body, provides a surrogate for the physical body, the experience of which is illuminated by the light, the color and intensity of which are themselves determined and controlled by both Nancy's spoken indices and the accompanying soundworld composed around them.

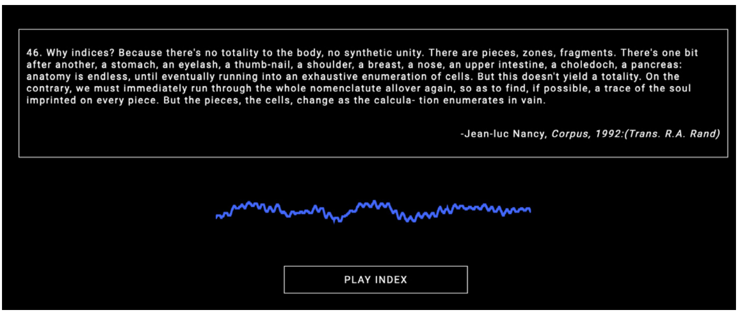


Fig. 4. Early Iteration of the piece.

Reflection

The piece is a reflection on translations through language, speech, vocalization, performance, music and technologies. The original indices were written in French. Jean-Luc Nancy's reading of them reveals a new layer of meaning through his use of prosody and intonation. We are presented with English translations of the text that must, to some degree, reflect the choices and interpretations of the translator Rand. The sentiment analysis introduces an additional layer of meaning/distortion. It is in essence, having been trained only on a corpus of Hollywood movie reviews, rating the sentiment of the translated indices as though they were Hollywood movie reviews. It does not always represent the translated text very well and rarely represents the information conveyed in Nancy's vocalizations in the original French. The colorspaces chosen to reflect the sentiment values introduce further culturally conditioned ideas about sentiment and emotion.

The use of sonic and musical materials to frame the texts brings yet another layer of distortion. The soundworlds evoked do not always match the content of the indices, sometimes they are built around the ebb and flow of Nancy's vocalizations as he reads. Sometimes around Rand's translation, and a number bare only tenuous relation to these materials.

Rarely are the original text, the spoken words, the translation, the sound, and sentiment analysis in harmony with one another.

Further, the translation of sound to light, the use of that light to reveal the 3D sphere, and the further mapping of sentiment to determine the direction in which the sphere rotates introduce further mutations of meaning. It is both Nancy's spoken words, and the soundworks they are set within here, which determine the color and intensity of the light. This light in turn reveals the dimensions and behavior of the sphere, which would otherwise remain cloaked in darkness. But while the light simply reveals the sphere, the sentiment score itself, according to the ml5 sentiment implementation, determines how that sphere behaves. In this way Nancy's words don't just illuminate the abstract body, but exposing the body to an interpretation of Nancy's text as translated by Rand and mediated by the sentiment model, directly affects how the body behaves.

However, the choice of a sphere as a surrogate for the complex human body, and our experiences of and through, it is a dramatic oversimplification. Reductionist tendencies of this nature are not uncommon in technical and scientific fields and in this installation, it allows for reflection on the vast difference between technologically mediated representations of the human body and the thing itself.

There is also a random factor at play here in the use of light. The sphere is lit from a light source that initially emanates from behind the sphere on the Z-axis to the right on the X. The focal point of the light shifts across the face of the sphere. The light source holds its Z-axis position but moves along the X and Y-axes as per an implementation of a simple "Random Walk" algorithm. This involves a simple step-wise movement across our WebGL canvas space where, at each timepoint, the direction of the step is random. This limited degree of randomness helps to counterbalance some of the more direct and deterministic mappings involved in the piece, representing those aspects of the body that we cannot predict or control.

There is a complex network of translations and interactions here between the original text, the English translation, the authors recorded indices, the compositions, the sentiment model, the virtual light and the spherical body. This multifaceted and sometimes discordant configuration however is in perfect harmony with Nancy's vision of the human body as expressed in his indices. As Nancy comments in Index 46:

> Why indices? Because there's no totality to the body, no synthetic unity. There are pieces, zones, fragments. There's one bit after another, a stomach, an eyelash, a thumbnail, a shoulder, a breast, a nose, an upper intestine, a choledoch, a pancreas: anatomy is endless, until eventually running into an exhaustive enumeration of cells. But this doesn't yield a totality... (Nancy 2008)

Acknowledgments. I'd like to acknowledge AMAE, Pier Giorgio De Pinto and Jean-Luc Nancy for instigating the wider project from which the work presented here has drawn and for involving my compositions in the project *58(+1)/63 Indices on the Body*. AMAE/DePinto also provided invaluable feedback on this paper.

Available at: https://stephenroddy.github.io/Indices-Online-xCoAx/

References

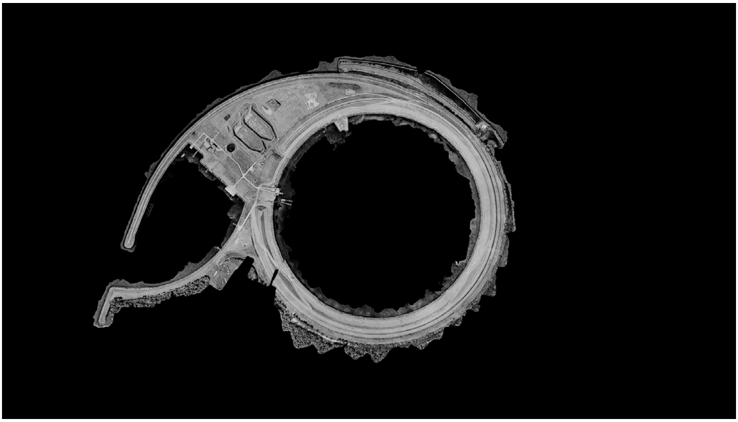
Nancy, Jean-Luc.
1992. *Corpus*. Paris: Éditions Métailié.

Nancy, Jean-Luc.
2008. *Corpus*. Translated by Richard A. Rand. New York: Fordham University Press.

Ml5js.org.
2021. ml5js·Friendly Machine Learning for the Web. [online] Available at: https://ml5js.org/reference/api-Sentiment/ [Accessed 22 April 2021].

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Tivon Rice
tivon@uw.edu
University of Washington, Department of Digital Art and Experimental Media, Seattle, USA

Models for Environmental Literacy

Keywords: Artificial Intelligence, Machine Learning, Photogrammetry, Digital Storytelling, Eco-Science, Eco-Philosophy, Eco-Fiction

***Models for Environmental Literacy* is a series of digital animations and A.I. generated narratives that creatively and critically explore the challenges of describing a landscape, an ecosystem, or the specter of environmental collapse through human language. The project further explores how language and vision are impacted by the mediating agency of new technologies. How do we see, feel, imagine, and talk about the environment in this post-digital era, when there are indeed non-human/machine agents similarly trained to perceive "natural" spaces? This project explores these questions, as well as emerging relationships with drone/computer vision and A.I..**

Description

In the face of climate change, large-scale computer-controlled systems are being deployed to understand terrestrial systems. Artificial intelligence is used on a planetary scale to detect, analyze and manage landscapes. In the West, there is a great belief in 'intelligent' technology as a lifesaver. However, practice shows that the dominant AI systems lack the fundamental insights to act in an inclusive manner towards the complexity of ecological, social, and environmental issues. This, while the imaginative and artistic possibilities for the creation of non-human perspectives are often overlooked.

With the long-term research project and experimental films *Models for Environmental Literacy*, the artist Tivon Rice explores in a speculative manner how A.I.s could have alternative perceptions of an environment. Three distinct A.I.s were trained for the screenplay: the SCIENTIST, the PHILOSOPHER, and the AUTHOR. The A.I.s each have their own personalities and are trained in literary work – from science fiction and eco-philosophy, to current intergovernmental reports on climate change. Rice brings them together for a series of conversations while they inhabit scenes from scanned natural environments. These virtual landscapes have been captured on several field trips that Rice undertook with FIBER (Amsterdam) and Bio Art Society (Helsinki) over the past two years. *Models for Environmental Literacy* invites the viewer to rethink the nature and application of artificial intelligence in the context of the environment.

Chapter One: *Whisper Poems*

The Baltic Sea – Finland
Duration 13’5’’

Whisper Poems maps the small islands surrounding Helsinki, which are rising twice as fast as the surrounding waters of the Baltic Sea. This is part of a 10,000 year process of post-glacial rebound, so instead of reflecting an uncanny image of human intervention, they present a more paradoxical image of a system operating in geo-historic rather than human timeframes.

Fig. 1. *Models for Environmental Literacy*, 2020. 4K Video, Computer Generated Text, duration: 36’40”. Link to complete documentation: https://tivonrice.com/models.html

Chapter Two: *Circular Conversations*

The IJsseloog – Netherlands
Duration 10’05’’

Circular Conversations maps the Ijsseloog, arguably the strangest visual landscape in the Netherlands – a perfectly circular island, 1 kilometer across, built for the deep storage of industrial toxic sediment. After first seeing this circle on satellite images, then during subsequent field trips to drone-photograph the site, I couldn’t help imagining it as a kind of monumental frame upon, or a portal into the past, present, and future of the local environment. In some ways, the IJsseloog is a kind of punctuation mark (like a period or a comma) in the story of the Zuiderzee Works, the land reclamation project that shaped the Netherland’s northern coastline.

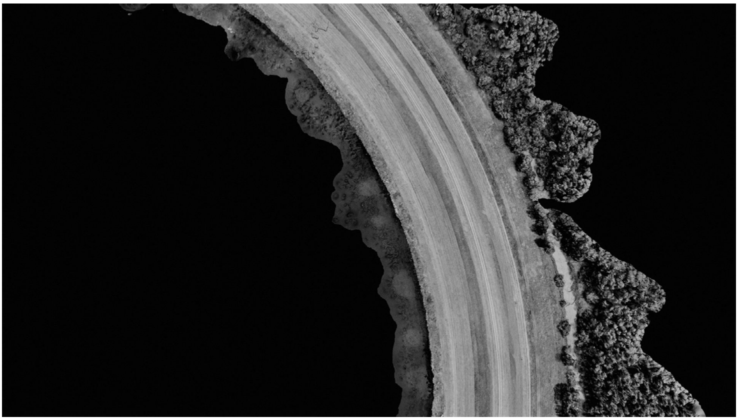


Fig. 2. *Models for Environmental Literacy*, 2020. Video still, Chapter 2.

Chapter Three: *Echo Chambers*

The Volkerak – Netherlands
Duration 13’13’’

Echo Chambers focuses on the southwest of the Netherlands, where the Delta Works creates a different kind of engineered environment. During FIBER’s *Cartographies of the Vanishing Now* workshop, we traveled to the Volkerak to observe the algae blooms lining the shores, and to discuss the complex cultural, hydrological, and agricultural histories that have deeply impacted that ecosystem.

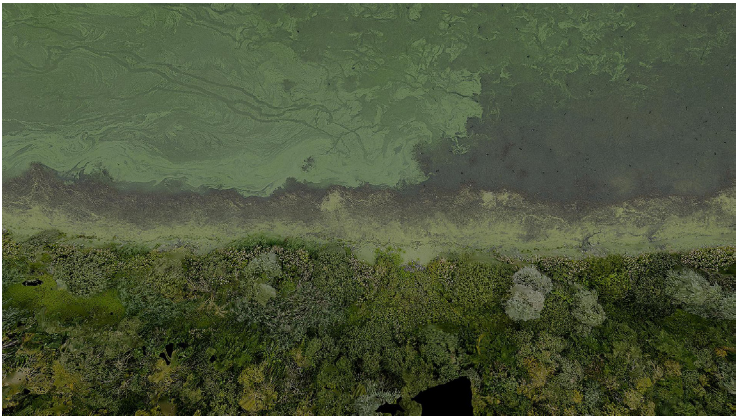
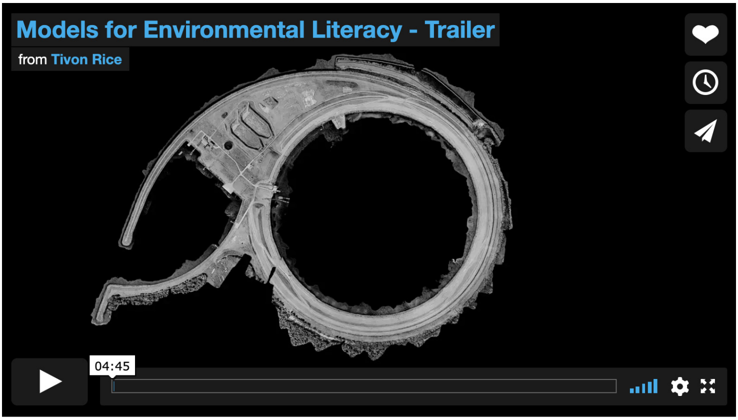


Fig. 3. *Models for Environmental Literacy*, 2020. Video still, Chapter 3.

Fig. 4. *Models for Environmental Literacy*, 2020. Link to Trailer: https://vimeo.com/459776036



Acknowledgements. This work was commissioned by FIBER for the 2020 festival and has been made possible with support from the Creative Industry Fund NL, Stroom Den Haag, Google Artists and Machine Intelligence, BioArt Society, and The University of Washington Center for Digital Art and Experimental Media.

Sound by Stelios Manousakis (NL/GR) & Stephanie Pan (NL/US), with voices by Esther Mugambi (AU/NL), Arnout Lems (NL), & Michaela Riener (AT/NL)

Complete Documentation: https://tivonrice.com/models.html

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Tiago Martins
tiagofm@dei.uc.pt

Mariana Seiça
marianac@dei.uc.pt

Pedro Martins
tiagofm@dei.uc.pt

University of Coimbra, Centre for Informatics and Systems of the University of Coimbra, Department of Informatics Engineering

Planar: Discovering City Soundscapes

Keywords: Geographic Map, Media Art Installation, Sonic Archive, Soundscape, Swarm Intelligence.

What characterises the sound identity of a city? What defines its most iconic soundscapes? How can these soundscapes be mixed, intertwined and played into creating a living, dynamic portrait of a city? *Planar* is a multimodal portrait of the Portuguese city of Coimbra, interpreted through an audiovisual installation for the visitors to uncover and experience a new perspective of this city. The audiovisual composition emerges through an aerial view, with an abstract representation of its streets and paths in an evolving representation of the standard city map. Insect-like beings serve as intelligent, living paintbrushes who uncover those monochromatic streets, alongside the blue river that runs across the city. Bird-like beings wander above these streets, travelling together in a swarm that randomly weaves its journey through the map. Their passage unveils the city' sounding places, becoming narrators of sonic fragments in an ephemeral composition that depicts the main soundscapes of Coimbra.

https://2021.xcoax.org/tma/

Description

Planar is an audiovisual installation that unveils the sounds of the Portuguese city of Coimbra through floating beings that randomly move over the city and listen to nearby sounds. The audience follows this journey from an aerial perspective, visualising these beings floating over a dynamic illustration of the city.

Planar emerged as a proposal for the participation in the fourth edition of *Dar a Ouvir. Paisagens Sonoras da Cidade (Give to Hear. City Soundscapes)*, an annual event that seeks to raise awareness of the act of listening as a possibility for discovery and knowledge by exploring sound as a creative medium. From July 11th to September 6th of 2020, artworks and performances from a multitude of artists were available to the public, fostering an auditory perspective of the city that reflects the role of sound in everyday life. This year, we proposed *Planar* (see Fig. 1) as a form of revisiting the city through an audiovisual portrait, based on a living representation of its streets, that confronts and rediscovers its most iconic soundscapes.

The installation comprises two main dimensions: the visual and the auditory. The visual system, implemented in Java with the open-source library Processing, implements swarm algorithms to simulate thousands of moving beings responsible for creating an abstract ever-changing painting of the city of Coimbra. The city paths are drawn by beings whose behaviour and movement follows the contrast between the white, vivid streets and the black, neutral background. As such, their movements naturally follow the defined streets and main areas, leaving a representative trail of their journey that draws a painting of the city. The life of these beings has its beginning and its ending in real-time during the installation, in a cyclic process of renewal where new beings gradually emerge to maintain the portrait alive. Besides the white-focused agents, the system also creates beings who draw the river area of the city in a bluish tone, creating a visual contrast in the representation that highlights this natural element that crosses the entire city (see Fig. 2). All these beings create a unique but recognisable painting of the city of Coimbra that emerges from their simulation. On top of the map painting, there is a flock of white beings flying with random direction, encountering the different soundscapes of the city. Each soundscape is visually represented with a yellow dot, placed in the respective coordinates where the sound was recorded, and are drawn with a blinking motion that mimics the city's lights (see Fig. 3).

Fig. 1. *Planar* (2020), audio-visual installation at Convento de São Francisco, Coimbra, Portugal.

For the audio element, implemented using the visual programming Max language, we created a dynamic composition that dwells on 61 soundscapes, which punctually rise and fall in a subtly ever-changing, flowing mixture. This dynamism is in constant dialogue with the visual element, portraying the uncovering journey of the flying beings. Technically, this dialogue takes place using the OSC (Open Sound Control) protocol for Processing to communicate with Max. A 10-file dynamic queue is the central driving force for the composition, responsible for loading and playing the sounds tagged by Processing, which sends two values for each sound: its index and distance to the swarm. This distance is sonically translated into two audio elements that define how each soundscape is played: loudness, that raises with the nearest sounds; and a delay effect, which becomes more pronounced with the farthest sounds. The queue is dynamically updated during the installation, with each visited soundscape echoing across the room while gradually fading, and impending sounds emerging with the swarm's journey that reveal the sonic city. The auditory composition is then a living mixture, weaved from a series of soundscape recordings of Coimbra's historical centre made by the sound artist Luís Antero, as well as recorded soundscapes by Aglaíze Damasceno, Mariana Seiça and Pedro Martins.

The physical installation of Planar was displayed in one of the rooms of the Convento de São Francisco, the most recent and major cultural centre of Coimbra. The installation was composed of four main speakers, arranged in a quadraphonic set, two projectors in two opposing walls, and a single, hidden computer to run the software structure. Continuously portraying the endless swarm journey over Coimbra's map, the installation invited its visitors to enter, observe and embrace their flight and sonic discovery in a dark environment, with the projectors providing the only source of light. Due to Covid-19 pandemic, the initially planned chairs for the visitors to quietly and more comfortably experience the installation were not included in the room. A video recording of the installation, portraying an audiovisual segment of the piece, can be found online,[1] as well as further information about the piece.[2]

1. https://cdv.dei.uc.pt/2021/planar.mp4

2. https://cdv.dei.uc.pt/planar/

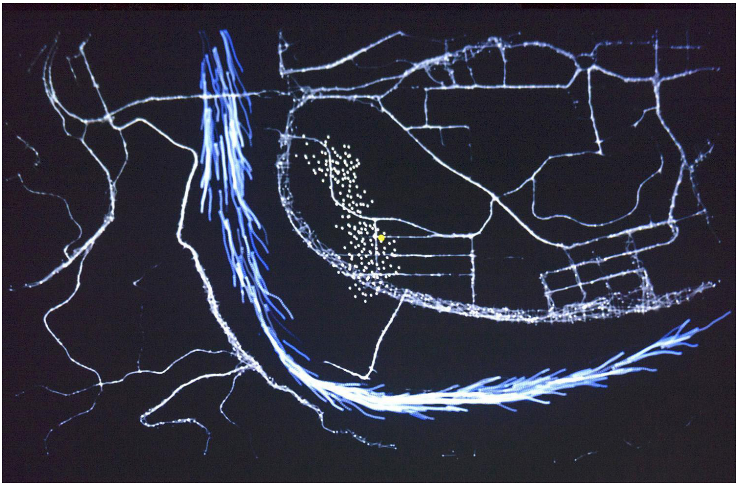


Fig. 1. *Planar* (2020), audio-visual installation at Convento de São Francisco, Coimbra, Portugal.

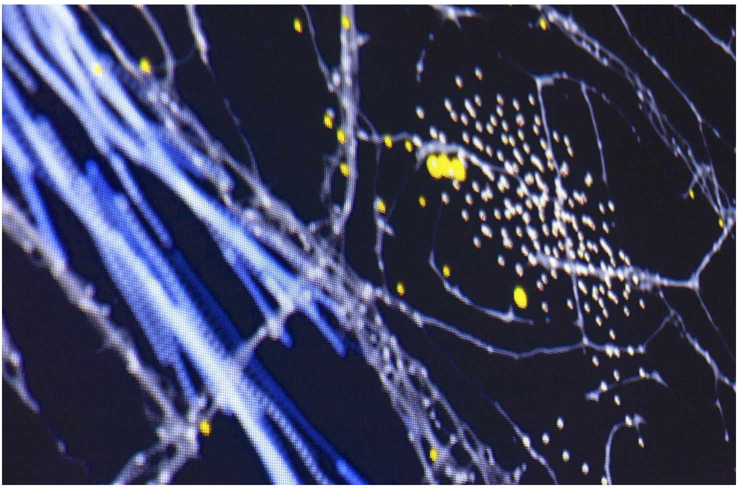


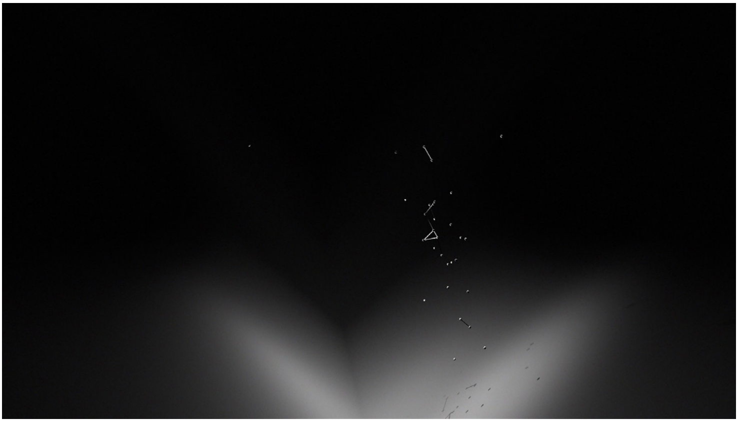
Fig. 2. *Planar* (2020), audio-visual installation at Convento de São Francisco, Coimbra, Portugal.

Although it is not a piece that directly feeds of real-time interaction with the ones who experience it, this artwork stands on a foundational flexibility that embraces multiple sound archives. The flying beings are adjustable to any environment, where different sound inputs can be chosen to be unveiled. This prevailing flexibility is a central characteristic of Planar, which we can even argue to be a universal sound-seeking system, explorer of not only a sonorous Coimbra, but also the sonic identity of every place with archived soundscapes. This capacity then expands to a full, scalable system, as the adaptability of its dimensions invites a multitude of audiovisual experimentations: the auditory mixture built over a dynamic structure, which embraces any intended sound for the flying beings to unravel, and the visual portrait, with its painting agents following whatever focus we define to draw a living portrait of a place. The system stands on its own, running isolated on a hidden machine with no listeners, or staged in a complex installation where these beings' journey comes to light, inviting its passing visitors to discover and reflect upon a city's sonic identity.

Acknowledgements. The authors would like to thank Convento São Francisco / Câmara Municipal de Coimbra, Jazz ao Centro Clube, Centre for Informatics and Systems of University of Coimbra, and the Department of Informatics Engineering of the University of Coimbra. This work is funded by national funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project CISUC - UID/CEC/00326/2020 and by European Social Fund, through the Regional Operational Program Centro 2020. The second author is also funded by the FCT - Foundation for Science and Technology, under the grant SFRH/BD/138285/2018.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Tasos Asonitis
tasos_a@hotmail.com
University of Manchester, UK

Latent Spaces

Keywords: Visualization, Sonification, Data, Aesthetics, Algorithm, Process, Object, Clustering

For a long time, artists have attempted to capture data relationships from the world that surrounds us and place them in aesthetic discourse. *Latent Spaces* is an audiovisual piece that converges with this significant body of work as much as it diverts from it. Instead of using data in a way to reflect the physical world, it deals with data as an autonomous observable object. In this context, the question "what does data represent" becomes irrelevant. The focus is shifted to the hidden spaces data can exhibit. Seeking to explore these spaces, the work uses visualization and sonification techniques of algorithmic processes. It hopes to discuss aesthetics not in terms of data sources but in terms of data dynamics.

https://2021.xcoax.org/tas/

Description

The original space that describes data is often multi-dimensional, and therefore visually inaccessible to humans. A hidden (latent) space results when this multi-dimensionality is compressed in two or three observable dimensions. The unfolding of this process creates interesting aesthetic implications which are explored in *Latent Spaces* through the intertwinement of computer graphics and sound.

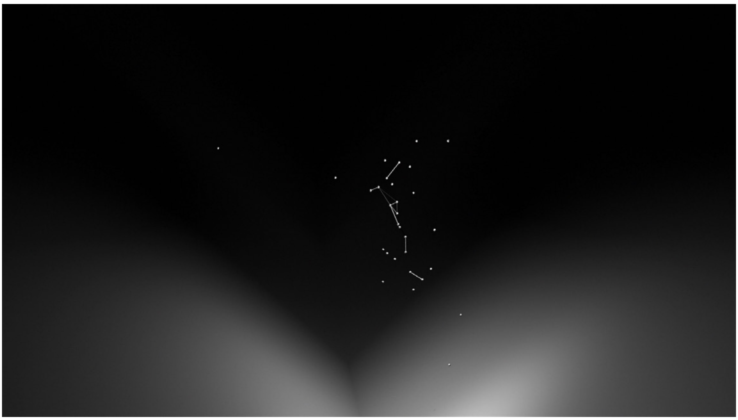
The piece demonstrates four different datasets undergoing dimensionality reduction through t-SNE, a popular algorithm used for this purpose. By using t-SNE, the multi-dimensional space of each dataset is compressed to three dimensions while maintaining its inner structure (Van der Maaten and Hinton 2008, 2579). This gives us the opportunity to observe the relationships among datapoints through the way they organize in space; similar datapoints are clustered together, while dissimilar ones are pushed further apart. This dynamic process forms the narrative for each of the four parts/studies that comprise *Latent Spaces*. The resulting point trajectories are sonified using parameter mapping sonification and freely composed material (Grond and Berger 2011, 363-365). In studies 1 and 3, sonification forms the main body of the sonic aspect, while in study 2 sound was composed and arranged freely, always in accordance with the visual action. In study 4 a combination of the two approaches was followed. The sonification was realized by treating the changing point positions and velocities as control signals driving various parameters in sound generating algorithms, from simple additive, subtractive and FM synths to granular samplers.

Each study employs a dataset of different size which in turn affects the magnitude of the space dealt with in the study. The studies/spaces are ordered by size. As we progress through them, attention is shifted from inner details and microactivity to larger forms and gestures. The goal of the piece is to remove the associative examination of data and pose the question of whether data relationships can be treated as an object with its own aesthetic qualities. For this reason, the sounds used for the realization of the work were mostly synthetic, with a few exceptions which were heavily transformed to prevent obvious real-world connections (Merino 2019, 15). Similarly, the visual part is focusing on the space emerging from the organization of datapoints, hence the lack of surrounding objects. Connecting lines among points are used for two reasons: to group together the points which present similarities and to create solid gestalts out of sparsely organized points (Droljc 2018, 21-22). The hidden spaces of data are presented independently of their sources, and the only information provided is the size of the dataset and the number of different classes (clusters) within it. Below is a short description for each of the studies in the piece.

Study 1: Connectedness

The first study deals with a small dataset. We observe how t-SNE is rearranging the point positions attempting to cluster them together according to their degree of similarity. During this process, connections among neighbouring (ergo similar) points are formed. The connections grow in number and intensity as the algorithm is recognizing the structure of the data more and more. A dipole is formed, with clearly separated elements on one side, and sparse textures on the other. From individual points and connections, a unified object gradually emerges.

Fig. 1. Snapshot from *Connectedness*.



Study 2: Coalescence

The points and their respective connections increase. They cannot exist as autonomous events anymore, forming instead an unstable whole that comes together and falls apart in a struggle for coherence. Individual points seem to play an important role still, however there are moments where they seem to vanish as a single homogenous unit prevails. As the connections stabilize, what was before a floating sonic texture now becomes a quasi-solid rhythm. From an amorphous cloud of points, structure and clear relationships are established. The algorithmic process is examined under the light of another dipole: noise against structure.

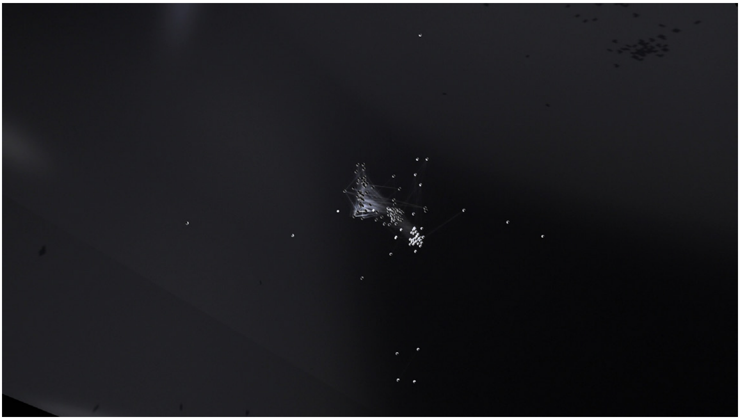


Fig. 2. Snapshot from *Coalescence*.

Study 3: Ecosystematicity

Two executions of the algorithm are juxtaposed. Operating in different timelines and placed against each other in an almost conversational manner, each of the instances is being treated as a malleable material that stretches, twists and bends while it reaches for equilibrium. The result appears once more unstable. Is each instance simply the sum of its parts, or does it extend beyond, as a self-contained entity? Does the co-existence of the two imply an ecosystem? This time, the algorithmic process is seen as dialogue. On a higher level, this dialogue takes place between two similar processes running side by side, exchanging textures and gestures. On a lower level, the dialogue becomes an inner mechanism of each entity, resulting in transition between activity and stasis.

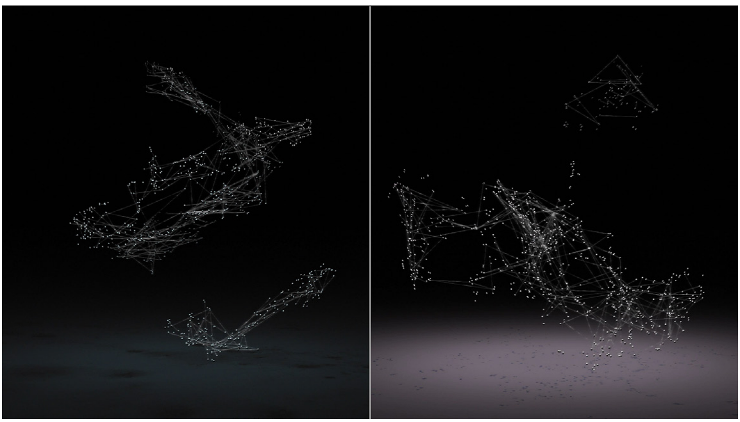


Fig. 3. Snapshot from *Ecosystematicity*.

Study 4: Entirety

In *Entirety*, only vestiges of microactivity can be witnessed. The study deals with the biggest dataset in the piece and brings forth the qualities of a large object that unfurls and reshapes until it reaches its definitive form. Once it does, clearly formulated clusters can be distinguished. Unlike the previous studies where a spatial reference was provided (for example the rectangular container in *Coalescence* or the ground in *Ecosystematicity*), in Entirety, space is the unbounded void. During the ending section, a distant and a close-up shot co-appear in split screen. The contrast between macrocosmic form and microcosmic detail, supported not just visually but sonically as well, serves as a conclusion for the entire piece. What started out as the product of individual relationships among (data)points, gradually agglomerated to gestalts that defy reduction to their constituents (Harman 2011, 8-10).

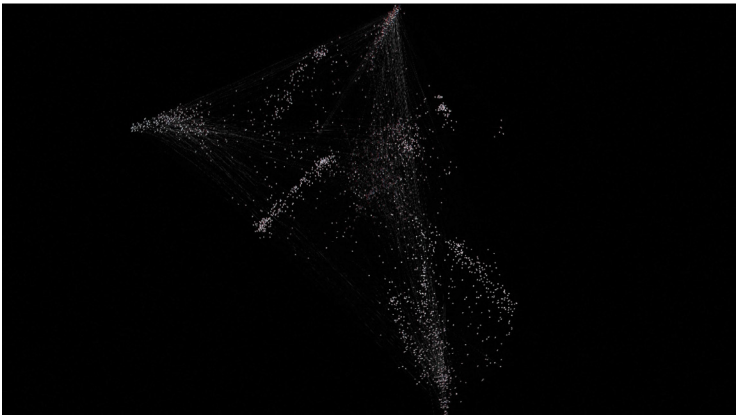


Fig. 4. Snapshot from *Entirety*.

Acknowledgements. This work was supported by the Engineering and Physical Sciences Research Council [grant number 2492452].

References

Droljc, Tadej.
2018. “Composing with Isomorphic Audiovisual Gestalts”. PhD diss., University of Huddersfield.

Grond, Florian, and Johnathan Berger.
2011. “Parameter Mapping Sonification”. In *The Sonification Handbook*, edited by Thomas Hermann, Andy Hunt and John G. Neuhoff, 363-398. Berlin, Germany: Logos Publishing House.

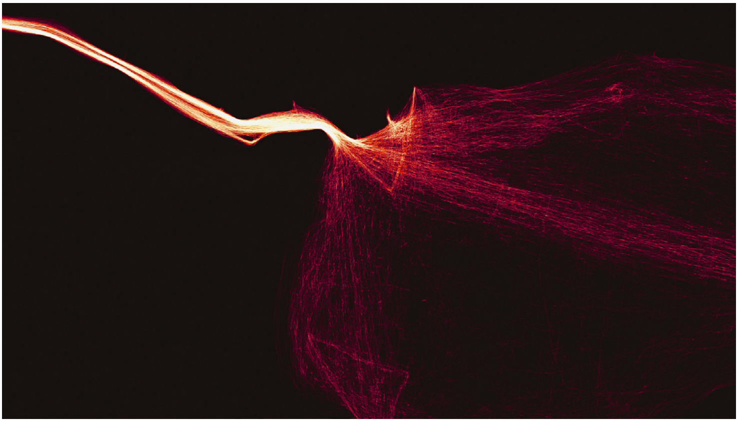
Harman, Graham.
2011. *The Quadruple Object*. UK: Zero Books.

Merino, Elías. 2019.
“Thingness: Compositional Strategies for Emerging Virtual Sonic Objects”. PhD diss., University of Huddersfield.

Van der Maaten, Laurens J.P. and Hinton, Geoffrey E.
2008. “Visualizing High-Dimensional Data Using t-SNE”. *Journal of Machine Learning Research*, no. 9(November): 2579-2605.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Fabian Weiss
info@fabianweiss.com
University of Applied Arts
Vienna, Vienna, Austria

In the Heat of the Day

Keywords: Body, Algorithm, AI, Digital Bodies, Tracking, Wearables

Algorithms are more and more structuring our world and they are at the forefront of shaping our current and future bodies. We are increasingly intertwined with algorithmic calculative devices as we consume information, inhabit space and relate to the world around us. Calculative devices transform the nature of human subjectivity, pushing at the limits of what can be read, analyzed and thought about, and with new forms of data aggregation come also more advanced forms of profiling human behavior. While a lot of the developments around algorithms are meant to be beneficial for our wellbeing, AI may lead to new forms of manipulation and surveillance, not necessarily in the form of authoritarian politics but in a more hidden and highly effective way: by changing the economy in a way that turns us all into smartphone cattle milked for our data.

https://2021.xcoax.org/fwe/

Description

The human body is a product of society in the sense that our handling, our knowledge, our feeling, and our notions of the body are defined by societal structures, values, technologies, and systems of ideas. On the other hand, the human body is a producer of society because our social organization is essentially affected by the physicality of acting individuals and the human body contributes to social production as people labor. Bodily (inter-)actions play a crucial role in the construction of social reality and the visual expression of an optimized body has, throughout history, been of interest to human societies. The topic of body politics has become ever-present – especially since the last decades of heightened individualization. Arthur Kroker (2012) asserts that we are "drifting through many different specular performances of the body" (Kroker 2012, 2) and in our current society, we occupy a multiplicity of bodies: imaginary, sexualized, disciplined, gendered, laboring, and technologically augmented.

Today, we are living in a decisive time, where technology, medical science, and interconnected knowledge disrupts our handling of the body and allows us to modify our bodies in dimensions never known before in order to push the 'human' to unchartered territories. Bodies are rendered as carefully cultivated images, drawn into conversational practice and discursive interaction. Algorithms are more and more structuring our world and they are on the forefront of shaping and enhancing our current and future bodies. We are increasingly intertwined with algorithmic calculative devices as we consume information, inhabit space and relate to others and to the world around us. Louise Amoore and Volha Piotukh sum up this current state of intertwined connection: "Just as being human may also be closely enmeshed with being algorithmic, these calculative devices also alter perception, filtering what one can see of big data landscapes, how one makes sense of what can be perceived" (Amoore & Piotukh 2015, 24).

Through our use of digital technologies and gadgets we expose massive chunks of data about ourselves and our surroundings, revealing details of our movements, activities, and behaviors. Calculative devices transform the nature of human subjectivity, pushing at the limits of what can be read, analyzed and thought about (Amoore & Piotukh 2015, 37) and with new forms of data aggregation come also more advanced forms of profiling human behavior, fueling the emergence of often poorly regulated business models and new forms of governmental and commercial dataveillance. Tracking regimes that we once have thought bizarre are becoming normal (Wolf 2010), challenging us to re-evaluate what normal means. By various means of seduction, coercion, lies, and co-optation, "everyday life has been irresistibly colonized by forces collectively known as Big Data" (Horning 2015). Corporations and state agencies use communications networks and digital surveillance to collect huge quantities of information on the activities of all individuals using their services in hopes of predicting their next moves.

From this data, digital profiles – digital bodies – are being created and they shape the treatment or response that individuals receive from state and non-state actors (Tactical Tech, 2021). Instead of cells and organs, digital bodies have data and metadata – with the connected parameters and data points growing day by day. Unlike a physical body that exists in one place, our digital bodies are scattered throughout the servers that make up the internet. Individuals are isolated or detached from their own digital bodies and cannot intervene: the digital shadows are controlled exclusively by the environment they live in (Lee & Toliver 2017, 6) and are increasingly exploited in order to model, anticipate and preemptively affect possible behaviors as well as track, control and suppress the flesh-and-bone individuals behind the digital bodies. While our physical bodies converge with digital ones, the collected data has more and more real-world implications.

Norbert Wiener was already sounding the alarm over 60 years ago how we are turning into Mechanical Turks when being interweaved to closely with big corporations and their tools: "When human atoms are knit into an organization in which they are used, not in their full right as responsible human beings, but as cogs and levers and rods, it matters little that their raw material is flesh and blood" (Wiener 1989, 185). Following Herbert Marcuse's argumentation about the different forms of domination of the so called free and non-totalitarian societies, "AI may lead to new forms of manipulation, surveillance, and totalitarianism, not necessarily in the form of authoritarian politics but in a more hidden and highly effective way: by changing the economy in a way that turns us all into smartphone cattle milked for our data" (Coeckelbergh 2020, 103).

The series *In the Heat of the Day* explores algorithmic structuring of the world by exploring and rearranging location data from fitness trackers made available through the service STRAVA and visually exposing the traces we leave somewhere in the cloud, acting as a driver of debate around topics of privacy, safety, and obedience. Through the abstracted images and highly stylized forms and colors, the viewer is confronted with the idea that machines and algorithms are looking at us and the data our bodies are generating constantly as well as the question of how our movements are informing the code and vice versa.

Fig. 1. Fabian Weiss,
In the Heat of the Day, #1.

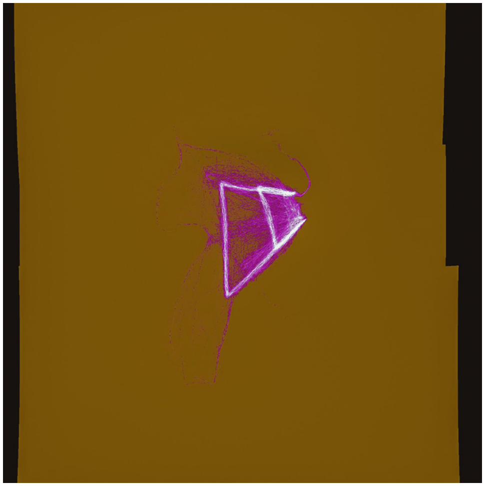


Fig. 2. Fabian Weiss,
In the Heat of the Day, #2.

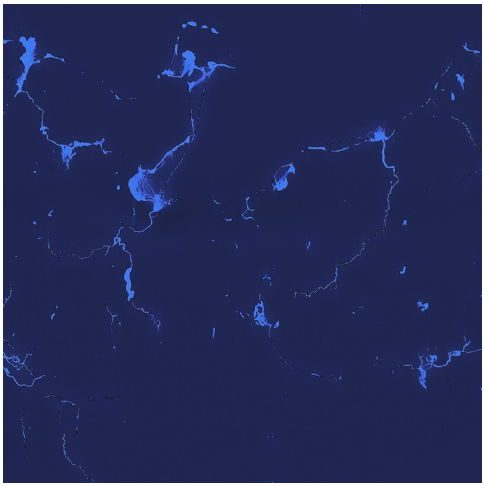


Fig. 3. Fabian Weiss,
In the Heat of the Day, #3.

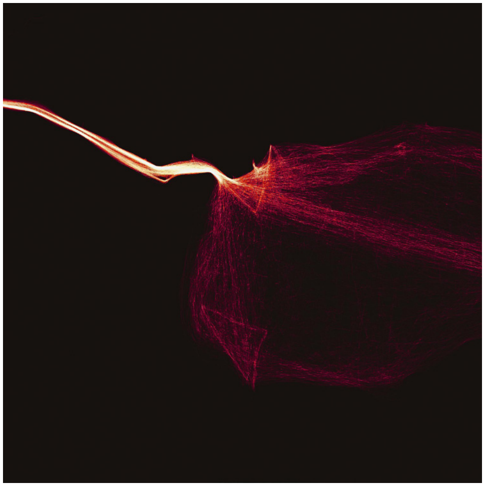


Fig. 4. Fabian Weiss,
In the Heat of the Day, #4.

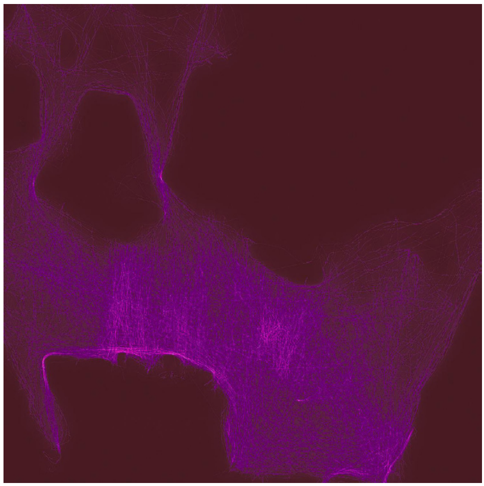


Fig. 5. Fabian Weiss,
In the Heat of the Day, #5.

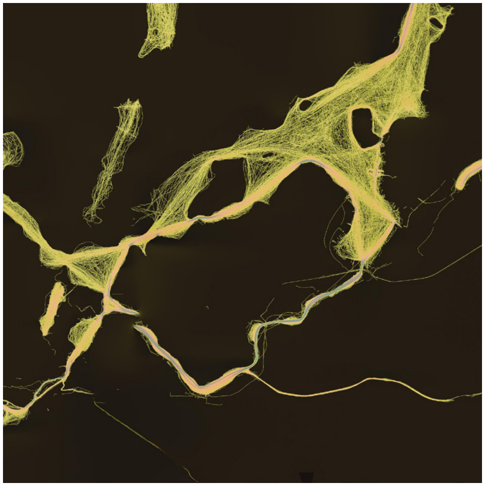
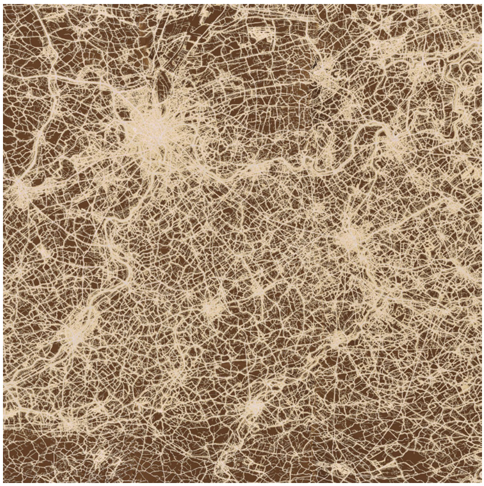


Fig. 6. Fabian Weiss,
In the Heat of the Day, #6.D



References

Amoore, Louise and Volha Piotukh.
2015. *Algorithmic Life. Calculative devices in the age of big data*. London: Routledge.

Coeckelbergh, Mark.
2020. *AI Ethics*. Cambridge, MA: The MIT Press.

Horning, Rob.
2015. "Hide and Seek: The Problem with Obfuscation". *Los Angeles Review of Books*, Published November 10, 2015. https://lareviewofbooks.org/article/hide-and-seek-the-problem-with-obfuscation/.

Kroker, Arthur.
2012. *Body drift: Butler, Hayles, Haraway*. Minneapolis: University of Minnesota Press.

Lee, Una and Dann Toliver.
2017. "Building Consentful Tech". Accessed January 15, 2021. http://www.lib.montana.edu/privacy-forum/Building-Consentful-Tech-Zine.pdf.

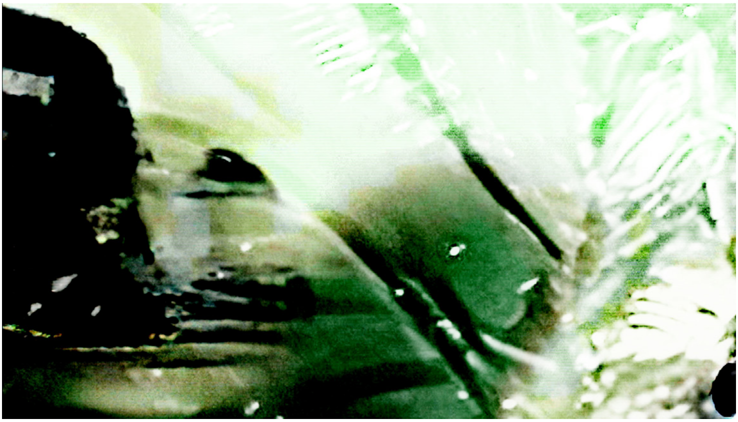
Tactical Tech.
"Shrinking Civil Space: A Digital Perspective". *Our Data Our Selves*. Accessed January 29, 2021. https://ourdataourselves.tacticaltech.org/posts/shrinking-civil-space-a-digital-perspective/.

Wiener, Norbert.
1989. *The Human Use of Human Beings*. London: Free Association Books.

Wolf, Gary.
2010. "The Data-Driven Life". *The New York Times Magazine*, April 28, 2010. https://www.nytimes.com/2010/05/02/magazine/02self-measurement-t.html.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Kai-Luen Liang
kailuensound@gmail.com
Independent artist,
United States

Blue Marbles

Keywords: Surveillance, Generative Adversarial Network, Sound, Experimental Film

Blue Marbles is a speculative short film about rare earth materials, tech labor, shifting geological landscapes, and modern neural network surveillance systems. It focuses on the seemingly "mundane" aspects of data collection, self-surveillance and examines the acceleration of the building of large surveillance networks in conjunction with advances in computer vision and neural networks in the context of modern China. The quick integration and digitization of large-scale national databases have developed in conjunction with a barrage of public relations media framing the acceleration of surveillance technology in the name of public security, personal safety, national identity, and societal stability. Public opinion and lack of discussion /options around surveillance and political participation produce numbing and silencing effects on the individual psyche. *Blue Marbles* looks at how modern Chinese surveillance hardware and software companies brand their products, the influence of Silicon Valley developments in surveillance capitalism, and how surveillance tropes are reassembled and packaged for public consumption. *Blue Marbles* repurposes these symbols of modern surveillance (the common images of the camera lens, the earth, symbols of prediction, the sounds of online hardware infomercials) as found footage to be used, sampled, trained on, and reassembled into a meditation on the complex intertwined nature of global and state-sponsored surveillance networks.

https://2021.xcoax.org/kll/

Description

Blue Marbles is interested in the seemingly "mundane and common" aspects of surveillance culture in the use of communication/social media apps to document and collect data on everyday life. It is an investigation of this feeling of inevitability and numbness that it produces while thinking broadly about the connections between labor and the extraction of physical materials involved in the production of surveillance camera hardware, data cleaning, and the rituals of documentation.

Although surveillance is not confined to representations of any specific space or form, I have decided to use common symbols and tropes found in Chinese surveillance hardware commercials as the basis for this film for the main purpose of creating a direct engagement with largely abstracted and hidden processes. In loosely analyzing commercials released by Chinese surveillance companies, Hikvision,[1] Da Hua, and Sensetime circa 2016-2019, some common symbols that appear are round spherical objects: the camera lens, the eyeball, the earth, crystal balls, etc. In addition to the symbols, the sounds and narration of these commercials were used, sliced, stretched, manipulated, and ripped apart to create a new sonic space where the tropes can exist in a limbo disconnected from the original sources. In addition, I specifically wanted to explore mass surveillance in China, a country often perceived in Western media as an alien or orientalized Other and make connections to the developments of surveillance capitalism in the US. Common interfaces of surveillance capitalism such as online gaming platforms, online shopping, and data collecting lifestyle apps integrate all of us in these vast networks across geopolitical boundaries and yet create vastly different conditions on how various demographics are being surveilled. Mainstream media Orwellian depictions of the Chinese surveillance state often brings a sense of disconnection from the way democratic countries see their own surveillance networks. It is easy to revert to Cold War metaphors and see China as an Other, an extreme edge case and yet it is perhaps the largest experiment of globally integrated mass surveillance known in history involving the cognitive labor and technology of multiple countries.

1. 2019 Hikvision Brand Video: Beyond Just Seeing https://www.youtube.com/watch?v=ZH6ltPzvKHc&t=5s

In China, the ubiquity of surveillance is everywhere; from the community apartment complexes where people live to UNESCO protected natural mountain scenery. As an outsider coming to visit, the feeling of being watched is everywhere and yet for the average Chinese citizen, the external gaze of surveillance has long been internalized. The camera lens is so commonplace that its physical presence is forgotten. Yet, the specter that hovers and floats over everything is felt like dead relatives. Walking on Chang An Ave in Beijing for the first time can feel like walking under a screen of a million artificial eyes and yet eventually the cameras meld into the landscape as birds perched on metal poles. The disconnection between the everyday workings of the surveillance state and the lives of a population with access to inexpensive smartphones, screens, and CCTV devices often create an unreal sense of distance. This detachement hides, rather than reminds, the interconnected nature of globalized surveillance technologies.

Rather than aiming at sensationalizing surveillance, I hope to highlight the numbing effects of a surveilled networked life. The data becomes mundane through sheer volume, a constant barrage of pixel values and double taps. Yet behind this barrage of data is a vast network of labor. Whole village economies became reliant on work categorizing images for machine learning datasets.[2] Entire towns mine Lanthanum to produce spherical camera lenses. Organic chickens tracked with blockchain.[3] The repetitive labor that produces a hazy mechanical gaze repeats itself in the way we watch, track, and digitally interact with even ourselves. According to Franco Berardi, the effects of cyberspace on cyber-time extends to the psycho-sphere creating a feeling of numbness and a lack of horizon or futurability (Berardi 2009). In the film, this lack of solid ground is represented by the NASA blue marble 3D simulation being fed into Pix2Pix next frame prediction generating the next frame of video based on what the model has learned from the input. This produces a strange "prediction" of the future of a projected earth being stretched and pulled apart. The original Blue Marble photograph of the earth was taken by the crew of the Apollo 17 spacecraft on December 7th, 1972. It showed an illuminated earth at 29,000 kilometers from the earth's surface. Perhaps one of the places where the image of Blue Marble was most viewed unknowingly was on the splash screen of the Chinese communication app WeChat, which has over a billion active daily users. Each time the app was opened from 2011-2017, one would see the famous Blue Marble image of the earth cropped behind a silhouette of a person in front of the earth. WeChat has over 1 billion active users who daily generate 45 billion messages, 410 million audio and video calls, and over a billion commercial payment transactions (Graziani 2019). The monitoring for blacklisted content in WeChat is constantly undergoing daily updates and shifting with what is happening locally and abroad. These shifts in data collection outpace the ability for us to process. We are forced to update with these changes. The way words are typed in chats, voice inflections and tones in the language are changed, and abstract symbols stand in place of content.

2. "'AI Farms' Are at the Forefront of China's Global Ambitions." Time, https://time.com/5518339/china-ai-farm-artificial-intelligence-cybersecurity/.

3. Wang, Xiaowei. *Blockchain Chicken Farm: And Other Stories of Tech in China's Countryside*. FSG Originals, October 2020.

These constant technological changes accelerate a feeling of constantly having to mentally renew. This constant process of updating ensures that the surveillance subject is never finished changing and is continually assembled and reassembled with no definite goal. It is a shapeshifting mass contained in a perpetual feedback loop. As we incorporate more of the data in our bodies, the surveillance system becomes parasitic, living off of the objects it surveils. Our memories and thoughts have migrated outside our bodies into data-flows. What are the psychological effects of melding our bodies and memories with the surveillance network which seems to expand with no end or horizon in sight?

It is this feeling of detachment and numbness towards surveillance that I attempt to explore in this film. Our repetition of actions has been completely integrated into the surveillance network as labor. The constant tectonic technological shifts happening at a speed that our bodies can no longer keep up with. What are these effects of repetition within the context of constantly shifting terrain? How does the body react when policies can no longer keep up with technological change? How does one find a stable ground to stand on? *Blue Marbles* is made as a meditation and reflection on these ideas using the tropes of traditional surveillance. It uses the language of surveillance as input to either be processed or analyzed as data and reprocessed as new images. The film is composed of image sequences created from datasets of surveillance camera products, Nasa Blue Marble images of the earth, rare minerals particularly Lanthanum (used to produce camera lenses among other things), Chinese Shanshui landscape paintings, and processed snippets of existing brand commercials. The datasets were then prepared and trained using StyleGAN ADA and Pix2Pix Next frame prediction models to create new images that make up the basis of the film. It is an experiment in using neural networks to create new hallucinations on the current state of global surveillance.

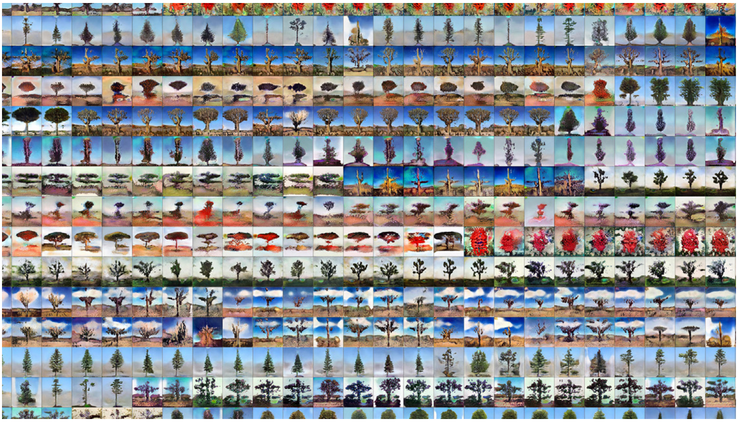
References

Berardi, Franco.
2009. *Precarious rhapsody: Semiocapitalism and the Pathologies of the Post-Alpha Generation*. London: Minor Compositions.

Graziani, Thomas.
2020. "¥800 Billion WeChat Mini-Program Transaction Volume in 2019: Tencent Annual Report." *WalktheChat*, Last modified: March 23, 2020. https://walkthechat.com/%c2%a5800-billion-wechat-mini-program-transaction-volume-in-2019-tencent-annual-report/.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Rihards Vitols
vitols.rihards@gmail.com
DXARTS, Seattle, USA

Mežs / Forest

Keywords: Forest, AI, Machine Leraning, Trees, Biodiversity, Speculative Art, Global Climat Change

The techno-ecologies concept which implies the integrated view on the interconnection of technology and ecology in providing the needed resources in the present world; my work is intended as a comment on the effects of the Anthropocene on the environment. *Mežs* looks at critical environmental challenges and how we can speculate on how nature might look in the future. Speculating on the future of forests; it proposes new computer-generated species of trees and traces their habitats by composing the soundscapes that surround them. The research will explore the use of artificial intelligence and machine learning algorithms in generative art. The project investigates how these algorithms can generate audiovisual and textual material that can form the basis of the artwork itself.

The outcome consists of a series of three artworks: an interactive online archive of trees and their soundscapes, a time-based work envisioning the world with the new tree species introduced, and an interactive book – an archive of the previously generated materials.

https://2021.xcoax.org/rvi/

Description

Mežš is an artistic research that explores the use of artificial intelligence (AI) and machine learning (ML) algorithms in generative art. Media artist and theorist, Philip Galanter describes generative art as:

> Art that refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art. (Galanter, 2003)

My artwork, namely, investigates how by creating a custom training dataset, a ML system can generate audiovisual and textual material that can form the basis of the artwork itself. *Mežš* is a speculative look into the future of forests; it proposes new species of trees that are computer-generated, and also traces their habitats by composing the soundscapes that surround them. This new species of trees could cover the earth in the future to maintain natural balance. The new trees are the result of evolution of existing ones and mutations between them. They have qualities from multiple trees from different environments that allow them to be more resilient to future environments, and in some cases, even migrate away from the environment if the conditions for their survival become too harsh. The artwork consists of a series of three artworks: the first work is an interactive online archive of trees and their soundscapes, the second is a time-based work showing how the world would look like with these new tree species, and the third one, is an interactive book archiving all the previously generated materials.

Mežš looks at artists that create their works with the help of AI concentrating on artworks that deal with artificial ecology, speculative futures, and critical design, such as *Artificial Remnants* by Sofia Crespo, *Cusp* by Jake Elwes, *Myriad* by Anna Ridler, and *Asunder* by Tega Brain, Julian Oliver, and Bengt Sjölén. For the research I am looking at the fields of generative art and techno-ecologies.

Sofia Crespo's work *Artificial Remnants* is part of an ongoing exploration of artificial life using deep learning to generate insects as well as their names and anatomical descriptions. My interest in this work focuses on the approach the artist has towards presenting her work online, and the methodology behind it. Jake Elwes' work Cusp is trained on a photographic dataset, the machine proceeds to learn the embedded qualities of different marsh birds, and in the process reveals forms that fluctuate between species. I am especially intrigued by the way the artist presents time-based fragments of the work in its natural habitat, through the use of panels and projection, Anna Ridler's project *Myriad* is an installation of thousands of hand-labeled photographs of tulips that are ML generated. My work was especially inspired by Ridler's approach of presenting a big dataset in a way where you can look at all of it, or a smaller part by interacting directly with it. Work Asunder by Tega Brain, Julian Oliver, and Bengt Sjölén responds to a growing interest in the application of AI to critical environmental challenges by situating this approach as a literal proposition, combining state of the art climate and environmental simulation technology. The artwork concept has inspired me to think about environmental challenges that nature needs to go through to provide for us and how we can speculate on how nature might look in the future.

Another concept which provides the theoretical context for my work is the term Techno-Ecologies, which refers to an idea which connects to the critical discourse about the Anthropocene era:

> everyday life is intimately interwoven with complex technological ecologies. I believe that we can no longer consider technology as the alienating "other". The idea that we "inhabit" technological ecologies, emphasises our connectedness to our environment and our dependence on available resources. The field of Techno-Ecologies builds upon the urgent call by philosopher Felix Guattari for an integrated perspective on the dramatic techno-scientific transformations the Earth is undergoing. (Smite, R., Kluitenberg, E., & Smits, R., 2012)

My first step into generating the imagery of the work was to put together a custom dataset of trees using a custom Python script that searches for tree images on the Internet. My script looks for images that are square and minimum 1024x1024 pixels in size. Next step was to select images where the tree is centred. The search started with a specific species of trees that grow in my home country Latvia followed by trees from my current location in Washington state and continue into more harsh environments like the tundra, desserts, the rainforest, and even underwater environments, ending with rear tree species. The script collected 4000 images that I manually filtered and selected the ones that fit my criteria. I ended up with 1000 images and 39 species of trees. Using the NVIDIA StyleGans2 ML algorithm It generated 120,000 new trees. The new trees were separated into 39 groups using the unsupervised KMeans clustering algorithm that groups similar data points together. Each new group of trees then went through the KMeans process again to separate similar images in the same group of images. I manually selected images of trees with the most interesting color palette, shape, and background, ending up with 1848 images of new trees.

Furthermore, I created computer-generated soundscapes to accompany the images of the trees. Using the tree species, the environments where they grow, and various forest types as keywords I wrote another custom Python script using the Freesounds API. All the collected sounds were edited to have the same length, and then were used to train a WaveGan ML algorithm. After eliminating files that contained silence, my new dataset contained 5825 sound files. These were used to generate short samples of soundscapes for each new tree species. With this process, I generated 125000 new soundscape samples. After removing the ones that consisted of white noise and once that were clipping, I manually assigned a soundscape by listening to it and imagining how a tree would move and interact with its environment.

To use AI not as a solutionist strategy for climate change, but to comment on the effects of the Anthropocene on the environment, to speculate about the potential of future imaginations by the collaboration of human and non-human agents; to investigate the poetics of using AI both visually, and also sonically, by creating an immersive experience. To explore the format of the interactive publication as a way of archiving and disseminating this research into AI, art and ecology.

Mežš means a Forest in Latvian. The website *mezs.ai* is an interactive digital archive consisting of 39 new tree species and soundscapes.

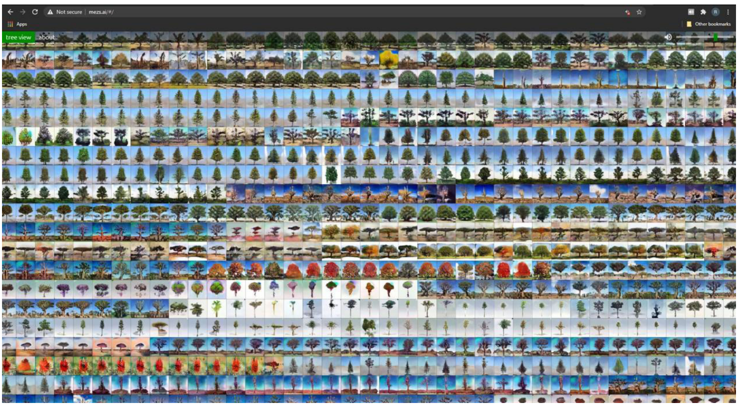


Fig. 1. Screenshot from the web page after entering it accompanied by all soundscapes.

Fig. 2. Screenshot of a selected tree for a closer look accompanied with its species soundscape.

Available at: http://mezs.ai

References

Elwes, Jake.
2019. *Cusp*. Retrieved April 08, 2021, from https://www.jakeelwes.com/project-cusp.html

Galanter, Philip.
2003. *What is generative art?* Retrieved April 08, 2021, from http://philipgalanter.com/downloads/ga2003_what_is_genart.pdf

Ridler, Anna.
2018. *Myriad (tulips)*. Retrieved April 08, 2021, from http://annaridler.com/myriad-tulips

Smite, Rasa, Kluitenberg, Eric, & Smits, Raitis.
2012. *Acoustic space*. Riga: Rixc.

Sofia Crespo.
2020. Artificial Remnants. Retrieved April 08, 2021, from https://artificialremnants.com/

Tega Brain, Julian Oliver, and Bengt Sjölén.
2019. *Asunder*. Retrieved April 08, 2021, from https://asunder.earth

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Kyle Booten
kyle.booten@uconn.edu
University of Connecticut, Storrs, USA

To Pray without Ceasing: An Interpassive Liturgy

Keywords: Care, Prayer, Interpassivity, Natural Language Processing, Web Application

To Pray without Ceasing is a web app that prays for the needs of Twitter users. Each day the system searches for tweets expressing needs (e.g. "I really need a hug right now") and, using various techniques of natural language processing to generate responses to these tweets, produces a 24-hour-long liturgy based on the "Liturgy of the Hours." Visitors to the web app activate it by tending to several virtual candles. As long as one of these remains lit, the system will proffer prayers. By participating in its ritual, viewers are invited to consider and feel what it would be like to put down their own worries and instead care for others without limits.

https://2021.xcoax.org/kbo/

Praying for Strangers

"I need a girlfriend." "I just need to move out of this apartment." "I really need to quit my job." Every day, every minute, Twitter users publish such plaintive confessions. On social media, however, solicitude is not equally distributed. Some users' heartfelt pleas receive thousands of retweets and replies expressing sympathy; other users have few if any followers and muster few if any kind responses. To receive care, one must increasingly struggle to be noticed within a digital attention economy. Would it not be better if everyone received some minimal measure of solicitude, a quantum of "Universal Basic Care"?

Yet this seems impossible. The logics of neoliberalism have turned us into what Byung-Chul Han calls "achievement subjects" (Han 2017b). We feel the need to spend each moment striving to become better versions of ourselves, better human capital. Even as social media makes it possible to notice the needs of others and to attend to these needs, we have less and less time to do so. No, we must be working and learning, or at least gaining followers for our own accounts. Even moments of pause or mindfulness, Han suggests, are justifiable only insofar as they recharge us for work. And, as Han explains, we do not live in a society of "'Love thy neighbor,' where we all realize ourselves in concert" (Han 2017b, 49). Instead we are violently isolated, competitive both with each other and with ourselves. To think about others offers no benefit; to do so is irresponsible, a sin against the perpetual commandment of self-optimization.

To Pray without Ceasing (topraywithoutceasing.com) is a web-application that rejects this hyper-competitive, achievement-oriented way of viewing the world. It does nothing but methodically and relentlessly pay attention to the needs of others. Each day it searches Twitter for expressions of need uttered by those users with few followers—the attention economy's dispossessed. The system produces an online liturgy based on the "Liturgy of the Hours," according to which Catholic clergy and members of religious orders (monks, nuns, etc.) pray at different times throughout the day, from "Matins" in the early morning to "Compline" late at night. At each of these Hours, the system prays in a slightly different way; this is meant to encourage the visitor to be patient in order to see how its variations unfold. Since each day the system harvests a new set of needs from Twitter, the work of prayer is never finished. Once it has gone through its 24-hour liturgy, it is already time to begin again.

Interpassivity

To Pray without Ceasing is a post-human religious ritual. The piece's title alludes to St. Paul's exhortation to the Thessalonians to "pray without ceasing"—a task better suited for a machine than a Thessalonian. However, *To Pray without Ceasing* does not pray on its own. It needs a human intervention, albeit a minor one: the visitor to the web app must light one of several candles. Once this simple but symbolically-resonant act is accomplished, prayers begin to appear above the candles in response to specific needful tweets. Soon a pop-up message encourages the visitor to go about their business, checking in every so often to relight the candles so that the prayers continue.

This interface (Fig. 1) is thus designed not for interactivity but for "interpassivity," a term that Robert Pfaller uses to describe the process of delegating consumption or enjoyment to other people or, just as often, to a non-human apparatus (Pfaller 2017). As Pfaller observes, interpassivity is fundamental to religious ritual. When a Christian lights a candle or a Buddhist spins a prayer wheel, these physical objects take over the responsibility of praying. Interpassive delegation of this sort fulfills a specific psychic function: the Buddhist and the Christian enjoy the self-satisfaction of being pious or religious while simultaneously being freed from the responsibility of actually being so, since the performance of piety has been totally externalized.

1. The default browser cursor has been replaced with the "Person with Folded Hands" emoji, forcing the user to assume a gesture of prayer.

Why resort to interpassivity? Pfaller observes that, after lighting a candle in a church, the religious person may "stay for a few minutes and then leave the church while the candle remains in his or her place, burning for a few more hours" (Pfaller 2017). The implication is that interpassivity produces an excess pleasure, a bonus. With *To Pray without Ceasing*, I hope to likewise allow people to experience an undeserved gratification. Tending to a digital candle is a very small act of labor, but it is not as easy as simply clicking a button. In fact, the web-interface measures how quickly the visitor's cursor moves and scolds her should it move too quickly.[2] This makes the lighting the candle somewhat more special than rapidly and mindlessly clicking around a screen. The visitor may feel that, through her mindful movements, she has done the necessary labor to activate a spiritual machine. Having done so, she can feel responsible for the prayers that the web app generates, even if she hardly pays attention to it, instead spending most of the day doing her own work and only infrequently returning to make sure the candles are lit. In fact, she may forget altogether that the app is running in another browser tab only to stumble upon it later in the day, realizing that she has been credited with praying several hundred prayers.

2. An html alert box interrupts the interface with messages such as "Your cursor is fleet. But this is a place for moving slowly." and "The ritual cannot be rushed."

Neoliberalism's emphasis on being better and better, deserving more and more, leaves the achievement subject exhausted and depressed (Han 2017a); this piece, on the other hand, offers a feeling of accomplishment, even of being virtuous and kind, that is refreshingly unmerited.

Fig. 1. Since the candles are lit, To Pray without Ceasing generates a prayer. A Tweet is placed upon the altar using Twitter's oEmbed API.

Computer-Augmented Prayers

As an apparatus that prays on behalf of someone interpassively, *To Pray without Ceasing* is different than a physical candle. Unlike mute wax, it generates prayers that are specific to each incoming need.

But "generate" is a slightly misleading term in this case. *To Pray without Ceasing* uses what I would call computer-augmentation rather than computer-generation of text. The system matches needs from Twitter with specific prayers that I have already written. It then automatically transforms my hand-written prayers in several ways: it revises them by substituting my rather pedestrian words with obscure Biblical vocabulary, adorns them with linguistic fragments derived from the King James Bible, and matches them with sententious Biblical proverbs. I can dimly recognize the prayers it produces as based on my language, yet they are refigured, given a heighted style and strangeness as if sent through a Biblical kaleidoscope. Because the system's prayers are based on my own words, I feel responsible for them; my one act of kind attention to strangers is multiplied. But because the system's prayers are augmented through techniques of natural language processing, I can feel as though I am responsible for more—and more interesting—prayers than I have actually myself written. This is another form of excessive or undeserved pleasure, a way of experiencing what it would be like to care deeply and specifically for each stranger whose needs I glimpse online.

Technical Details

To Pray without Ceasing, using the Twitter Search API, gathers tweets that begin "I need" and "I just need," filtering out those by users who have even a modest number of followers. For each of these Needy Tweets, it tries to find a semantically similar need from a list of Target Needs that I have manually composed. This is accomplished by encoding both the Needy Tweets and the Target Needs as sentence vectors using a pre-trained model (Reimers and Gurevych 2019) and comparing the cosine similarity of each Needy Tweet to each Target Need. The advantage of this approach is that sentence vectors can capture the latent meaning of a sentence; the cosine similarity between the Need Statement "to be cozy and dreaming" and the Target Need "to sleep" is high, despite a dearth of shared vocabulary between them.

Each Target Need is associated in a dictionary with a prayer, each prayer consisting of eight different sentences (for each of the liturgical hours: Matins, Lauds, Prime, Terce, Sext, Nones, Vespers, and Compline). For instance, the Target Need:

```
“to visit my family and friends”
```

is associated with the prayer:

```
"May you be {VBD.embraced.recognized} by your {JJ.true.beloved.chosen.
given} {NN.family.belonging.holiday}"
```

This prayer is written in a custom markup that allows me to hastily compose prayers while noting what words I want the system to algorithmically emend. Embraced in brackets are a part-of-speech tag followed by a series of search terms. *To Pray without Ceasing* tries to substitute these typically boring words with words that are more resonant but that possess a similar meaning. The system searches a list of Biblical words, sorted according to part-of-speech, for those that are similar according to cosine similarity of pre-trained word embeddings (Mikolov et al. 2013). For instance, the above sentence may be transformed into:

“May you be proclaimed by your faithful firstling”

To adorn a sentence, *To Pray without Ceasing* relies on linguistic fragments automatically extracted from the King James Bible using spaCy's dependency parsing (Honnibal et al. 2020). For instance, using this parser, I extracted all (*adjective, noun*) combinations, such as (“pure”, “water”) as well as all of the (*noun, prepositional phrase or relative clause)* combinations, such as (“sleep”,of “a labouring man”). The system may adorn the above sentence like so:

“May you be proclaimed by your faithful firstling; behold—this firstling faithful as commandments”

Finally, every so often the system may refer to a semantically-relevant proverb (a verse from the Books of Proverbs and Ecclesiastes). Once again, semantic relevance is operationalized as cosine-similarity of sentence vectors between a prayer and a proverb. The above sentence may be matched with a proverb like so:

“May you be proclaimed by your faithful firstling; for it is written: Wealth maketh many friends; but the poor is separated from his neighbour.”

Available at: http://www.topraywithoutceasing.com

Acknowledgements. I am grateful to Nokturno.fi for supporting the development and debut of this work while I was their Fall 2020 poet-in-residence.

References

Han, Byung-Chul. 2017. *The Agony of Eros*. Translated by Erik Butler. Cambridge, MA: The MIT Press.

Han, Byung-Chul. 2017. *Into the Swarm: Digital Prospects*. Translated by Erik Butler. Cambridge, MA: The MIT Press.

Honnibal, Matthew, Ines Montani, Sofie Van Landeghem, and Adriane Boyd. "SpaCy: Industrial-Strength Natural Language Processing in Python." *Zenodo* (2020): doi: 10.5281/zenodo.1212303

Mikolov, Tomas, Ilya Sutskever, Kai Chen, Greg Corrado, and Jeffrey Dean. "Distributed Representations of Words and Phrases and their Compositionality." In *Advances in Neural Information Processing 26*, 3111–3119. Lake Tahoe, UT, Dec 2013.

Pfaller, Robert. 2017. *Interpassivity: The Aesthetics of Delegated Enjoyment*. Edinburgh, UK: Edinburgh University Press.

Reimers, Nils and Iryana Gurevych. "Sentence-BERT: Sentence Embeddings Using Siamese BERT-Networks." In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing* and the *9th International Joint Conference on Natural Language Processing*, 3982-3992. Hong Kong, China, November 2019. Association for Computational Linguistics.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Ben Benhorin
benhorin@gmail.com
Shenkar College of Engineering, Design and Art, Ramat-Gan, Israel

GIFCinema

Keywords: Net Art, Generative, Films, Subtitles, GIFs, Speech Synthesis, APIs

GIFCinema is a net art website generating audio-visual experiences that are constructed in real-time and are unique to each viewer and view. Initiated by the viewer's search for a film title (the 'seed'), three generative systems and several different APIs – animated visuals, real-time speech synthesis and search algorithms that prove to be fairly unexpected – are combined to create a new type of generative experience. The *GIFCinema* web app works as follows: upon the viewer's search for a film title, the search algorithm instantly finds its subtitles on the net. Playback then begins in the original timing and rhythm, but instead of displaying the original movie visuals, it reconstructs the movie based on animated GIFs and a machine-voice rendering of the dialogue text. The result is a new type of film, crowd-sourced from the visual wisdom of the web, constructing a visual *zeitgeist* of web pop-culture in real time.

https://2021.xcoax.org/bbe/

Description

Do you remember that distant period when our state-of-the-art technology was so primitive, we had to wait 30 minutes to download a movie, and still naively believed in an emerging technology called BitTorrent? With the advent of pirated and mainstream commercial streaming services, we have become accustomed to much more immediate media experiences. If it takes more than a few seconds we start to lose interest and move on to the next craving…

But what is a good film if not script, dialogue and timing? As artist and designer Ben Benhorin's *GIFCinema* web app demonstrates, you do not need much more than that for a rich multimedia experience: you can give up the video and audio altogether (the larger components in the world of digital files) and stick with the basics. For every movie out there, the *GIFCinema* web app allows you to use the film's downloaded il/legal subtitles file (a small text file containing the entire script, dialogue and timing), and experience the movie instantly in a new format using the vast media databases available on the web.

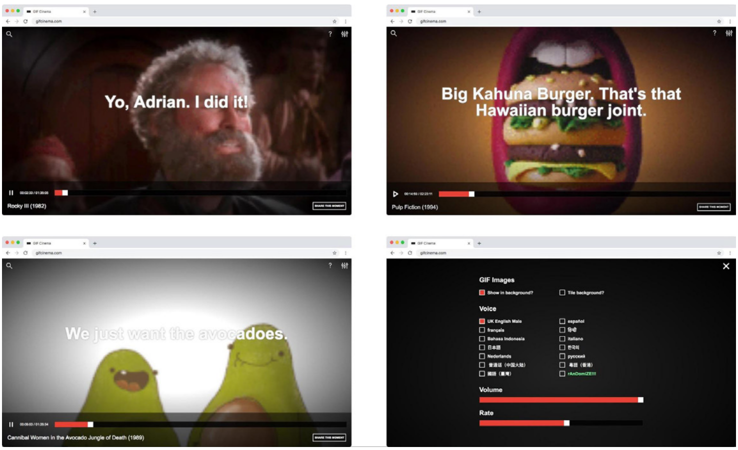


Fig. 1. *GIFCinema* website screenshots.

As you type your favorite film name into the search box, the *GIFCinema* web app fetches and downloads the subtitles — but it won't show you the movie you've chosen. Instead, it reassembles the movie with animated GIFs based on each word and sentence in the subtitles and re-enacts all the dialogue in one (or many) of the robotic voices available through the text-to-speech API. The result is a completely new 'film', a real-time generative construction of visual net culture created by different generative systems: subtitles from the opensubtitles.org API, animated visuals from the giphy.com API, speech synthesis via the web text speech API, and search algorithms that sometimes prove to be smarter than expected, making cross-cultural references and returning unexpected results.

This work was first created out of pure curiosity, an exploratory journey by an artist / designer / coder fascinated by the feasibility of the idea. By combining a few search algorithms and public APIs of various online data services, an infinite series of generative media works are created, placing cultural landmarks and fashionable internet memes in a completely different artistic context.

The experience starts by asking the viewer to type a query into the search field. The query is sent to opensubtitles.org, and leveraging the search capabilities of that platform, a subtitles file (.srt) is returned. The file is then parsed, and playback begins. Each line of text is displayed in the correct timing of the original film, and as each line is encountered it is both read out loud by the text-to-speech API, and also sent to giphy.com. The search algorithm of that API returns a set of results for each query, and one image or animated GIF is then randomly picked and displayed. This adds an inherent element of randomness and surprise to the result, creating an unexpected, often humorous and rewarding experience. While playing the animated images, the text-to-speech algorithm reads out the film's original dialogue in a robotic voice.

The interface also offers a variety of options for customizing the user's experience. One can watch the movie in a variety of voices and accents and experience it through films & TV series from all genres and periods. For example, you can choose to play spaghetti westerns in an Italian accent ('Alice' or 'Luca'), romantic comedies in Korean ('Yuna') or actually hear the text sung and not read ('Good News'). It can also be customized to show no visuals at all – transforming the experience to be more similar to a podcast or the bygone 'radio drama'.

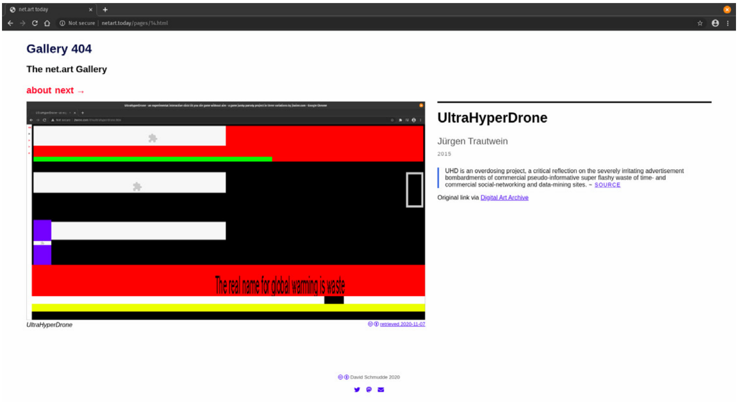
The work raises the question of originality, copyright, piracy, and the cultural aspect of media duplication and distribution today. Who is the creator of each of these unique generative films? The original creator of the film? The collective that contributed to creating the visuals? The creator of the code who published it on the web? Or is it the viewer who actually uses it?

Crowd-sourced subtitles for pirated films are presented alongside visual memes of duplicated content, which present an up-to-date picture of the visual world of pop web culture. The current network culture is based almost entirely on referents and endless duplications, and this work happily joins the celebration.

Available at: https://www.gifcinema.com

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



David Schmudde
d@schmud.de
Chief Technology Officer,
Yorba, Berlin, Germany

Gallery 404

Keywords: Fine Art, Internet History, Net Art, Art Preservation, Telematic Art.

Digital artifacts are trivial to copy but very difficult to preserve. *Gallery 404* highlights over twenty years of misplaced and broken digitally-native works of art from the net.art movement. net.art embodies the output of a generation of web pioneers. Much of it has already been lost to time. *Gallery 404* responds to this loss of culture by showing the work as it naturally appears on today's world wide web. The pieces feature missing plugins, broken links, fatal errors, mismanaged URLs, API issues, and incompatible stylesheets. Digital rot is foregrounded in an emphatic statement on the value of culture in cyberspace.

https://2021.xcoax.org/dsc/

Description

Gallery 404 collects and displays hyperlinks to prominent net.art artworks on the world wide web. These links point to a place where net.art *happened*. The links are displayed alongside of more traditional media: written biographical information and images of the artwork's current state.

The holdings of *Gallery 404* no longer function as the artists originally intended. Each artwork has yielded to the passing of time. But in a medium where calculations are made at unimaginable speeds, time itself seems to pass faster. Some of these artworks took less than a decade to decay into unrecognizable states.

Gallery 404 is net.art today. Much of what was created by the first generation of digital natives is now broken. While some works of net.art have benefited from institutional preservation, even these are vulnerable to software updates, infrastructure changes, and negligence.[1] As software eats the world, it also consumes itself.

1. The Whitney Museum of American Art 2013 restoration of *The World's First Collaborative Sentence* (Douglas Davis 1994) is probably the most salient example. As of January 2021, it no longer functions properly.

The Preservation of Net.art

Net.art is a peculiar art form. Its growth paralleled the emergence of the commercial internet. The lack of a formal language or framing device made the work difficult to spot; "art" websites and "non-art" websites looked similar. There were few celebrity practitioners and virtually no exhibition spaces.

The net.art movement liberated artists and audiences from Duchamp-style Modernism. Duchamp's Modernism crystallized when the artist submitted *Fountain*, a urinal bought at a hardware store in Manhattan, to the Society of Independent Artists exhibit in 1917. *Fountain* brought the power of art-signifying frames to the forefront: "this urinal is art because it is being exhibited as art."

Net.art lacked an equivalent to trendy exhibition spaces, deliberate lighting, and expensive picture frames. The blurred boundaries were reflected in pieces such as *Airworld*[2] and website awards like Alexei Shulgin's *WWWART MEDAL*,[3] which presented "non-art" websites awards for providing a "definite 'art' feeling" (Murakami 2013).

2. Airworld is currently archived at in Rhizome's *Net Art Anthology* at https://sites.rhizome.org/anthology/airworld.html.

3. *WWWART MEDAL* is still available at http://www.easylife.org/award/.

While much has been written on how the "internet never forgets," much of what was created in the last twenty plus years has disappeared from neglect or deliberate corporate purging. This includes countless websites, Flickr (2019), and Tumblr (2018) accounts, all of Google+ (2019), all of Geocities (2009), and 50 million songs by 14 million artists on MySpace (2003-2015) (Le 2020, Shaban 2019).[4]

4. This is in spite of the best efforts of the Archive Team, the Internet Archive, and similar initiatives around the world.

net.art was a generation's attempt to plant a cultural stake in cyberspace. Their work is a reflection of what the internet was and could be. But the cultural artifacts of the first digital natives are quickly being lost to time. *Gallery 404* presents this broken history in its unvarnished reality.

Historical Context

The world wide web is just one part of the internet. Some historical context will help convey the difference between net.art and the telematic art that existed in the years prior (Frazer 1995, Hoffmann 2020).

» 30 August 1969: the ARPANET, an early military computer network, comes online in the United States. The network is used to coordinate information and share computing resources.

» 15 July 1980: Minitel, a popular public computer network, comes online in France. This network is used to provide online services to the general public.

» 1 January 1983: the ARPANET adopts TCP/IP, the fundamental protocol of today's internet. The usage of the internet expands to fulfill many governmental and academic interests.

» 12 March 1989: Tim Berners-Lee proposes the world wide web (www) in Information Management, a Proposal.

» 6 August 1991: Tim Berners-Lee publishes the first website on the internet.

» 2 October 1992: The Scientific and Advanced-Technology Act is passed, allowing the US taxpayer-funded internet backbone to "be used substantially for additional purposes" beyond research and education (i.e. commercial use).

» April 1995: the world wide web becomes the most popular protocol on the internet backbone (NSFNET 35).

» 30 April 1995: the public internet backbone (NSFNET 41) is officially decommissioned, marking the birth of today's commercial internet.

Net.art arrives in the early 1990s, after the invention of the world wide web and the legislative move to open the internet up for "additional purposes." Artists immediately created work that reflected the cultural milieu of the time. For example, as the internet started to shift from interoperable public spaces to siloed corporate spaces by the turn of the millennium, parallel concerns about the corporatization of the internet are reflected in prominent net.art artworks like *Toywar*[5] (1999) and the aforementioned *Airworld* (1999).

5. Toywar has been documented on Etoy's official site at http://history.etoy.com/stories/entries/49/index.html.

It can be difficult to see a technology's implicit political bias decades removed from its use. Today's centralized algorithms for search (Google) and social (Facebook) are fundamentally different than yesterday's homespun webring. Cultural artifacts are the best evidence of what kind of internet is not only possible, but just as plausible.

Available at: http://www.netart.today

References

Frazer, Karen D.
1995. NSFNET: A Partnership for High-Speed Networking, Final Report 1987-1995. Merit Network, Inc.

Hoffmann, Jay.
2020. "The Web's Timeline 1989-1994." The History of the Web. Accessed April 24, 2021. https://thehistoryoftheweb.com/timeline/?date_from=1989&date_to=1994.

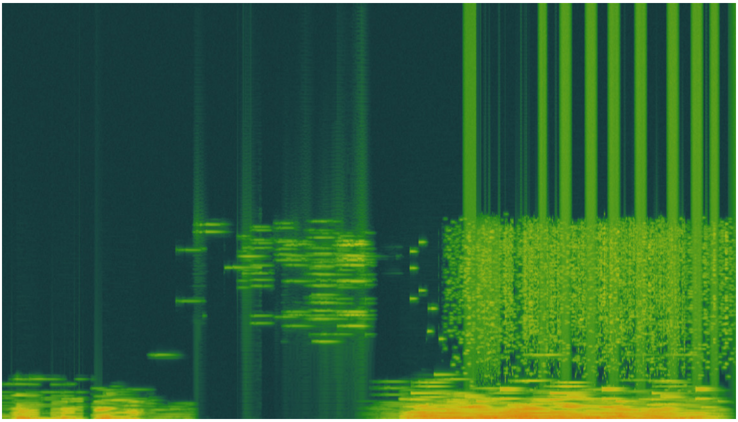
Le, Vivian.
2020."The Lost Cities of Geo." 99% Invisible. Accessed April 24, 2021. https://99percent-invisible.org/episode/the-lost-cities-of-geo/.

Murakami, Kenta.
2013. "The Demise of Net. Art: A Look at Artifacts Past." Digital America. Accessed April 24, 2021. https://www.digitalamerica.org/the-demise-of-net-art-a-look-at-artifacts-past-kenta-murakami/.

Shaban, Hamza.
2019. "Loss of Old Myspace Artifacts Highlights the Impermanence of the Web." The Seattle Times. Accessed April 24, 2021. https://www.seattletimes.com/business/loss-of-old-myspace-artifacts-highlights-the-impermanence-of-the-web/.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Jim Reeve-Baker
J.reeve-baker@sms.ed.ac.uk
University of Edinburgh, Reid School, Edinburgh, UK

Pink and Blue: Clusters and Layers of Time-Stretched Artefacts; Juxtaposition of Drones, Rapid Gestures, and Unaffected Blue Noise

Keywords: MP3, Data Compression, Artefacts, Noise, Composition, Aesthetics.

The work is part of a research project that is investigating the production and aesthetic of MP3 data compression artefacts and how they can be used for creative purposes. By cascading colours of noise and transient signals through MP3 encoders set to low bitrates and sample rates, effects and artefacts have been generated and act as the base material for composing with. Additional signal processing is kept to time stretching and arrangement, allowing greater opportunity in time and space to hear the artefacts. This work uses pink and blue noise and exhibits several compression effects, including birdies, bandwidth limitation, and signal gaps. The work seeks to explore the sonic possibilities of a process and aesthetic that is essential to and ubiquitous throughout digital communication, and attempts to harness a set of sounds whose creative potential can still yet be examined.

https://2021.xcoax.org/jrb/

Description

The research project, which this artwork is a part of, is investigating the sonic quality of MP3 encoded audio, creating compression artefacts and effects that are then used in the process of composing fixed media sound art and music. Through tests and experiments, artefacts and effects have been generated, analysed, and categorised, creating a taxonomy and indexes in the pursuit of understanding their characteristics and generation. Once created, these artefacts are used as the fundamental material for composing sonic works.

The sonic characteristics of the MP3 have been studied for decades from engineering (Erne 2001; Herrera Martinez 2007), cultural (Sterne 2006), and artistic perspectives (Bienoise 2018), but there are still areas to explore and understand. As digital communications become increasingly relied upon, particularly during recent periods of mass isolation, so this medium and its characteristics are increasingly consumed.

The compression artefacts that form the sound quality of MP3 audio include the reduction of complexity in noisy signals creating pitched artefacts called birdies; the amplification of quantization noise causing a pre-echo effect; inconsistencies in stereo encoding creating movement across the stereo field; delayed attacks at the beginnings of encodings; amplitude fluctuations in textures and decays; gaps and breakages in a signal; and bandwidth limitation caused by low sample rates or brick-wall filters built into the encoders.

These effects and artefacts were produced by subjecting noise colours and transient signals to multiple passes through an encode/decode cycle of the iTunes and Lame MP3 encoders, a process called cascading. The noise colours being used are violet, blue, white, pink, and red noise which have different amplitudes across their frequency range. While white noise has, on average, a flat amplitude across the frequency range blue noise increases by 3dB for every ascending octave and violet noise increases by 6dB for every ascending octave. In contrast, pink noise decreases by 3dB and red noise decreases by 6dB for each ascending octave. After their production these artefacts are then arranged, using compositional techniques developed by microsound and electroacoustic composers such as Curtis Roads (2001) and Denis Smalley (1997).

It is a goal of this project to contribute to a wider artistic practice which considers media as not only a transmitter but also a generator of sound, and by appropriating this sound, to seek out new relationships between transmission and generation. This project therefore follows in the footsteps of various artists who have sought to reframe extraneous sounds as the theme of their work.

These works include Music for *Blank Cassettes* (2018) by Phil Maguire wherein an ostensibly blank cassette is played back, exhibiting the format's sonic qualities; and Ryan Maguire's project *The Ghost* in the MP3 (Maguire 2014) which uses the audio that would be removed during the MP3 encoding process as its aesthetic focus. Additionally, the musician Pole has used damaged audio equipment to create idiosyncratic glitched loops in his records *1* (1998), *2* (1999), and *3* (2000), leaning into the agency of the machine and exploring the relationship between accidental and intended sounds; and, beginning in the early 1960s, Milan Knižák created new assemblages and collages of music by gluing sections of broken vinyl records together, exploring the limits and affordances of the format, resulting in the *Broken Music* series of works (1979, 1983, 1989).

Through analysis, amplification, and arrangement, this project seeks to work the thematic shifts described above – extraneous to intrinsic, ignored to heard, and accidental to intended – into the sounds and artefacts of MP3 compression, and in doing so attempts to bring these sonic qualities into a wider artistic discussion that repositions the medium at the centre of the work.

The Piece

The submission has been created using pink noise encoded at a bitrate of 8kbps and a sample rate of 24kHz, and blue noise encoded at bitrates of 8kbps and 16kbps and a sample rate of 24kHz, creating birdies, signal gaps, and bandwidth limitation.

The amplitude qualities of blue and pink noise have resulted in artefacts sitting in different areas of the spectrum. As pink noise has a higher amplitude in its lower frequencies, when it is encoded as above, artefacts are fixed within a range of up to 4kHz. Blue noise, however, has greater amplitude in higher frequencies, therefore after being encoded using parameters above, the artefacts sit in a wider range: from 500Hz to 11kHz, with greater concentration of artefacts above 4kHz.

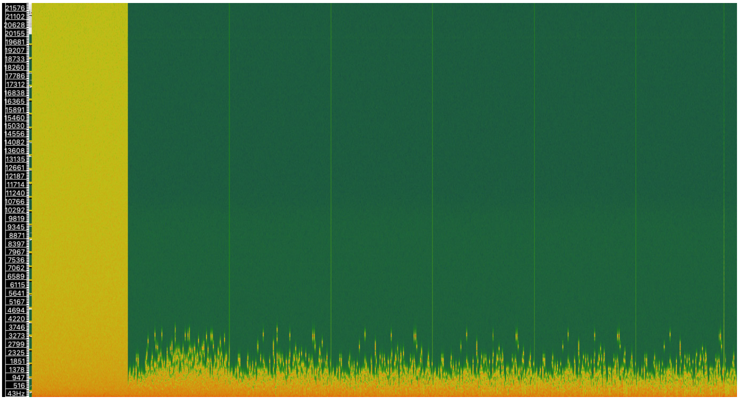


Fig. 1. Spectrogram showing a compilation of unencoded pink noise followed by six iterations of cascaded pink noise encoded at 8kbps and 24kHz. Bandwidth limitation can be seen between 0Hz and 4kHz, and birdies artefacts between 1kHz and 4kHz.

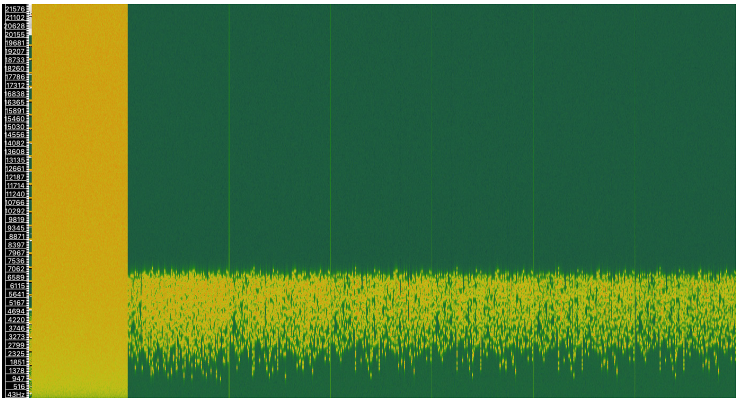


Fig. 2. Spectrogram showing a compilation of unencoded blue noise followed by six iterations of cascaded blue noise encoded at 8kbps and 16kHz. Bandwidth limitation can be seen between 500Hz and 11kHz, and birdies artefacts can be seen between 1kHz and 2 kHz.

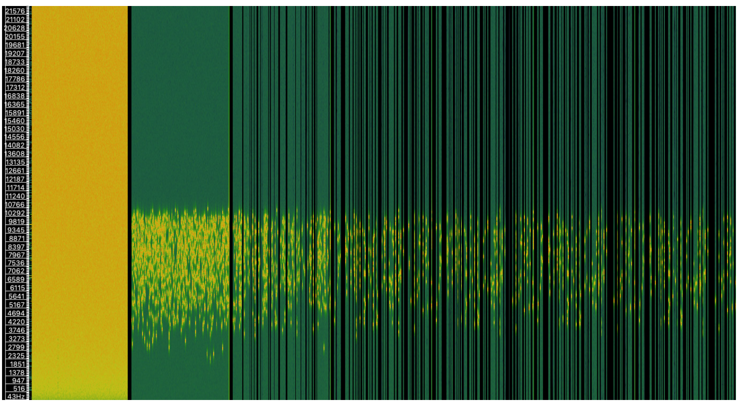


Fig. 3. Spectrogram showing a compilation of unencoded blue noise followed by six iterations of cascaded blue noise encoded at 8kbps and 24kHz. Bandwidth limitation can be seen between 2kHz and 11kHz, signal gaps can be seen throughout.

The two different bitrates of blue noise have created varied coarseness of texture. The higher bitrate of 16kbps results in a more continuous texture, while the lower 8kbps bitrate has a rougher sound made up of shorter artefacts, resulting in clearer, discrete birdies and signal gaps.

As the artefacts created in this process are on a micro time scale – that being ‘a time scale that extends down to the threshold of auditory perception (measured in thousandths of a second or milli-seconds)’ (Roads 2001, 4), many were time-stretched and arranged giving more time and space for their characteristics to be heard, to increase sonic variety, and to apply electroacoustic compositional techniques.

Layering artefacts, or series of artefacts, in their natural micro timescale, has resulted in shifting densities of rapid discrete artefacts exhibiting their textural and gestural qualities. By shifting artefacts time scales from micro to sound-object (a basic unit of musical structure, ranging from a fraction of a second to several seconds) to meso (groupings of sound objects into hierarchies of phrase structures, measured in seconds or minutes) (Roads 2001, 3), they could be arranged into various densities that change over time. These include clouds, clusters (Roads 2001, 14-17), streams, flocks (Smalley 1997, 116-117) and allow for greater exploration of artefacts’ morphological content, while also exploring their potential for sonic variation.

The clusters and layers of artefacts create sound masses of ‘sustained frequencies that fuse into a solid block’ (Roads 2001, 15). This is particularly effective with the sinusoidal qualities of the time-stretched birdies, and, as individual voices are added or removed, movement is created over a period of minutes, acting as a valuable means of structuring the composition. Artefacts were arranged in time and space using a DAW, which allowed for automated manipulation of the stereo field and amplitude of voices. This gave greater opportunity for artefacts’ properties and morphologies to be heard, while also creating a greater sense of motion and gesture within larger densities of sound.

The overall structure is split into three sections. The first two sections are made up of clusters of meso length artefacts created from pink noise in the first section and blue noise in the second section. The third section uses meso length pink noise artefacts acting as drones over which micro and sound-object length blue noise artefacts are layered. Bursts of raw blue noise appear throughout the third section, eventually acting as the final voice into which the other artefacts disappear.

Conclusion

The work explores the aesthetic of the MP3 format, regarding it not just as a transmitter or archival technology but also as a means of generating and affecting sound. By cascading signals, artefacts and effects have been stressed and amplified and act as the primary material for arranging and processing in the pursuit of composing sonic art and music. The artefacts and effects contribute to a sonic and musical vocabulary that is specific to compressed digital media, and is also an echo of artistic and musical practices that incorporate extraneous noises, ignored and accidental sound, and technological mediation. Using compositional techniques from microsonic and electroacoustic fields, the work investigates artistic possibilities of the effects and artefacts being generated through MP3 data compression.

References

Bienoise.
2018. *Most Beautiful Design*. Mille Plateaux, floppy disk, MP3.

Erne, Markus.
2001. "Perceptual Audio Coders 'What to listen for'". In *Proceedings of the 111th Audio Engineering Society Convention*, New York, USA. September 21-24, 2001. Convention Paper 5489.

Herrera Martinez, M.
2007. "Evaluation of Audio Compression Artifacts." *Acta Polytechina*, 47 (1): 12-16.

Knižák, Milan.
1979. *Broken Music*. Multhipla Records, Vinyl LP.

Knižák, Milan.
1983. *Broken Music.* Edition Hundertmark, Cassette.

Knižák, Milan.
1989. *Broken Music.* Berliner Künstlerprogramm des DAAD, Flexi-disc.

Maguire, Phil.
2018. *Folamh, endless*. Hemispharenokukyo, Cassette.

Maguire, Ryan.
2014. "The Ghost in the MP3." Paper presented at the 40th International Computer Music Conference joint with the 11th Sound Music Computing Conference: Music Technology Meets Philosophy: From Digital Echos to Virtual Ethos. Athens, Greece, September 14-20, 2014. http://hdl.handle.net/2027/spo.bbp2372.2014.038

Pole.
1998. *1*. Kiff SM & Matador Records, CD.

Pole.
1999. *2*. Kiff SM & Matador Records, CD.

Pole.
2000. *3*. Kiff SM & Matador Records, CD.

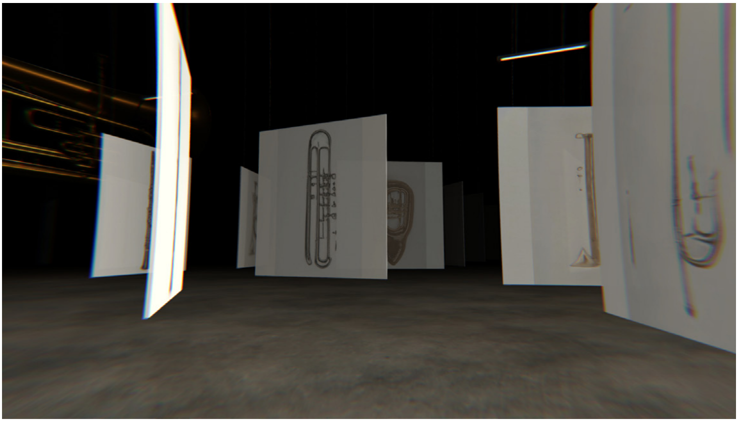
Roads, Curtis.
2001. *Microsound. London*, England & Cambridge, Massachusetts: The MIT Press.

Smalley, Denis.
1997. "Spectromorphology Explaining Sound-Shapes." *Organised Sound*. 2 (2): 107-26.

Sterne, Jonathan.
2006. "The mp3 as cultural artifact." *New Media and Society*. 8 (5): 825-842.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Jules Rawlinson
jules.rawlinson@ed.ac.uk
University of Edinburgh, Edinburgh, UK

w[i]nd: An Interactive and Generative Audio-visual Composition/Installation in Procedural and Orchestrated Space

Keywords: Aesthetics, Audio-visual, Generative Design, Immersion, Presence, Sound Art, StyleGAN, Virtual Environment

w[i]nd is an interactive and generative audio-visual composition / installation in procedural and orchestrated space. This project aims to be a rich and immersive visual and sound art experience in a first-person Virtual Environment (VE). The VE consists of an array of audio-visual exhibits of images of wind instruments created by generative image synthesis techniques coupled with samples of physically modelled synthesis and processed acoustic recordings that exhibit a range of characteristics of augmentation and abstraction. In addition to the displayed exhibits, there are a number of very large-scale three-dimensional models of conventional wind instruments emitting untreated sustained tones typical of these instruments that reciprocally contrast with and comment on the synthesised sounds and images. First person motion, underlying algorithmic parameters and triggers on exhibits are used as a mechanic to influence the sonic density and character of the experience. Among other things, the work explores open sonic form, timbre and character in non-linear interactive experiences and contributes to research into the use of sound and sounding objects as an approach to presence and immersion, orientation, navigation, interaction and "ergodic musicking" (Oliva 2019) in VEs.

https://2021.xcoax.org/jra/

Description

w[i]nd is a virtual sound and image installation that brings sound, images and interactions together at scale to create a participatory and dynamic audiovisual work (Rawlinson 2020).

Procedural space is used as a term to describe the algorithmic and generative variety in sound and image as a function of space, and to account for responses to interaction with space through real-time, programmatic parameter control of sonic output. Orchestrated space is used as a term to describe the fixed spatial arrangement of musical register and timbre across the VE. The work is a walking simulator built with Unity and Wwise game audio technologies and it is informed and inspired by historical experimental spatial composition and open and mobile form works, and recent immersive sound and image installations.

Effort is required to navigate the work's fragmented audiovisual landscape as an act of "ergodic musicking" (Oliva 2019) in which the user plays a participative role in the construction of their experience of the work as they traverse space, blurring the role of composer and performer in the reconfiguration of soundscape. The simulation of a gallery space for the VE is a meta-place that combines characteristics of real space and computer-generated navigable space. The framing of the VE by the computer screen brings immersion at a cinematic level, through the composition of the exhibits in two-dimensional space. The virtual visitor has agency to explore and wind their own way through the VE which is rich with both perceptual and emotional affordances through unfolding audio-visual narrative.

In this VE users are involved and included in a mediated perceptual experience that aims to cause a subjective sense of presence as, and through, sensory immersion and transportation. Factors of presence and immersion are designed into the work as a methodology. Presence causing form variables in the work include: number, scale, dimensionality, resolution, colour and field of view of visual elements; number, spatial realism, frequency range and dynamic range of sonic elements (Lombard and Ditton 1997); natural real-time interaction, consistency of multimodal information, scene realism, environmental richness, movement perception and degrees of control (Witmer and Singer 1998). The virtual character of the work allows for many more spatial sound sources than would generally be possible in real life, and a controlled experience. Through considered visual staging, fixed and aleatoric combination of sound, and motion and proximity-based mechanics and processes the scope, integration and resolution of the work is extended in terms of audiovisual impact and immersive effect.

The starting point for the work was image synthesis of hybridized, augmented and imperfect simulacra of wind instruments using Style-Based Generative Adversarial Networks (Karras, Laine and Aila 2019) with a dataset of images of wind instruments held by the University of Edinburgh's musical instrument collection. The features in the images that are generated are at times smeared and simplified, at others glitched, complex and distorted, or liquid and abstract. Overall there's a painterly quality in the colour, stroke and texture to the generated images that reflects impressionist modes of music and sound. The visual work includes images from a number of training stages, where new models were created from the output of a previous model as a recursive feedback process, further amplifying the learned features, biases and errors in the neural representational latent space.

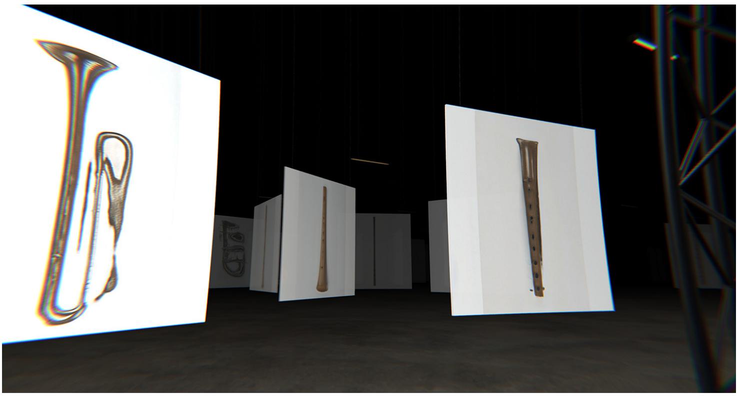


Fig. 1. Screenshot of *w[i]nd* Virtual Environment.

A sample library of physically modelled synthesis was created as a sonic response to the visual qualities of the generated images, both in terms of their likely acoustic character as simulacra of woodwinds or brass instruments, but also in respect of the aesthetic properties and features of the images so that pitch, amplitude and timbre are unstable, with rapid spectromorphological shifts between sustained material, sliding tones and fluttered and transient gestural articulations. The work also makes use of processed and untreated recordings of wind instruments to further extend the sonic character of the work.

The synthesized images are displayed as photorealistic exhibits that are procedurally hung in a large virtual exhibition space with an industrial character that in real world measurements would be 500x 500m in dimension with a labyrinthine procedural distribution of irregular large open areas and smaller pockets of space that connect and separate dense clusters of exhibits. These open spaces offer some relief to the scale and density of the image exhibits, but can also be disorienting due to the variation in form and opacity of the surrounding images and the low light levels in the VE.

Each exhibit emits highly localized audio (best experienced via headphones) of varying stability of pitch, amplitude and timbre triggered by first-person proximity.

The audiovisual exhibits are clustered, dispersed and rotated such that the visitor is granted multiple viewpoints and points of audition, and the exhibits often prevent the user from moving in a linear, straightforward way forcing spatial interaction. The image exhibits are double sided allowing for multiple dialogues as exhibits are rotated to often face more than one other image, allowing for metamorphosis of experience, as the images and sounds are combined, compared and considered by the virtual visitor, and present themselves in new ways. There's a blurred audiovisual diegesis through the juxtaposition of various orders of reality, simulacra and abstraction together with audiovisual relationships that are observed through the "spatial magnetization of sound by image" (Chion 1994, 70) as users attempt to locate or relate sound sources to what's visible to them.

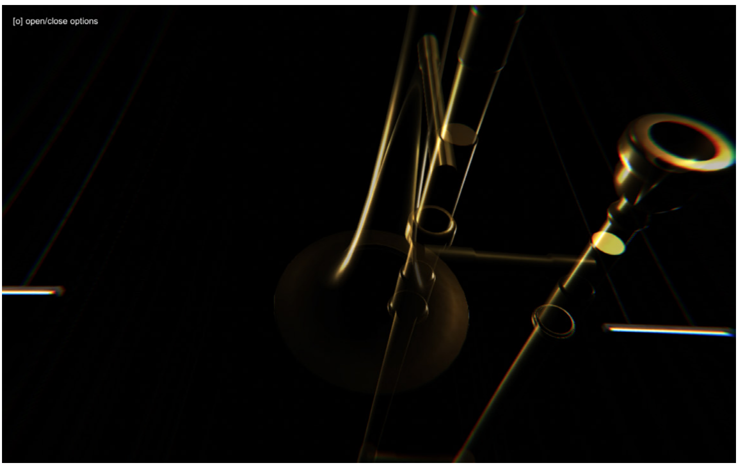


Fig. 2. Screenshot of w[i]nd Virtual Environment – Overhead instrument.

Three-dimensional models of wind instruments of partly-transparent, saturated character are hung overhead at significantly larger than life scale. These models regularly emit untreated sustained tones typical of these instruments. Density of audio events increases with proximity, and sounds travel across moderate distance in the VE, allowing users to orientate themselves and navigate by sound. The positioning of these models results in variation in timbre and register as a form of orchestration in space. Parameterized filtering and reverberation effects extend perceptual spatial characteristics. Stochastic and aleatoric generation of audio events leads to clusters of extended harmony and ambiguous tonality.

A smaller number of exhibits that are different in character to the main images, instruments and each other, are present in pockets of space. These exhibits are obscured and revealed by virtual visitor movement, and draw attention through contained active motion, staging and sound. Proximity triggers on these exhibits switch layers of audio on and off, extending indeterminate compositional scale and structure.

A final group of audio emitters playing constantly looping material of longer duration are randomly distributed throughout the space. The spatial experience of these emitters sits between the highly localized experience of the image exhibits and the more distant models, and the character is often highly unstable in terms of pitch, amplitude and timbre throughout the loop. In addition to the emitter outputs, audio is fed into a low-level processing chain of doppler and granular effects. The depth and value of these effects are affected by real-time parameter control dependent on first-person location and motion.

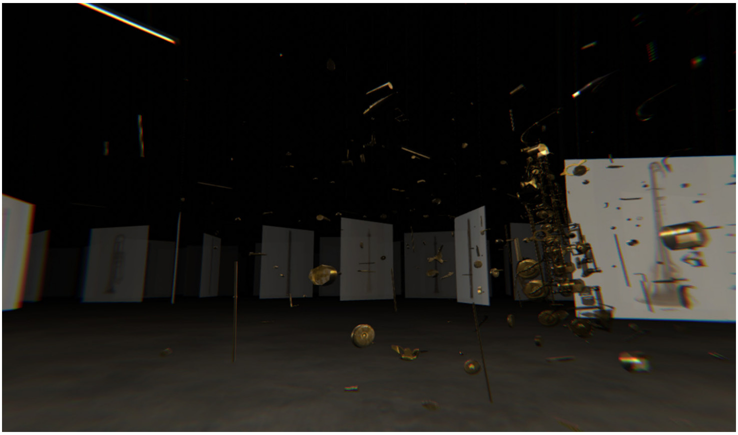


Fig. 3. Screenshot of *w[i]nd* Virtual Environment – Exploded granular saxophone.

Anecdotal feedback from users has so far been positive including comments such as "a convincing and coherent physical space with dynamic, fluid content that is responsive to gazing and micromovement". One user said "there's a clear connection between space, motion and sonic output… a good range of musical events and gestures makes the environment come to life… it responds in surprising ways… there's always something new that makes you want to keep exploring and looking for surprises". Another noted "the spatial arrangement of the visual and also auditory components was compelling, motivating me to spend more time within the installation that I might have done."

The work presented here combines natural and exploratory modes of interaction and degrees of control in a multimodal presentation offering movement perception, environmental richness and scene realism. The experience is dynamically configured in space and time. Open spaces and stable sounds act as connectors giving shape to the experience, while clustered and variable elements demand attention and focus or invite curiosity and may be seen as attractors and retainers through "perceptual opportunities" (Fencott 2005). Overall, the approaches taken in developing the work have resulted in an immersive and engaging experience with characteristics of agency and presence.

Standalone applications for Mac and PC are available at : https://pixelmechanics.itch.io/wind.

References

Chion, Michel.
1994. *Audio-Vision: Sound on Screen. New York*, NY: Columbia University Press.

Fencott, Clive.
2005. “A Methodology of Design for Virtual Environments.” In *Developing Future Interactive Systems*, edited by Maria-Isabel Sanchez-Segura, 66-91. London: Idea Group Publishing

Karras, Tero, Samuli Laine, and Timo Aila.
2019. “A Style-Based Generator Architecture for Generative Adversarial Networks.” Paper presented at 2019 *IEEE/CVF Conference on Computer Vision and Pattern Recognition* (CVPR), Long Beach, CA, 15-20 June 2019. https://doi.org/10.1109/CVPR.2019.00453

Lombard, Matthew, and Theresa Ditton.
1997. At the Heart of It All: The Concept of Telepresence. *Journal of Computer Mediated Communication*, Vol. 3, No. 2, September 1997. https://doi.org/10.1111/j.1083-6101.1997.tb00072.x

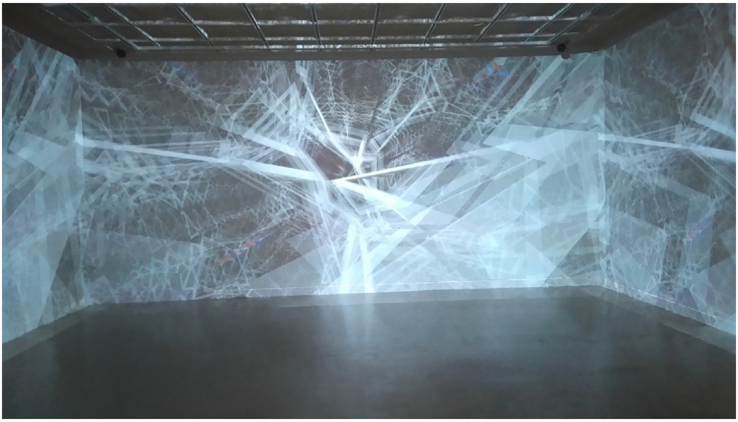
Oliva, Costantino.
2019. Musicking with Digital Games. Paper presented at DiGRA 2019 *Game, Play and the Emerging Ludo-Mix*, Kyoto, Japan, 6-10 August 2019.

Rawlinson, Jules.
2020. *w[i]nd* [Unity Standalone Application]. https://pixelmechanics.itch.io/wind

Witmer, Bob G., and Michael J. Singer.
1998. “Measuring presence in virtual environments: A presence questionnaire”. *Presence: Teleoperators and Virtual Environments*, 7(3), 225–240. https://doi.org/10.1162/105474698565686

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Robert B. Lisek
lisek@fundamental.art.pl
Institute for Research in Science and Art, Wroclaw, Poland

Karolína Kotnour
kotnokar@fa.cvut.cz
Faculty of Architecture, CTU, Prague, Czech Republic

Suprasymmetry

Keywords: Environment, Evolutionary Strategy, Flow, Intelligence, AI, Immersion

Suprasymmetry is a project that deals with AI and dynamic immersive environments. I use neural networks to explore non-euclidean geometries and sound spatialization. I have developed machine learning methods that extend granular and pulsar synthesis in composing and new methods of building and transforming virtual environments. I was particularly interested in the problem of presence and flow in virtual environments. The project proposes a new strategy for creating evolving structures based on the idea of adaptation to a dynamically changing environment and with the use of advanced machine learning and AI methods. The evolving architecture uses physical and virtual processes that are transformed and assembled into structures based on environmental properties and capabilities. The project investigates a living dynamic system as a complex set of natural and cultural sub-processes in which each of the interacting entities and systems creates complex aggregates. It deals with natural processes, communication flows, information networks, resource distribution, dense noise masses, a large group of agents and their spatial interactions in the environment. By significantly expanding existing research, the project creates a meta-learning model useful for testing various aspects of adaptation to a complex dynamic environment. This refers to the difficulty of designing artificial agents that can intelligently respond to evolving complex processes.

https://2021.xcoax.org/rli/

Description

The article is organised as follows. The first part focuses on the concept of a dynamic environment. Then the concept of an evolutionary architecture is introduced based on the ideas of adaptation to environmental changes. Popular machine learning algorithms and neural networks have a limited range because they deal with individual tasks and are not sufficient for modelling complex adaptation processes. Therefore, we propose an approach based on advanced methods such as meta-learning, in which the knowledge gained to solve one task can be generalized and applied to many other tasks. We present the applications of meta-learning to analyse and create architecture and art. We test our framework in the form of an immersive installation.

Dynamic Environments

In our view, urban and architectural structures are complex multi-dimensional structures in which natural processes and interactions of large groups of agents, communication flows, information networks, and others are intertwined. The above structures undergo continuous transformations. A dynamic environment is any space that surrounds us and the structure of which changes over time or is modified by groups of agents. There are closed spaces with relatively well-defined boundaries and others that do not have well-defined boundaries, which we can call open spaces. These environments are usually rich, complex, unpredictable, and can generate significant "noisy" data, unstructured and sometimes very dynamic changes.

Adaptation

Evolving Architecture uses the features of natural design processes and relies on dynamic adaptation to environmental changes (Frazer 1995). The analogies of evolving architecture should be understood not only in terms of the applied natural processes of development of forms through natural selection, but also in the restless tendencies towards optimization and self-organisation that significantly improve the efficiency and power of diverse prototyping. Architecture is designing for survival, designing for life, and emphasizes the need for a responsible approach to the transformation and formation of energy and materials. The solution to dynamic environmental problems is to link architecture with a contextual understanding of the structure of nature. At the same time, in computer science, methods inspired by the process of natural selection such as genetic algorithms have been developed widely, e.g. design, games, image processing and robotics. Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on biologically inspired operators such as mutation, crossover and selection. A particular example is Hyper-NEAT (Stanley 2009), which we used to transform 3D objects. The principle of the algorithm is the simple weight evolution in a topologically static neural network (CNE) or the evolutionary adaptation of the covariance matrix (CMA-ES) strategy, to the weight and topology evolution (NEAT) and intermediate weight coding (HyperNEAT). All algorithms encode artificial neural networks (ANNs), which are represented by weights and connectivity (also called topology). The first two algorithms only search the ANS weights, while the last two can also modify the topology.

Evolutionary Strategies and Meta-learning

Deep artificial neural networks (DNNs) are multilayers networks of nodes and connections between nodes (weights) typically trained via gradient-based learning algorithms, namely backpropagation (LeCun 2015). The next step was to research and implement Evolutionary Strategies, which means transformation of architectural objects in time. This can be done by modifying selected layers in the neural network or by using the population-based genetic algorithm (GA). We evolve the weights of a Deep Neural Network by applying additive Gaussian noise in such a way that the general features of the training class of 3D objects are kept, but its evolution is possible. We created a mechanism for controlling hyperparameters of the neural network and ipso facto for controlling generated output numbers that represent new geometry. In this way it is possible to create a fully universal 3D object generator, and propose a new method of designing complex original art and architectures. Evolution strategy described above is a step toward research focused on the self-organization of complex structures from random elements. This method is general enough to become the starting point for meta-learning research and creating universal toolkit that supports artists, architects and designers.

Working with large data sets obtained from a changing environment requires advanced machine learning methods. We tested various AI methods for modelling and generating new architectural forms. In particular, we use Transformers that work by using convolutional neural networks together with attention models, making them much more efficient than previous models. We have previously tested recurrent neural networks RNN, long short-term memory networks LSTM and VAE variational autoencoders (Lisek 2020). The transformer model is a seq2seq model which uses attention in the encoder as well as the decoder.

Transformers have been used for many (conditional) sequence generation tasks, such as machine translation, constituency parsing, protein sequence generation and can be used for architecture design. Transformer models consist of an Encoder and a Decoder. The Encoder takes the input sequence and maps it into a higher dimensional space (n-dimensional vector). That abstract vector is fed into the Decoder which turns it into an output sequence. The output sequence can be in any sequence of numbers, symbols, etc. The attention-mechanism looks at an input sequence and decides at each step which other parts of the sequence are important. Self-attention, is an attention mechanism relating different positions of a single sequence in order to compute a representation of the sequence. Self-attention can be intuitively explained using a text example, when reading this text, you are temporarily focusing on the word being read, but at the same time your mind still keeps the important keywords of the text to provide context. In our research we worked with sequences of numbers that represent 3D object as positions of its particles/elements and velocity (Vaswami 2017).

Our approach for analysing and creating evolving architecture is based on meta-learning. Meta-learning is the next generation of artificial intelligence systems. Meta-learning goes by many different names: learning to learn, multitask learning, transfer learning, zero shot learning, etc. People easily transfer knowledge acquired in solving one task to another more general task. This means that we naturally recognize and apply previously acquired knowledge to new tasks. The more the new task is related to our previous experience, the easier we can master it. In contrast, popular machine learning algorithms deal with individual tasks and problems. Transfer learning attempts to change this by developing methods to transfer knowledge acquired in one or more source tasks and using them to improve learning in a related target task. The goal of transfer learning is to improve learning in the target task by using knowledge from the source task. Techniques enabling knowledge transfer will constitute significant progress in AI and art.

We have developed a learning strategy for a set of neural network modules that can be combined in various ways. We train different modular structures on a set of related tasks and generalize to new tasks, composing the learned architectural modules in a new way. For composing, we use concatenation, addition and product operators. We quickly learn something about a new task based on previous tasks without training our model from scratch. Our system finds two or more suitable modules that can be combined as optimal solution for a new task.

Fig. 1. Evolutionary strategies.

Immersive Installation

An interesting direction of research on contemporary art and architecture is related to the problem of immersion, creating virtual environments and sound spatialization. Virtual environments also provide an excellent space for testing machine learning methods. Restrictions introduced during the pandemic motivated me to research potential of AI and virtual architecture for the evolution of society. Our research was focused on a role of Presence, Flow, Immersion, and Interactivity. We were particularly interested in the problem of presence and flow in VE. Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another. Presence is a normal awareness phenomenon that requires directed attention and is based in the interaction between sensory stimulation, environmental factors that encourage and enable immersion. Flow is a state of experience where someone is completely absorbed and immersed in an activity. We researched relations between presence, adaptation and interactivity, e.g., how interactivity and adaptation improve the experience of presence. We tested our meta-learning approach as immersive installation and VR. We studied how various new methods of operation in virtual architecture can influence future social structures. We created immersive architectural installations that were presented during *Siggraph Asia 2020* and at Institute of Electronic Arts.

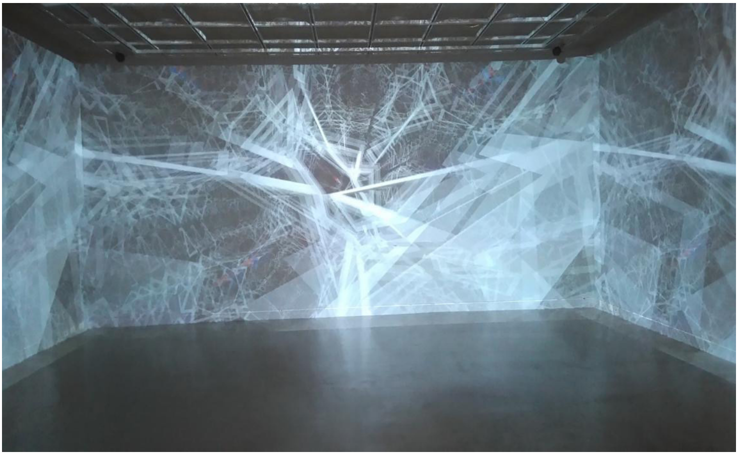


Fig. 1. Suprasymetry, immersive installation, detail http://fundamental.art.pl/SUPRASYMMETRY.html

Space-time Synthesis

The project focuses also on synthesis of time and space. Breaking symmetry creates new time and space. A space created in the project is never static and is constantly changing. Space is never something given, but rather the result of an empirical body that determines the timing of its actions. Space emerges from the unpredictability of becoming as a series of potential expressions of pure movements, defined as differentiations. It is a process of becoming, that is, not a unity of predetermined systems or a crystallised structure, but a constantly evolving assembling and unfolding mechanism. There is no division between the performer and the environment. The "inner" space is topologically in contact with the "outer" space. The flow from the outside to the inside, in various scales and dynamics. The external is not a fixed boundary, but a moving, vibrating matter. Pulsar quantisation of time and space, mass of pulsating particles and sound events transform the performance space. The performer now begins chasing vibes, causing a new series of interactions and shifts. Spatial transformability. It is a transforming and transmuting system that is constantly evolving. Everything is involved in the continual process of transforming into something else – everything is opened up and put together. Multidimensionality. Composing events and spaces into other spaces. A hyper-dimensional space in which the horizon or axis system does not exist. Performances and installations conceptualise an experiential, living, vital body. The body is a multiple pattern that tries to gain stability through action. Bodies transcend time by acting, entering time, and connecting with other bodies and their activities. The space is revealed only as a result of synchronisation and connection.

Future Research

The goal is to create new support tools in the form of software for researching and developing adaptive architecture and art. The above research is fundamental to an art and architecture of the future that will be well adapted, in particular a flexible safe architecture that accommodates mass migrations and crisis situations such as pandemics. It is also necessary to create large groups of researchers, architects and urban planners that change and adapt the architecture of our cities and suburban to the new needs of their inhabitants. I research more flexible and general algorithms that adopt to many tasks (Liquid Time-constant Networks). Usually, a neural network's parameters are locked into place after training. In contrast, in a liquid neural network LTCN, the parameters are allowed to continue changing over time and with experience. The resulting models represent dynamical systems with varying time-constants coupled to their hidden state, with outputs being computed by numerical differential equation solvers.

References

Frazer, John.
1995. *An Evolutionary Architecture*, London: Architectural Association Publications.

Holland, John H.
1992. *Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence*. (1st ed.), Cambridge, Mass: M.I.T. Press.

LeCun, Yann., Bengio, Y. & Hinton, G.
2015. "Deep learning". *Nature*, 521 (7553): 436-444. Available at: http://www.nature.com/articles/nature14539 [Accessed January 03, 2021].

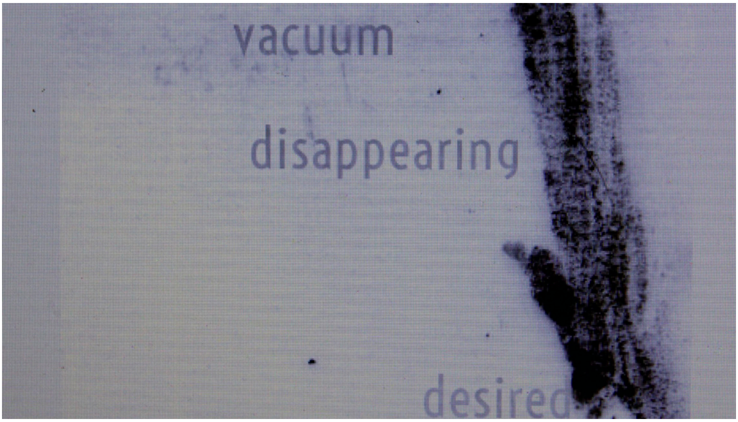
Lisek, Robert B.
2020. Meta - Composer. Report. Institute of Advanced Study, CEU.

Stanley, Kenneth O., D'Ambrosio, D.B. & Gauci, J.
2009. "A Hypercube-Based Encoding for Evolving Large-Scale Neural Networks". *Artificial Life*, 15 (2): 185-212. https://www.mitpressjournals.org/doi/abs/10.1162/artl.2009.15.2.15202 [Accessed January 03, 2021].

Vaswami, Ashish et al.
2017. "Attention is all you need". In *NIPS'17: Proceedings of the 31st International Conference on Neural Information Processing Systems*, 6000–6010. New York, USA: Curran Associates.

Hanns Holger Rutz
rutz@iem.at
University of Music and Performing Arts Graz, Institute of Electronic Music and Acoustics, Graz, AT

Nayarí Castillo
castillo-rutz@tugraz.at
Graz University of Technology, Institute of Spatial Design, Graz, AT



In|fibrillae

Keywords: Reconfiguration, Unravel, Web Audio, Personal Space, Sound Art

This audio-visual web piece explores the possibilities of defining a new type of personal aesthetic space in the audience's browser, reconfiguring and transposing a former interactive multi-channel installation piece for a physical 100 m² space. How can the underlying principles of filtration, fibres and latent sonic spaces be applied to this new type of space? How can a meaningful sound art experience be created for personal laptops and desktop computers, an experience that one wants to return to, surviving the short-lived attention economy of the screen space and the crowded browser tabs?

https://2021.xcoax.org/hru/

Description

In|fibrillae is a reconfiguration of an audio-visual installation for a real space into the online browser space. It unravels the previous piece into hundreds and thousands of small fibres, in order to transpose the original materiality for a personal space at somebody's home.

Its origin is the piece *in|filtration* that was conceived for esc media art lab Graz in 2020, placing twelve rows à four widths of fabric, 48 speakers and 96 infrared sensors in the space. The driving question for the new piece is, how elements of such a specific and physical structure can be selected and poetically transformed to make (new) sense for an audience that "opens" the piece, possibly in their private surroundings, in a browser tab, while preserving some of the conceptual underpinnings of the originating piece. Almost everything speaks against such a reconfiguration: You can no longer walk around in a large and open space, flooded by daylight, surrounded by the city, to discover the localised sounds in the room. You now find yourself in an unknown, personal, individual space, perhaps with headphones or your home stereo, and the small visual rectangle of your laptop's or desktop computer's screen.

Where it Comes From

To understand the new piece, we first want to describe the originating scenario, which is also documented online.[1] *in|filtration* was a collaboration between the EU project MAST (Master Module in Art, Science and Technology) at the Institute of Spatial Design of TU Graz, and FWF project Algorithms that Matter (Almat) at the Institute of Electronic Music and Acoustics (IEM) of KUG Graz. During the workshop *Algorithmic Space Studies* (2019), students of MAST were tasked with developing prototypes for a space installation in esc media lab, learning about algorithmic processes, and preparing for the presence of a sound installation within the space. Based on one of the prototypes, a grid situation of gradual visual filtering and accompanying fabric materials was selected (Fig. 1).

1. https://www.researchcatalogue.net/view/711664/711665 (accessed 12-Apr-2021).

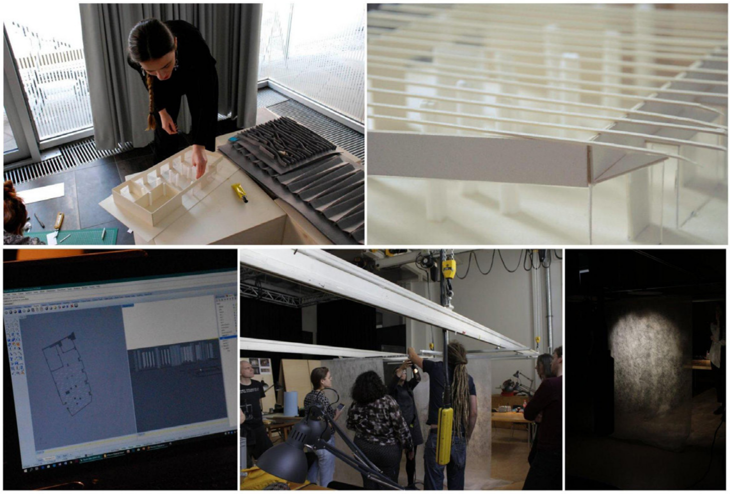


Fig. 1. Top: Model prototype during the workshop. Bottom left: CAD model of the visual prototype. Bottom centre and right: Testing the fabric material in the light laboratory.

The conceptual frame for the compound piece was the question of algorithmic segmentation and its potential for a positive interpretation of societal segmentation. Segmentation is a core principle of analysis in many different disciplines, such as biology (literally to disassemble organisms, but also the sequencing of DNA), in music and phonology (to structure the stream of sound), or in informatics (to formulate and implement an algorithm). It is also an artistic operation, ranging from film cut to the sampling of sounds and other existing materials. What we are interested in this project is to understand the segmentary, not as an expression of isolation or fragmentation, but on the contrary, as a decentralised surface of "fitting pieces" whose meaning emerges through assembly by the audience.

How can exchange happen between otherwise disconnected and uncommunicative segments? We introduce the notion of persistent and inconspicuous processes of exchange, leakage, filtration, grafting of xenomorphic elements onto others. Surfaces and membranes between adjacent actors and systems are not only regarded as forms of dissociation, but as partially permeable layers, thus allowing imaginings, signals, materials, light and sound to propagate and melt the identities of the separate. A translucent and sensorial space body acts as a vessel for sound structures that migrate between two seemingly opaque computer systems. Space is seen as a basic precondition, not just for architecture, but also for our lived environment. The physical space is interwoven with an algorithmic space, sounding and sensing its environment. Algorithmic space is not primarily the result of form generation but of an intrinsic speculative movement and the interaction with humans who write code and experiment with it. Making visible and audible the exchange processes between humans and machines becomes a means of critically articulating this space (Fig. 2).

Fig. 2. Installation views.

The sound composition translates two mutually coupled systems used in the improvisation project *Anemone Actiniaria* (Rutz / Pirrò) into the installative context. Instead of two human performers, the two systems are replicated six times each, and augmented with processes that act as simple autonomous improvisers themselves. The departing point again is space and spatiality: first, there is the distinction between a common space and an individual (or inner) space. The common space is what is shared as structure between Rutz' six nodes. This is a repertoire of forms; forms of topology in the sense of a sound situation in *SoundProcesses* — the system Rutz uses for improvisation — a graph of connected nodes. The individual space is opened through genetic programming of synthetic sounds. The identity is divided into a given form of a "trunk space", and a reflected one through the introduction of sensor data. The "trunk space" is obtained from digital scans of drawings created from tracing tree trunks on wax paper. These drawings were previously used as one component of the video piece *Inner Space*. Now the scans were algorithmically transformed into sounds which served as targets or attractors to the genetic programming of sound synthesis structures, each row in the space associated with one trunk drawing. The signal processing repertoire is constrained to "rectangular forms" (rectangle and impulse waveforms), frequency filtering, and non-linear filtering and distortion, to create a correspondence with the visual and the conceptual space of the piece. The structures thus obtained were algorithmically augmented with input points that spatially extend the sound and allow it to be modulated by the sounds coming from the neighbouring nodes in the space (microphones pointing outside the gallery are used at the ends of the line). The sensor data is used to issue transformations on the *SoundProcesses* structure, for example altering the balance between the neighbouring nodes, or inverting (flipping) parameter ranges (Fig. 3).

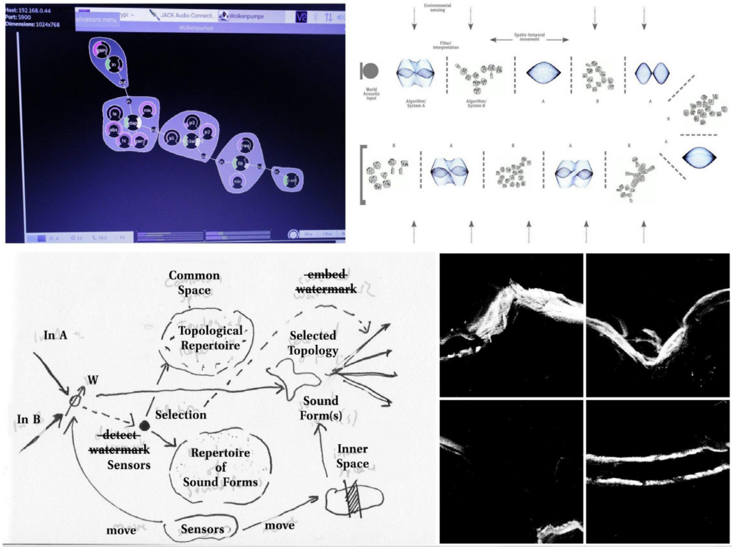


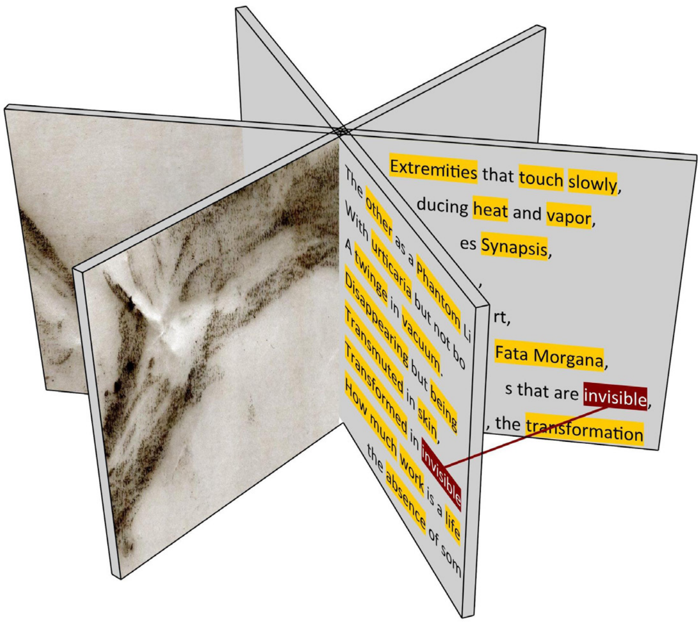
Fig. 3. Elements of sound composition. Top left: Wolkenpumpe / SoundProcesses improvisation interface of one node. Top right: Original 6+6 interleaving of two systems. Bottom left: Basic algorithmic spaces and procedure per node ("watermarking"-grafting had been removed for simplicity). Bottom right: Frames from invisible "trunk space" that directs the genetic programming.

Where it Went

The new piece is documented online[2] and accessible at https://www.sciss.de/exp/infibrillae/. It is a conscious transformation of the originary visual and auditive scene. Sonically, it focuses only on one of the two algorithmic sound systems (*SoundProcesses*), and reinterprets its gestures under the new acoustic and spatial conditions. Instead of a matrix of movement sensors, different subtle ways are probed as means of "walking" through the virtual space or corpus of sounds.

Fig. 3. https://www.researchcatalogue.net/view/711664/1111185 (accessed 12-Apr-2021).

The scanned images of the tree trunks are explicitly used as visual material, indicating six spaces through which one can move. At any one moment in time, the visitors find themselves in one of these audio-visual spaces, shown as a square "window" into a larger underlying virtual surface. Each space is also identified by a set of poetic words that appear and disappear in the “trunk surface”. The visitors can either consciously move the cursor around to explore the sounds and words, triggering invisible sensory regions that influence the sound, or simply observe what is happening, as the system slowly starts to move by itself. The poetic sets contain bridging words that cause the piece to move into an adjacent space. Conceptually, the six spaces form a sort of carousel, as depicted in Fig. 4



Technologically speaking, the developments of browser capabilities, in particular the introduction of the *Web Audio* API and the *Web Assembly* virtual machine, make it possible to run ambitious real-time generative sound pieces in the browser. In the end of 2020, we ported the *SuperCollider* sound server (*scsynth*) to this new technology, allowing *SuperCollider*-based sound pieces to run on the audience’s browser without the need to stream audio from a web server. In a second step, Rutz’ computer music framework *SoundProcesses* was ported to the browser as well, allowing a translation of the original installation code base to the new situation. While an obvious approach for transporting sound pieces would be to setup the software on a server, and understanding the server as a kind of remote space that is statically present like a virtual gallery one can visit any time, *in|fibrillae* makes a deliberate decision to run purely on the front-end side of the browser, exploring this volatile "space" that is created ad-hoc as a person opens the project's URL in a tab. Using local storage, the piece's state is not only individualised for everyone who visits the project, but one may return to the piece at a later point in time and find it in a similar state as one left it. *in|fibrillae* plays with this volatile permanence.

Acknowledgements. *in|filtration* was supported by the European Commission, the Austrian Science Fund (FWF AR 403-GBL) and Stadt Graz Kulturjahr 2020. Original credits: Sound composition – Hanns Holger Rutz, David Pirrò. Visual composition – Xhylferije Kryeziu, Carolina Silveira, Gaja Znidarsic. Mentors – Nayarí Castillo, Franziska Hederer, Carlotta Bonura. Sensors – Richard Dank. Light – Alexander Krug.

Available at: https://www.sciss.de/exp/infibrillae

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Nima Bahrehmand
nima.bahrehmand@colorado.edu
The University of Colorado, Boulder, United States

Study of a Movement

Keywords: Social protest, Police violence, Video Installation, AI motion Tracker, Motion Capture, Performance, Re-enactment

Study of a Movement is an artistic research project that attempts to create a multi-channel video installation in which viewers will be able to observe police violence in social protest in different reframing experiences. The project will consist of three different forms of moving-images: 1) the original video documentation overlaid with AI-generated skeletal animations; 2) the secondary documentation of performers reenacting the original movement; and 3) the tertiary video rendering of the performance through motion capture. By creating a diverse visual interpretation, this project aims to generate for viewers an experience of violence in social protest in which race, gender, culture, class, and geography are decentered. By applying AI motion trackers to the footage, one can see how the machine understands embodied movement in twisted social confrontations. At the core, this project asks, "Does the AI even care?" Furthermore, by juxtaposing all the aforementioned visual components, this project bridges the gap between AI training (understanding) and body training (teaching) of human interaction.

https://2021.xcoax.org/nba/

Description

The *Study of a Movement* project contains three sets of videos. The first is a collection of AI motion tracker analysis of violent police footage gathered from social media (Fig. 1). The second is documentation of performers reenacting the found footage (Fig. 2). Finally, the third type consists of animation of the performers' bodies from the reenactments of the footage (Fig. 3). The original footage will include street fights, protests, as well as confrontations between the public and police, with the aim of comparing and analyzing such social inter-actions. In addition, I will incorporate a series of animations by using motion capture of performers reenacting the offensive moves in the street fighting and protest recordings. The final output forms a third and important aspect of this project where the motion-captured characters are stripped of their original cultural and operational significance.

Fig. 1. AI motion tracker analysis of footage.

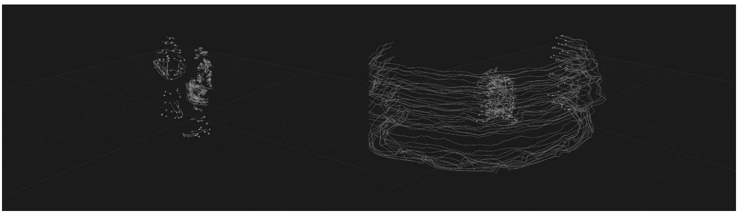


Fig. 2. Docume.ntation of re-enactments.

Fig. 3. Mocap animation of re-enactments.

It is essential to point out that the elements of this project will be drawn from the content of videos gathered from social media mainly focused on social unrest. While the camera is currently the main tool for recording the truth, the reality is that this 125-year-old device currently acts as a politicized apparatus rather than a device for the multitudes. Thus, it rarely captures necessary images. Among the thousands of documentary and fictional images, these are the fleeting moments and seconds that capture the brutality of regimes, the atrocities of usurpers, and the slaughter of conquerors. As an example, there is a picture of a twelve-year-old Palestinian boy, Muhammad al-Durrah, lying in his father's arms, stuck in the middle of a military confrontation in which he has killed. Another example is the dismal glance of a teenage girl looking at the Nazi film camera before she was taken to a death camp. In general, the protest images that are recorded and broadcasted by people on social media look similar to the above examples. However, there is a fundamental difference: they were both recorded by those who were not in danger. The Muhammad al-Durrah video was captured by a France 2 cameraman and the film about the death camps was made by an SS cameraman. In contrast, in the protest recordings, those who record the images are just as endangered as the people in their frames.

It is usually coincidence and fate that captures moments like the protests as if they were the reality itself that came to the lens. The first-person intermedia figure quality of the footage creates a sensory aesthetic in which the audience could grasp the notion of "we, the people" through the depoliticized lens of the person inside the location of oppression. On one level, by putting all this AI-analyzed footage on a loop, I will try to challenge the audience’s notion that we are unable to watch this documentation many times and yet have their authenticity increase every time we watch them. On another level, I attempt to visualize a simulation of an AI training algorithm that has a repetitive environment.

Everyday Street Fight as Preparation for Future Revolution

The primary idea of this project came to my mind when I was doing an art residency in Mexico City in the summer of 2018. At the introduction of the residency, participants were strongly advised to avoid visiting the Tepito barrio as it is the most dangerous neighborhood in Mexico City. Tepito, as we have been told, is a region that is controlled by its inhabitants and where police are not welcome. My curiosity to explore Tepito seduced me to visit the region and none of those words could stop me. Tepito is not far from the Zocalo where traditionally protests and marches have occurred often. It is a region with numerous outdoor markets in which inhabitants trade their wares. All residents collaborate with each other to survive and to resist. Tepito is also known as the birthplace of famous Mexican boxers and fighters. It is the place in which people train their bodies as their only tool to protect their land from the invasion of rulers.

Cordoned off zones are part of the contemporary globalization of cities that can exist in any country. My multichannel video and sound installation project, *Invisible Presencea*, focuses on a similar situation as in Tepito, in an unnamed neighborhood of my hometown, Kerman, Iran. Similar to the inhabitants of Tepito, this unnamed region has elected to occupy a piece of land due to poverty and circumstance. The squatters built their homes and businesses there, finding their own sources of electricity and water. Eventually, the leaderless group persuaded the local government to recognize them as an independent community. During a very brutal confrontation, the inhabitants forced police to leave their region and destroyed the police station.

Comparing Tepito's situation with the neighborhood in my hometown, we realize that they both function and act in a similar way. While they are both tagged as a dangerous, unsafe, and violent zone, we might see them as alternative and prototypical independent zones in the middle of neoliberal urbanized cities. These two neighborhoods, known as pseudo-suburban regions, are two symbols of resistance in the global westernization phenomena. All the stories around these two neighborhoods, particularly hearing about the way people train their bodies to protect their region from the state invasion, made me think differently about street violence. It seems that increased violence in urbanized regions becomes an unconscious method of self-training for future conflict between the rulers and the multitudes. In other words, when people are frustrated by living under corrupt regimes, they spontaneously shift their social movements to internal wars.

Urban theorist Mike Davis in *Planet of the Slums* (2006) says slums are like “volcanoes waiting to erupt” and that their explosion might herald the emergence of “some next, unexpected historical subject” carrying a “global emancipatory” project. Other social thinkers, such as Jo Beall in *Cities, terrorism, and Urban Wars in the 21st century* (2007) and Dennis Rodgers in *Slum wars of the 21st century* (2009) view the spectacular gang violence in Latin America as representing the response of the dispossessed to their excluded status. Gangs, in fact, correspond to vanguard forms of what James Holston calls “insurgent citizenship” (2008), attempting through violence to carve new spaces for possible alternative futures within the context of their wider exclusion.

Furthermore, Lonnie Athens, a senior research criminologist at Georgetown University Law Center has developed a theory of violent socialization or, as he terms it, "violentization" (2004). In his research, he believes violentization is a phenomenon rooted in social experiences. He describes the process of passing through violence in four stages: 1) brutalization, 2) defiance, 3) dominance engagement, and 4) virulence. In these four stages, he discusses how an individual goes from being a suppressed person to a suppression tool.

As part of analyzing artworks with the same concept, it is necessary to talk about *Real Violence* (2017) by Jordan Wolfson, which was shown in the 2017 Whitney Biennial. In the controversial work, the viewer puts on a VR headset and sees a character bashing in another man's head, to the point where you cannot tell if the victim is alive. During the Q&A section of Wolfson's conversation around this artwork with Rhizome's assistant curator of Net Art and digital culture, Aria Dean, a lot of challenging questions arose regarding the relationship between violence, gender, race and age which the artist failed to fully answer. In contrast to this art project is Autumn Knight's video art called *Instructions for Fights* (2017). It is a documentation of a performance rehearsal in which Autumn Knight and Chelsea Knight took part while preparing for a live performance at the New Museum in NYC in 2015. It shows how the behavior of the instructor could be different in relation to the gender and race of his pupils.

A Prototype for Deidentification of the Violence

By approaching street violence and its relationship to protest as a social phenomenon this project is aiming to answer these questions:

Are the perceptions of violence in social protest still experienced in terms of race, culture, class, and geography?

Will this stripped-down version allow audiences to form new perceptions of violence and its underpinnings?

By removing all the identity elements from the gestures, this project aims to generate a cross-cultural understanding of violence and protest. In addition, the documentation of the reenactment and reaction of performers during the production phase of the project played a very significant role. Reenactment of performers during the motion capture process will happen in a situation in which performers will review each footage several times to mimic the movement of people. All the conversations with the performers and their ability or disability to mimic the content of the footage aims to challenge the notion of how much the interpretation of the social situation might change during the reviewing and reenactment of it. That is to say, I believe that the performers who react to these acts of violence and brutality will themselves become part of this video installation. Contrary to popular belief that art is a means of escaping the present reality, I seek to open people's eyes to their present state through these objects and situations. By arousing the performer's senses and directing them into emotional reactions, they will be subjected to the brutal crimes of sovereigns.

Summary

All the elements of the *Study of a Movement* video installation project are going to be combined together to create a single web page video installation in order to represent a prototype in which the viewer has the chance to have different socio-political interpretations. By putting together AI-analyzed found footage from social media, along with the motion capture animation of their reenactments, this project invites the audience to reconsider how they process and interpret the actual recorded violence. At the same time, viewers have the opportunity to shift their eyes from the images in which they are able to recognize each element of the images such as police, people, buildings, and gears, to the animated reenactment images which represent the same gestures without geography, race, gender, and gears. Furthermore, by applying an AI motion tracker to the footage, this project leaves the audience guessing as to whether or not machine vision and prediction will influence the future evolution of social systems in general.

References

Athens, Lonnie H., ed.
2004. *Violent Acts and Violentization: Assessing, Applying, and Developing Lonnie Athens' Theories*, Sociology of Crime, Law and Deviance, 4. Amsterdam: JAI.

Beall, Jo.
2007. "Cities, Terrorism and Urban Wars of the 21st Century." Working Paper no. 9, Series 2, Crisis States Research Centre, LSE: London.

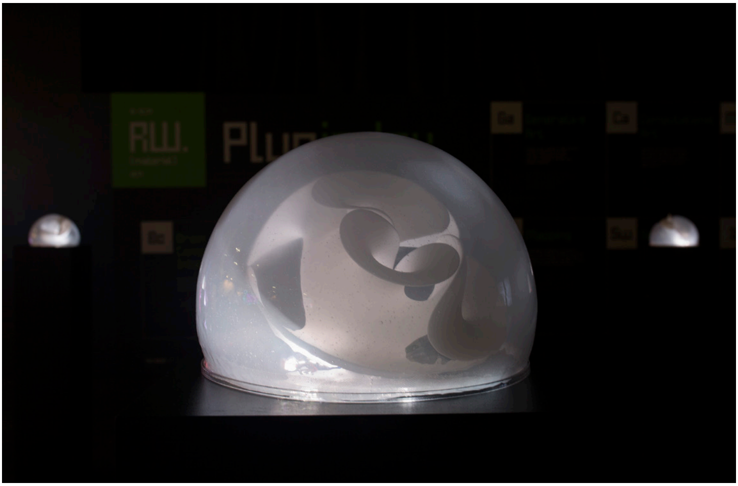
Davis, Mike.
2006. *Planet of Slums*. London; New York: Verso.

Holston, James.
2008. *Insurgent Citizenship: Disjunctions of Democracy and Modernity in Brazil*. Information Series. Princeton: Princeton Univ. Press.

Knight, Autumn.
2017. I*nstructions for a Fight* - 4'08" Single-channel video.

Rodgers, Dennis.
2009. *"Slum Wars of the 21st Century: Gangs, Mano Dura and the New Urban Geography of Conflict in Central America."* Development and Change, 40 (5): 949–76.

Wolfson, Jordan.
2017. *Real Violence*, Virtual Reality Installation.



Şölen Kıratlı
solenk@gmail.com
University of California, Santa Barbara, USA

Hannah E. Wolfe
hewolfe@colby.edu
Colby College, Waterville, ME, USA

Alex Bundy
alex@planetariummusic.com
Planetarium Music, Santa Barbara, CA, USA

*Equal contribution between the authors

Cacophonic Choir: An Interactive Installation

Keywords: Interactive Installation, Machine Learning, Sonic Interaction Design, Digital Design and Fabrication, Embodied Interaction, Physical Computing

Cacophonic Choir **is an interactive installation aimed at bringing attention to the first-hand stories of sexual assault survivors, and the ways such stories may be distorted by the media and in online discourse. The work is composed of nine embodied vocalizing agents distributed in space. Each agent tells a story. From a distance, the viewer hears an unintelligible choir of fragmented stories and distorted voices. As the viewer approaches an agent, the story becomes sonically clearer and semantically more coherent. When in the agent's immediate personal space, the viewer can hear the first-hand account of a sexual assault survivor. The work has two versions, one intended for physically present exhibitions and the other for virtual exhibitions.**

Description

Cacophonic Choir is an interactive installation aimed at bringing attention to the first-hand stories of sexual assault survivors, and the ways such stories may be distorted by the media and in online discourse. Digital and mass media can empower oppressed people by providing them with platforms for sharing their stories, as we have seen in the *#meToo* movement. Participation on these platforms can, however, also expose the stories to doubt, distortion, and hostility. For example, it has been found that on Twitter, tweets that engage in victim blaming get retweeted more than ones that support sexual assault survivors (Stubbs-Richardson et al. 2018). Media coverage of sexual assault, especially combined with the hostility and distortion that one often finds on these platforms, can be overwhelming to survivors. *Cacophonic Choir* is aimed at both reflecting these feelings of being overwhelmed, and encouraging people to step away from these arenas to listen to individual survivors' accounts. While sexual violence is a systematic problem, the experiences of those who have survived it are all different and deserve to be heard.

Fig. 1. Cacophonic Choir (2019) is composed of nine embodied vocalizing agents distributed in space. ©Şölen Kıratlı & Hannah Wolfe. Photo credit: Gökhan Tugay Şeker.

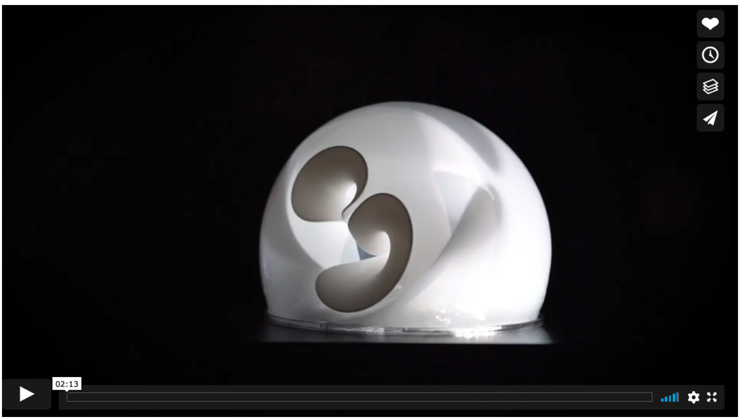


Fig. 2. A video asset (https://vimeo.com/364662275). Cacophonic Choir (2019) is composed of nine embodied vocalizing agents distributed in space. ©Şölen Kıratlı & Hannah Wolfe.

The installation is designed to embody and reflect this feeling of inundation in the face of hostility and distortion, while highlighting the first-hand stories of the sexual assault survivors. It is composed of nine embodied vocalizing agents distributed in space (Fig. 1, 2). From a distance, the agents all look alike, and their vocalizations are sonically distorted, semantically fragmented, and indistinguishable from one another, altogether forming an unintelligible choir. As the viewer approaches a particular agent, three things happen gradually. First, the voice of the approached agent becomes sonically more clear and less distorted. Second, the utterances of the voice become semantically more coherent. And third, the membrane that envelopes the agent gets brighter and more transparent, rendering the unique form inside visible. When in the agent's immediate personal space, the viewer hears the first-hand account of a sexual assault survivor. Here, we are using spatial distance between the agent and the viewer as a metaphor for the 'distance' between the original story as told by the survivor and its renditions in social and mass media.

Fig. 3. The discrete mapping of space to neural net models.

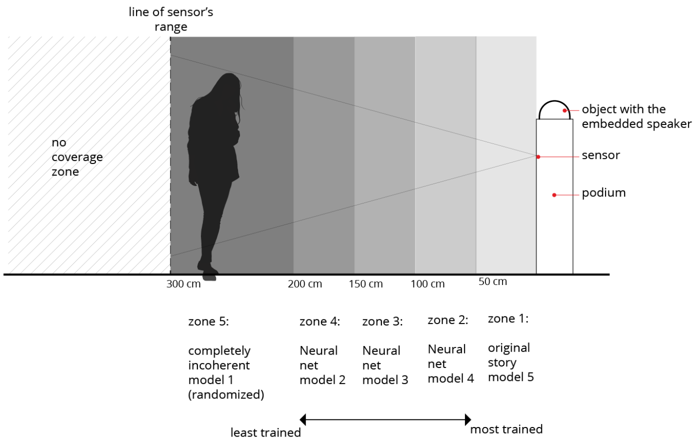
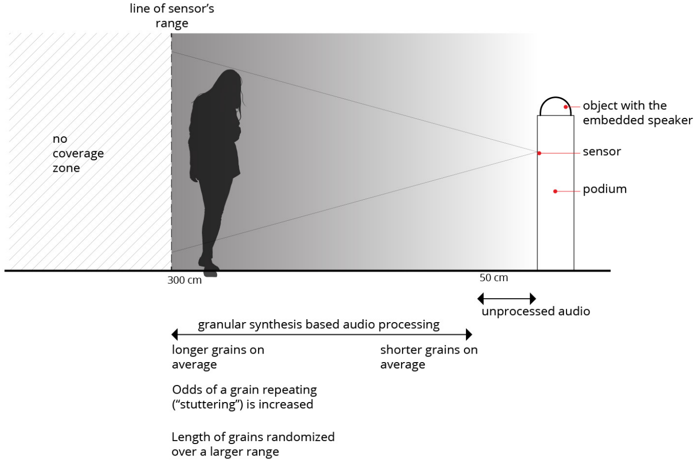


Fig. 4. The continuous mapping of space to parameters of audio processing.



For this piece, the data we used consists of over 500 first-hand accounts of sexual assault survivors collected from *The When You're Ready Project*, an online platform for "survivors of sexual violence to share their stories and have their voices heard" (Reid 2019). The aim of this installation is not to inform the visitor precisely of statistics and data about sexual assault, but rather to reflect the ways in which the stories may be amplified or distorted in online media. To this end, using the *textGenRNN* library, we trained an LSTM (long short-term memory) recurrent neural network model on stories from *The When You're Ready Project*. The idea was to capture the system at various levels of training, so that we could modulate the original narrative, generating versions of the narrative with different levels of semantic distortion. We used text-to-speech synthesis to convert the generated texts to audio. This helped us modulate the linguistic and auditory coherence of these narratives based on the proximity of the observer to the narrator. Using a proximity sensor, we mapped distances between the agent and the viewer to the different training levels of the RNN (Fig. 2). The full narrative is revealed only when one is in very close proximity to a given voice.

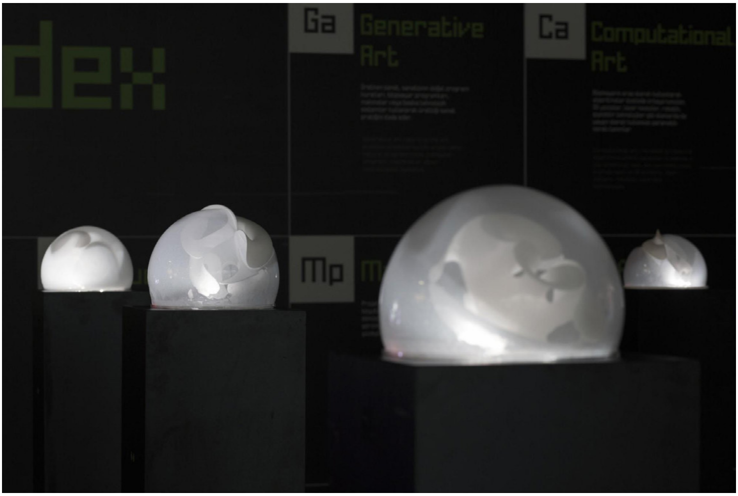


Fig. 5. The body of each agent is composed of a sculptural form encased in a soft translucent membrane. Some of these forms are fully contained within the membrane, while others burst outwards.

In addition to this semantic modulation, the installation also responds visually and sonically to the viewer's proximity. The sonic response employs text-to-speech synthesis and granular synthesis to create a stuttering effect which dissipates as a visitor comes closer, representing how survivors' stories are distorted (Fig. 3). The visual response is light-based. The body of each agent is composed of a sculptural form encased in a soft translucent membrane (Fig. 4). Some of these forms are fully contained within the membrane, while others burst outwards. Proximity of the visitor modulates the light source within the membrane. As a result, the translucent membrane gets gradually more transparent as one approaches the agent, revealing the intricate geometric form within. Here, our intention was to reflect the fact that the individuals and their voices may look and sound alike from a distance, but when focused on individually, each is found to be complex and unique. This simple light-based interaction, coupled with the material properties of the sculptural elements (i.e. transparency) also allowed us to reflect the inherent tension in the public coverage of private events – since opaqueness and transparency have strong connotations of privacy and publicness in many cultures.

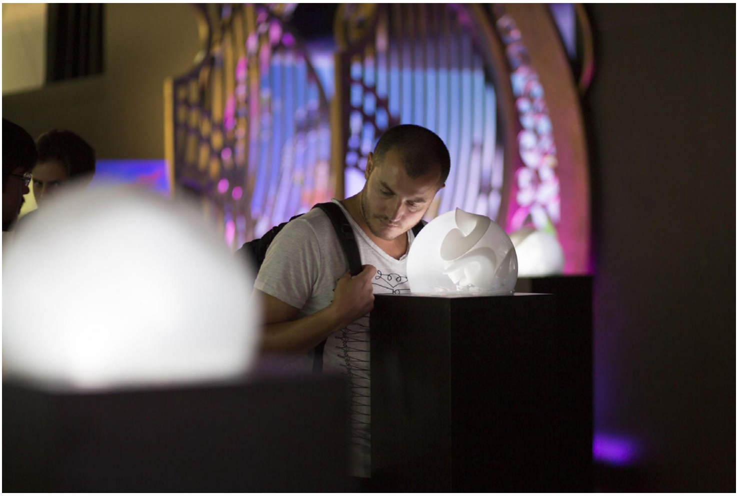


Fig. 6. *In Contemporary Istanbul's Plug-in '19* exhibition, the piece was located in a fairly noisy environment, which caused the visitors to come very close to a given agent and place their ears directly next to it, creating an unintended, but desirable level of intimacy. Photo Credit: Gökhan Tugay Şeker.

Cacophonic Choir has two implementations: an embodied interactive installation, and a virtual environment built using the Unity framework. In the virtual environment the semantic and sonic coherence of the agents are modulated and spatialized by the distance the visitor is from them. As the visitor moves closer to an agent the membrane becomes more translucent, revealing the parametric form within. We are exploring different layouts and visualization techniques; the current version of the virtual environment reflects the original layout of the agents in the physical installation.

Cacophonic Choir was produced in 2019 and debuted in the sub-exhibition titled *Plug-in '19*, within *Contemporary Istanbul*, an international contemporary art fair. The piece was located in a fairly noisy environment, which prompted visitors to put their ears directly next to the agents in order to hear them over the din. This created an unintended but desirable level of intimacy while listening to these emotionally hard-to hear stories (Kıratlı & Wolfe et al. 2020). Furthermore, *Cacophonic Choir* was exhibited in *SIGGRAPH '20*, which took place virtually, and won SIGGRAPH Art Gallery's "Best in Show" award. For this exhibition, we started developing a virtual version of the work (Wolfe & Kıratlı et al. 2020) using Unity, which we then also exhibited in IEEE Visualization Conference's Art Program '20. As of 2021, *Cacophonic Choir* continues to evolve in both virtual and physical platforms. We will continue exhibiting this work both in the digital and physical modalities and plan to study the differences in the way that visitors interact with the work virtually and in person.

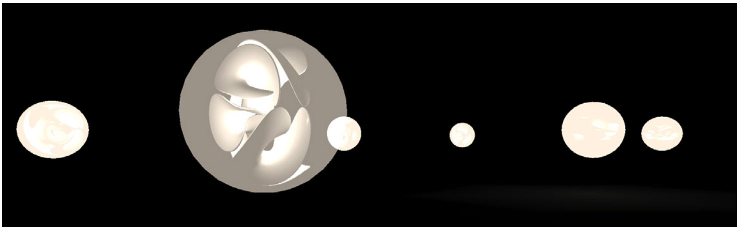


Fig. 7. A virtual version of the work can be found at cacophonic.cs.colby.edu

Virtual Version: https://cacophonic.cs.colby.edu/

References

Kıratlı, Şölen, Hannah E. Wolfe, and Alex Bundy. 2020. "Cacophonic choir: an interactive art installation embodying the voices of sexual assault survivors." *Leonardo*, 53 (4): 446-450, The MIT Press. https://doi.org/10.1162/leon_a_01935

Reid, Lauren. 2019. "The When You're Ready Project": www.whenyoureready.org/aboutwyr [Accessed 14 February 2021].

Stubbs-Richardson, Megan, Nicole E. Rader, and Arthur G. Cosby. 2018. "Tweeting rape culture: Examining portrayals of victim blaming in discussions of sexual assault cases on Twitter." *Feminism & Psychology*, 28 (1): 90-108.

Wolfe, Hannah E., Şölen Kıratlı, and Alex Bundy. 2020. "Cacophonic Choir - Virtual Experience": https://cacophonic.cs.colby.edu/ [Accessed 14 February 2021].

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Dávid Maruscsák
davidmaruscsak00@gmail.com

Máté Bredán
bredan.mate@gmail.com

Mátyás Boldizsá
boldi@5martstudio.com

Unaffiliated,
Budapest, Hungary

Dynamical Systems

Keywords: Feedback, Generative, Interactive, Installation

Dynamical Systems is an audiovisual installation consisting of two artworks. Both artworks explore the concept of feedback and iteration. They allow the viewers to deliver input data with their bodies and gestures and create alterations in the presented artworks' behavior. These alterations may lead to momentary chaotic behavior. Without any input, the artworks regulate into a balanced state. Each artwork inheres a physical structure and projected imagery. Additionally, the installation includes interactive sound design, which evolves by monitoring the changes in the presented artworks. Initially, the artworks are designed for on-site presentation, interacting with the viewers standing in front of them. In this submission, we propose an iterated version of the installation, which fulfills online communication requirements. We present our artworks as a video stream. A video conference accompanies our system. Our system analyzes the webcam feed of the participants present in the video conference, providing remote interaction.

https://2021.xcoax.org/dma/

Fig. 1. Documentation of the installation exhibited at MŰTŐ gallery during the Budapest ArtWeek 2020.

Fig. 2. Dávid Maruscsák's artwork. The horizontal white threads are stretched between the side of the frame, creating the projection screen.

Description

The installation's concept relies on the popular term called the butterfly effect, denoted by Edward Lorenz. The term describes a concept of such systems whose initial condition highly affects their long-term evolution. Dynamical systems are open to outside influences. Positive feedback present in these systems amplifies their internal system over time, leading to chaotic behavior. This sensitivity to subtle changes suggests the idea of holism, where each action has the potential to influence the dynamics of the whole world.

In the proposed installation, the central concept recurses into two individual artworks. Both of them rely on the principles of chaos, especially on positive feedback loops and on fractals' aesthetics. Their author determines their initial condition, but they remain open for user input.

Fig. 1. Documentation of the installation exhibited at MŰTŐ gallery during the Budapest ArtWeek 2020.

Initially, the interaction between the user and the artwork would occur on-site at the exhibition space. We would track the position and the viewers' motion in the specified areas in front of each installation. Both artworks would accept multiple inputs. Each user's position in the space would affect a randomly assigned parameter, making each artwork oscillate between chaotic and orderly behavior.

For example, the artworks might amplify their internal behavior when a user is present. Meanwhile, another user might start to interact with the installation, which can result in several conditions. For example, it may amplify the artwork's internal working even more, resulting in chaotic behavior, or even out the artworks' behavior, causing them to return to an orderly behavior.

Máté Bredán's interaction system builds on the attributes and possibilities of online communication. It aims to emphasize the main idea of our installation system. We present the artworks online as a video stream. The participants can join a video conference and provide input data through their webcams. The interaction system tracks the participants' heads and hands. Using a combination of an OpenCV face tracker with a pre-trained Deep Neural Network and blob tracking, it determines their position inside the camera's frame. This setup aims to model the term of the butterfly effect truly. Hence anyone who joins the video conference can alter the artworks from any point in the world.

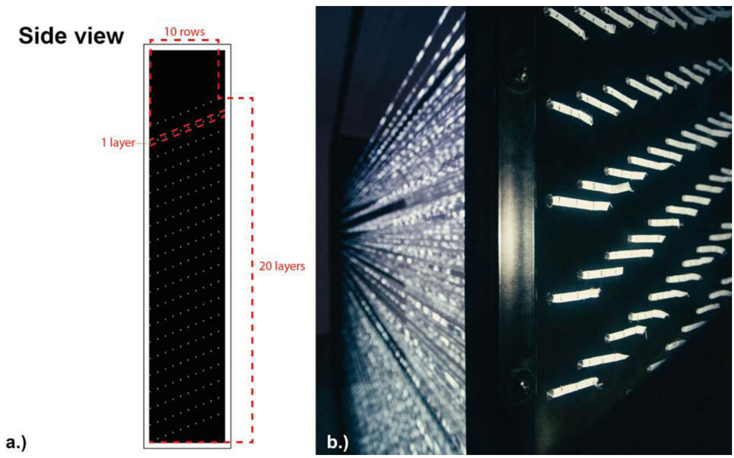


Fig. 3. a.) The layout of the horizontally stretched white threads. One layer consists of ten rows. The installation consists of twenty layers. b.) Documentation of the finished structure.

Dávid Maruscsák's artwork consists of a custom-built projection screen. It is a 3-dimensional object. It consists of a steel frame (3, 3 x 2,6 x 0,5m). White threads stretched horizontally between the left and right sides of the frame serve as the projection screen. The installation consists of twenty layers of these threads. Each layer is a set of ten threads expanding from the front of the frame to the back. The layout of these threads resembles the layered aesthetic of fractals. This projection surface aims to structure the projected image and to divide the flat image in space. The projected image is a generative animation. The generative animation relies on a positive feedback loop system. This system has ten iterations. Each of them has a unique appearance predetermined by its author. These iterations are changing randomly over time. Initially, the artwork would monitor the position and the gestures of the users standing in front of it. The users can alter the look of each iteration and also generate a motion with their gestures. The online version of the system monitors the viewers present in the video conference and their motion.

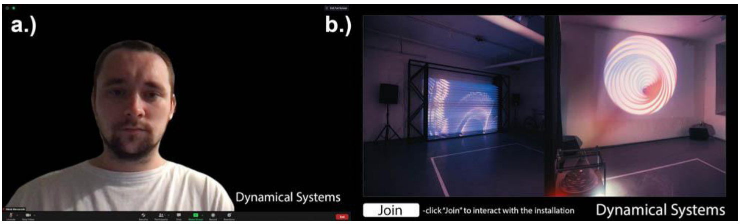


Fig. 4. a.) Example of the user's zoom appearance with a background provided by us. b.) Example of the website, while streaming the installation. The button with the "Join" script leads to the video conference, where the users can interact with the installation.

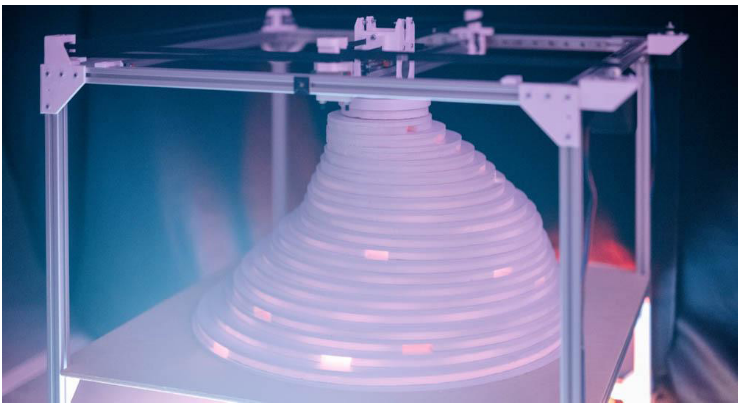


Fig. 5. Boldizsár Mátyás's artwork. Twenty rings form the kinetic sculpture. The adjacent parts are attached. The bottom ring is static, and electrical motors control the top ring's position.

Boldizsár Mátyás's artwork is a geometrical shape, which depicts similar forms on many levels inspired by the fractals' aesthetics. It is a kinetic sculpture built from twenty rings. These rings are building on each other, and with every step, their radius gets smaller. Each ring connects with its adjacent parts. The bottom ring is static, and electrical motors control the top ring's position. As the top ring moves, it attracts the rings below. The motion creates various phases and poses to the kinetic sculpture. LED lights are lighting up the inner area of the sculpture. A camera monitors the sculpture's inner area, and its image gets projected onto the wall behind the sculpture. The projection depicts an inward shrinking spiral. The viewers can control the position of the top ring and how the lights behave. In the initial scenario, the viewer's position in the designated area in front of the sculpture would affect the parameters mentioned above. The sculpture would analyze the viewers' layout and correspond to an averaged value in a multi-user scenario. This dialogue between the users and the artwork would alter both the sculpture's outer and inner look. We redesigned this artwork's interaction method, which generates the motion from the participants' video feed.

The sound reacts to the two artworks. It is creating a feedback loop between the users and the installation. The sound design is calm, ambient music, which can turn into a cacophony when the artworks show chaotic behavior. The online streaming features the sound design along with the video.

Acknowledgements. We would like to thank Áron Pfitzner and Péter Fancsikai for the sound design, Levente Lukács and Zsófia Temesvári for the exhibition opening performance, Cseh Dániel and Mátyás Csiszár for helping with the Arduino script, János Pap for the custom-built projection screen, József Tasnádi for supervising the concept and Bence Szemerey for the documentation.

References

Abraham, Ralph & Ueda, Yoshisuke.
2001. *The Chaos Avant-Garde: Memories of the Early Days of Chaos Theory*. Series A, Vol. 39. Singapore: World Scientific Publishing Co. Pte. Ltd.

Briggs, John.
1992. *Fractals: The Patterns of Chaos: Discovering a New Aesthetic of Art, Science, and Nature*. New York: Touchstone.

Chodos, Alan.
2003. “Circa January 1961: Lorenz and the Butterfly Effect.” *This Month in Physics History*, APS News. Vol. 12, No.1

Stacey, Nic.
2010. *The Secret Life of Chaos*. (TV documentary). London: BBC Four.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Aaron Oldenburg
aoldenburg@ubalt.edu
University of Baltimore, Baltimore, USA

Desert Mothers

Keywords: Meditation, Anchorite, Concious Environment, Artificial Intelligence, Psychedelics

This is an exhibition of the work, *Desert Mothers*, a meditative, multiplayer networked experience. The rationale and iterative process for creating this project are discussed in the article, and the software is made available online for attendees to play during the conference. In this game, players begin in the same procedurally-generated environment. This begins to diverge for each player as their personal environment, composed of individualized weather and hallucinations, responds emotionally to the player's actions. The constraints within which the players interact are discovered during play, and revolve around the body, breath, drawing in the air, and out-of-body exploration of flora, fauna, and abandoned human habitations. The game has its inspiration in group psychedelic and meditative experiences, such as Ayahuasca ceremonies. There is a slippery relationship between the player and their body as separate from elements in the environment, as they explore the landscape from the perspectives of other flora and fauna. This can be downloaded and experienced synchronously between remote participants, either using a virtual reality device or a flat screen with a game controller.

https://2021.xcoax.org/aol/

Description

The game *Desert Mothers* takes as its experiential reference points group meditation, as well as psychedelic spaces such as those of Ayahuasca ceremonies. Gameplay takes place in a procedurally-generated, three-dimensional desert environment. Players are connected over a network and begin in the same space, all seated cross-legged in near proximity, facing the center (Fig. 1). Each player's actions are observed by a game object whose script analyzes their actions and initiates changes to the environment based on its analysis.

I frame this within the code as an environmental entity with “moods” that respond to each individual player. These states of mind for the environmental entity use terms such as “transcendent,” “rapt,” “delighted” and “overstimulated.”

The entity conveys these moods with weather and other environmental events, including changes in animations for all the flora and fauna, as well as animated, hand-drawn visions presented to the player. The visions are often circular and jagged (Fig. 2).

In addition to these weather and time changes, the player modifies their landscape directly. With their in and out breaths, they can focus on objects in the landscape and bring the object toward and away from them. These changes are not passed over the network, so each player's individual environment begins to diverge from that which is experienced by the other players.

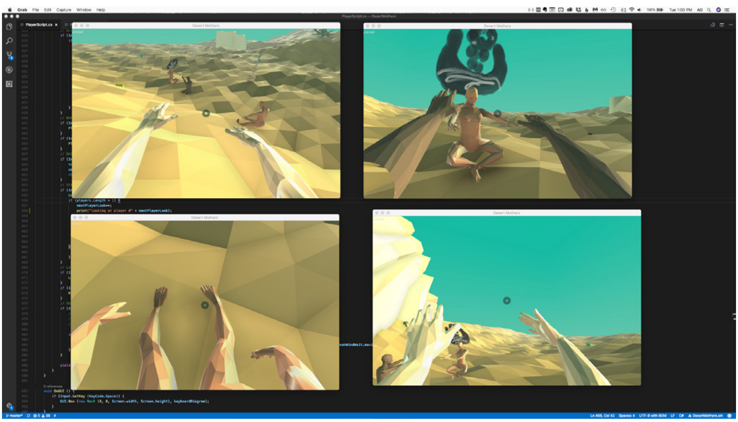


Fig. 1. Multiple screenshots of instances of an early version of Desert Mothers running, demonstrating multiplayer functionality.

Fig. 2. 2D animation instantiated in the game world as part of the environmental response (from early work-in-progress).

Each player views the world from either a flat computer screen, an Oculus Rift virtual reality (VR) headset, or an Oculus Quest 1 mobile VR device. Input varies depending on the system. Non-VR players use an Xbox-style gamepad controller. The interface corresponds to bodily actions: moving the hands through space, turning the whole body, breathing, squeezing fists, stretching their legs, and clapping. The Oculus Rift and Quest, through their Touch controllers, function similarly, with the additional embodied interactions of the hands moving through three dimensions based on the player's hand location and turning one's full body rather than hitting controller buttons. When fists are squeezed, the player can create drawings in the air, which other players can see. The environment evaluates the way the player has drawn: hesitantly, quickly, with large gestures, and so forth, and changes its mood based on this evaluation.

The title references early Christian women who lived an anchoretic life in the desert (King 1983). Although the hermeticism of the reference would appear to contradict the multiplayer gameplay, there is a certain isolation that happens in the game with the increasingly differentiated experience each player has of their own personal landscape. They are together in the same space, but there is little interaction.

The choice of a desert environment was informed by its implication in the forming of major religious traditions and spiritual encounters. Roslynn D. Haynes, author of Desert, credits the landscape of the desert in the birth of monotheism, as:

> a desert landscape under a vast, monochromatic sky may suggest a unified world, the work of one creator, whereas a scene in which the eye is continually diverted by trees, rivers or mountains encourages either an animistic view that individual objects have an independent existence created by separate spirit beings, or a rationalist paradigm of the world as a collection of material objects under our control (Chapter 5, Paragraph 3, Haynes 2013).

The desert is an apt environment for a game that simulates an autonomous, ever-present entity, with its own hidden logic communicated through a "language" of weather and time.

Attention to environment references an important step in the preparation for a psychedelic (as well as meditational) experience, that of "set and setting." This is a term that, though coined by psychedelic advocate Timothy Leary in 1961, is based on a concept that dates to early pioneer in psychedelic therapy Al Hubbard. Hubbard is thought to be the first proponent of the idea that one's environment and initial state of mind has a powerful effect on one's experience of LSD (Hartogsohn 2017). The desert, which historically functions as "a place of spiritual purification and enlightenment," through its "physical harshness" and "lack of material and sensory distractions from spiritual contemplation" (Chapter 5, Paragraph 4, Haynes 2013), seems an ideal setting for provoking a meaningful psychedelic experience.

Iterative Development

Feedback was collected through in-person playtesting where written, oral and observational reactions were collected. It was collected from a varied group of playtesters, including college students and faculty in University of Baltimore's Simulation and Game Design program, attendees at Baltimore's ArtScape festival, participants in a local game developer meetup, and an open critique at a local arts non-profit.

Some players were frustrated by perceived limitations. My initial goal had been to find a mapping for every button on the Xbox controller and allow its affordances to create the boundaries within which players could experiment to figure out what they could do. The player's avatar is locked into a seated position that resembles meditation. Players felt limited by the restriction, a restriction which I felt was more in line with a meditative experience. A major point of feedback was that players wanted to be able to move throughout the environment. One playtester said, when informed of my reasoning for the seated avatars, that her preferred method of meditation was a walking meditation.

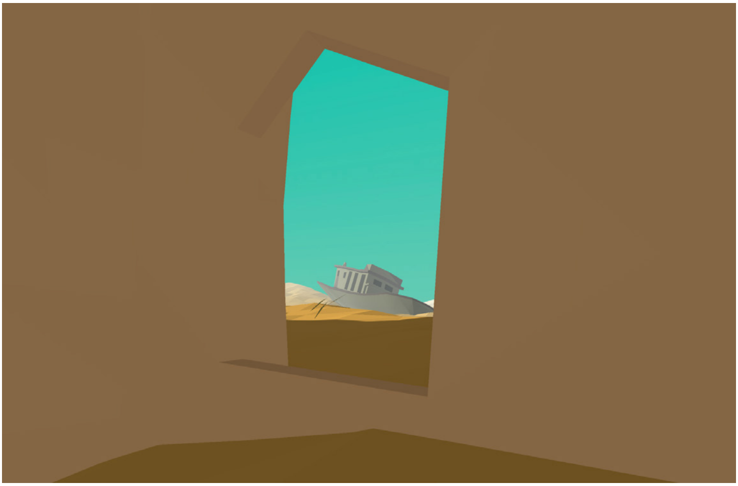


Fig. 3. Out-of-body exploration.

This led to my implementation of my out-of-body mechanic. Initially, players only had the ability to see themselves from the distorted point of view of individual plants and uninhabited buildings in the environment. Due to the aforementioned feedback, I gave players the ability to enter abandoned structures as a disembodied camera, a sort of mental excavation of an archaeological site (Fig. 3). Although exteriors of the buildings are often the same for each player, upon entering, participants view interiors that diverge from those of other players.

References

Hartogsohn, Ido. 2017. "Constructing Drug Effects: A History of Set and Setting." Drug Science, Policy and Law 3 (January). https://doi.org/10.1177/2050324516683325.

Haynes, Roslynn D. 2013. *Desert: Nature and Culture*. [Ebook]. Chicago: Reaktion Books.

King, Margot. 1983. "The Desert Mothers: A Survey of the Feminine Anchoretic Tradition in Western Europe." *Fourtd21eenth Century Mystics Newsletter*, 1983. http://hermitary.com/articles/mothers.html.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Zoe Li
Qlix19@pratt.edu
Shenzhen, China

Comb Machine: The Regulation of Hair

Keywords: Computer Vision, Installation, Machine, Robotic Art, Computational Art

She, the hair entity with wheels, is offered a certain degree of freedom. She wanders around as she wants and remains free, until summoned by the comb machine. The artist displays an installation to demonstrate an institutional system. The institutional system shows an interactive relationship between two parties, in which a ruled party has a certain degree of freedom in a power relation, if she obeys the principles formulated by the ruling party. In the installation, the ruling party is a comb machine, whereas the ruled party is a hair entity with wheels. The hair entity with wheels can wander around till the comb machine rings the bell for the sake of regulating her behaviors. However, the conduct of combing is not necessarily for the aim of tidying her hair, thus she may leave with messy hair. After all, she gets her freedom till the next bell ringing.

https://2021.xcoax.org/zli/

Description

The behavior of combing symbolizes the regulation of hair, trying to make the hair compliant. The combing machine regulates the wig robots at a certain time by combing their wigs. Most of the time the wigs remain “free” and they wonder around. The installation tells a story that the wig robot has to conform to the combing machine, but they still have “freedom”. The thesis project tries to discuss the relationship between freedom and regulation within an institutional system.

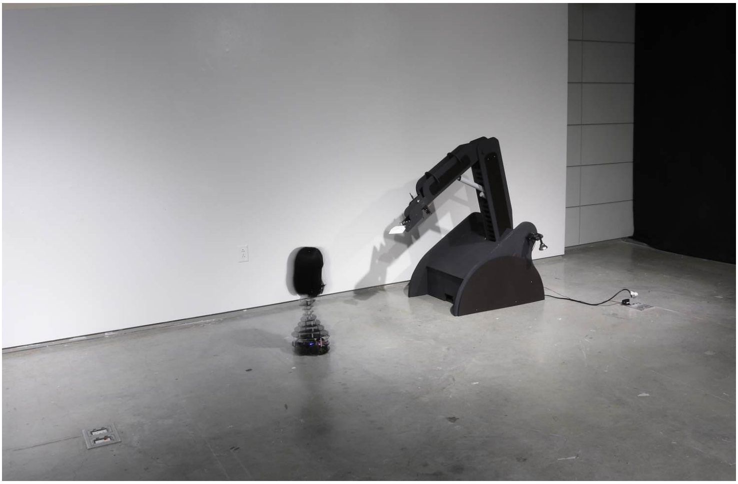


Fig. 1. Installation view.

Regulation

Regulation is defined as “A rule or directive made and maintained by an authority.”[1] By regulation, I mean making things in order. In a societal context, it will be putting people in order, or establishing rules. Combing, for me, is a behavior that tries to put the hair in order and making them conform. I am trying to depict an image that an authority figure (the combing machine) is trying to regulate the non-authority figure (the wig robots). The authority is not only limitedly referring to schools, but also the other institution that has a voice of certainty. For example, the doctors in hospitals, the patients take pills whatever the doctors give for the patients’ “own good”. I intend to sympathize the audience by having these robots to be combed and make them think about the moment that they were “combed”.

1. English Oxford Living Dictionary, s.v. “regulation”, accessed April 28, 2019, https://en.oxforddictionaries.com/definition/regulation.

Freedom

> Moreover, the fullest realization of our freedom requires us to recognize not only that this different form of relation, which is cooperative rather than controlling, exists but also that it is constitutive of, rather than in opposition to, our freedom. (Bredlau 2020)

There is a lot of art that talk about freedom. Heri Dono's sculpture *Born* and *Freedom* (2004) depicted an ironic image of human and animal, having four humanoid birds that are chained by four dog-like figures. All the figures have similar smile on their faces. The artist discusses the freedom in the context of the relation between human and animal. *WeiweiCam*, a project conducted by Ai Weiwei, is a self-surveillance website streaming his home in order to comment on his detention at Beijing Airport. Ai Weiwei intends to comment on freedom in the context of government surveillance.

In my project, I intend to discuss freedom within institutions. There is always freedom once you follow the rules. As the bell rings, the freedom that the wig robots have will be paused. They have to follow the rules, i.e., to be combed, in order to acquire the next period of freedom. We all have this kind of freedom. Freedom is defined as "the power or right to act, speak, or think as one wants without restraint",[2] but in reality, you have to sacrificed something to exchange the freedom to some extent. The project has two paradoxical circumstance, as we have in reality, one is that the wig robots have the freedom to wander around, the other is that the wig robots have to be combed once the bell rings. So, do the wig robots have freedom or not? This is a question that I propose to ask the audience.

2. "English Oxford Living Dictionary", s.v. "freedom", accessed April 28, 2019, https://en.oxforddictionaries.com/definition/freedom.

The installation includes a combing machine, a hair entity and a bell. The combing machine, which is a big robotic arm with a comb as its hand, is installed beside a wall. The hair entity, which is a robot with wheels wearing a wig, wanders around within a predefined area (see fig. 2). The bell is installed on the comb machine (see fig. 3) and rings every 10 minutes. Once the bell rings, the hair entity will come to the combing machine and be combed as figure 5 shows.

The hair entity's movement refers to automatic obstacle avoidance car kit. They detect the obstacles in front of them and change direction in advance. The obstacles include the audience. The interaction between the audience and the hair entity is showed as figure 5.

Fig. 2. Installation view when the hair entity wanders around.

Fig. 3. Installation view when the bell rings.

Fig. 4. Interaction between the audience and the hair entity. Nov. 30, 2020.

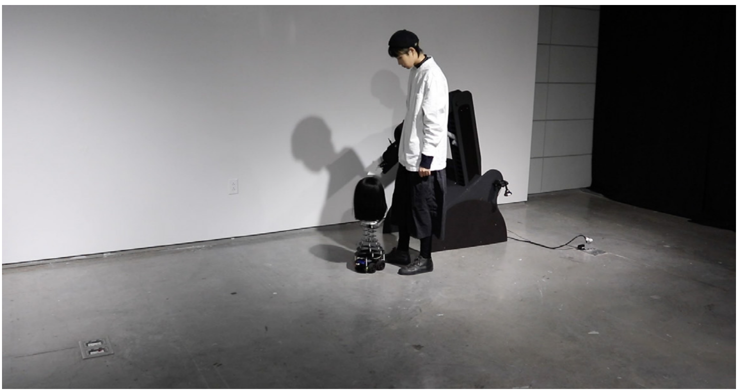


Fig. 5. Installation view when combing.

Preview of the video documentation: https://vimeo.com/488766766

References

Bredlau, Susan.
2020. "Demanding Existence: Dewey and Beauvoir on Habit, Institution, and Freedom." *The Journal of Speculative Philosophy*. 34(2) 141-158.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Alyssa Aska
Composer,
Graz, Austria

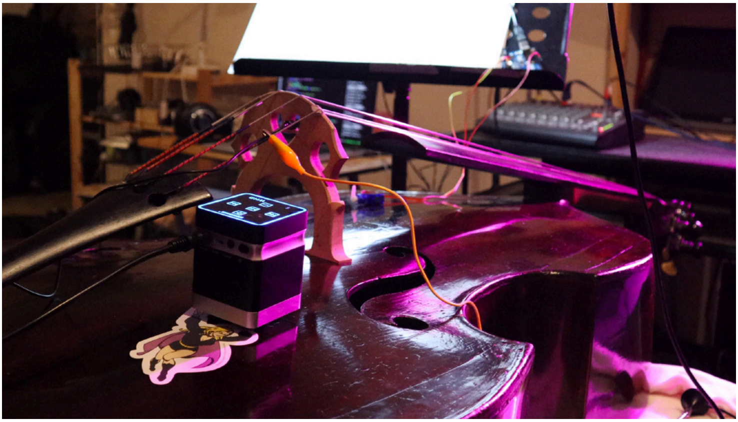
Alisa Kobzar
Composer and Media Artist,
Graz, Austria

Alexander Kremser
Web Designer and Artist,
Graz, Austria

Margarethe Maierhofer-Lischka
margarethe@mur.at
Independent Researcher
& Artist, Graz, Austria

Daniele Pozzi
Sound and Media Artist,
Graz, Austria

* We would like to mention and thank also Pablo Marina, who joined the project team later on.



As if They Were Flowers: A Virtual Multimodal Exhibition

Keywords: Artistic Research, Autonomous Systems, Exhibition, Virtual Worlds

Autonome Systeme (AS) is a sound and media art project hosted and carried out 2020-2021 by the Graz-based platform for net art mur.at. The project questions the positioning of systems with 'autonomous qualities' in music and art making. It engages with the liminalities between autonomy and automation, whole and parts, observer and observed, systems and environments, and looks for the artistic affordances of the space in between them. AS culminates with an exhibition in July 2021 that gathers artworks developed by a group of five young artists confronting these themes. Under the title _As if They Were Flowers_, the exhibition will feature various types of artefacts in both the sound and visual domains that are presented physically in an art space in Graz as well as online in a dedicated virtual reality environment.

https://2021.xcoax.org/aas/

Context, Central Questions and Topics

The development of learning, self-adaptive systems, which are capable of sensing and acting on their environment, and their embedding in our everyday life, brought the buzzword 'autonomy' to everyone's lips. Be it autonomous cars, drones, or the next ‘artificial intelligence’ that is supposed to help us in the household, autonomous systems have permeated many different fields, including science and industry, society, and even art. Despite the fact that such systems seem ubiquitous, the question 'what makes a system autonomous?' has not a univocal answer. However, when analysing autonomous systems in different fields, the concept of 'autonomy' is often examined in conjunction with the idea of ‘agency’, as such systems can sense, act in, and affect their environment. What this 'act' means largely depends on the context, and this ambiguity generates infinite understandings of the idea of 'autonomy' itself.

Our project aims to engage and play with this ambiguity from an artistic perspective: How can existing notions of 'autonomy' and 'systems' from fields like robotics, system theory, game development and sound art contribute to collective artistic practice? What kind of creative relationships can we establish with 'systems' having 'autonomous qualities' both from the position of making art as well as from an audience’s viewpoint? We seek to explore this in an open feedback process: we develop imaginative and playful ways of integrating those ideas into art, while observing how this affects our artistic practice itself and subsequently our insights into the topics we work on.

Methods and Previous Stages of Work

Autonome Systeme is a practice-focused artistic research project carried out by means of a self-organised collective working group that began in September 2020. Members of our group consist of five young artists from different fields (sound art, media art, media design / coding, music, robotic art, radio art). We establish a process that we describe as iterative co-composition. Across regular meetings and brainstorming sessions, and also incorporating input from external peers and professionals from the fields of sound and media art and aesthetics, we create, transform, and exchange ideas, sketches, and works across several cycles of iterations. The result of each stage flows into one or several collective works that are presented to the public. We also maintain a blog to document our individual working processes – a creative diary reflecting about code, text, parsing, and automated perceptions.

Each iteration consists of three phases: generation, parsing and evaluation / output, and focuses on one topic that represents a central aspect of autonomy. These iterations allow our own creative processes to become a kind of automaton, feeding individual inputs into a collective mechanism of creation / composition. We formulate boundaries for each phase (e.g. the impulse we begin with, how to transform it), and rules and parameters used to engage with the system itself, thus implementing what we call a "multimodal artistic parser". The result of this parsing process consists of sounds, visuals, or even physical objects. In the final stage of collective evaluation, these are eventually connected to form another unified system. Our procedure is inspired by analogue and digital techniques of “autonomous” parsing or generation: programming language parsers, André Bretons “automatic writing” (Graw 2002), and game design paradigms such as the ECS (Entity Component Systems) introduced by Adam Martin (Martin 2007).

The result of the first iteration, which focused on the “autonomous self”, was a sound work, presented on Radio Helsinki on January 17, 2021 for the international radio art festival Art's Birthday. The procedure we chose was a reductive transformation: while the initial inputs should be diverse in format, the output (result) of the iteration had to be in one given medium, sound. Each artist generated one sketch / artefact in a different medium, developing an aspect of the meaning of 'self' and how it relates to 'autonomy'. We produced and exchanged computer patches, visuals, text-based art, and a series of analogue photographies that were then creatively converted into sounds, applying procedures of text-to-speech, text-as-score or image-as-score. In the third step a remix of these artefacts was collectively created, which resulted in the piece *#unSELFed*, a 20 minute sound work.

The second iteration takes the results of the first stage further, questioning autonomy and interdependence of sensory experiences under the theme “artificial intuition”. As a medial constraint, all artefacts we create are designed to be part of a virtual space which will also later become a part of the final exhibition. One seminal idea is to realize a performative sound installation featuring an acoustic feedback system involving an acoustic instrument (double bass) and interactive electronics, which will be captured and presented as a 3D video recording with ambisonic sound. Another room will be designed to host a virtual re-elaboration of *#unSELFed* as a spatial audio experience.

The third iteration is resulting in the final exhibition, which will take place in physical format as well as in a dedicated virtual world on Mozilla Hubs designed by the project team. Our central topic will be "autonomous ecosystemics". This topic, as well as the title of the exhibition *As if They Were Flowers* is inspired by Richard Brautigan's poem "All Watched Over by Machines of Loving Grace" that presents a utopian-dystopian dream of a world where physical and digital beings coexist and form a so-called "cybernetic ecology" (Brautigan 1967). Much like we re-mixed, re-imagined, and re-distributed our initial inputs to create *#unSELFed*, we will take the same approach to create new digital representation of the work-in-progress materials and the final artworks of all our three iterations. Additional materials will be presented to visualize our working process, including generated texts, visualisations of keywords, and sonic fragments from our initial research. All of these materials will be inter-related, creating their own microsystems and feeding into the broader ecosystem of the virtual exhibition.

Autonomous Systems project website:
https://hubs.mozilla.com/acATgSH/autonomous-lobby

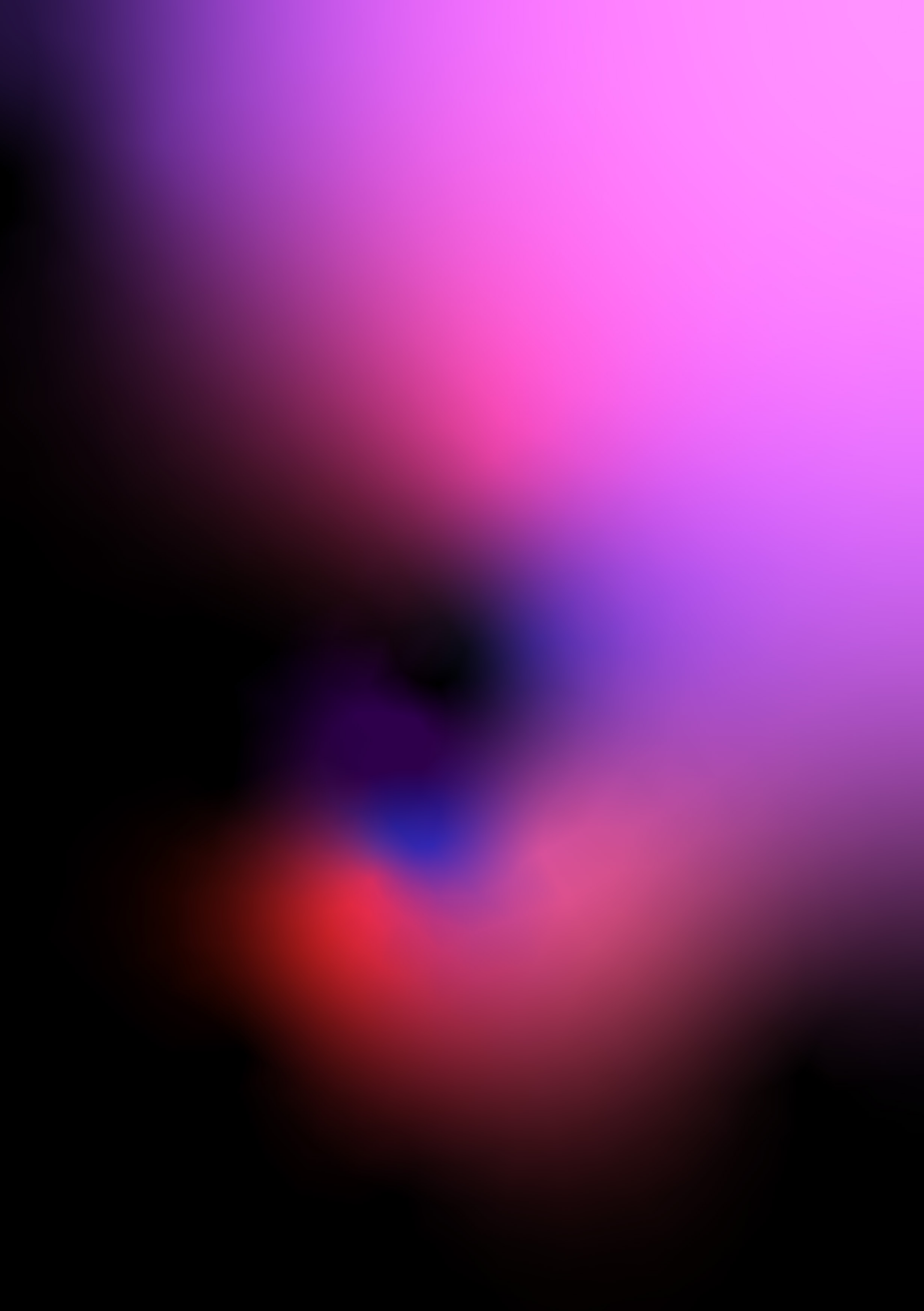
References

Brautigan, Richard.
1967. *All Watched Over by Machines of Loving Grace*. San Francisco: The Communication Company.

Graw, Isabelle.
2002. "Wie von selbst. Über die Aktualität der 'écriture automatique'". *Texte zur Kunst*, No. 48, December 2002.

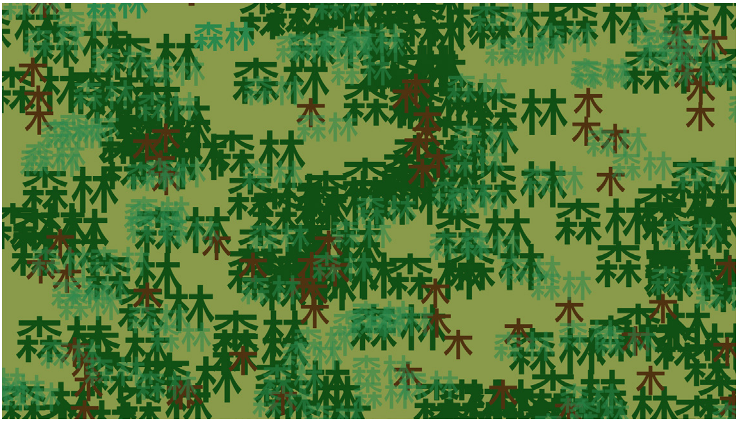
Martin, Adam.
2007. *Entity Systems are the Future of MMOG Development*, Published 3 September 2007. http://t-machine.org/index.php/2007/09/03/entity-systems-are-the-future-of-mmog-development-part-1/ [referred to 03.02.2019].

Performances



xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Yuzhu Chai
yzhuchai@gmail.com

Speak, Pen: A (non)-Instructional Performance

Keywords: Instrument, Concrete Poetry, Visual Poetry, Collaboration, Language, Narrative, Storytelling, Community building, Platform

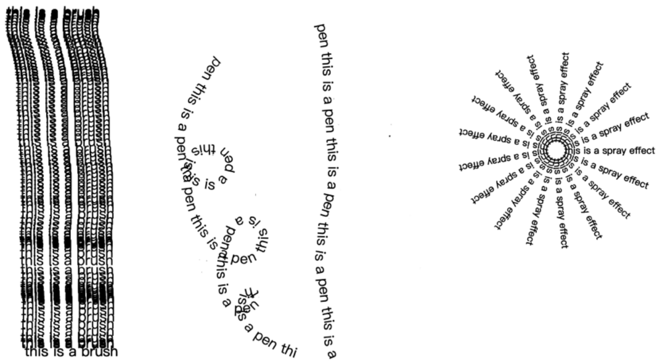
Speak, Pen **is a web-based art tool programmed in JavaScript. It's a drawing tool that replaces the traditional paintbrush with custom text inputs. Users are free to use text on the canvas to make visual poetries, interactive drawings, and performances, etc. Created during a radical tool workshop, the work explores the materiality of text, and ways in which users experiment with text beyond its semantic functions. A** ***(non-)Instructional Performance*** **is a live drawing performance combined with vocal narration. Presented as a series of "tutorials", the performance explores the possibilities of using** ***Speak, Pen*** **while unfolding the theories and story behind its creation.**

https://2021.xcoax.org/ych/

Description

Texts have long been used as a medium of conveying both meaning and visual aesthetes. While some artists like Jenny Holzer and Barbara Kruger utilizes texts to get out powerful messages in their artwork, others like Ed Ruscha who's painting often depicts texts as still life objects also emphasize the shapes and compositions of the words themselves. In concrete poetry, meaning is conveyed by graphic patterns of the texts, and rhythm is experienced through the composition. And for digital art, although unseen, every work is power by pieces of text – code.

Fig. 1. 3 types of brushes from *Speak, Pen.*



Influenced by visual poetry and the poetics of code, *Speak, Pen* is a digital drawing art tool that replaces the traditional paintbrush with texts. It features basic drawing functions inspired by the classic MS paint, so is its user interface. By arranging the characters from the text input in unique ways, *Speak, Pen* can compose different brush textures (Fig. 1). By utilizing the details of the typeface like letter spacings, ascender, and descender, the trailing texts can create different densities to the stroke. The "pen" option features a thinner stroke line, by printing out the letters of the text inputs individually. And the "spray-paint" effect rotates the text inputs around the mouse position. It outputs a flower-like visual, making each letter droplets from the spray can. The art tool also features an eraser function that prints out texts with the background color, displaying it as the negative space in the drawing. Other functions display texts on the canvas dynamically, like movement, fading, and resizing. "In digital media, concreate poetry gains two more levels of expression outside of linguistic and graphic qualities – time and interaction" (Simanowski, 2004).

As an art tool, *Speak, Pen* invites the users to explore those interactions in creative ways. A (non-)Instructional Performance is a live drawing performance combined with vocal narration. Presented as a series of "tutorials", the performance explores the possibilities of using *Speak, Pen* while unfolding the theories and story behind its creation. For example, in one part of the performance "you are my house", I explore the utterance and the multi-sensory aspect of the text, creating a visual and audio poem that comes into being while demolished. The repetition of the sonic elements in the poem is synonymous with the action that I have to perform to continue writing and reading.

Fig. 2. Drawing "you are my house" with *Speak, Pen.*

Fig. 3. Drawing of a forest with *Speak, Pen.*

Informed by my fellow electronic writers, I am largely concerned with the presentational and the representational functions of texts and code, and ways that makers convey messages with words beyond their representational functions. As a Chinese artist, language for me is inherently more visual than sonic. To write in Chinese, in a way is to deconstruct the characters into patterns that would inform the meaning of the words. In the performance, a forest is drawn with the Chinese characters "wood" and "forest" (Fig. 2), texts are used as objects here with their suggested meaning. Later in the performance, the trees got cut down and turn into matches (Fig. 3). And in this drawing, the character "i" is used dynamically to create the burning flames. Used as a paintbrush, texts become a powerful material that can express an aesthetic, convey meaning, and perform actions.

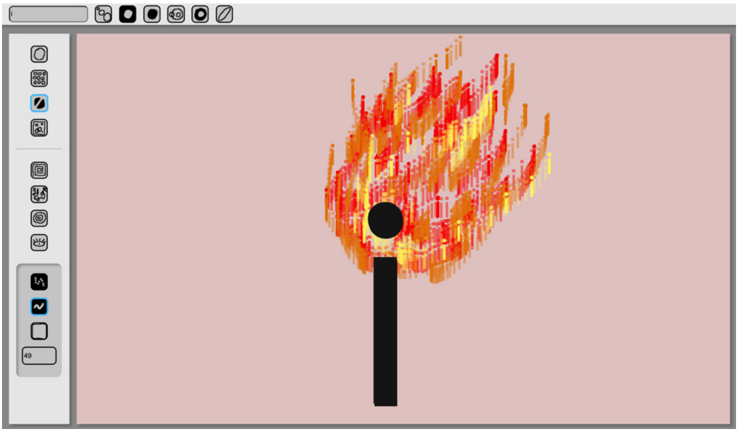


Fig. 4. Drawing of a burning match with *Speak, Pen.*

First created at a radical tool workshop at SFPC, *Speak, Pen* takes inspiration from other "radical" tools that encourage DIY spirit and playfulness – like Nathalie Lawhead's Electric *Zine Maker* and *Become a Great Artist in 10 Seconds* created by Michael Brough and Andi McClure. *Speak, Pen* is programmed with JavaScript as a web-based drawing tool for accessibility. It is not just a digital drawing tool, but rather, a community that aims to inspire makers to experiment with texts beyond their daily functions. It is something that can be performed, alone, or alongside others. You are invited to create with it however you like, the intention to use texts thoughtfully to convey messages or simply use words as images is completely up to the users. The makers can then upload their creations to the community page where they will continue to inspire others and be inspired. The work itself grows from it too, I will constantly add new functions to the tool, as performances and interactions with audiences add iterations to its original form. I intended to blur the lines between users and the creators or mediators of a platform. Our community guidelines are based not on rules for how to use the text brush, but examples of how past audiences have experimented with it. Borrowing from Lori Emerson's blog titled 'making as meaning', the meaning of the works lies not within the interpretation of the texts in the drawings, but the different engagements with the tool within and outside its community.

References

Chun, Wendy Hui Kyong. 2011. *Programmed Vision: Software and Memory, Cambridge*, MA: The MIT Press.

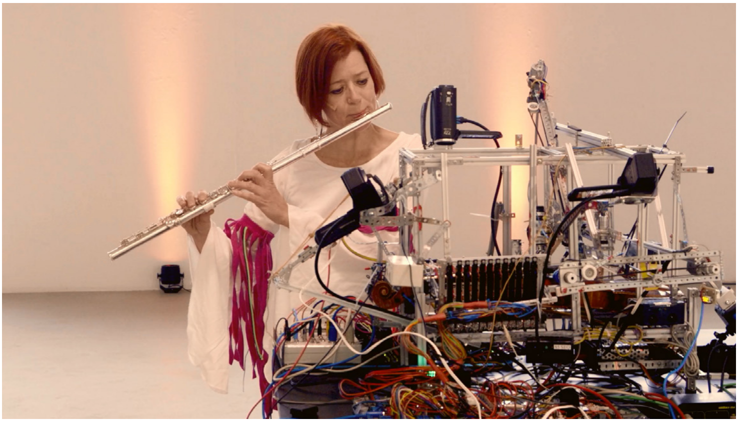
Emerson, Lori. 2010. *"Making as Meaning: from Dirty Concrete to Critical Code."* Net Poetic, May 24, 2010. http://www.netpoetic.com/2010/05/making-as-meaning-from-dirty-concrete-to-critical-code/

Galloway, Alexander R. 2006. *Protocol*. Cambridge, MA: The MIT Press.

Simanowski, Roberto. 2004. *"Concrete Poetry in Digital Media."* Dichtung-digital, March, 2004. www.dichtung-digital.org/2004/3-Simanowski.htm.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Karl F. Gerber
kfg@improvise.de
Independent Practitioner,
München, Germany

Approaches for Flute, Alto Flute and Interactive Violin Automaton

Keywords: Interactive, Automaton, Distancing, Violin, Flute

Even before the Corona Pandemic became known, I had the idea for an interactive piece with my violin automaton. One of the parameters for the communication was the distance of the player to the apparatus. Striking coincidence with social distancing and loneliness during lockdown. The title of the work has a double meaning: musical and physical approach of the flautist to the automaton.
On the one hand, the interactive system with the violin automaton represents a flexible improvisation system for the flutist. On the other hand, it is an enigmatic labyrinth in which the performer moves. The flutist assumes a responsibility for controlling the machine; in addition to making sense of her improvisation, the sound of the flute. Soloist Ms Karina Erhard was involved in the process of composition and technical optimization for months and provided valuable contributions. The piece is dedicated to her. The use of technology is rather playful and does not compare to robotics. The automaton allows extended sounds and rhythms by means of three bows, vibrato, percussion on the strings and ponticello. New sounds emerge from conflict rhythms between vibrato and tremolo. The offered video shows with many close-ups the interactions of the duo partners.

https://2021.xcoax.org/kfg/

Prehistory

Approaches is an interactive piece for flute and my self-constructed violin automaton. I have been performing with the automaton in galleries and on stages since 2012. Mostly by controlling the automaton from stored MIDI data, i.e. fixed media performances. Less often as formula improvisation in real time. Again and again instrumentalists approached me, who wanted to interact with this machine musically. This is how *Approaches* came into being as the first fully elaborated work with a flutist as a duo partner.

Compose to Improvise

As is not unusual in creative processes, I not only composed, but also made parallel changes to the automaton. I aimed at the possibility of improvisation for the soloist. In general, one can prepare algorithms for interactions for this purpose. It would be more attractive if these were not static. However, I did not want to prescribe a time sequence (cues), but leave it to the soloist which of the prepared algorithms she chooses. This selection is done by approaching the sound sculpture from six different directions. The generated sensor signal selects the algorithm, additionally the measured distance is used in the algorithm (together with the flute signal). On the one hand, the interactive system with the violin automaton represents a flexible improvisation system in which the flutist can navigate. On the other hand, it is an enigmatic labyrinth in which the performer moves in order to reach musical "exits".

Additional Challenges for the Flutist

The flute playing is addressed to two receivers: the listener - as usual - and the machine. The flautist also takes responsibility for its response - far away from AI. In this configuration, the flute has a dual role: it controls the machine, but its playing should also function musically as a duet. There is a description of the reaction for the six movements, i.e. a score. The mostly very direct - but not trivial - reactions of the machine have led to considerable learning curves. Developing this requires difficult learning with surprises. The learning effects are the result of testing the reaction algorithms by playful improvisation of the flautist with the system. In parallel, the system was refined. This simultaneity in learning has demands not known in traditional music.

There you will find a stable and refined concept of traditional instruments and art of playing, which has been stabilized over the years.

System Considerations

The technical game involves the step-by-step testing of the coupled system from many parts: G2M Pitch2MIDI module, the NI Reaktor panels, infrared distance sensors, the digital2CV converters for the fingers and bow motors. Conversely, the analog Control Voltage of the Infrared Sensors are converted back to MIDI by the Doepefer module. Not to forget the in-ear monitoring and head microphone transmitter for the flautist. Over many months, the builder and composer - also with the support of the flutist - refined control and hardware. My use of technology is rather playful and does not compare to industrial robotics. A mechanical-acoustic sound generator brings many limitations and challenges to the implementation. Even artifacts of the actuator are implemented musically: the strings are also played percussively. New sounds are also created with conflict rhythms between (frequency~) vibrato and (bow~) tremolo.

As “interactive music without loudspeakers” the concept stands in an exciting own development strand of sound art and visualization.

Self-Understanding

With the violin automaton, every viewer finds his or her own approach, there are many of them: Do you want to see a parody of classical virtuosity or a protest against sweet string sound? The technical structure of the Automaton also has an improvisational character; after all, it is a work in progress that is constantly evolving. So the appropriation of different technologies and arts by a single artist? This contrasts with the modern industrial division of labour for software, firmware, system architecture, model making, 3D printing, rapid prototyping, mechatronics, quality management, production engineering, etc. What is sought is not the universal genius, but a coherently chosen combination of basic skills in various fields: Authoring technology, self-employment, musical instrument making. Not to forget craftsmanship and material procurement. A great fortune for the project is the fact that I can holistically control and optimize all technical components of the machine.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Daniel Bisig
ad5041@coventry.ac.uk
Coventry University, Coventry, United Kingdoms
daniel.bisig@zhdk.ch
Zurich University of the Arts, Zurich, Switzerland

Ephraim Wegner
ephraim.wegner@hs-offenburg.de
Offenburg University, Offenburg, Germany

Medienkulturwissenschaft Albert-Ludwigs-Universität Freiburg

Harald Kimmig
hakim@haraldkimmig.de
Freelance, Freiburg im Breisgau, Germany

Strings P

Keywords: Simulation-based Interaction, Sound Synthesis, Generative Art, Audiovisual Performance, Improvisation

Strings **is an audiovisual performance for an acoustic violin and two generative instruments, one for creating synthetic sounds and one for creating synthetic imagery. The three instruments are related to each other conceptually, technically, and aesthetically by sharing the same physical principle, that of a vibrating string. This submission continues the work the authors have previously published at xCoAx 2020. The current submission briefly summarizes the previous publication and then describes the changes that have been made to *Strings*. The P in the title emphasizes, that most of these changes have been informed by experiences collected during rehearsals (in German *Proben*). These changes have helped *Strings* to progress from a predominantly technical framework to a work that is ready for performance.**

https://2021.xcoax.org/dbi/

Fig. 1. Rehearsal Still

Introduction

Strings represents the newest iteration in a series of works by the authors that combine acoustic and synthetic instruments in an open improvisation setting. This openness is complemented by generative principles that are shared by all instruments. The principles affect the interaction among the instruments and their means of producing acoustic and visual output. This establishes a strong aesthetic correlation even during moments of free and independent play. In *Strings*, the shared principles are based on the physical phenomenon of a vibrating string. In case of the acoustic instrument, a violin, this principle forms part of its natural sound production mechanism. In case of the synthetic instruments, this principle is translated into computer simulations that operate as generative mechanisms for creating synthetic sounds and images.

A first version of *Strings* has been described previously (Bisig and Wegner 2020). This earlier publication focused on the academic and artistic contexts that inform the work and the details of its technical implementation. This came at the cost of a missing discussion of a rehearsal. The current submission rectifies this by highlighting how observations made during rehearsals inspired further developments. The remainder of this text is structured as follows: the "Background" and "Implementation" sections of the previous publication are briefly summarized, the insights gained during rehearsals and their influence on further developments are presented, and possible future directions for research and development are outlined.

Background

The realization of *Strings* is inspired by two different applications of generative techniques: their integration as elements of control for a digital instrument and their use to create correlations between different media.

Interactive generative systems, especially those that are based on the simulation of familiar natural principles, can respond to interaction in a manner that is easy to understand. This effect can be exploited to improve the naturalness and intuition of interacting with digital instruments (Mulder and Fels 1998, Pirro and Eckel 2011, Castet 2012). Furthermore, generative systems can potentially exhibit complex behaviours. This reduces their level of predictability, which in turn offers possibilities for exploration and experimentation (Johnston 2009).

Generative systems can be used to concurrently control the creation of different media. This provides interesting opportunities for collaboration among artists (Bisig and Kocher 2013, Alaiou etal. 2014), can establish aesthetic correlations among the different media (Momeni and Henry 2006), and exposes to an audience the underlying generative principles (Momeni and Henry 2006, Johnson 2009).

Implementation

An overview of the main technical components and their control by three performers is shown in Fig. 2. *Strings* combines two generative systems that simulate the vibration of strings by means of a mass-spring-damper model. The simulated strings are used to control the creation of synthetic sounds and images.

The activity of both generative systems is predominantly controlled by the violinist. The violinist's visual appearance and acoustic output are recorded by a camera and a microphone, respectively. The camera image is analyzed by detecting salient image points. These points are tesselated into a triangulated surface which serves as basis for constructing a mass-spring system that in turn controls the creation of synthetic images. The microphone recording is analyzed by calculating a frequency spectrum. Based on the energy in each frequency bin and the consonance relationships among them, a subset of bins is selected. These bins are then used to excite through a simulated resonance effect the simulated strings in both generative systems.

The generative system that controls sound synthesis simulates several one-dimensional arrays of interconnected springs. The topology of these arrays is defined in advance and doesn't change during simulation. The generative system that controls image synthesis simulates two-dimensional meshes of interconnected springs. These meshes are created from a live camera image and their topology changes dynamically.

The simulated springs are translated fairly directly into acoustic and visual output. The spring arrays are sonified by mapping the deflection of mass-points into amplitudes of a waveform. The spring-meshes are visually rendered as triangulated surfaces whose coloring and opacity is controlled by the live camera image and the amplitude of the springs' oscillations, respectively.

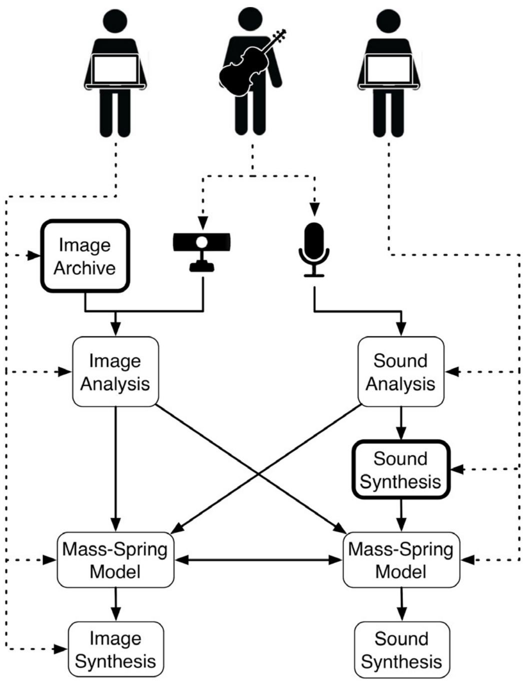


Fig. 2. Implementation. The schematic figure depicts the main technical components of Springs. Solid arrows represent data flow between these components. Dashed arrows represent interactive controls by the performers. The components represented by boxes with thin outlines were already part of the original implementation. Components shown as boxes with thick outlines were newly developed.

Rehearsal and Development

During last year, the authors have extensively rehearsed Strings. A visual impression of a rehearsal is shown in Fig. 1. Several excerpts from video recordings of these rehearsals are available online.[1][2][3] The purpose of these rehearsals was

1. Video Excerpt 1
2. Video Excerpt 2
3. Video Excerpt 3

three fold. 1) To familiarise the violinist with the interactive controls and the synthetically produced media. 2) To establish an iterative process of continued development and evaluation. 3) To devise an outline for a performance structure.

This submission focuses on the first two aspects.

During rehearsals, it became apparent that the mechanisms for establishing a correlation between the activities of the violinist and the generative systems worked so effectively that it was to the detriment of the aesthetic richness of the performance. Furthermore, it also became evident that the level of interactive control among the three performers was too heavily tilted towards the violinist. As consequence, the synthetic outputs of the generative systems mostly mirrored the visual and acoustic presence of the violinist.

Based on these observations, several adaptations have been made to the generative systems. In the following description, the adaptions are grouped into those that increase aesthetic diversity and those that re-balance interactive control.

Aesthetic Diversity

The generative system that produces synthetic audio has been altered in several ways. The number of strings that can be modelled was increased by porting parts of the implementation from CSound to C++ . This offers the possibility to concurrently simulate a large number of strings with only some contributing to the audible output while the others remain muted. Thanks to this, an *archive* of sonically diverse strings can be prepared ahead of time and then selectively chosen from during the performance. Another change concerns the mechanism of excitation of the simulated strings. In the original version of *Strings*, the spectral analysis of the microphone recording directly excited the simulated strings. This direct excitation has been abandoned by introducing an additional sound synthesis layer that mediates between spectral analysis and string oscillations. The additional layer combines several simple sound generators including sine oscillators, impulses, impulse chains, and white noise. These generators are controlled by the spectral analysis. The generators' output is then used to excite the simulated strings. Via this indirect excitation, the simulated strings can reproduce a wider range of acoustic phenomena, such as plucking and bowing.

The generative system that produces synthetic images has also been modified. One modification concerns the image material that serves as input for creating a two-dimensional mesh of simulated strings. Rather than to rely solely on the live camera image for this purpose, additional images can now be retrieved from a collection of pre-stored images and combined with the camera image. The purpose of this modification is similar to that of employing an *archive* of pre-configured simulated strings for sound generation. It permits to create a collection of source images and processing settings that can be tested ahead of time for their capability to generate a wide diversity of visual results. As second modification, an additional mechanism for controlling the movement of the simulated springs has been devised. The mechanism introduces forces that make the simulated mass-points move at pre-determined velocities. Depending on the mass-points' interconnection by springs, this mechanism causes the meshes to organise into multiple regions that exhibit different rotational movements. As a result, the diversity of behaviours of the image generating system increases.

Interactive Control

Several of the previously described modifications have been implemented not only for the purpose of increasing aesthetic diversity but also to shift the balance of interactive control.

The presence of an intermediate sound synthesis layer replaces the direct relationship between the violinist's acoustic output and the synthetically generated sounds by a more flexible correspondence. This offers more opportunities for interaction for the laptop-performer who can freely select during the performance which of the intermediate sound synthesis systems responds to the violinist's acoustic output and excites the simulated strings. The availability of an *archive* of pre-designed simulated strings frees the laptop-performer largely from concerns that the interactive manipulation of the simulated strings causes the simulation to become unstable. The archived strings can be tested ahead of a performance for their stability. Furthermore, currently sounding strings don't need to be strongly modified to obtain different acoustic results. Instead, such results can be achieved by selectively un-muting strings from the *archive.*

The establishment of an *archive* of images that serve as source material for creating simulated string meshes and the addition of forces that cause the mass-points to move at pre-defined velocities have made the synthetic image generation process more flexible and independent from the activities of the violinist. Accordingly, these aspects offer more opportunities for creative experimentation by the laptop-performer. The performer can chose different source images and thereby influence the generated spring meshes independently of what is happening on stage. Furthermore, the performer can combine resonance-based string oscillations with directly controlled mass-point velocities and thereby alter the dynamics of the resulting synthetic image.

It's important to mention that these changes have not only shifted the balance of interactive control among the performers, but they have also established two different levels of interaction. On a regular level, interactivity controls some of the properties and behaviours of the generative systems. This level has already existed in the first version of *Strings*. But in addition, a meta level of interactivity has now become available. This meta level controls to what extent regular interactivity is shifted from the violinist to the other performers. These changes have a large impact on the improvisation situation.

Outlook

The authors expect that additional performances and rehearsals will inspire further improvements of the generative systems. Under the assumption that the setup with its three distinct instruments remains the same, the authors envision the following modifications.

Currently, the meta level of interactivity is exclusively available to the laptop performers. This level of interactivity should also be made accessible for the violinist. But for this, additional gestures by the violinist need to be integrated as control cues. It might be useful to employ non-sound producing gestures for this purpose. But the camera and microphone based tracking that has been used so far is ill suited for this task. It is complicated to analyze a camera image for specific gestures and non-sound producing gestures can't be recorded by a microphone. For this reason, the authors plan to integrate wearable sensors such as inertial measurement units and/or respiration sensors into the stage setup.

Concerning the diversity of the synthetic outputs, the approach followed by adding a mediating sound synthesis layer warrants further exploration. This approach is attractive since it preserves the functional and aesthetic coherence between the acoustic and digital instruments and simultaneously expands the diversity of results. The authors plan to investigate how this approach can also be adopted for the image producing generative system.

References

Bisig, Daniel and Kocher, Philippe. 2013. *Trails II*. Proceedings of the Consciousness Reframed Conference. Cairo, Egypt.

Bisig, Daniel and Wegner, Ephraim. 2020. *Strings*. Proceedings of the Eight conference on computation, communication, aesthestics & X (xCoAx), pp. 299-312.

Castet, Julien. 2012. *Performing experimental music by physical simulation*. Proceedings of the International Conference on New Interfaces for Musical Expression. Michigan. USA.

Fdili, Alaoui, Sarah, Cyrille Henry, and Christian, Jacquemin. 2014. *Physical modelling for interactive installations and the performing arts*. International Journal of Performance Arts and Digital Media 10, no. 2, pp. 159-178.

Johnston, Andrew James. 2009. I*nterfaces for musical expression based on simulated physical models*. PhD diss.

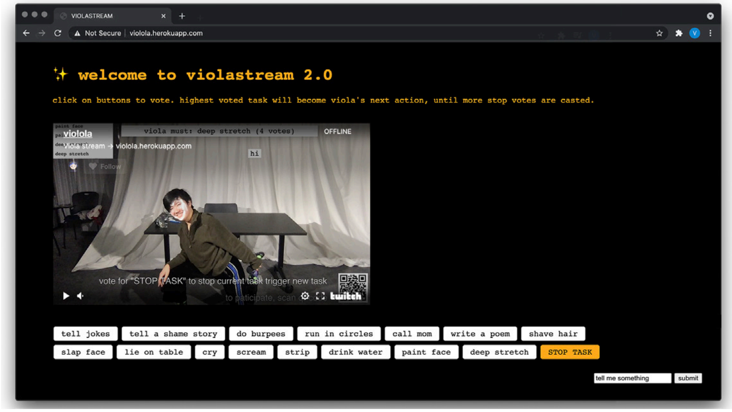
Momeni, Ali and Henry, Cyrille. 2006. *Dynamic independent mapping layers for concurrent control of audio and video synthesis*. Computer Music Journal, 30(1), pp.49-66.

Mulder, Axel and Fels, Sidney. 1998. S*ound sculpting: Manipulating sound through virtual sculpting*. Proceedings of the 1998 Western Computer Graphics Symposium, pp. 15-23.

Pirrò, David and Eckel, Gerhard. 2011. *Physical Modelling Enabling Enaction: an Example*. Proceedings of the New Interfaces for Musical Expression (NIME) Conference, pp. 461-464.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Viola Leqi He
lh1783@nyu.edu
Interactive Telecommunication Program,
Tisch School of the Arts,
New York University,
New York, U.S.

VIOLASTREAM: An Interactive Performance

Keywords: Performance, Livestream, Cybernetics, System, Agency, Web, COVID-19

VIOLASTREAM is an online, interactive performance that utilizes web technologies in order to explore the performer’s body as it relates to others. The core of this performance is a system I devised, handing control to my audiences who collectively vote for my behaviors. At my isolated performance space, a computer displays and reads the audiences’ votes and comments in real time, and asks me to carry out the highest voted tasks. While the audiences act as commanders and spectators, Viola’s body performs the role of the object and machine, creating a cybernetic relationship through webcam and livestream as medium.

https://2021.xcoax.org/vhe/

Description

In 2020, live streaming saw a global rise in popularity due to the COVID-19 pandemic. According to StreamElements and its analytics partner Arsenal.gg, global viewership has increased by 15% on YouTube Gaming, and 10% on Twitch, peaking at around 1.7 billion hours in November. Streaming is growing into a medium that's become rather ubiquitous in various forms of media consumption, with new possibilities opening up to artists, educators and media practitioners.

The core of VIOLASTREAM is a system where I hand control to my audiences who collectively vote for my behaviors online, live-broadcasted to the very people who cast these votes. Through a hand-coded HTML webpage (see Figure 1) that embeds the voting system, a comment input box, and a livestream where the votes are counted, comments are shown, and highest voted tasks are carried out by me, the performer, in real time, all the information sent through different devices at different locations connects into one networked interaction. The webpage is connected via socket.io, a JavaScript library that enables server-client communication, to a p5.js sketch, which displays as an overlay of the livestream on Open Broadcaster Software (OBS). With the implementation of p5.speech, a p5.js extension with text-to-speech functionality, individual inputs merge into one computational voice feeding me orders and information. All the audiences, in turn, become one spectating commander, while the performer's body act as the object and machine, creating a cybernetic relationship through livestream as a medium.

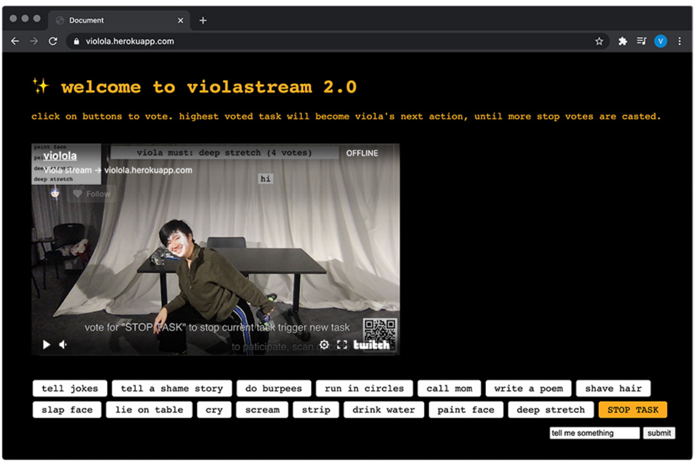


Fig. 1. The Webpage that houses VIOLASTREAM.

Inspired by the works of performance artists Tehching Hsieh and Marina Abramović, who often inspect their own bodies and identities in relations to others, I wonder about how participatory, time-based performances challenge personal agency in human-to-human communications, and how that would be changed, disrupted, or enhanced with the involvement of internet and computational machines. My interest was not exactly in pushing boundaries of performance art, but rather questioning those relationships in the current reality. In 2020, live interactive performances on digital media is no longer an unfamiliar act, as we see a rise of streamers, gamers and sex workers on different live-streaming platforms encouraging controlled interactivity as means to boost engagement and monetization. Internet personalities such as Twitch user Ludwig host continuous live-streaming for days and even weeks, exposing their daily lives while making certain choices available for the audiences (gifting, subscribing in exchange of longer streams, certain requests, as well as sometimes harmful fan-initiated interventions). However, as a performer that emphasis on their commonality as an everyday person, offering control of minute, mundane movements that are only slightly too intimate to perform for strangers online, my question for agency in this human-machine-human relationship is a confrontation to the mild hell of daily awkwardness.

VIOLASTREAM's two iterations were performed three times in different spaces. The initial version, performed on October 6, 2020, was created under the prompt of "self-reinvention", aiming to discussing what it means to give up agency in my day-to-day life. It was set up at my apartment, with tasks I could complete from my bedroom and kitchen. The audiences were able to vote on the webpage and converse in the Twitch chat of my stream, but I didn't address them during the performance. (see Figure 2)

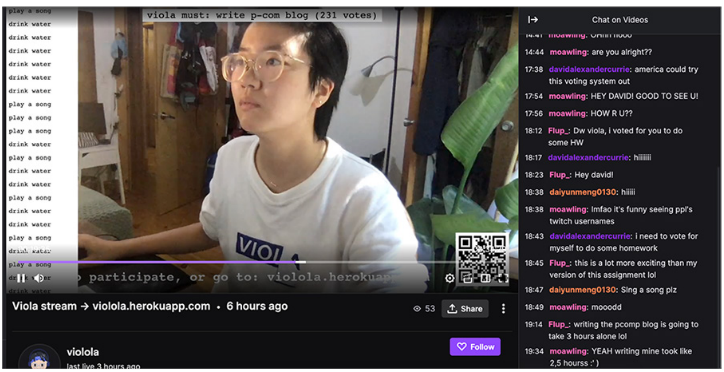


Fig. 2. Screenshot of Livestream during first Performance.

On December 16 & 17, 2020, VIOLASTREAM 2.0 was performed twice for the online ITP Winter Show at NYU Tisch School of the Arts. Taking away the emphasis of a domestic environment, I created a "neutral" performance space to conduct more intimate tasks, while tweaking the voting system as well as creating a continuous interactive feedback loop with comment input and text-to-speech functionality. I intentionally included tasks that would make me uncomfortable, and the eventual performances, as a result, felt a lot more emotional and personal. This is a project that I plan to continue developing, through setting up in different spaces and interacting with different audiences, refining the system along the way. Proposal of the 3.0 version, if presented in the conference, would potentially involve a network of lights and cameras that can be selected and controlled by the audiences.

Entering this performance, I was aiming to explore the choreography of control as I, creator of the feedback system, invite the computer into my relationship with other humans, using live-streaming as medium. In her text "On Software, or the Persistence of Visual Knowledge", Wendy Hui Kyong Chun examined computation as an act of command, and therefore puts the programmer in a position of power with a pleasurable sensation of control, which is closely related to the gendered history of programming (Chun 2005). I felt strongly that the anxiety of lack of control in this performance was, at the same time, empowering and liberating. Just like women in early computing who worked as "human computers", as both the indicator and indicated, I, a human who occupies a female body, find my roles of programmer and performer to be complimentary and contradicting. While the machine delivers the commands from the spectators attempting to control me, it's also an embodiment of myself.

From time to time taken by the kindness of the audience, there was also a sense of collectiveness in individual acts of command. Performing during a global health crisis is to work through shared experiences of solitude, isolation, and, according to Yuk Hui, "a time of catastrophe" in which we should seek "a concrete solidarity" (Hui 2020). VIOLASTREAM amplifies the "interconnected nodes" in a "network society" in the accelerating digitization age, creating a networked system that magnifies each nodes in relations to the others as well as the center connection (Castells 1996), even if it's just within a temporary community of participants in this performance. With every comment communicated, every vote read and calculated (some responded and acted out), viewership, together with the participation of the "unbiased" machine that runs the algorithm, creates an ecosystem beyond a simple performer-audience relationship.

Acknowledgements. VIOLASTREAM is only possible with the help of my friend and collaborator David Currie, who contributed tremendously to the back-end development process. Faculties at NYU's Interactive Telecommunication Program: Mimi Yin, Melanie Hoff, Anastasis Germanidis, and Dan Oved, thank you for your support and advice.

References

Castells, Manuel.
1996. *The Rise of the Network Society*. Malden, MA: Blackwell Publishers.

Chun, Wendy HK.
2005. *On Software, or the Persistence of Visual Knowledge*. Cambridge, MA: Grey Room. The MIT Press.

Hui, Yuk.
2020. *One Hundred Years of Crisis*. e-Flux.

Peisner, David.
2021. *Concerts Aren't Back. Livestreams Are Ubiquitous*. Can They Do the Job?. New York, NY: New York Times.

Wilde, Thomas.
2020. *Livestreaming market report: Twitch keeps setting records and 'Just Chatting' continues rapid growth*. GeekWire.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Seth D. Thorn
seth.thorn@asu.edu
School of Arts, Media + Engineering
Arizona State University, Tempe, AZ, USA

Machinic Intersection: Not—Yet—Chaconne

Keywords: Augmented Violin, Machinic Heterogenesis, Composed Instruments, Haptics, Enactive Thought, Classical Remix, Guattari, Deleuze

The *Chaconne* is the final movement of J. S. Bach's *Partita in D Minor* for solo violin. Recreating this piece with an augmented violin I developed, I draw it into a plunderphonic culture enabled by technologies of reproduction and performance. By means of signal processing techniques I construct through trial and error and a novel shoulder rest I designed that attaches to my acoustic violin, giving tangible feedback related to the digitally-reprocessed sound, my system exemplifies Guattari's notion of "machinic heterogenesis." That is, in creating and performing *Not—Yet—Chaconne*, I follow a flow of matter generated by a heterogenous machine acting transversally across corporeal, material, affective, algorithmic, and semiotic domains, with the score being just one part—a musical "piece," hence partial, "not yet"—belonging to this technical ensemble. Real-time signal processing and improvised development of digital musical instruments not only narrows the interval between musical conception and realization but also transforms that interval by jutting its locus to the sensorimotor level, to the biological organism itself, which symmetrizes action and perception, generates a fine-grained consistency, and potentiates a fresh "non-human enunciation."

https://2021.xcoax.org/sdt/

Parting with the Chaconne

The *Chaconne* is the final movement of J. S. Bach's *Partita in D Minor* for solo violin. In the title of my interpretation of this piece I prepend the words "not yet," echoing Heidegger's exigency not to think being as objective presence.[1] The long dashes intensify this theme of delay and deferral. From the perspective of *Being and Time*, these words might resonate with a violinist feeling the intensity of the music's demands, which are marked by the "striking indefiniteness" of a call (Heidegger 1996, 253). The violinist, unable to catch up with those demands, "is" in the mode of temporality of the "not yet." But what holds for the violinist is also true of the musical "piece": the music is partial, not yet. It betrays an incompleteness, a desire for interpretation, a future that cannot be fully anticipated or controlled by "its" composer: Bach's Chaconne is not a thing, but a point of departure, an inscrutability that—like the futurity that makes writing, according to Derrida, *différance*—differs and defers (Derrida 1982, 7-8).

1. "Da-sein, as itself, has to *become*, that is *be*, what it is not yet" (Heidegger 1996, 226).

If the autobiographies of the great violinists narrate this calling and this struggle, Arnold Steinhardt's—the celebrated first violinist of the Guarneri Quartet—is no exception, and many pages are dedicated there to recollecting a lifelong aspiration to answer the *Chaconne's* call, often regarded as the summit of the solo violin repertory. Steinhardt reports on his attempt to decipher the work's cryptic and suggestive symbology: "If you took the number of bars in the Chaconne, 257, and added its digits together, the total was Bach's name again: 2 + 5 + 7 = 14" (Steinhardt 2008, 191).[2] Speculating on the combinatorial possibilities, however, only yields further questions. Working from a facsimile of Bach's score, Steinhardt makes a less arithmetic observation:

2. "Bach certainly knew the numerical value of the letters in his name (that is, B=2, A=1, C=3, and H=8) and often used their sum, 14, as a kind of musical signature" (Ibid).

> Of the few Bach manuscripts I had seen in facsimile this was by far the most beautiful, its undulating waves of notes hinting at motion and something rhapsodic in the music's character. (Ibid, 187)

The material quality of the marks suggests that what the score signifies is inseparable from how it signifies: do these marks not also suggest something about the music—that is, signify—in their very manner of signifying?

Reflecting on the intimacy of the "what" and the "how" only fortifies the sense that the *Chaconne* is anything but an objectively present thing, the proper interpretation of which would be accessible by way of scrupulous musicological probity. Looking at the *Urtext*, rather, still more emphatically reveals the score to be a point of departure rather than one of arrival. This is one way to understand and approach the work, *Not—Yet—Chaconne*, that I am presenting here. To use literary critic Samuel Weber's sharp phrasal verb pinning together futurity and historical remembrance, I am "parting with" the *Chaconne* (Weber 2008). I follow the work of others who part with pieces by drawing them into remix cultures enabled by technologies of reproduction[3] and performance, such as neoclassical composer Max Richter's magnificent Recomposed. Richter reworks portions of Vivaldi's *Four Seasons* by means of postmodern minimalist techniques such as looping and phasing to develop an extraordinary new composition. This music is shot through with plunderphonia and the mechanics of industrial machines that plunderphonic culture is built upon—tape recordings and machinic loops—that migrated into musical scores during the twentieth century and were anticipated and celebrated early on by the Italian Futurists.

3. Such reproduction is nothing new: the title of Walter Benjamin's well-known essay is properly translated as "reproducibility" (*Reproduzierbarkeit*)—not "reproduction"—and as Weber convincingly argues, this reproducibility is already a movement of *différance*: "To therefore define these processes as quasi-transcendental, structuring possibilities is to shift the emphasis from the ostensibly self-contained work to a relational dynamic that is precisely not self-identical but perpetually in the process of alteration, transformation, becoming-other" (Weber 2008, 59).

My approach, however, is different, insofar as no consummate written score results from the musical machine I steer, but neither does that machine operate on the basis of an instrument that entirely preexists it. Such is the situation of the electronic work, which is more symmetrically realized in the relative simultaneity of the development of the "score" and means of sound generation, the "instrument"—terms less appropriate to an ontology of electronic music. This situation, in fact, prompted Adorno to show great admiration for Stockhausen's notion of electronics works, insofar as the affirmation of impermanence rallies against the bourgeois category of property:

> Stockhausen's concept of electronic works—which, since they are not notated in the traditional sense but immediately "realized" in their material, could be extinguished along with this material—is a splendid one of an art that makes emphatic claim [sic] yet is prepared to throw itself away. (Adorno 1997, 177-8)

Machinic Intersection

Alongside deconstructive and historical-materialist approaches, Adorno's comment points to another way by which the status of the musical score qua transcendental object, and thereby the classical ontology of musical works, is transformed by digital performance technologies. The music of both Bach and Richter is written for a set of instruments preexisting that music. Stockhausen's compositions are not "realized" in this way through performance, but his situation is, nevertheless, quite different than the one that holds today, which is—to take up the question of deferral again—not only a matter of the shrinking interval between conception and realization, but of the jutting of the locus of that interval to the sensorimotor level, to the biological creature itself, thus to the symmetry not just between score and instrument but between *action and perception* (Thorn 2021).

Real-time signal processing affords an approach to the construction of musical instruments that requires neither the instrument nor the music to be modeled in advance. Thus, for such "composed instruments" and the music they make, in which gestural and sound producing parts are mechanically decoupled in order to be written in a mutable discrete code (Schnell and Battier 2002), the development can advance through improvised negotiation between mechanical and final causes—*non-hylomorphically*, in other words (Thorn and Sha 2019). By trial and error, the salient features of the instrument can be constructed through an abductive process. The choices in the mathematical analysis of the feature vectors construct a sound, a new one, that has never been heard. "Actuated" digital musical instruments, which place electromechanical actuators into instruments in order to give them tangibility (Overholt, Berdahl and Hamilton 2011) are the most compelling example of this sensorimotor symmetry that can be enacted, newly, off the cuff.

Fig. 1. The vibrotactile shoulder rest I use with my augmented violin.

My approach to creating *Not—Yet—Chaconne* — and here I look to a very different, even incommensurate tradition to open up the philosophical consequences of this new sensorimotor situation—is positioned at what Felix Guattari calls the "machinic intersection" (Guattari 1995, 47). To develop this work, I part with the *Chaconne* by improvising on its figures: stretching and repeating them, moving through the score non-linearly while devising novel feature vectors, bespoke synthesizers, and fresh sampling techniques in my code. This machinic assemblage is intensified by my use of a shoulder rest with tangible feedback I developed that attaches to my violin (Thorn and Lahey 2019). Shoulder rests are ubiquitous accessories used by upper string players for ergonomic support, but mine is the first to embed electrical hardware. Coupled to the violin with coated rubber feet that dampen the transmission of vibrations, the shoulder rest lies across the violinist's collarbone and chest, enabling multimodal feedback felt against the player's body—as if it were emanating from the violin itself—yet has less pronounced effect on the violin's acoustic body. In the software, a dedicated return track for the actuators enables precise construction of the vibrotactile dynamics. Lower-latency processing might be sent to the shoulder rest, for instance, while more extended processing is steered solely to the room monitors or open-back headphones I wear. "Playing the room," as violinists have done for centuries by engaging architectural acoustics, I explore this digitally-crafted space, the mixed reality of ambient digital logic and preexisting material acoustic affordances (of discrete reflections and fused reverberation tails.)

As an itinerating artist practicing "nomad science," what I follow in creating *Not—Yet—Chaconne* is a "flow of matter" generated by a heterogenous machine acting transversally across corporeal, material, affective, algorithmic, and semiotic domains (Deleuze and Guattari 1987). Musical notation is a "part" or "piece" among others in this technical ensemble (Sha 2013, 29). Insofar as my shoulder rest has evolved into a functionally synergistic and concrete form—Gilbert Simondon's criterion for technical progress (Simondon 2017)—belonging at once to the violin, the music, and the sensorium of the human performer making the music, it is also a clarifying example of Guattari's notion of machinic heterogenesis (Guattari 1995) and the increasing consistency of the musical assemblage, priming it for the eruption of novel musical forces. My performance is emblematic of a larger project I am undertaking, namely to make these machines available to other violinists, especially classically trained ones still unfamiliar with algorithmic sound and signal processing, who may find it compelling to transform canonical violin repertory with which they are familiar by means of real-time transformation. Tinkering with code, the musician activates heterogenesis. New modes of subjectivity are invented in "follow[ing] a line (of flight)," philosopher Elizabeth Grosz writes, recapitulating Deleuze and Guattari, "giving sound to what has not been heard before," (Grosz 2008, 57).

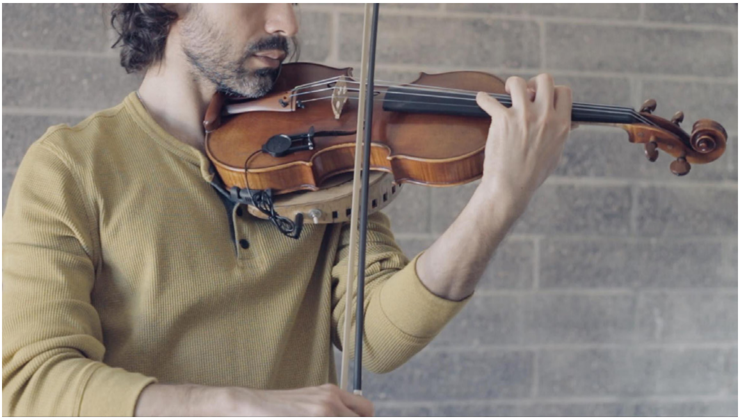


Fig. 2. A new shoulder rest prototype with on-board digital signal processing and sound diffusion. The enclosure for this model was designed and constructed by my colleague, Byron Lahey.

To properly compose an event, a consistency must be wrenched from chaos.[4] Grosz offers the elucidating example of a floor:

> The floor, ever acquiring smoothness, suppleness, and consistency, makes of the earth and of horizontality a resource for the unleashing of new and more sensations, for the exploration of the excesses of gravity and movement, the conditions for the emergence of both dance and athletics. (Grosz 2008, 14)

My vibrotactile shoulder rest is just such a way to wrench consistency from chaotic forces, from the heterogeneity at the machinic intersection, which in the nascence of real-time composed digital instruments just a few decades ago lacked the suppleness affording a more convincing integration, a surface that one could grip. The struggle with digital musical instruments is a struggle for a fine-grained, "molecular" consistency (Thorn 2019), but consistency should not be mistaken for unity, that is, for an utter flattening that would dissolve heterogeneity and thereby lose the material and conceptual resistance critical to musical production (Evens 2004, 160-73).[5] The shrinking interval between musical conception and realization—catching up to the action-perception substratum, where it brings symmetry and consistency—constitutes progress. Actuated/tangible digital instruments raise the bar.

According to Guattari, machinic heterogenesis produces a "non-human enunciation" (Guattari 1995, 47). To conclude my short essay, I will briefly try to answer: in what sense could this be true of the musical assemblage *Not—Yet—Chaconne*?

4. See Deleuze and Guattari's description of the "sound machine" in *A Thousand Plateaus* for a trenchant excursus on consistency vis-à-vis electronic sound synthesis (Deleuze and Guattari 1987, 343).

5. Musicians who do not build their instruments know this, too: "[S]heer homogeneity is no recipe for making music together" (Sennett 2012, 14).

Sensorimotor research pertains to the organism, the biological creature. In *Not—Yet—Chaconne*, the line between this organism, the musical instrument, and the music is no longer so clear and distinct as in the classical ontology, with the transcendental artistic object—the "score"—being realized in performance. Where does the instrument end and the body begin? The consistency of the machinic assemblage, made evident by this increasing porosity, generates a non-human enunciation. Furthermore, because the system is developed through tinkering and exploratory movement rather than a *priori*, top-down design, it resembles a biological structure, "a patchwork of subnetworks assembled by a complex process of tinkering, rather than a system that results from some clean, unified design" (Varela, Thompson and Rosch 2016, 105). The "thought" in these microstructures is not reflective but enactive, an accumulation of "thinking in movement," to use dancer-philosopher Maxine Sheets-Johnstone's richly undecidable phrase (Sheets-Johnstone 2011, 419-49). In this way, too, the dynamic process produces a non-human enunciation.

References

Adorno, Theodor W.
1997. *Aesthetic Theory*. Minneapolis: The University of Minnesota Press.

Deleuze, Gilles and Felix Guattari.
1987. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: University of Minnesota Press.

Derrida, Jacques.
1982. *Margins of Philosophy*. Chicago: The University of Chicago Press.

Evens, Aden.
2005. *Sound Ideas: Music, Machines, and Experience*. Minneapolis: The University of Minnesota Press.

Grosz, Elizabeth.
2008. *Chaos, Territory, Art: Deleuze and the Framing of the Earth*. New York: Columbia University Press.

Guattari, Felix.
1995. *Chaosmosis: an Ethico-Aesthetic Paradigm*. Indianapolis: Indiana University Press.

Heidegger, Martin.
1996. *Being and Time: A Translation of Sein und Zeit*. Albany: State University of New York Press.

Overholt, Dan, Edgar Berdahl and Robert Hamilton.
2011. "Advancements in Actuated Musical Instruments." *Organised Sound* (16) 2. Cambridge: Cambridge University Press.

Schnell, Norbert and Marc Battier.
2002. "Introducing Composed Instruments: Technical and Musicological Implications." *Proceedings of the 2002 Conference on New Instruments for Musical Expression*. Dublin.

Sennett, Richard.
2012. *Together: The Rituals, Pleasures and Politics of Cooperation*. New Haven: Yale University Press.

Sha, Xin Wei.
2013. *Poiesis and Enchantment in Topological Matter*. Cambridge, MA: The MIT Press.

Simondon, Gilbert.
2017. *On the Mode of Existence of Technical Objects*. Minneapolis: The University of Minnesota Press.

Steinhardt, Arnold.
2008. *Violin Dreams*. New York: First Mariner Books.

Thorn, Seth D.
2021. "Flows of Inhomogeneous Matter: Improvising an Augmented Violin." *Organised Sound* 26 (1). Cambridge: Cambridge University Press.

Thorn, Seth D.
2019. "A Computational System for Violin: Synthesis and Dissolution in Windowless." *Leonardo Music Journal* 29. Cambridge, MA: The MIT Press.

Thorn, Seth D. and Byron Lahey.
2019. "A Haptic-Feedback Shoulder Rest for the Hybrid Violin." *Proceedings of the 2019 International Computer Music Conference*. New York City.

Varela, Francisco, Evan Thompson, and Eleanor Rosch. 2017. *The Embodied Mind, revised edition: Cognitive Science and Human Experience*. Cambridge, MA: The MIT Press.

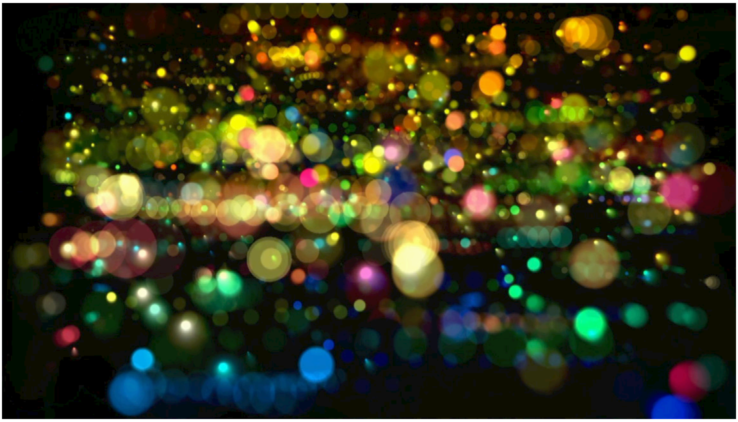
Weber, Samuel.
2008. *Benjamin's -abilities*. Cambridge: Harvard University Press.

Thorn, Seth D. and Sha Xin Wei.
2019. "Instruments of Articulation: Signal Processing in Live Performance." *Proceedings of the 2019 ACM International Conference on Movement and Computing*. Tempe.

Sheets-Johnstone, Maxine.
2011. *The Primacy of Movement: Expanded second edition*. Philadelphia: John Benjamins Publishing Company.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org



Ryan Olivier
ryankolivier@gmail.com
Indiana University South Bend, South Bend, Indiana, USA

Partial Decisions: For Solo Performer and Interactive Audiovisual System

Keywords: Interactive Multimedia, Audiovisual, Real-Time Performance, Semi-Improvised, Algorithmic, Max/MSP/Jitter

Partial Decisions is a real-time, semi-improvised work for a solo performer and an interactive audiovisual system of over 600 individual tones and shapes. The work models the results of individuals choosing to come together or strike out on their own. The performer exploits the results of those decisions to shape various sonic and visual outcomes, which in turn shape future results. While the performer can merely impose limits on the decision-making capabilities of the modeled community, imposing those limits can yield unexpected results, sometimes beautiful, sometimes chaotic, and sometimes beautifully chaotic. Each performance is unique and opens up a chance for new possibilities, a chance for newfound beauty from the partial decisions of the many.

https://2021.xcoax.org/rol/

Description

Partial Decisions is a real-time, live-streamed, semi-improvised work for a solo performer and an interactive audiovisual system of over 600 individual tones and shapes. The work models the results of individuals choosing to come together or strike out on their own. Before the work begins, the performer set initial limits on the system and then initiates the first decision. Throughout the work, the performer can change those limits, closing off certain pathways while opening others. While the performer can merely impose limits on the decision-making capabilities of the modeled community, imposing those limits can yield unexpected results. Of course, responding to the results of artistically imposed limits will yield new result, perhaps desired or unintended, creating an artistic feedback loop.

Statistical modeling visualizations used by media outlets to show trends and potential outcomes of human behavior, especially at the start of the coronavirus outbreak, served as a partial inspiration for the work. The graphic simulations published by the Washington Post were particularly arresting: https://www.washingtonpost.com/graphics/2020/world/corona-simulator/. One interesting consideration is the effect of the visualizations themselves to inform and perhaps even change the future behaviors of those that view them. This work is an artistic improvisation on this 'observer effect' for in it, the program runs a model of decisions and the performer reacts to these partial decisions of the computer further altering future decisions. The results often render sonic and visual landscapes both beautiful and haunting.

The work was created using Cycling74's Max/MSP/Jitter and features a few limiting controls for the algorithmic system. This particular performance features up to 640 sine tone oscillators and accompanying colored spheres. During the work, each individual object will either wait to act for a chosen amount of time, participate as a member of a harmonic spectrum over an active fundamental, join other partials as a member of the harmonic spectrum of the next selected fundamental, or strike out on its own and select a new fundamental using a just-intoned intervallic ratio chosen from the first nine partials. Amplitude envelopes and durations are also algorithmically assigned as well as any inharmonic deviations from the whole number ratios. There is also a probability control over the decision to join or strike-out which the performance can choose to manipulate.

When partials are participating as members of the same fundamental, they will vertically align both in the visual plane as well as in the stereo-field. They can, however, choose to abandon that origin point and move out on their own. Their visual height within the alignment is a simple mapping of their frequency. The color of each partial is a combination of a mapping of their fundamental to the color spectrum and scaled by a similar mapping of the partial number. The performer also has final control over how many individuals can be let into the system and when the simulation ends. Each performance is unique and opens up a chance for new possibilities, a chance for newfound beauty from the partial decisions of the many.

Fig. 1. Partial Decisions Still.

Fig. 2. Performance Documentation https://drive.google.com/file/d/1Acab7RYrtj0Ep7PaNdPaipZ0wIS9vLeF/view

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Mariana Seiça
marianac@dei.uc.pt

Sérgio M. Rebelo
srebelo@dei.uc.pt

Nuno Lourenço
naml@dei.uc.pt

Pedro Martins
pjmm@dei.uc.pt

**University of Coimbra, Centre for Informatics and Systems of the University of Coimbra, Department of Informatics Engineering
Coimbra, Portugal**

#ESSYS*: An Online Happening

Keywords: Media Art, Internet Art, Sonification, Emotion Analysis, Happening, Participatory Art, Twitter

#ESSYS* is an online-based happening that unveils the underlying emotions in Twitter data. Built over the sonification system ESSYS, musical pieces are continuously generated and played online as an expression of Twitter's most prominent emotions. The authors of each tweet become the conductors of this happening, devised as an audiovisual showcase, where we hear Twitter's emotions, and we see the leading words that reflect this emotional dimension. The autonomous system is the performer in constant dialogue with each participant, in a unique event dependent on how the system itself interprets the tweets and their emotions, how it generates musical pieces, and how each audience member feeds the system and composes the happening's narrative. The system will endlessly compose as long as tweets with the hashtag #essys_xcoax are shared, in an ever-changing, audiovisual event to expose the driving emotions of #ESSYS*.

https://2021.xcoax.org/mse/

Description

We live in a time where digital media and Artificial Intelligence (AI) have been increasingly part of the living fabric of human interaction and communication. This promoted a fertile ground for the development of a synergetic relationship between innovative communication platforms. With this evolution, cyberspace has gradually become one of the most strategic and global places for communication, allowing a fast, efficient and customised share of data and personal thoughts (Clark 2010). Social networks have taken key importance on this paradigm shift, promoting the amplification of these user-generated contents through social media as active and effective platforms for sharing personal information online (Armstrong and Stojmirovic 2011; Rich 2015). More than just peer-to-peer communication, ideas and perspectives are shared inside a community of followers or friends who can share within their network, in an intertwined cycle of exchanges who define social tendencies and the communities themselves. Social networks have also been of key social importance in the democratisation of access to information for anyone. Nevertheless, the lack of moderation in these platforms also promotes the amplification of rumours and questionable information, fomenting the diffusion of misinformation. The emergence of AI employment to mediate and facilitate content promotion has made this feature of social networks more evident and accessible, easily providing tools to generate fake content. Currently, one may observe that this diffusion of doubtful information has a large impact in our societies, for instance, influencing national elections, *e.g.* (Bovet and Makse 2019), or promoting the diffusion of non-scientific and conspiracy theories, *e.g.* (Cinelli et al. 2020). This way, the emotions that people feel about the current condition of their societies, sometimes, may not be reasoned. However, these emotional views are still shared every day on these platforms, fomenting strong, social perspectives and status that can influence entire communities.

We propose an online happening that mirrors this social attitude, devising an audiovisual composition made by the *Emotion Sonification* SYStem (ESSYS) (see (Seiça et al. 2017)) which expresses real-time written tweets using our hashtag #essys_xcoax. More than a mere portrait of chosen tweets, we intend to draw a portrait of the emotions behind those tweets, unveiling a hidden, emotion-driven dimension representative of its participants. This way, the proposed performance is based on an autonomous system that independently collects the tweets, understands them, and translates their perception of the community to their audiovisual environment.

The concept of happening as a timely, unique event is inevitably connected to the environment, context, or social gathering where it takes place. Its conception and technical requirements may be multiple instantiated, replicated, even improved, but the event itself, its intrinsic effects and outputs, and how each member in the audience interacts with the artefact, will take a distinct form each time it is held. Happenings have been a form of personal, artistic and participatory expression since the 1950s, and its former definition by Allan Kraprow. His professor John Cage's *4'33 piece* (Kahn 1997) is, in itself, a musical happening each time it is performed, living through the audience's own existence. In a similar way, #ESSYS* occurs as a participatory new media artwork, where an autonomous system, ESSYS, takes the role of the performer. The system promotes one symbiotic relationship of dependency with its audience, appropriating the twittered text from the audience as feedstock to drive the performance. The system is born and embodies the role of a human performer, subject to the audience writings and bound to the emotional words of each audience member.

In practice, the system artefact is composed of two modules. The first module is responsible for the textual analysis of the tweets. The second module produces the audiovisual content, both visual and auditory.

The first module performs a textual analysis on the tweets employing Natural Language Processing approaches to recognise what are the predominant emotions in each tweet. The system is continuously searching for new tweets posted containing the hashtag #essys-xcoax through the Twitter API. For each tweet, the analysis follows a set of lexicon-based approaches, performing the following steps: it preliminary prepares the text to the semantic analysis by (I) translating the text to English, if necessary; (II) removing the contracted word forms; (III) replacing emojis by their meanings; (IV) replacing abbreviations and slang expressions by its formal forms; (V) replacing the words by their lemmas; (VI) replacing negations with antonyms; (VII) removing the stop words; and, finally, (VIII) tokenising the text. Subsequently, it performs a lexicon-based analysis of each word of the text, using a word-emotion association lexicon, developed by Mohammad and Turney (2012). Currently, the word-emotion association lexicon presents data about the relation of eight basic and prototypical emotions of Robert Plutchik's Wheel of Emotions (Plutchik 2001), i.e. anger, anticipation, disgust, fear, joy, sadness, surprise and trust, with 15 000 English words. Whenever an emotion is recognised in a word of one tweet, the words and the emotion detected are saved. In the end, we define the intensity of the relation between the emotions detected and the text by summing the number of emotions recognised in the tweets. In the end, we get an 8-value list for each tweet, where each value is representative of the quantitative presence of each emotion in it. This method was developed using the natural language facility library fin,[1] the IBM Watson Language Translator[2] and the Merriam-Webster Dictionary API.[3]

1. https://finnlp.gitbook.io/fin/

2. https://www.ibm.com/cloud/watson-language-translator

3. https://dictionaryapi.com/

On the other hand, the second module is responsible for the creation of the audiovisual elements of the artwork. This module examines the textual analysis from the tweets posted in the last five minutes to understand what is the most recognisable emotion that defines the audiovisual environment. This module comprises two simultaneous processes: the generation of the auditory composition by the ESSYS system; and the visual generation.

The auditory composition is adopted as the main dimension of the artefact, with a continuous, ever-changing musical piece that flows through each emotion. The composition is continuously generated using ESSYS, developed for producing automatic musical pieces representative of emotions. Currently, it is capable of producing audio pieces for the eight Plutchik's emotions, and it is built over two software tools: a Max patcher for the MIDI generation; and an Ableton live set to produce the final sounds. As a rule-based system founded by Western music rules, it is structured over two major musical aspects: melody and harmony. According to the probabilities defined for each emotion, the melodic line is shaped based on a melodic scale, which is in turn defined by the harmonic progression chosen for each emotional context. These progressions are predefined for each emotion, combining different chord natures, different voicings and their sequence. The melody notes are chosen randomly depending on the melody scale, which specifies the type of note (scale note, chord note or chromatism), the duration (from whole to eighth notes) and the intervals between them. For the tone quality, we used several timbres and synthesized sounds associated with each emotion, to create compositions embedded in the ambient music genre. For this platform, the timbres were adapted to use free VST plugins, more specifically the Spitfire Audio LABS[4] virtual instruments.

4. https://labs.spitfireaudio.com

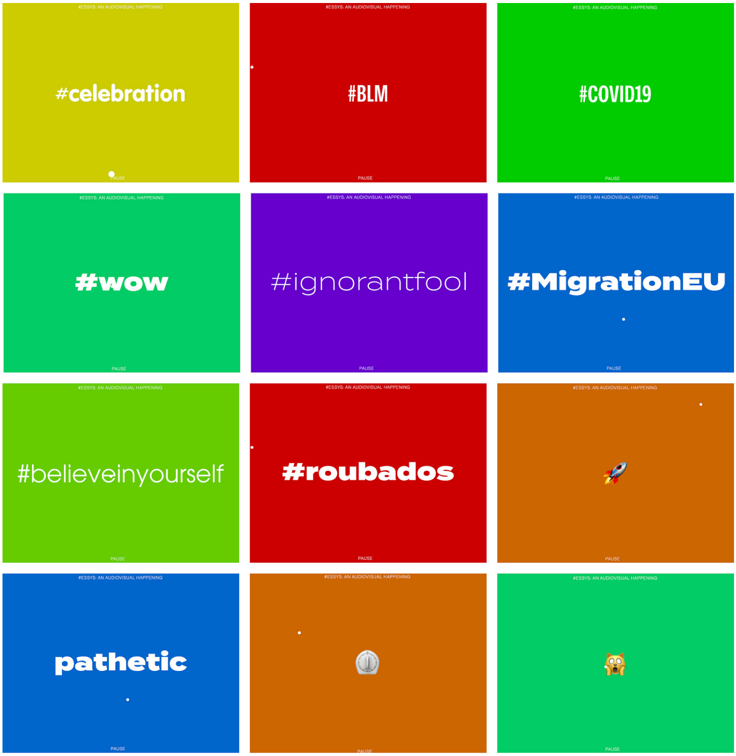


Fig. 1. Screenshots of the #ESSYS platform for the eight emotions.

The visual environment of the artwork emerges as a complementary visual stimulus to the sonic environment created by ESSYS. This environment is defined by a plain coloured background, whose colour changes based on the most present emotion in the analysed tweets, gradually transitioning from one tone to the next following the emotional ride. The colour-emotion mappings are based on the colour defined by Plutchik for each emotion: (I) yellow to joy; (II) yellow-green to trust; (III) green to fear; (IV) turquoise to surprise; (V) blue to sadness; (VI) purple to disgust; (VII) red to anger; and (VIII) orange to anticipation. Also, the most rated and representative parts of each tweet, from words to emojis, randomly take centre stage in the canvas, featured through ten distinct typefaces and loaded dynamically by Adobe Typekit,[5] that represent the variability of the emotions themselves. The relation between the typefaces and emotions are based on the works of Hyndman (2016) and Koch (2012), taking into consideration typeface's features such as weight, serifs, terminal shape and letter width. Figure 1 displays some examples of visual artefacts created by the system, with

5. https://fonts.adobe.com/typekit

6. https://cdv.dei.uc.pt/essys_happening/

more examples and information found at the hyperlink below.[6] Figure 2 presents a screenshot of a video demonstrating the system running using a set of testing tweets.

Fig. 2. Demonstration video of a #ESSYS platform using a set of testing tweets. https://cdv.dei.uc.pt/2021/essys_happening_demo.mp4.

#ESSYS* promotes a reflection on the authorship of the artistic use of AI systems, as well as the relationship that this kind of system may create with the audience. First, what is the role of the audience in this happening? Although the system generates the experience autonomously, it needs data created by people to produce it. This creates a symbiotic relationship between the audience and the machine to generate collaborative artworks, i.e. the system lives out of human data, whose opinion is in turn transformed as the artwork is experienced. Second, who can we consider to be the creator? Is it the system, which technically produces the content? Is it the system's designer, responsible for its building rules and elemental behaviour? Or is it the audience, the feeders of the artefact, whose shared tweets maintain the artefact alive and in continuous creation? Finally, the system reflects the potential of AI systems to mediate the generation of artworks that, even without a political statement, embodies the people's data in order to produce personal and contemporary significance to its viewer.

We can say the authorship of #ESSYS* is inevitably shared between the system and its audience, the living machine and its human fuel, without which it gradually silences and fades into quiet darkness. As such, it is only available during the conference, at http://essys.dei.uc.pt/happening, with its related hashtag revealed at the conference opening. As a timely, unrepeatable piece, #ESSYS* is unpredictable as well, as its contents, either the shared thoughts from the audience or the words picked by the system, are unforeseeable. What will the joined emotions of the audience be? What themes will arise? What aspirations, fears, desires, goals or hopes will be revealed during this event? How will they be a reflection of this community, or even society itself? During this xCoAx edition, write #essys_xcoax and it will find out for you.

Acknowledgements. This work is partially supported by national funds through the Foundation for Science and Technology (FCT), Portugal, within the scope of the project UID/CEC/00326/2019. Previous studies in this work are financially supported by Institute of Interdisciplinary Research of University of Coimbra under its program of financial support of scientific activities. The first and second authors are funded by FCT under the grant SFRH/BD/138285/2018 and SFRH/BD/132728/2017, respectively.

References

Armstrong, Helen, and Zvezdana Stojmirovic. 2011. *Participate: Designing with User-Generated Content*. New York, NY: Princeton Architectural Press.

Bovet, Alexandre, and Hernán A. Makse. 2019. "Influence of Fake News in Twitter during the 2016 US Presidential Election." *Nature Communications* 10 (1): 1–14.

Cinelli, Matteo, Walter Quattrociocchi, Alessandro Galeazzi, Carlo Michele Valensise, Emanuele Brugnoli, Ana Lucia Schmidt, Paola Zola, Fabiana Zollo, and Antonio Scala. 2020. "The Covid-19 Social Media Infodemic." *Scientific Reports* 10 (1): 1–10.

Clark, David. 2010. "Characterizing Cyberspace: Past, Present and Future." MIT CSAIL, Version 1: 2016–2028.

Hyndman, Sarah. 2016. *Why Fonts Matter*. London, United Kingdom: Virgin Books.

Kahn, Douglas. 1997. "John Cage: Silence and Silencing." *The Musical Quarterly* 81 (4): 556–98.

Koch, Beth E. 2012. "Emotion in Typographic Design: An Empirical Examination." *Visible Language* 46 (3): 206–27.

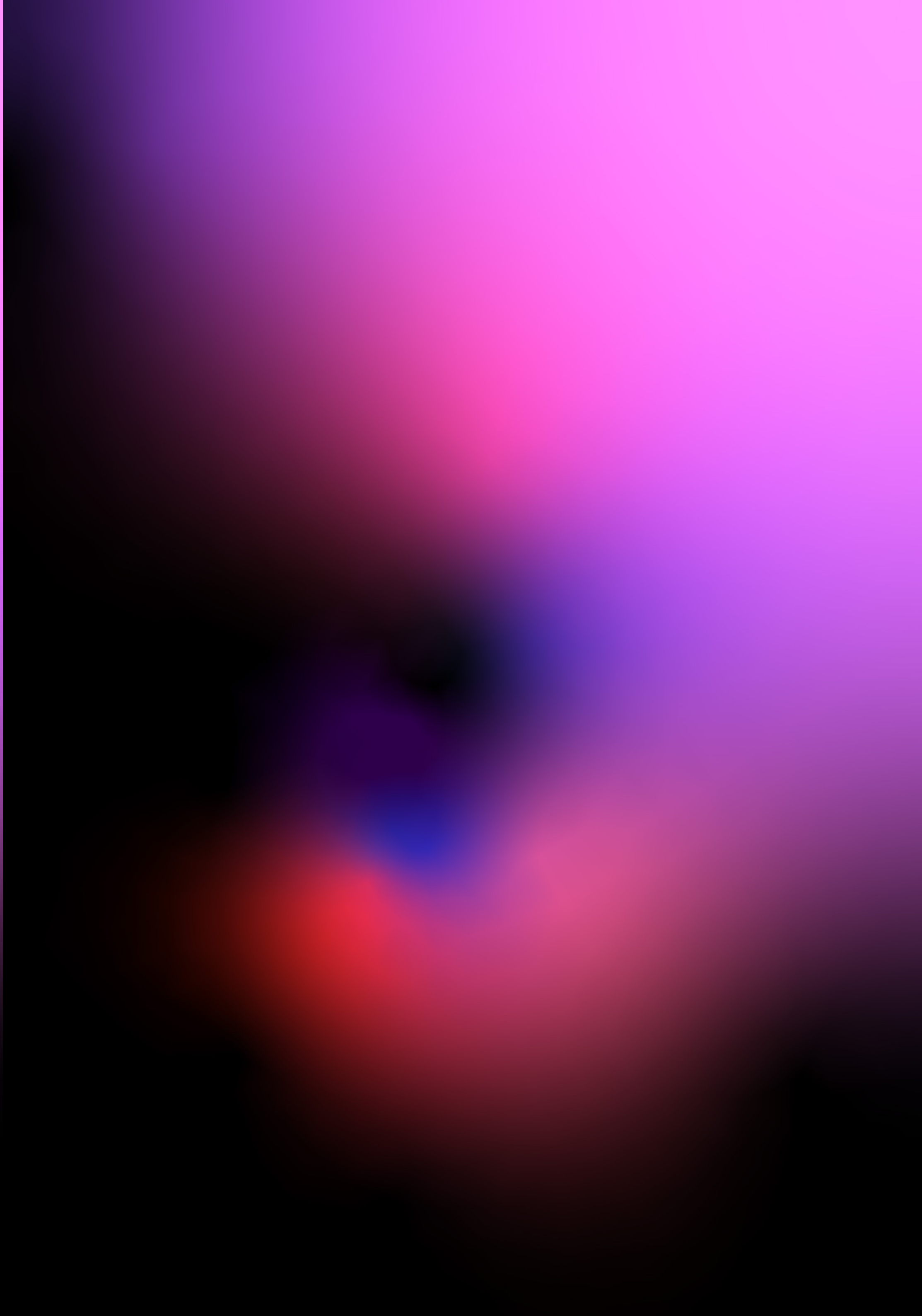
Mohammad, Saif M., and Peter D. Turney.
2012. “Crowdsourcing a Word-Emotion Association Lexicon.” *Computational Intelligence* 29 (3): 436–65.

Plutchik, Robert.
2001. “The Nature of Emotions: Human Emotions Have Deep Evolutionary Roots, a Fact That May Explain Their Complexity and Provide Tools for Clinical Practice.” *American Scientist* 89 (4): 344–50. http://www.jstor.org/stable/27857503.

Rich, Jon.
2015. “Facebook: A Court of Ignorant, Cruel Judges.” In *The Internet Does Not Exist*, 150-162. Berlin, Germany.

Seiça, Mariana, Rui (Buga) Lopes, Pedro Martins, and F. Amílcar Cardoso.
2017. “Sonifying Twitter’s Emotions Through Music.” In *Music Technology with Swing - 13th International Symposium, (CMMR)* 2017, Matosinhos, Portugal, September 25-28, 2017, Revised Selected Papers, edited by Mitsuko Aramaki, Matthew E P Davies, Richard Kronland-Martinet, and Sølvi Ystad, 11265:586–608. Lecture Notes in Computer Science. Springer.

Doctoral Symposium



xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Mise-en-jeu Framework for Analysing the Design Grammar of Videogames

Keywords: Media Art, Internet Art, Sonification, Emotion Analysis, Happening, Participatory Art, Twitter

João P. Ribeiro
up201601392@edu.fba.up.pt
Faculty of Engineering,
University of Porto, Portugal

Our research focuses on Game Studies, Game Design, Player Experience, Videogame Spaces and Cinematic Techniques. In videogames, the mediated space's language has not yet been well established. Addressing this, we developed the mise-en-jeu proto-framework, a system that attempts to address the lack of a unified game design syntax. The continued development of the Mise-en-jeu Framework we propose aims to help resolve this by constructing instruments for game design's study. We will conduct mixed research, embrace various genres, and consider player experience. Such studies are vital for the mise-en-jeu framework's success and need urgent development, as designers strive to find unified frameworks for comprehending and projecting level design mechanics, but find a limited amount of research available.

Introduction and Purpose

Concepts from traditional audiovisual schools of thought should be applied in the comprehension of videogames, even if videogames are by no means traditional audiovisual media. Videogames are artefacts that provide specific types of experiences (Kirkpatrick 2011, 1), in part due to their interactive nature, which supports innovative aesthetic happenings. This research aims to find how gameplay, from players and designers' viewpoints, is affected by a game's visual, sonic, behavioural, and interaction languages. We will identify rules and design standards used throughout videogames.

The primary goal of this project is addressing the question:

1. What is the grammar of the mise-en-jeu, and how can it be used in game design?

With it, these secondary questions arise:

2. What models have been developed that may be useful?
3. What is the epistemological definition of the mise-en-jeu?
4. What is the impact of the mise-en-jeu on experiencing a game?
5. Which mise-en-jeu analysis and design tools can be provided to game designers?
6. Which are the variables, codes and conventions of the mise-en-jeu framework?
7. How can the framework be tested?

To answer these questions, we established these objectives:

1. Elaborate a framework with the dimensions of the mise-en-jeu.
2. Provide design patterns of the mise-en-jeu, allowing for an easy way to understand the framework's application.
3. Deliver a study on the impact of the mise-en-jeu on players' experiences.

Survey of Related Work

Our project considers contributions from academics studying the audiovisual output of videogames. The MDA Framework (Hunicke et al. 2004) helps designers conceiving enjoyable experiences. It is defined as Mechanics, describing the game's components; *Dynamics*, describing the mechanics' run-time behaviour acting on player inputs and each other's outputs over time; and Aesthetics, representing desirable emotional responses evoked in players (ibid.).

Spatiality in games implies multi-layered understandings of players' spatial experiences. It was advanced by Henri Lefebvre's notion of *social space* (Wood 2012, 89). Social space does not represent "a thing among other things, nor a product among products: rather, it subsumes things produced and encompasses their interrelationships in their co-existence and simultaneity" (Lefebvre, as cited in Wood 2012, 89). Janet H. Murray adds to Lefebvre's social space, saying that social structure is a foundational and expanding conduct of the human experience, so people need not be confounded when it replicates through virtual worlds. However, we must inquire what environmental factors allow social structure to arise (2012, 148). Murray also summarises the key-affordances of digital objects: they are *procedural, participatory, encyclopaedic, and spatial* (51-68). Henri Lefebvre introduced another vital concept, that of dialectics of triplicity, distinguishing three types of space: *objective, conceived, and lived* (1980). Edward Soja refined Lefebvre's ideas into *trialectics* – similar to dialectics but including *real* and *imagined* spaces. The *lived* space "never stands alone, totally separate from its precedents or given absolute precedence on its own" (1996, 70).

Michael Nitsche (2008) introduced a model with five spaces: rule-based, "defined by the mathematical rules that set, for example, physics, sounds, AI, and game-level architecture" (15); *mediated*, "defined by the presentation, which is the space of the image plane and the use of this image including the cinematic form of presentation" (16); *fictional*, "the space imagined by players from their comprehension of the available images" (16); *play*, in which players act within the rules of the game and the physical devices accommodating the play experience (16.); and *social*, "defined by interaction with others, meaning the game space of other players affected" (16). The importance of Soja's trialectics is recognisable here, promoting a unidirectional exchange of information between all spaces not present in Nitsche's model. Soja's framework defines third space and argues it contains the two preceding spaces. Within the third space, all the spaces come together (1996, 65).

We also considered the Eye Space Framework (Chang & Hsieh 2017), which proposes a taxonomy of compositional elements and their importance and significance, with four categories: *primary subject, distractions, backdrop, and guiding information*. We also analysed Heather Logas' work (2005), *distinguishing cinematic* and *cinematography* in videogames and establishing the importance of colour values. Girina (2013) identified the need for the mise-en-jeu framework.

Fernández-Vara states that games may be studied from other media's perspective, like *cinematography* and *Design*. She also understands videogames' idiosyncrasies. Rather than regarding games as just a form of expression, we may see them as objects encoding values and concepts that players decipher and communicate with (2019). To create our framework, we will scrutinise mise-en-scène, analysing works like Louis Giannetti's Understanding Movies (2014). We will also establish videogame-exclusive variables.

We established a prototype of the framework with these variables: *Lighting Key, Camera Proxemics, Camera Perspective, Shapes, Area Of Phase Space, Depth Of Field, Horizon Of Intent, and Setting* (Ribeiro et al. 2018).

Table 1. Summary of variables and possible values of the mise-en-jeu framework (Ribeiro et al. 2018).

Possible Results	**Variables**							
	Lightining Key	**Camera Proxemics**	**Camera Perspective**	**Shapes**	**Area of Phase Space**	**Depth of Field**	**Horizon of Intent**	**Setting**
	High-key	Extreme Long shot	Side Scrolling	Circle	Tight	Existent	Can be represented with a geometrical coordinate system.	Descriptive, with depth changing depending on scope.
	Low-key	Long shot	Isometric	Square	Loose	Non-existent		
	High-contrast	Full shot	Third person	Triangle				
		Medium shot	First person					
		Close-up	Over the shoulder					
		Extreme close-up	Side static					

Approach

We will use mixed methods, since our problem is theoretical as well as practical. Different phases of our work need different methodologies; thus, we distributed the methodology along various phases.

Phase 1: Literature Review

We have started organising the literature review and research methods. We have been searching for publications we deem relevant, using academic search engines, namely *Google Scholar, ResearchGate, ProQuest,* and *Scopus*. We have listed and indexed our results according to their subject matters and significance. Subsequently, all resulting texts will be organised and articulated into an extensive literature review.

A portion of this phase has been carried out in preparation for papers we publish as a result of our research. Some papers are pending acceptance for publication or have been accepted.

The final review will provide some context to work we have done regarding the mise-en-jeu, including theories in game design, interaction design, and ludology. It will present models that attempt to resolve the mise-en-jeu proto-framework's shortcomings. Videogames often use codes developed in other media and academic fields. Some reviewed theories are not native to videogames but are useful to their study, such as those in media geography and film theory.

Phase 2: Mapping the Variables, Codes, and Conventions

This phase consists of 6 sub-phases. We expect to start by identifying and expanding the elements of the framework. We expect to chart many variables that we had not previously identified through bibliographical research and the play of many works. We also expect to categorise them into larger groups containing interrelated variables (e.g., sonic, visual, behavioural, and interactive). None the less, we have already identified some parameters that we will study to provide contributions to the framework: *Horizon of Intent, Patterns of Design, Passing of Time, Impact of Colour,* and *Sound in the Mise-en-jeu*. The Horizon of Intent cannot be mapped using interviews or surveys; we will gather information on a population's sample through language-agnostic geometry-derived methods. In the histograms of our case studies' analysis, geometrical cues will allow us to recognise repetition in the analysis's visual manifestations, resulting in *design patterns*. Towards examining temporal continuities, our subjects will play videogames of different genres. A mixed nature analysis will be conducted to verify who is in control of the *passing of time*. We will use a multi-method approach to understand the impact of colour, using eye-tracking, surveys, and interviews. To test *sound in the mise-en-jeu*, we will use ethnography-derived methods, framed by literature research (Roberts 2002, 6), resorting to "documents of life" (Plummer 1983).

Phase 3: Studying the Phenomenology of the Mise-en-jeu

To determine the effect of the mise-en-jeu on player experience, we will define a stratified population. A sample of that population will interact with select case studies. They will be subject to the Games Experience Questionnaire (GEQ) (IJsselsteijn et al. 2013) – a qualitative instrument used to understand player experience. We will also use the GameFlow model (Sweetser & Wyeth 2005), which allows for verbal and non-empirical player enjoyment measurements.

The GEQ evaluates game experience as scores, explores players' emotional and communicative participation, and gauges how participants feel after ending a session of play (IJsselsteijn et al. 2013, 3). The GameFlow model allows us to establish player enjoyment patterns through game heuristics and user-experience literature (Sweetser & Wyeth 2005, 2). Combined, these allow us to survey players' perception of play as experienced from their perspective. The labelling and organisation of our data on players' experiences', along with the testing of our hypotheses and the literature review, will allow us to make a phenomenological description of the mise-en-jeu. It will provide the basis for an epistemological description.

Phase 4: Testing

We will evaluate the applicability and effect of mise-en-jeu in practice. This process involves describing success variables, obstacles and threats. We will consider all the factors arising from its application by examining the interrelationship between individuals, procedures and the framework. This examination will take the form of semi-structured interviews and focus groups, which allow us to understand game play experiences (Eklund 2015), as well as usability evaluation.

To enhance applicability, we will produce application directives focused on intuitive design, ease of learning, efficiency of use, memorability, error frequency, and subjective satisfaction (USDHHS n.d.). Our preference for integrating usability evaluation within the testing phase arises from a trio of crucial goals: improving framework features, decreasing implementation expenses, and getting the flexibility of techniques.

Phase 5: Debate & Synthesis of Results

The synthesis will be a reflection period where we will read and reassess our results and our work principles. The synthesis entails gathering our findings, building a discussion with previous studies, and establishing a roadmap for further studies.

Phase 6: Thesis Writing

By using a precise structure, we will write the thesis throughout the PhD. This phase is the last writing period, as parts of the thesis will be published as articles.

Progress and Expected contributions

We plan on editing all the studies in peer-reviewed publications. They allow us to construct a final report using the papers as a base, grounding it and giving it relevance and validity. This method does not mean adaptations will not be made, as they are necessary for the continuity and connection of topics in a document as extensive as a PhD thesis.

As we write, we have already published some articles related to the topic of our thesis. They are the following:

1. Ribeiro, João P., Miguel Carvalhais, and Pedro Cardoso. Forthcoming. "Categorising the Sonic Experience in the Soundscapes of Videogames." In *Perspectives on Design: Research, Education and Practice II*. Forthcoming.
2. Ribeiro, João P., Miguel Carvalhais, and Pedro Cardoso. 2020. "Connection of Dynamic Temporal Continuities in Videogames." In EIMAD 2020: *Advances in Design, Music and Arts*, edited by Daniel Raposo, João Neves, José Silva, Luísa Correia Castilho, and Rui Dias, 195–212. Springer Series in Design and Innovation, vol 9. Springer, Cham. https://doi.org/10.1007/978-3-030-55700-3_14.
3. Ribeiro, João P., Miguel Carvalhais, and Pedro Cardoso. 2020. "Sound in the Mise-En-Jeu: Conveying Meaning through Videogames' Mediated Space." In *AVANCA | CINEMA 2020*. Forthcoming.

4. Ribeiro, João P., Miguel Carvalhais, and Pedro Cardoso. 2018. "Mise-En-Jeu: A Framework for Analysing the Visual Grammar of Platform Videogames." In VJ2018 — *10th Conference on Videogame Sciences and Arts*, edited by Miguel Carvalhais, Pedro Amado, and Pedro Cardoso, 86–108. Porto: i2ADS – Research Institute in Art, Design and Society, University of Porto, Faculty of Fine Arts. https://vj2018.fba.up.pt/files/Papers/PagesfromVJ2018-Proceedings-full-5.pdf.

Below we provide a provisional title of the publications we anticipate producing:

» A Taxonomy of the Simulation of the Depth of Field Effect in Videogames
» A Phenomenological Study of the Mise-en-jeu
» Mapping Players' Horizon of Intent in the Mise-en-jeu
» Patterns of Design in the Mise-en-jeu: A Holistic Analysis Approach
» The Impact of Colour on Players' Experience of the Mise-en-jeu
» Usability and Applicability of the Mise-en-jeu Framework
» The Mise-en-jeu Framework: A Summary of Findings

References

Cardoso, Pedro. 2016. "Playing in 7D: An Action-Oriented Framework for Video Games." Ph.D., University of Porto. http://hdl.handle.net/10216/82685

Chang, Yu-Ching, and Chi-Min Hsieh. 2017. "Eye Space: An Analytical Framework for the Screen-Mediated Relationship in Video Games." *Art and Design Review* 05 (01). Scientific Research Publishing:84–101. https://doi.org/10.4236/adr.2017.51007.

Eklund, Lina. 2015. "Focus Group Interviews as a Way to Evaluate and Understand Game Play Experience." In *Game Research Methods: An Overview*, 133–48.

Fernández-Vara, Clara. 2019. *Introduction to Game Analysis*. 2nd ed. Taylor & Francis.

Giannetti, Louis D. 2014. *Understanding Movies*. 13th ed. Pearson.

Girina, Ivan. 2013. "Video Game Mise-En-Scene Remediation of Cinematic Codes in Video Games." In *Lecture Notes in Computer Science*, 8230 LNCS:45–54. https://doi.org/10.1007/978-3-319-02756-2_5.

Hunicke, Robin, Marc LeBlanc, and Robert Zubek. 2004. "MDA: A Formal Approach to Game Design and Game Research." *Proceedings of the Challenges in Games AI Workshop*, Nineteenth National Conference of Artificial Intelligence. AAAI Press.

IJsselsteijn, Wijnand A., Yvonne de Kort, and Karolien Poels.
2013. "The Game Experience Questionnaire." Eindhoven: Technische Universiteit Eindhoven.

Kirkpatrick, Graeme.
2011. *Aesthetic Theory and the Video Game*. Manchester University Press.

Lefebvre, Henri.
1980. *La présence et l'absence: contribution à la théorie des représentations*. Casterman.

Logas, Heather.
2005. "Mise-En-Scène Applied to Level Design: Adapting a Holistic Approach to Level Design." DiGRA 2005 *Conference Changing Views: Worlds in Play*, April. http://summit.sfu.ca/item/190.

Murray, Janet H.
2012. *Inventing the Medium: Principles of Interaction Design as a Cultural Practice*. 1st ed. MIT Press.

Nitsche, Michael.
2008. *Video Game Spaces: Image, Play, and Structure in 3D Worlds*. 1st ed. MIT Press.

Noiwan, Jantawan, and Anthony F. Norcio.
2006. "Cultural Differences on Attention and Perceived Usability: Investigating Color Combinations of Animated Graphics." *International Journal of Human-Computer Studies* 64 (February): 103–22. https://doi.org/10.1016/j.ijhcs.2005.06.004.

Plummer, Kenneth.
1983. *Documents of Life: An Introduction to the Problems and Literature of a Humanistic Method*. G. Allen & Unwin.

Potier, Victor.
2014. "Mise en jeu de la production aux usages d'un jeu sérieux. Le cas d'une entreprise du secteur du jeu vidéo." *Sciences du jeu*, no. 2 (October). https://doi.org/10.4000/sdj.329.

Ribeiro, João P., Miguel Carvalhais, and Pedro Cardoso.
2018. "Mise-En-Jeu: A Framework for Analysing the Visual Grammar of Platform Videogames." In VJ2018 — *10th Conference on Videogame Sciences and Arts*, edited by Miguel Carvalhais, Pedro Amado, and Pedro Cardoso, 86–108. Porto: i2ADS – Research Institute in Art, Design and Society, University of Porto, Faculty of Fine Arts. https://vj2018.fba.up.pt/files/Papers/PagesfromVJ2018-Proceedings-full-5.pdf.

Roberts, Brian.
2002. *Biographical Research*. Open University Press.
Soja, Edward W. 1996. Thirdspace: Journeys to Los Angeles and Other Real-and-Imagined Places. 1st ed. Blackwell Publishers.

Soja, Edward W.
1996. *Thirdspace: Journeys to Los Angeles and Other Real-and-Imagined Places*. 1st ed. Blackwell Publishers.

Sweetser, Penelope, and Peta Wyeth.
2005. "GameFlow: A Model for Evaluating Player Enjoyment in Games." *ACM Computers in Entertainment*. Vol. 3, No. 3. Article 3A. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.97.480&%20rep=rep1&type=pdf.

U.S. Department of Health & Human Services.
n.d. "Usability.Gov: Improving the User Experience." Accessed April 26, 2020. https://www.usability.gov/.

Wolf, Mark J. P.
2001. *The Medium of the Video Game*. University of Texas Press

Wood, Aylish.
2012. "Recursive Space: Play and Creating Space." *Games and Culture* 7, no. 1 (January 2012): 87–105. https://journals.sagepub.com/doi/10.1177/1555412012440310

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Beyond Code Poetry: an Exploration of Programming Languages Performed from the Artistic Practice

Keywords: Code, New Materialities, Programming, Literacy, Speculation

Marta Pérez-Campos
marlapecampos@gmail.com
UPV/EHU: University of the Basque Country, Research in Contemporary Art, Bilbao, Spain

The main goal of this thesis is to seek an approach to programming languages from an artistic point of view. To do so, it is necessary to address the different readings that we can make of a piece of code and its influence on today's society, as proposed by the so-called Software Studies.
All this without losing sight of contemporary art. Since its emergence, this discipline has gained relevance due to the presence of technology and therefore of software in our daily lives.
With this thesis, we propose an exploratory study that tries to demonstrate the hypothesis and central theme of this research: to consider programming languages not exclusively as instruments or tools that allow us to program a machine, but to exploit other properties that we find in them, such as their artistic and expressive value. In order to put the theoretical part into practice, a series of projects and workshops will be created in which an approach to programming languages away from their utilitarian function and close to experimentation and criticism will be proposed, aimed at people with or without programming knowledge.

Purpose of the Research and its Importance to the Field

The presence of computer devices in all areas of our lives, both public and private, has sparked in recent years an important reflection within the world of art and the humanities. Although computers have been related to art since its beginnings, as a tool from which to generate work, in recent decades a more critical view has been developed towards this use of technology as a tool for creation. In the last ten years, this critical position has extended to include the very language that encodes and gives life to computer devices, leading to a reflection on the need to know how to program as something that is essential today. This thesis is part of this cultural challenge: can we approach programming languages from a perspective far removed from their automatism and closer to the poetic?

The aim of this thesis is to elaborate a state of the art that will allow us to understand the origin of the reflections that are made about software from the humanities. This will serve as a basis for analysing the artistic and expressive value that we can find in them and on which other artists and researchers have already reflected in the past. In this way, the artistic possibilities of programming languages in themselves will be explored: to search within them for other functions that are far from the automatism that characterizes them and closer to artistic creation.

Another main purpose will be to reflect on the supposed neutrality of software. To analyze the political, aesthetic and critical component that both software and the activity of writing software contain, and to propose different approaches to programming that take these components into account.

Brief Survey of Background and Related Work

Before beginning to analyze the artistic and aesthetic value of programming languages, it will be necessary to investigate the process that led from the handwritten word to the electronically coded word, passing through the typed word. The publication used as a reference for this will be *Language, Technology and Society* by the computational linguist Richard Sproat. In it, this transition is presented as a necessary process with the emergence of computing and the first programmable computers.

The emergence of the first programming languages and their democratization was accompanied by a reflection on their potential beyond their original functionality. One of the first publications to explore this idea is the book *Computer Poems*, published in 1973, which includes a series of algorithms whose reading and execution brings them close to poetry. Within this experimentation with programming languages we find those known as esoteric programming languages (esolangs) that have been classified and analyzed in depth by artists, programmers and researchers such as Nick Montfort or Daniel Temkin. In this type of languages, although most of them are Turing complete, experimentation, semantics or aesthetics are more important than their efficiency as programming languages.

Already in 2012 and within the discipline known as Software studies, we find a detailed analysis of the implications that programming languages present today carried out by Geoff Cox in his book *Speaking Code: Coding as Aesthetic and Political Expression*. It discusses the political and social implications of writing code. In the first two of the four blocks into which the book is divided, Cox analyzes the nature of code by comparing it in the first block with the spoken word (speech) and in the second block by making the inverse comparison, looking at how our speech resembles code from a political dimension.

In the third and fourth blocks of this book he analyzes our relationship with and through code, and in turn analyzes various projects that use code to criticize the very structures that have arisen thanks to it.

Speaking Code proposes new forms of criticism and practices that combine natural and artificial languages, appealing to the creation of a starting point in which to write from a recombination between code and natural languages. Following the path proposed in this publication, Mark C. Marino proposes in his book *Critical Code Studies* an analysis of programming languages from their political, social and aesthetic component, inquiring into the meaning that writing an algorithm has today and emphasizing the context in which that algorithm has been written. It seeks to analyze why and how code is written, what meanings we can extract and how to interpret what is and what is not written, trying to build bridges between the humanities and the sciences.

This search for meaning and analysis of algorithms was previously carried out in the publication *10 PRINT CHR$(205.5+RND(1)); : GOTO 10* in which only one line of code is analyzed throughout the book. This single line is sufficient to expose how to write and read using this type of languages and to try to glimpse what position software has in our culture. To try to understand this position, it is necessary to approach the functioning of computing today as proposed by

John Maeda in his book *How to Speak Machine: Computational Thinking for the Rest of Us*. In it, with an informative tone, the author exposes the main characteristics to take into account when we dive into analyzing and understanding what software is today.

A reinterpretation of the software and hardware of a computer is also found in the idea of 'Black Gooey' described by the artist an activist American Artist. Defended in an article and exemplified by a series of artistic installations that reflect on the origins of the GUI and its transformations from a black interface to a white interface. His thinking is aligned with that of those researchers who, using artistic projects, defend the lack of neutrality both in the internal part (software) and in the physical elements (hardware) that make up a computer.

Another link between the humanities and the sciences can be found in the analysis of programming languages from a humanistic perspective by Annette Vee and Warren Sack. In her publication *Coding Literacy: How Computer Programming is Changing Writing* Annette Vee reflects on the statement 'everyone should learn how to code' and the real implications that this statement can have in our society. Vee emphasizes that spreading programming skills across the population will not only lead to people being able to get a job in the technology industry, but also to people using that knowledge in a critical or different way, as in the case of *hacktivism*, and may lead to the emergence of new platforms and systems. It will be these deviations in the use of code that we will analyze and seek to promote in this thesis.

Warren Sack, for his part, relates programming languages to the arts in his essay *The Software Arts*. He defends the creation of software as the result of a search already begun in the seventeenth century: that of an artificial language that would serve as a connection between the liberal and mechanical arts. Two chapters will be of special interest for this thesis, the one focused on the translation between the physical world and the code and the one focused on the relationship between code and rhetoric.

This relationship between code and art, that point at which an algorithm is read as a text with expressive capabilities, is a constant in most of the publications considered for this research and will be the starting point for building this thesis.

Description of the Proposed Approach

It is important to emphasize that this is an artistic research. Although this thesis involves the approach to areas such as computer science or linguistics and authors who are outside the boundaries of art, all of them serve us to build an approach, a point of view and a practice all of them artistic.

In order to approach the subject of programming languages, software, and their relationship with contemporary art, it will be necessary to begin by defining a series of key concepts and ideas that will appear as constants within the research. Their definition will allow us to generate starting points and to delimit the area of interest. Some of these concepts are: poetry, automated language, esoteric languages, transcription, writing, literacy, meta-critic and critic, new media art, software, hardware and interface.

Structurally, the thesis is divided into three blocks, the first two being theoretical and the third practical. The theoretical part corresponding to the first and second blocks will be built from bibliographical references, articles and web pages of researchers and artists, as well as interviews with experts. More specifically, the first of these blocks will focus on the process of word automation and this will serve as a thread to elaborate the historical context and then the state of the question. This state of the question will contain those investigations and theories that have analyzed the various components of software: aesthetic, political, critical and social.

The second block will show the various *deviations* and speculations that the art world has proposed with respect to technology, with manifestations such as Glitch Art, Net Art or the creation of esoteric programming languages or *esolangs*. For its elaboration it will be necessary to make reference to artists in whose projects the software has moved away from its functionality and that have served to generate a critique on the own used means.

The third block seeks to demonstrate empirically, through workshops and artistic projects, the theoretical postulates enunciated in the first two blocks. It is proposed to use a series of procedures to evaluate the ideas defended in the theoretical part. The first of these consists in the elaboration of surveys aimed at artists belonging to the field of new media, in which they will be invited to reflect on ideas surrounding the hypothesis that concerns us. We will speculate on the idea of creating a manual of bad practices that will allow us to experiment with the possibilities of the code, relegating its functionality to the background.

The proposed workshops will seek to transfer the reflections formulated throughout this thesis to people belonging to different fields and not exclusively related to the world of art or computing. In this way, the aim is to be able to compare and analyse the results for the subsequent elaboration of conclusions.

Expected Contributions

The expectations and main results of this research are the creation of interdisciplinary fields of knowledge and action that have an impact both within society in general and within the processes pertaining to contemporary art.

It also seeks to contribute to the expansion of the frontiers of knowledge within contemporary art research by analysing current artistic manifestations whose presence in the contemporary world is increasing. Another purpose of this research is to highlight the implications of the presence of software for education, culture and art today.

Apart from the theoretical research, a fundamental part of this thesis is the creation of artistic projects and interventions that allow to illustrate and put into practice the postulates defended. In this way it will be possible to analyse empirically the acceptance and viability of the theoretical assumptions.

Progress Towards Goals

This research began in 2019/2020, the year in which I started to collect bibliographic material to address the definition of those basic (and problematic) concepts that have allowed me to delimit and focus the research area. These concepts serve as the basis for the creation of the conceptual framework.

During this second year, I am developing the first block of research: the conceptual framework and historical context, connected to the state of the art. I will combine this research with the conceptualization and implementation of artistic projects.

References

Bailey, Richard.
1973. *Computer Poems*, Drummond Island, MI: Potagannissing Press.

Berardi, Franco.
2012. *The Uprising: on Poetry and Finance*. Semiotext(e) intervention series 14. Los Angeles: Semiotext(e).

Berardi, Franco.
2018. *Breathing: Chaos and Poetry*. Semiotext(e) intervention series 26. South Pasadena, CA: Semiotext(e).

Cox, Geoff.
2013. *Speaking Code: Coding as Aesthetic and Political Expression*. Cambridge, MA: The MIT Press.

Galloway, Alexander.
2012. *The Interface Effect*, Cambridge: Polity Press.

Maeda, John.
2019. *How to Speak Machine: Computational Thinking for the Rest of Us*, New York: Penguin.

Manovich, Lev.
2002. *The Language of New Media*. 1st MIT Press pbk. ed. Leonardo. Cambridge, Mass: MIT Press.

Marino, Mark.
2020. *Critical Code Studies*, Cambridge, MA: The MIT Press.

McCormack, Jon, and Mark D'Inverno, eds.
2012. *Computers and Creativity*. Berlin ; New York: Springer.

Montfort, Nick, Patsy Baudoin, John Bell, Ian Bogost, Jeremy Douglass, Mark C. Marino, Michael Mateas, Casey Reas, Mark Sample and Noah Vawter.
2012. *10 PRINT CHR$(205.5+RND(1)); : GOTO 10*, Boston, MA: The MIT Press.

Papert, Seymour.
1980. *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books.

Quaranta, Domenico.
2013. Beyond New Media Art, Brescia: Link Editions.

Sack, Warren.
2019. *The Software Arts*. Cambridge, MA: The MIT Press.

Simanowski, Roberto.
2011. *Digital Art and Meaning: Reading Kinetic Poetry, Text Machines, Mapping Art, and Interactive Installations*. Electronic mediations 35. Minneapolis: University of Minnesota Press.

Sproat, Richard.
2010. *Language, Technology and Society*, New York: Oxford University Press.

Temkin, Daniel.
2017. Language Without Code: Intentionally Unusable, Uncomputable, or Conceptual Programming Languages, in CITAR, Vol. 9, No. 3, Portuguese Catholic University.

Vee, Annette.
2017. *Coding Literacy: How Computer Programming is Changing Writing*, Cambridge, MA: MIT Press.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

The Intersubjective Cyborg as Producer of Surreal and Autonomous Graphic Design Doctoral Symposium

Keywords: Intersubjectivity, Cyborg, Collage, Automatism, Performance, Graphic Design.

Lydia Czolacz
lydia.czolacz@hud.ac.uk
PhD Researcher,
Huddersfield, England

This research considers the influence of collage and surrealist techniques upon the practice of contemporary women graphic designers participating in visual culture today. The study poses two theoretical models: the intersubjective cyborg that extends and develops the analysis and legacy of female Surrealist artists in their recent resurgence, and the Mobius Strip analogy that encapsulates and assists in uniting collage, automatism and Surrealism through digital and analogue processes. Although the primary focus for this research is practice and the process of collage, it poses a framework to be used as an interdisciplinary tool that promotes the intersubjective cyborg as a producer of surreal and autonomous graphic design.

Purpose of the Research and its Relevance in the Field

In the last ten years there has been a resurgence in British curatorial engagement with women artists and Surrealism and a re-imagining of their legacy: *Angels of Anarchy* (Manchester Art Gallery 2009), *Dreamers Awake* (White Cube 2017), *Lee Miller and Surrealism in Britain* (The Hepworth 2018), *Dorothea Tanning* (Tate Modern 2019), *Dora Maar* (Tate Modern 2019) and more recently *Phantoms of Surrealism* (Whitechapel Gallery, 2021). The legacy of women artists and Surrealism had been previously overshadowed by André Breton's *Second Manifeste du Surrealisme* in which he declared "the problem of woman is the most marvellous and disturbing problem in all the world" (Breton, Seaver and Lane 2008). In re-appraising the importance of women in the Surrealist oeuvre, a significant focus has been placed upon the reawakening of female practitioners and their unconscious processes. This focus liberates women from the societal and political constraints of Surrealism at the time, and signifies a conceptual shift where women associated with the movement are no longer labelled as muses but rather artists in their own right. This re-imagining initiates new conversations in appreciating the legacy of a once overlooked feminist and Surrealist practice with a particular interest in a performative uncovering of the self and other.

The purpose of the research is to build upon this recent re-engagement by extending the legacy to contemporary practice, such as graphic design, where 2D, 3D and 4D collage are unrivalled forces for exploration of the unconscious. This approach also reimagines the way in which design processes are utilised as a way to uncover the self and other. My research proposes two new theoretical foundations; the intersubjective cyborg and the Mobius Strip analogy. The intersubjective cyborg rejects gender-specific binaries and seeks a new kind of totality (Haraway 1985). Through the act of un-gendering in performative design where the practitioner also becomes the subject of their own work (Jones 1998) and the associated creative outputs become an extension of the self (McLuhan 1964) the research develops intersubjectivity. The Mobius Strip analogy advances the idea that 'automatic processes' associated with Surrealism have been developed, utilised and referenced by contemporary female designers – and that techniques associated with collage and creative play (accessing the unconscious mind and exploring dream-like states) have allowed the medium of collage to traverse a Mobius Strip – moving between an analogue plane to the virtual and back.

These theories are explored within my own creative practice, where new advanced software such as Processing (Fig. 1) and Cinema 4D (Fig. 2) become a vessel for spawning autonomous collages and provide a platform to transgress design boundaries through contemporary technological translations of analogue and digital working.

Brief Survey of Background, Description of the Proposed Approach and Current Progress

The research poses two new theoretical approaches: the intersubjective cyborg that is used as a tool for understanding female Surrealist artwork and its application in contemporary culture, and the Mobius Strip analogy that suggests how Surrealist techniques of contemporary and autonomous collage can be applied and 'read.'

The Intersubjective Cyborg Extension

The intersubjective cyborg extension is a theoretical model that surrounds the legacies and re-imaginings of female Surrealists posed by this PhD.

The Surrealist artist Leonara Carrington, whose artwork explores the notion of the self through unconscious animalistic representations with an added sense of autonomous and alchemic mysticism, is used as an exemplar. Carrington reconfigures the male gaze by placing the self as a focal point in her artwork. She embarks on a journey of individuation by utilising visual extensions of the self, that in turn undergo ungendered cyborg transformations by removing bodily signifiers that stereotypically represented women in other Surrealist artworks of the time.

In developing the intersubjective cyborg I argue that there are opportunities for this theoretical framework to be applied to contemporary culture and in particular graphic design. To date there has been limited exploration of the relationship between Surrealism and the graphic disciplines, particularly from a feminist or intersubjective perspective. One of the most notable contributions came from art critic Rick Poynor, who wrote *Dark Tools of Desire* (Poynor 2007) for Eye Magazine, and curated the exhibition Uncanny: Surrealism and Graphic Design at the Moravian Gallery, Czech Republic in 2010. Although Poynor's research encompasses all aspects of design, my research highlights a specific feminist intersubjective approach that considers technique as well as aesthetics. Therefore, my practice currently explores the integration of the ideas foregrounded in the analysis of female Surrealists within contemporary culture, furthering a performative extension of the self/myself/other as a graphic practitioner.

My research believes that the intersubjective cyborg is already deeply embedded within mainstream contemporary culture. This can be seen, for example, in the graphic representations orchestrated by musician, Claire Boucher, also known as Grimes, who not only transgresses boundaries through live music performance, but considers ungendered and intersubjective extensions of the self through graphic interpretations including album covers, tour posters and promotional material.

The Mobius Strip Analogy

The Mobius Strip analogy is the underlying methodological approach of this research. The analogy encapsulates all three theoretical underpinnings: Surrealism (as seen in M.C Escher's *Mobius Strip I*I (1963)), non-binary intersubjectivity and the relationship between theory and practice-based research. The strip signifies movement and is used to explore the continuity between different theories; The Mobius Strip as extension of traditional Surrealist technique of Exquisite Corpse, the Non-binary Mobius Strip through fluidity and ungendering in practice and the Mobius Strip as a pathway to unlock infinite 3D/4D spaces within Graphic Design.

There are two sides to the Mobius Strip analogy: the analogue plane and the digital plane. When using collage as the prime example, the analogue plane pays homage to the traditional Surrealist

technique of automatic drawing; a methodology used to promote unconscious practices that suppress conscious or rational control during the process of making where "[the author] is no longer a bicycle of their senses" (Aragon, 1924). This particular technique can be seen in Madame Fondrillion's Mediumistic Drawing (1909) a piece that was reproduced in the Surrealist publication *La Révolution Surréaliste* (1925).

My practice is currently situated within the digital plane, that considers a virtual type of automatism introduced through new technical translations of design. Although cut and paste techniques are still present, the new digital translation traverses through multiple realities by utilising modern software such as Cinema 4D and Processing, that encourages practitioners to consider new aspects of design that were not readily available before, such as volume, compression, texture, material and moving image. Although they exist on separate planes, this research acknowledges their co-existence. It presents an interchangeable, hybridised process of analogue and digital working, which creates a space for new forms of curation. The combination of these planes demonstrates a way that practice can move forward, and although the research primarily focuses on the process of collage, the framework lays a foundation that can be adapted to fit other creative disciplines. By 'tapping into' 4D realities, where the audience's sensory perceptions are altered due to transgressed boundaries, this research presents new realities for automatist graphic design.

Through a close analysis of a selection of graphic works by female designers and a consideration of their unconscious imaginings and workflow, this research shows how their collages may be 'read' (Fig. 3). It is of material interest to this study that the fluid digital tools available to a designer coincide with the physical process of collage, and therefore the adoption of these tools support the Mobius Strip analogy. For example, a simple cut and paste motion is a conscious decision of creating fluidity in a composition but through a process of trial and error combined with the unexpected (whether this is through an analogue or digital process) becomes an unconscious design methodology. This process is seen in the work of graphic designers Jessica Walsh and Leta Sobierajski who have adopted these techniques and whose personal work also aligns with notions of the intersubjective cyborg. In this sense the research argues that the language of collage has become a universal tool, yet what makes the works by all of these designers so compelling and powerful is their ability to become producer and subject of autonomous design whilst delving into their own surrealities.

Expected Contributions

This research aims to lay new theoretical foundations in graphic design by utilising the intersubjective cyborg model and Mobius Strip analogy as vessels for unleashing and understanding the self and other in graphic design practices. Additionally, the analysis initiates new conversations around Surrealism, performance and design through experimentation with automatist and curative collage that considers the capabilities of technologies such as processing, coding, 3D and 4D modelling where technologically advanced techniques such as volume, material and texture have contributed to spawning 'automatic processes' associated with Surrealism. These 'automatic processes' reimagine and rethink the Surrealist legacy in relation to Graphic Design and computational aesthetics.

Progress Towards Goals

This practice-based research is in the final year of completion. It constantly reflects the intersubjective cyborg extension and the Mobius Strip analogy through personal practice linking theoretical approaches to emergent processes. This study understands a need to look back in order to move forward and consider new ways of expressing the individual self. My practice currently explores a digital archive that encompasses both sides of the Mobius Strip analogy, where analogue and their digital translations and contemporary digital processes work in tandem with each other. The archive is translated through Processing, where code is fundamental in spawning contemporary automatic processes that are then translated through Cinema 4D as a way of uncovering my personal self where there is a freedom to become a producer of surreal and autonomous graphic design (Fig. 4 & Fig. 5).

Acknowledgements. I would like to express my deep gratitude to Dr. Anneké Pettican, who has provided me with invaluable support and guidance throughout my years at University. I am extremely grateful for her time, motivation and dedication.

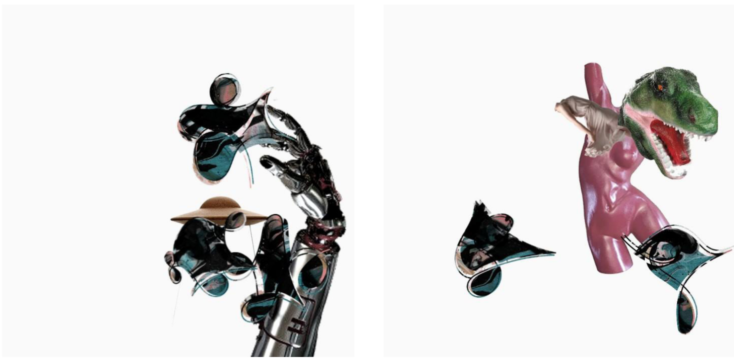


Fig. 1 *Czolacz, Automatism* (2021). Example outcome from the Processing code that generates autonomous collages every 3 seconds based on personal sigil designs and .PNGs.

Fig. 2 *Czolacz,The Curative Body (2020).* Exploration of using 3D objects in Cinema 4D, using Surrealist methodologies.

Fig. 3 *Czolacz, The Curative Cloth (2020).* Further exploration of the intersubjective extension using cloth and colliders within Cinema 4D to create texture and depth.

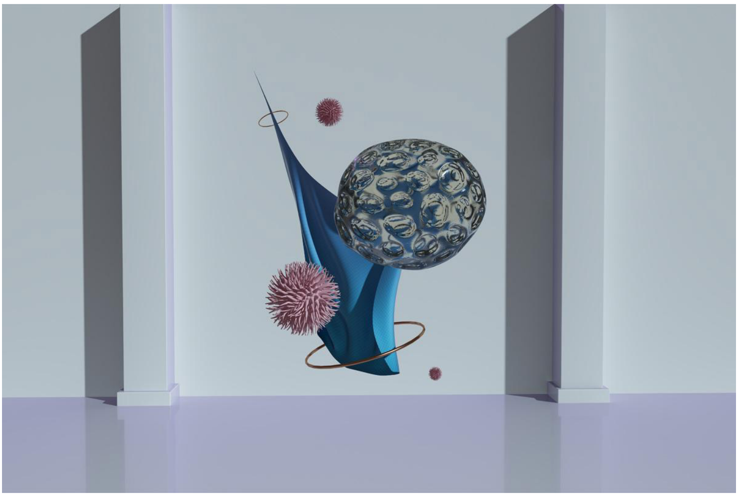


Fig. 4 *Czolacz, The Marble Effect (2021).* Beginning to use animation and camera effects to alter sensory perceptions. https://vimeo.com/511804564.

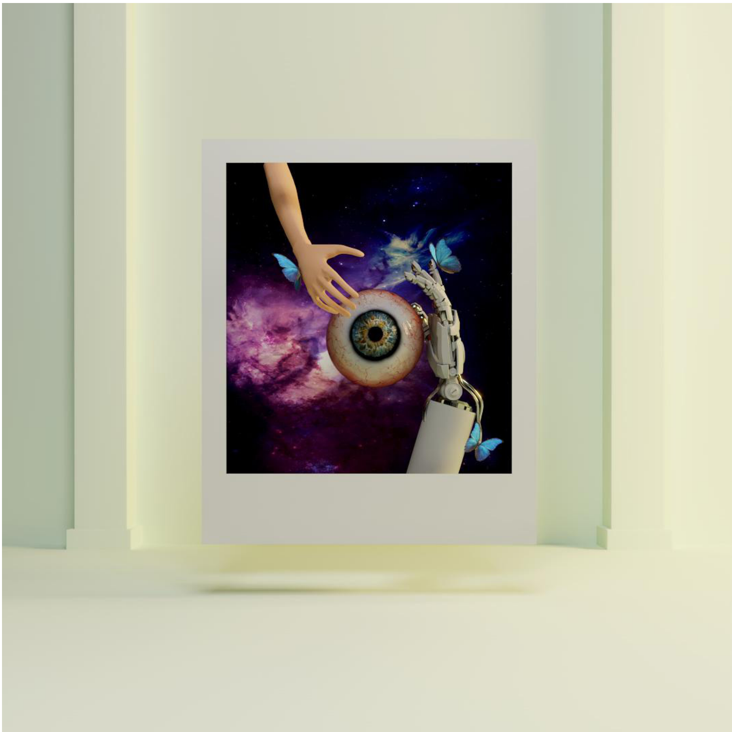


Fig. 5 *Czolacz, Integration (2021).* Beginning to use animation and camera effects to alter sensory perceptions. https://vimeo.com/534802241.

References

Allmer, Patricia.
2009. *Angels of Anarchy*. [Exhibition]. Manchester Art Gallery, Manchester, United Kingdom.

Aragon, Louis.
1924. *"A Wave of Dreams."* Translated by Adam Cornford. [Online]. Available at: https://www.surrealism-plays.com/Aragon-Dreams.html [Accessed 12th February 2021].

Breton, André, Pierre Naville and Benjamin Péret.
La Révolution Surréaliste. 1924. [Place of publication not identified].

Breton, André, Richard Seaver and Helen R. Lane.
Manifestoes of Surrealism. Ann Arbor: University of Michigan Press, p.180.

Clayton, Eleanor.
2018. *Lee Miller and Surrealism in Britain*. [Exhibition]. The Hepworth, Wakefield, United Kingdom.

Foote, Cameron and Nayia Yiakoumaki.
2021. *Phantoms of Surrealism*. [Exhibition]. Whitechapel Gallery, London, United Kingdom.

Greeves, Susanna.
2017. *Dreamers Awake*. [Exhibition]. White Cube Bermondsey, London, United Kingdom.

Haraway, Donna.
1985. *"A Cyborg Manifesto: Science, Technology and Socialist-Feminism in the Late Twentieth Century."* Socialist Review, pp.65-107.

Jones, Amelia.
1998. *Body Art/Performing the Subject.* University of Minnesota Press.

Lewis, Emma.
2019. *Dora Maar*. [Exhibition]. Tate Modern, London, United Kingdom.

McLuhan, Marshall.
1964. *Understanding Media: The Extensions of Ma*n. McGraw Hill.

Poynor, Rick.
2007. *"Dark Tools of Desire."* Eye Magazine. [Online]. Available at: http://www.eyemagazine.com/feature/article/dark-tools-of-desire [Accessed 12th February 2021].

Poynor, Rick.
2010. *Uncanny: Surrealism and Graphic Design.* [Exhibition]. Moravian Gallery, Brno, Czech Republic.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Swarm Labour: The Aesthetics of Sentient Machine Collectives at Work

Keywords: Swarms, Labour, Sentient Machines, Social Insects, Biomimicry, Media-Archaeology, New Media, Swarm Intelligence

Samuel Beilby
samuel.beilby@research.uwa.edu.au
Masters of Fine Arts Candidate, University of Western Australia, Perth, Australia.

Advancements in swarm intelligence, biomimetic robotics and related swarm technologies offers an interesting intersection of biological phenomena and machine assemblage. Electrical engineers, entomologists, artists, cultural and media theorists have long observed the labour methods and organisational structure of social insects as a communication system that can be applied to contemporary digital systems and networking. Amongst such swarm technologies of today, this thesis shall focus the development of biomimetic robot swarms in warehouses and sorting centres owned by information technology companies. Situated in a corporate context, swarming machines are in a constant slippery state of reconfiguration as they perform labour tasks that, although effective, appear incomprehensible, chaotic, and alien to the human eye. This thesis will examine the cultural significance of the insect motif in the development of swarm technologies and suggest that figures such as the ant have had their insect-technics appropriated for techno-capitalist use. Through a practise of media-archaeology, a review of insect organisation, socio-cultural symbolism, and their alien figure allows for a discussion on current and future potentials for the integration of swarm intelligence and sentient machines and what this means for the human/animal/machine relations of tomorrow.

Purpose of the research and its importance to the field:

The purpose of this research is to speculate upon human/machine/animal relations that have, through biomimicry, and a practise of media archaeology, manifested as swarm intelligence applications in the field of robotics. This research will theorise about human/machine/animal exchange fuelled by the machine learning revolution as a burgeoning field of mechanical system labour which has resulted in the emergence of sentient swarming machines. The notion of sentience is one fraught with ambiguity. However, in this context, I shall approach the issue of "perceived sentience" as a marker for the ability to demonstrate situational awareness and self-relation (Negarastani, 2018, 20-29). My research will involve: (1) A thorough historical analysis of how prevailing sociocultural and political representations of insects have contributed to the application of insect technics (insect organisation and behaviour) in mechanical tools such as robotics, and later, in machine learning (Parikka, 2010, 1-25). In other words, this project entails a critical review of somewhat forgotten or archaic swarm media to help better understand emerging swarm media of today (Parikka, 2012, 136-139). (2) I will assert that, through applying the behaviour and labour strategies of social insects to machines via swarm intelligence algorithms, artificial assemblages such as robotics, and machine learning tools are awarded a certain *animal spirit,* "creating in the process a series of fantastic hybrids" (Lippet, 2000, 187). (3) This thesis will research swarming technologies employed within corporate warehouses and sorting centres in correlation to underlying shifts brought about by the machine learning revolution: including a transformation of class relations and workplace relations between human, machine, and in the case of swarms, insects. Therefore, as information technology companies integrate swarms into their workforce, it is important to survey the accelerating technological forces that have driven history and that are driving the future of labour today – an issue which calls for a contemporary audit and updating of class struggle for humans and swarming animals (Wark, 2004, 089-125). (4) Finally, a creative component in the form of an art installation comprising of a swarm of small robotic arms, generative sound and visuals shall be created, exhibited and discussed throughout the paper where relevant in relation to the theme and research areas listed above.

Brief survey of background and related works

Swarms were seen as a potential case study for biologists and roboticists in the late 1980's, due to a growing interest in cellular automata – particularly for their ability to "produce patterns of significant complexity starting from simple rules" (Beni, 2004, 1). Research in the field of biomimetic assemblages that could self-organise and navigate their surroundings based on a process of exploration and exploitation (the gathering of resources and information to inform behaviour), pointed to the idea of an insect swarm as an accessible point of reference to such traits (Majid al-Rifaie, and Bishop, 2013, 85-85). The term "swarm" seemed appropriate to electrical engineering researchers Gerardo Beni and Jing Wang, as, in addition to being a great buzz-word, it encapsulated the interchangeable, disposable, and elementary nature of the individual units that successfully evoked their vision for decentralised robotic systems (Beni, 2004, 1-2). In 1989 Beni and Wang proposed the swarm as the ideal figure for which to base future developments and research in the realm of decentralised robotics systems with their paper, *Swarm Intelligence* in *Cellular Robotic Systems* (Beni., and Wang, 1993, 704). Prior to this, the study of social insects' swarming labour systems was developed by biologist E.O Wilson (Wilson, 1962, Abstract). However, it was not until decades later that de-centralised labour systems from nature were considered as a case study for the artificial simulation of swarming organisation through system algorithms such as *Boids* (Roy., Biswas., and Chaudhuri, 2014, 57).). In more recent years, swarm intelligence has been researched in fields beyond natural science and electrical engineering. Cultural media theorists Jussi Parikka and Eugene Thacker have approached the organisational behaviour of social insects as having revealing correlation to the contemporary networks and intelligent agents. Such theoretical speculation ties philosophical discourse of non-human communication with a re-contextualisation of biological processes and information to the realm of networks, systems and machines. Publications like *Insect Media: An Archaeology of Animals and Technology* (Parikka, 2010), *Biomedia* (Thacker, 2004), and *The Parasite* (Serres, 2007) offer a techno-theoretical account of the scientific application of superorganism organisation found in ant colonies. The result is a transformative examination of how, through biomimetic artificial systems, de-centralised networks of the natural world can shape how we think of media technologies. This thesis' notion of swarm intelligence as a labour force extends these ideas of insect organisation as a form of media to the socio-political realm, citing concerns for prominent workers in the age of machine learning; humans, insects, and machines. Regarding issues of displacement of the human, and insect worker due to the employment of mechanical system assemblages, the writings of McKenzie *Wark's Hacker Manifesto* becomes relevant. Wark proposes a modernisation of class conflict, one that denotes a possessive "vectoralist" class that monopolises the content of the "Hacker" class (Wark, 2004, 024-045). Hackers consist of musicians, writers, artist, philosophers, biologists and researchers that "hack" through creating new abstractions of information that contain the possibility for new worlds (Wark, 2004, 014-015). My paper will suggest that, with a little adjustment to Wark's definition of Hacker class, micro-world building insects can perhaps be integrated into this list of hackers, since she states:

> All abstractions are abstractions of nature. Abstractions release the potential of the material world. And yet abstraction relies on the material world's most curious quality – information. (Wark, 2004, 014)

Moreover, we can also connect Wark's concept of the creative "hacker" worker role to the potential for creative AI and how the artistic process of the artificial artist might compare to that of the human artist (Mazzone, and Elgammal. 2019, 1-4). – and again, to the creative labour process of the insect superorganism. The theory of Ant colonies as hackers takes Wark's contemporary notions of class conflict and applies them to biomimetic machine learning developments that have arisen from a corporate practise of media archaeology.

Contemporary digital, new media, robotic, generative, and sound art serves as a practical tool to assist in relaying such themes of machine learning, swarming insect behaviours, animal spirits, post human assemblages, and displacement of the worker amongst a techno-capitalist landscape. Media art venues such as Ars Electronica (Linz Austria), ZKM Centre for Art and Media (Karlsruhe, Germany) and Bildmuseet (Umea, Sweden) allow for a dissemination of ideas and discussion regarding machines, digital systems and intelligent agents. The recent collaboration between the Ars Electronica Futurelab and NNT (Japanese Telecommunications Company) *Swarm Arena* (2018), (see Fig. 1), presents a physical demonstration of a robot swarm that capitalises on their entertainment value by depicting how unmanned aerial and ground vehicles (UAVs and UGVs) would be utilised to display big data of spectator sports in a stadium environment. In-line with themes of swarm intelligence, but placing a greater focus on insect-media and the world-building potential of superorganisms, is Nicolas Mangan's *Termite Economies – Phase 1* (2018), (see Fig. 2). The display of 3D printed termite mounds, visuals and sound navigates the issue of exploitation of insectoid activity for economic gain. Carsten Nicolai and Marko Peljhan's *polar^{m} [mirrored]* (2010) installation reiterates similar aesthetics of nonhuman assemblages surveying natural resources (see Fig. 3). Here, the artists employ robots that use computer vision and electromagnetic radiation detection to gather radioactive data of granite boulders, gathering invisible information to be generated into visuals and sound that is perceivable to a human audience. Additionally, the recent work of Michael Candy has proved to be influential to this project. Candy, as his website states, “works with the vocabulary of robots... to mediate the liminal realm that technology oppresses on the physical world.” His autonomous robotic *Cryptid* (2019), (see Fig. 4), depicts an insectoid robot with six glowing legs constructed by LED lights that gradually traverses a space with animalistic movements “... in contrast to contemporary automata” (Candy, 2019).

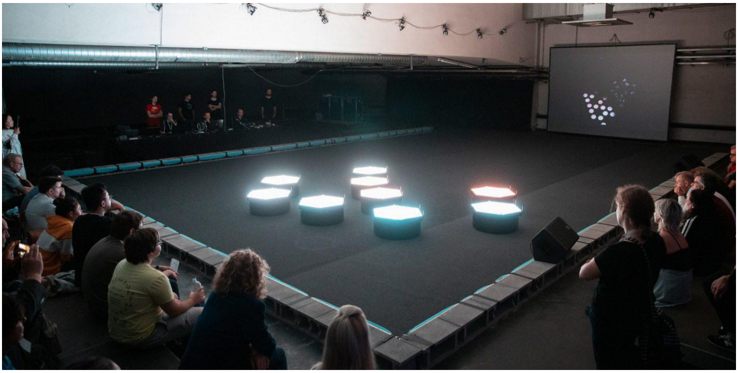


Fig. 1. *Swarm Arena* (2018), Ars Electronica Futurelab and NNT. Installation view, photography credit: Jürgen Grünwald. Source: https://ars.electronica.art/futurelab/en/projects-swarm-arena/.

Fig. 2. *Termite Economies - Phase 1* (2018), Nicolas Mangan. Installation View, photography credit unknown. Source: http://nicholasmangan.com/selected-works/termite-economies-phasel.

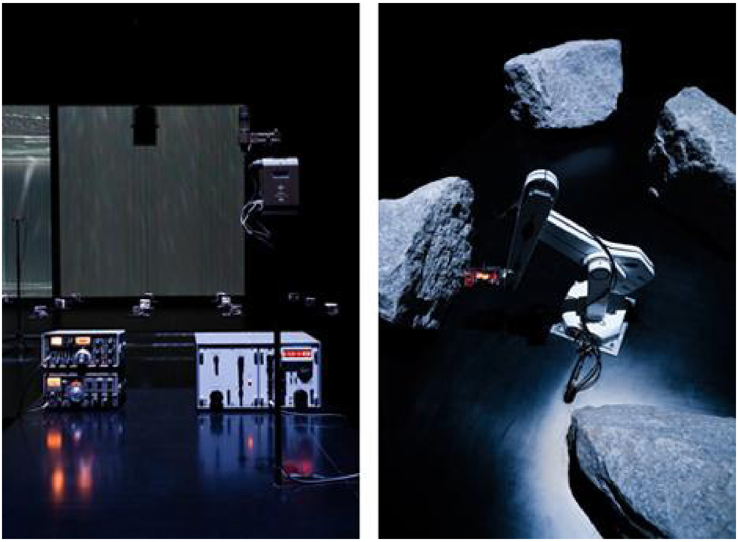


Fig. 3. *Polar*^{m} (2010), Carsten Nicolai and Marko Pelijhan. Installation view, photography credit: Ryuichi Maruo. Source: http://www.shift.jp.org/en/archives/2010/12/polarm.html.

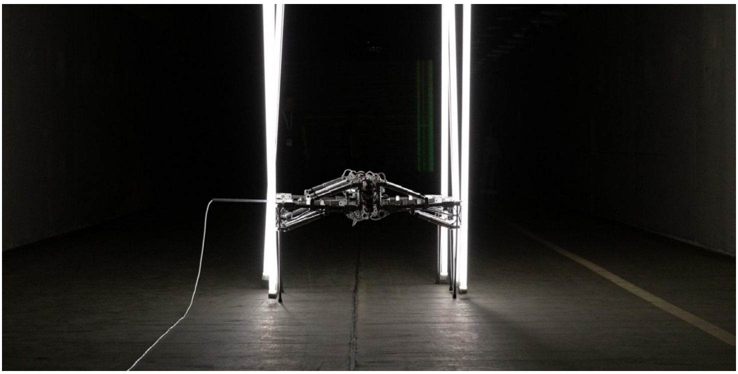


Fig. 4. *Cryptid* (2019), Michael Candy. Installation view, photography credit: Jürgen Grünwald. Source: https://ars.electronica.art/outofthebox/en/cryptid/.

Description of the proposed approach

This research project will be carried out in-line with what media theorists have termed as a practise of media archaeology. This shall involve, as media archaeology stipulates, a combination of cultural, and media theory to enhance arguments regarding current and future applications of new media technologies that reference archaic media forms, challenging the teleological notion of linear technology. As such, this paper is concerned with anthropomorphises of machine/animal spirits and also how swarm technologies have the potential to blur human/animal/machine relations in and beyond a workplace context. Taking a historical approach, this thesis will examine the employment of insect technics in mechanical apparatuses, from as early as the late 19th century, in relation to entomological discourse and prominent social allegory found in literature, folklore and even scripture that glorifies the insect figure as an undisputed expert of self-organisation. Jumping forward, this will be contrasted to the contemporary landscape of industrial systems labour. The result will be a mapping of where insects and human stand within the machine learning revolution of present day, detailing the historical applications of swarm intelligence, the use of ACO (ant colony optimisation) algorithms, and displacement of biological swarming animal labour and human labour. Subsequently, a theoretical framework of animal/machine hybrid spirits existing within an industrial and techno-capitalist context shall be constructed. The creative component of this research will involve an exhibition of an installation comprised of multiple robots displaying swarm-like behaviours in a factory setting. However, in light of the appropriation of ant's insect technics for corporate use, and also workers' rights/struggles, the robots will become agitated, restless, and even angry with their situation: gyrating violently as though they embody the trapped *animal spirits* of an ant colony that has been captured for techno-capitalist employment. Through this creative approach, I wish to amplify the sensory qualities, and atmosphere of corporate biomimetic swarms: their animalistic, jittery sounds, gyrating movements, and overall sentient ambiance.

Expected contributions

This thesis and creative work aim to contribute the budding discourse of theoretical speculation regarding the intersection of insect labour systems and autonomous network technologies. Through an examination of state of the art applications of swarm intelligence, as well as a historical overview of sociocultural representations of insects and how these attitudes towards superorganism organisation strategies inform robotic design, I wish to detail possible repercussions of an emerging swarm intelligence labour force. By investigating the ant colony and their insect-technics (Parikka, 2010), I will review the techno-capitalist condition in relation to the corporate appropriation of animal labourer for economic gain, and suggest that we can add social insects to Wark's list of creative hackers that fall victim to capital production. Hacked into machine assemblages, insect media challenges the way we observe, interact, and think of nature-mimicking sentient machines in the work place. In reference to the displacement of human workers since the industrial revolution, and today's displacement of insect labour systems, the creative component will offer these theories a speculative mood of discontent, anguish, and struggle, as expressed by a robotic swarm display.

Progress towards goal

This research project is being facilitated by the Masters of Fine Arts (Research) course at the University of Western Australia. Starting the degree in February, 2020, the research and development of the creative work has been underway for 12 months, with 12 months remaining (February, 2022). My progress includes a several thesis section drafts, experimentation with 6-degree-of-freedom robotic arms, an installation prototype, and a detailed outline of how to incorporate a machine vision sensor to several of the robotic arms for an artwork planned to be exhibited in Perth in February, 2022.

Acknowledgements. I would like to acknowledge the traditional custodians of the land, the Whadjuk people of Boorloo boodja, on which this paper was written and on which this ongoing research takes place. I would like to recognise their strength and resilience and pay my respects to their Elders, past present and future.

References

Beni, Gerardo.
2004. “From Swarm Intelligence to Swarm Robotics.” In: Şahin E., Spears W.M. (eds) Swarm Robotics. SR 2004. *Lecture Notes in Computer Science*, 3342 (Spring): 1-2. https://doi.org/10.1007/978-3-540-30552-1_1.

Beni, Gerardo, Wang Jing.
1993. “Swarm Intelligence in Cellular Robotic Systems.” Proceed. *NATO Advanced Workshop on Robotics and Biological Systems.* Italy, June 26-30 (1989): 704. https://doi.org/10.1007/978-3-642-58069-7_38.

Candy, Michael.
n.d. “Michael Candy: ABOUT.” *Michael Candy*. Accessed February 9, 2021. https://michaelcandy.com/ABOUT.

Lippet, Akira.
2010. *Electric Animal: Toward a Rhetoric of Wildlife*. Minneapolis: University of Minnesota Press.

Majid al-Rifaie, Mohammad, and John Mark Bishop.
2013. “Swarmic S ketches and Attention Mechanism.” Vividus Solutions LTD, and Goldsmiths, University of London, respectively: 85-86.

Mazzone, Marian, and Ahmed Elgammal.
2019. Art, Creativity, and the Potential of Artificial Intelligence. *Arts*, 8 (1): 1-4. https://doi.org/10.3390/arts8010026.

Negarestani, Reza.
2018. I*ntelligence and Spirit*. Cambridge, Massachusetts: MIT Press.

Parikka, Jussi.
2010. Insect Media: *An Archaeology of Animals and Technology.* Minneapolis: University of Minnesota Press.

Parikka, Jussi.
2012. *What is Media Archaeology?* Cambridge: Polity Press.

Roy, Sangita, Biswas Samir, And, Sheli Sinha Chaudhuri.
2014. “Nature-Inspired Swarm Intelligence and its Applications.” *International Journal of Modern Education and Computer Science* 6 (12): 57. 10.5815/ijmecs.2014.12.08.

Serres, Michel, Lawrence R. Schehr, and Gary Wolfe.
2007. *The Parasite*. Minneapolis: University of Minnesota Press.

Thacker, Eugene.
2004. *Biomedia*. Minneapolis: University of Minnesota Press.

Wark, McKenzie.
2004. *Hacker Manifesto*. Cambridge, Massachusetts: University of Harvard Press.

Wilson, Edward O.
1962. “Chemical Communication among Workers of the Fire Ant Solenopsis saevissima (Fr. Smith) 3. The Experimental Induction of Social Responses.” *Animal Behaviour*. Volume 10, Issues 1–2: Abstract. https://doi.org/10.1016/0003-3472(62)90143-4.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Mind the Gap Between Platform and Brain

Keywords: Ecomedia, Capitalocene, E-waste, Networked Performance, Art Platforms, Critical Making

Kimberley Bianca
circuitboardplatform@protonmail.com
Department of Critical Media Practices at University of Colorado, Boulder, United States

This practice-based research project generates applied knowledge of the prospects and problems of participation and exchange of technological artefacts. I introduce my research assemblage, *circuitBoard*, a blended online and community platform for critical making. With the premise that critical making and art platforms can evaluate social inequity, challenge institutional hierarchies, and question how capitalism and colonialism have destroyed ecosystems, the theoretical lens of ecomaterialism analyses media and technology-based artistic praxis. The research outcomes include community-based platform design and performative modes in developing activities that encourage more inclusive participation during crises.

Purpose of the Research

We are in the Capitalocene. The mining of the materials needed to produce technology artefacts is only increasing, and discarded consumer gadgets produce large amounts of electronic waste (e-waste). Up to 50 million tonnes of e-waste is made every year (Kumar, Holuszko, and Espinosa 2017). Congruently, software processes and our digital products and labour run on physical hardware and energy consumption. They depend on this same natural resource extraction and manufacturing system, exposing how digital infrastructures are inherently material and exploitative of people and ecosystems. We are also amidst the COVID-19 pandemic, highlighting how diseases become pandemics due to ecological and socioeconomic injustices. In this research, ecomedia platforms present as spaces for creativity, healing, cooperation, and action.

Ecomedia platforms concern anthropogenic impact on the environment; including representations of nature, interventions in ecosystem configurations, participatory approaches to environmental communication, and the resource demands and effects of technological infrastructures (Ziser 2016). Rather than bringing people together to solve a problem, we can collaborate on possibilities with critical making. Ratto and Ree (2012) describe critical making is "to use material forms of engagement with technologies to supplement and extend critical reflection and, in doing so, to reconnect our lived experiences with technologies to social and conceptual critique." This research investigates how critical making, artists, educators, facilitators, activists, technology, artefacts, cultural capital, and public participation are parts of a cognitive ecology.

Background and Related Work

Analysing media and praxis through the framework of ecomaterialism requires consideration of three tenants as proposed by Hunter Vaughan (2018): 1) Media practices have material impacts; 2) Material culture is the byproduct of distribution and consumption; 3) The environment is the primary source of labour. My review of works includes maker spaces, ecomedia art, and networked platforms. The following are selected projects.

Thomas Thwaites *The Toaster Project: Or a Heroic Attempt to Build a Simple Electric Appliance from Scratch*, took nine months to mine the resources, mould the metals, create the wiring, and complete a functioning toaster. Thwaites' findings on resource extraction and exchange, consumer behaviour, and labour systems are manifold. However, most striking is the argument that sustainability is not an act of self-reliance,but a cooperative effort that can serve different purposes depending on the values that we share (Thwaites 2012). An influential factor of individuals cooperating on networked platforms is how Cox and Pezzullo (2015, 213) present "self-initiating movements" through bottom-up accessible tools. For example, *Trashlab* and *Waterwheel* are self-initiating movements. Based in Helsinki, Pixelache's organisation Trashlab aims to generate a community of artists, designers, hackers, recyclers, and activists to address electronic waste with creative approaches. While *Trashlab's* format is similar to maker spaces, they do not have a permanent physical location, and they distribute their activities online and in different locations to reach different communities. *Waterwheel*, developed by Suzon Fuks and Inkahoots, was an online, interactive, and collaborative platform for sharing media, knowledge, ideas, performances, and presentations about water. Waterwheel facilitated collaborative engagement with artists, scientists and audience participants.

Ecomedia and maker platforms are increasingly discontinued due to lack of funding. Alternatively, they can become machines of capitalist exploitation (Goriunova 2019). Therefore, media practitioners are becoming dependent on appropriating a network of centralised social media platforms, despite the adverse environmental effects and breaches of our information rights. The potential of ecomedia platforms means leaders and stewards representing diverse human cultural beliefs and artefacts can confront the coloniser's worldview hierarchy and provide alternatives to environmental science communication.

Proposed Approach

CircuitBoard is a blended-media arts platform that harbours creative communication around e-waste, planned obsolescence, and awareness of disproportionately affected individuals. The platform is blended in that it is both online and community-based. The aim of the online platform is for exchanging resources, peer-production, and community skills-sharing. Since the interaction model between the components selected should be a logical chain, and the open-source projects I assemble should have more or less well designed and documented APIs, their integration should pose feasible. I will map the exchanges of technology and artefacts during activities by tagging objects we use and tracing movements between people across the platform and the workshops. I am not interested in the objects' points, but the lines between them— the relations between people.

The forming of community partnership projects offers cross-generational possibilities to access technologies and repurpose media. Rather than relying on corporations to implement greener processes and circular manufacturing, there are creative possibilities— communities are agents of change. They can be highly influential in raising awareness of environmental and social issues, revealing peer-to-peer, community, and national implications around sustainability and equitable access to technology. An ongoing question I have with *circuitBoard* is, how can we be engaged with the goals of sustainability as a stimulant and not as a restriction? Thus, this praxis centres on community-centred caring that allows for justice and climate health.

Facilitators can help artists, participants, and collaborators find socially engaged ways of generating ecomedia projects. My participatory research approach includes my process and values into the facilitation of activities and platform design. As a play participant, practice-based researchers play by being engaged members in activities (Tracy 2013, 109). I must be reflexive and maintain the respective subjectivities of the people I interact with, assuring my approach is descriptive and instructive rather than prescriptive.

Contributions

Currently, I am co-facilitating *makerBoard*, a program with vulnerable youth and new foster parents to develop a distributed maker platform. Concurrently, I am developing *futuresBoard*, a blended workshop program for upcycling technology around the theme of 2051 with CU Boulder's Environmental Center. circuitBoard can also host a participatory archive and networked performances. With the 2020 *circuitBoard* project *Murphy's Law* Or:, networked performance was a way to examine materiality, collaboration, authorship, and distributed cognition.

These *circuitBoard* projects are iterations of the platform and will be a part of the *circuitBoard* assemblage. Each project is an offshoot that the partners I work with can develop independently of circuitBoard as a social open-source approach. Likewise, their findings will continue to inform my research and future iterations of *circuitBoard*. The prospecting vision is to continue to develop the online platform with a cumulative networked community showcase running on *circuitBoard* as the final phase for my PhD research.

Progress

This research is iterative, and as I am in the second year of the PhD program, I must reflect on my exploratory practice-based activities thus far and develop a sound community-based design methodology to form a research proposal for the following two-years.

In mapping out how networked performance can further inform my research, a promising aspect is improvisation, which is accessible to anyone who has something to show or share without the commitment of making an artefact. It also transitions the focus from materiality to making as a performative act. There is an emerging inquiry into a platform that hosts activities at the intersection of performance and critical making. Consequently, I advocate a community-based platform that is ecologically mindful, assembling individual and collaborative contributions, resources, and stories.

References

Cox, J. Robert and Phaedra C. Pezzullo. 2016. "Digital Media and Environmental Activism". Chapter. In *Environmental Communication and the Public Sphere*. 4th ed. Thousand Oaks, California: SAGE Publications, Inc.

Goriunova, Olga. 2019. "Digital Subjects: An Introduction." *Subjectivity* 12 (1): 1-11.

Kumar, Amit, Maria Holuszko, and Denise Crocce Romano Espinosa. 2017. "E-Waste: An Overview on Generation, Collection, Legislation and Recycling Practices." *Resources, Conservation and Recycling* 122: 32-42.

"Pixelache | Trashlab". 2021. *Pixelache.Ac*. Accessed February 10. https://www.pixelache.ac/projects/trashlab.

Ratto, Matt and Robert Ree. 2012. "Materializing Information: 3D Printing and Social Change." *First Monday* 17 (7).

Thwaites, Thomas. 2012. *The Toaster Project: Or a Heroic Attempt to Build a Simple Electric Appliance from Scratch*. Unabridged. New York, NY: Princeton Architectural Press.

Tracy, Sarah J. 2013. *Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact*. 1. Aufl. ed. Chichester, West Sussex, UK: Wiley-Blackwell.

Vaughan, Hunter. 2018. "Screen Theory Beyond the Human: Toward an Ecomaterialism of the Moving Image." Chapter. In *The Anthem Handbook of Screen Theory*, edited by Hunter Vaughan and Tom Conley, 103–18. Anthem Press.

"Waterwheel | An Interactive Platform Exploring Water As A Topic & Metaphor". 2021. *Water-Wheel.Net*. Accessed February 10. https://water-wheel.net/.

Ziser, Matthew. 2016. "Ecomedia". In Adamson, Joni; et al. (eds.). In *Keywords for Environmental Studies*, 75–76. New York: New York University Press.

xCoAx 2021 9th Conference on
Computation, Communication, Aesthetics & X

2021.xCoAx.org

Civic Games: Video Games as Instruments for Human Autonomy in the Digital Era

Keywords: Human Autonomy, Digital Literacy, Civic Engagement, Civic Media, Participatory Design, Game Design, Video Games

Juliana Valentim
up201700031@edu.fe.up.pt
Faculty of Engineering University of Porto, PhD Program in Digital Media, Portugal

Societies have faced common issues regarding modern technology's impact on civic life, such as rising populism regimes and information disorder, which have shaken the global democratic order. The media technology, especially the social networks, have facilitated extensive monitoring of the population and control of communication infrastructures. This research embraces media literacy and civic competence knowledge to strengthen human autonomy in the digital era. This study aims to gather qualitative data from a participatory design process with citizens, journalists, and designers and offers an opportunity to explore civic potentialities by integrating their demands into video games driven to positive social change impact. In the end, this project will provide a conceptual framework that articulates design principles and guidelines and an exploratory game kit to support future-based research in civic media, digital literacy, and game design. Its current work is focused on a literature review and co-design sessions to validate the first version of the framework and develop a video game prototype.

Context

This research explores alternative practices to strengthen human autonomy in the digital age. It embraces the argument from the Critical Theory of Technology in which advocates for radical democratization of technological societies to create a sustainable new order (Feenberg 2002). Thereby, the Critical Theory depends on democratic participation to integrate public demands into a technical sphere. It means that social actors should take action to redesign the modern technology to create social change in the world. So, one possibility to support that idea is to enhance individuals with knowledges to engage in civic life. It might lead social structures to reconcile broader freedom with more meaningful forms of interconnection. Moreover, the other possibility is to boost citizens with media literacy skills and competence. The new technology, especially the Internet and social media, have allowed individuals to get loads of information at an unprecedented rate and enable social control, despite a range of innovative and dynamic initiatives that have leveraged these technologies. Thus, this research embraces the Critical Theory to explore how to strengthen human autonomy by exploring a participatory design process to translate civic potentialities into video games and foster positive social change in the technological society.

Goals and Research Questions

As previously mentioned, civic competence and media literacy are essential interrelated dimensions to strengthen human autonomy. Therefore, this research aims to foster agency with civic media literacy by using a qualitative intervention to support civic engagement. With scientific rigour, it seeks to support existing game design and technologies with its core principles for broadening skills and competencies of autonomy. Finally, this study proposes mapping the interplay between Democracy, Design, and the Critical Theory of Technology, supporting scholars in future-oriented research in these fields. Thus, this study possesses two main research questions:

1. How can video games promote skills and competencies of autonomy to support civic engagement?

2. What core design principles and guidelines are required for this intervention to foster autonomy in players?

Also, secondary questions lead the research in the following topics:

» How will this intervention promote social cohesion?

» How will players formulate ethical values from video games?

» Which civic media literacy will video games embedded to support human autonomy (critical consciousness, tolerance, creativity, interdependence)?

» What types of gameplay can be most effective for human autonomy?

Relevance

This exploratory research will provide a conceptual framework for designing video games, including the core principles of autonomy and can support both industry and education institutions. It may also enhance research in computer ethics and participatory design with collaborative epistemologies related to community values and pluralism.

Moreover, this research provides a straightforward pathway for involving academics and designers in the contemporary debate around the radical changes to build the future condensing technical and social functions. The findings may provide evidence to increase conversation between scientists and citizens and elucidate how to better communicate scientific knowledge in an approach that makes sense to a layperson to learn about science.

The following section provides a brief background regarding media literacy, civic competencies, and possibilities to use video games to explore both knowledge pieces. The Section 'Methodology' describes the integrated methodology used, and Section' Contributions and Future Work' presents the expected results and contributions. Finally, the Section' Progress Towards Goals' gives the stage the research is.

Brief Background

Societies have faced common issues regarding modern technology' impact on civic life, such as rising populism regimes and information disorder (Wardle and Derakhshan 2017), which have shaken the global democratic order (Mihailidis 2019). The media technology, especially the social networks, have facilitated extensive monitoring of population and control of communication infrastructures (Buolamwini and Gebru 2018; Zuboff 2019). The trust in politicians, institutions, and media has vanished in contemporary society (Castells 2015; O'Connor and Weatherall 2019), so have the sense of freedom to build and prune the own social network, it seems a great form to individuals protect themselves and survive together (Pariser 2011; Rushkoff 2019).

This paper provides a brief background to enlighten how to strengthen human autonomy in the digital era. So, there are two types of interrelated knowledge, which aim to foster agency and encourage civic engagement. The first knowledge is media literacy. Misleading communication and falsehoods are thriving more than accurate information, so people need skills and competencies to critically interpret news and information and produce civic responsibility contents (Hobbs 2020). So, citizens can be informed agents to play a crucial role in the public sphere (Afshar and Asadpour 2010).

Renee Hobbs, an internationally recognised authority on media literacy education, claims that media education should focus less on journalism practices and more on propaganda education (Hobbs 2010).

Her perspective is incredibly singular because disinformation strategies come along whether in an ad, meme, political discourse, or news to influence people's hopes, fears, and dreams.

The second knowledge is civic competence. It is a central concern to bridge political tolerance, activate civic participation, and support citizens to make informed decisions (Delli Carpini and Keeter 1996; Shah et al. 2009; Lupia 2002). As aforementioned, social media platforms have mediated public debate and facilitated nationalist politicians to control the population by their communicational infrastructure (Mihailidis 2019). Thus, it is also a case for the technological society to enhance civic competence whether the lack of transparency and accountability of the digital technology and social media platforms remains enabling the democratic destabilization.

Some initiatives, such as Games for *Change*[1] and *Tiltfactor*[2], have used video games to support ethical values, critical thinking, decision-making, and creativity (Gee 2004; Bogost 2008; Flanagan 2009). Besides, scholars have explored video games in psychological intervention to confer cognitive immunity against misinformation (Roozenbeek and van der Linden 2019) and offer new opportunities to engage with young audiences, delivering other forms of new consumption (Sicart 2008; Bogost et al. 2010; Grace et al. 2016; Grace and Hone 2019).

1. http://www.gamesforchange.org/

2. https://tiltfactor.org/

Although this paper has shown the new technology's impact on civic society, it also enlightens new opportunities to explore digital media, such as video games, to create novel models of communication and positively impact technological society.

Methodology

The project began by observing the digital environment's challenges in contemporary societies and identifying the patterns across different cultures, especially in Western democracies. The rise of neo populism, the spread of disinformation, and the interplay between politics and conspiracy theory are some phenomena identified that emerge from cyberspaces.

During the Master in Multimedia at the Faculty of Engineering, University of Porto, Portugal, in the 2018/2019 academic year, the author developed an experiment and conducted interviews to explore the problem. The study designed a "fake news" video game prototype, entitled Lado B (2019). This study provided initial insights into the potential of critical game design in producing arguments for players through a playable system and fostering critical thinking and communication skills in the context of media literacy.

Phase 1: Literature Review

Since then, this project has focused on the literature review to provide a theoretical board and formulate hypothesis to address the research problem. Essentially, the literature review grounds the first version of the conceptual framework, which articulates design principles and guides to support co-design sessions. In the following bullet points, this paper highlights details of the study fields:

1. Philosophy of Technology: Critical Theory of Technology.

2. Social Sciences: Critical Theory, Communication Studies, Theory of Social Movements.

3. Design: Critical Design, Critical Game Design, Human-Centred Design, Participatory Design.

4. Computer Science: Human-Computer Interaction, Game-Computer Interaction, Networks.

Phase 2: Conception and Development

This study will gather empirical data by using models of co-design to validate the conceptual framework and develop an exploratory game kit. So, this research agenda purposes an exploratory and experiential technical public sphere (Feenberg 2002) with designers, journalists, and citizens, meaning an exploratory model to integrate their demands into video games for social change. It might lead researchers learn from small communities how to design technology for their needs in terms of cultural, communicational, and ethical aspects. Also, this intervention employs workshops and interviews to gather qualitative data using video games prototypes as research instruments. After the prototype's tests, this study will take the following phase to organise the data and explore insights to might answer the research questions.

Phase 3: Analysis and Conclusions

This research will organise and analyse the data gathered using the Thematic Analysis (TA) method by Braun and Clarke (2012). This method allows the researcher to see and make sense of collective meanings and experiences. So, the approach to TA offers a meaningful interpretation of the data set by applying a six-phase process to TA: (1) Familiarisation with the Data; (2) Coding; (3) Searching for Themes; (4) Reviewing Potential Themes; (5) Defining and Naming Themes; and (6) Producing the Report. After that, it will review the research goals and hypothesis to possible answer the research questions. The study will proceed with the evaluation of the guidelines, design principles, and the iteration of prototypes. The exploratory game kit (conceptual framework and games) will be available to open access on the Web and may be used in different contexts, across cultures, and extended in future works.

Phase 4: Dissemination

The dissemination of this study takes place into following potentials publications: 1) Phase 1: a review paper to address the systematic literature review of the field; 2) Phase 2: a short paper to publish initial findings and preliminary analysis; 3) Phase 3: a long paper with data analysis and concrete results; and 4) Phase 4: a long paper to publish the complete study and results of the framework. These publications are mainly aimed at the following conferences for scientific dissemination: Revista Estudos de Jornalismo,[3] Culture and Games Sage Journal,[4] SOPCOM,[5] spcVideojogos,[6] ECREA,[7] EDUCON,[8] and xCoAx.[9]

3. http://www.revistaej.sopcom.pt/

4. https://journals.sagepub.com/home/gac

5. https://www.sopcom.pt

6. http://www.spcvideojogos.org

7. https://www.ecrea2020braga.eu/

8. http://educon-conference.org/current/

9. https://xcoax.org/

Contributions and Future Work

The contribution of this research is to provide a framework for designing civic media artefacts, which incorporates core design principles and guidelines of human agency and civic engagement. These may be useful to support designers to create for collective empowerment and social justice. It also extends to the cultural industry by encouraging media producers in developing products that can include communities rather than reproduce structural inequalities. It will also provide a package that includes some games to support educators who wish to use them in the classroom during media literacy training. It intends to continue an essential conversation about collective challenges to conduct more social cohesion and discuss these principles in terms of their implications for future-based research through critical design. Finally, it aims to serve as a potential roadmap for media producers, considering building a new communication ecosystem.

Progress Towards Goals

This research is focused on the literature review to set the core principles for autonomy and address hypothesis (Phase 1). In March of 2021, it has started co-design sessions (Phase 2) with a group of students from .iX.2021, a post-graduation in *Design, Web and Games* of the University of Porto. This collaboration appears as an opportunity to validate the theoretical board and develop a game prototype, which will support the data gathering in the following steps. The preliminary findings will result in a short paper to publish it in the next semester of 2021.

Acknowledgements. I thank my supervisors Pedro Cardoso, António Coelho and Ricardo Melo for help with the organisation of this research paper and review efforts. This work is supported by Fundação para a Ciência e a Tecnologia - FCT and ESF funding (2020.08355.BD).

References

Afshar, Mohammad, and Masoud Asadpour.
2010. "Opinion Formation by Informed Agents." Journal of Artificial Societies and Social Simulation 13 (4). https://doi.org/10.18564/jasss.1665

Bogost, Ian.
2007. P*ersuasive Games: The Expressive Power of Videogames*. Cambridge, MA: The MIT Press.

Bogost, Ian, Simon Ferrari, and Bobby Schweizer.
2010. *Newsgame: Journalism at Play*. Cambridge, MA: The MIT Press.

Braun, Virginia, and Victoria Clarke.
2012. "Thematic Analysis." In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), APA handbooks in psychology®. APA handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological (p. 57–71). American Psychological Association. https://doi.org/10.1037/13620-004

Buolamwini, Joy, and Timnit Gebru.
2018. "Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification." Proceedings of Machine Learning Research 81:1–15, 2018 Conference on Fairness, Accountability, and Transparency. https://damprod.media.mit.edu/x/2018/02/06/Gender%20Shades%20Intersectional%20Accuracy%20Disparities.pdf

Castells, Manuel.
2015. *Networks of Outrage and Hope: Social Movements in the Internet Age*.
Cambridge, UK: Polity.

Delli Carpini, Michael X., and Scott Keeter.
1996. *What Americans Know about Politics and Why it Matters*. Yale University Press.

Feenberg, Andrew.
2002. T*ransforming Technology: A Critical Theory Revisited*. New York: Oxford University Press.

Flanagan, Mary.
2009. *Critical Play: Radical Game Design*. Cambridge, MA. London, UK: The MIT Press.

Gee, James Paul.
2003. *What Video Games Have to Teach Us About Learning and Literacy*. New York, US: Palgrave Macmillan.

Grace, Lindsay.
2010. "Critical Gameplay: Design Techniques and Case Studies." In Designing Games for Ethics: Models Techniques and Frameworks, 128-41: IGI Global.

Grace, Lindsay, and Bob Hone.
2019. "Factitious: Large Scale Computer Game to Fight Fake News and Improve News Literacy." In CHI Conference on Human Factors in Computing Systems Extended Abstracts 8 pages. Glasgow, Scotland, UK. ACM, NY, NY, USA: CHI'19 Extended Abstracts. https://doi.org/10.1145/3290607.3299046

Hobbs, Renee.
2010. "News Literacy: What Works and What Doesn't." In The Association for Education in Journalism and Mass Communication (AEJMC) Conference. Denver, Colorado.

Hobbs, Renee.
2020. *Mind Over Media: Propaganda Education for a Digital Age*. New York, US: W. W. Norton & Company.

Lupia, Arthur.
2002. "Deliberation Disconnected: What it Takes to Improve Civic Competence." In Law and Contemporary Problems, 65(3), 132-154. https://core.ac.uk/download/pdf/205452777.pdf

Mihailidis, Paul.
2019. Civic Media Literacies: *Re-Imagining Human Connection in an Age of Digital Abundance*. New York, US: Routledge.

O'Connor, Cailin, and James Owen Weatherall.
2019. *The Misinformation Age: How False Beliefs Spread*. New Haven, US: Yale University Press.

Pariser, Eli.
2011. *The Filter Bubble: What the Internet is Hiding from You*. New York: The Penguin Press.

Roozenbeek, Jon, and Sander van der Linden.
2019. "Fake News Game Confers Psychological Resistance against Online Misinformation." Palgrave Communications 5, no. 65. https://doi.org/10.1057/s41599-019-0279-9.

Rushkoff, Douglas.
2019. *Team Human*. New York, US: WW Norton & Company.

Shah, Dhavan V., Jack M. Mcleod, and Namjin Lee.
2009. "Communication Competence as a Foundation for Civic Competence: Processes of Socialization into Citizenship." In Political Communication, 26(1), 102-117. https://journals.sagepub.com/doi/10.1177/0093650212436712

Sicart, Miguel.
2008. "Newsgames: Theory and Design." In International Conference on Entertainment Computing - ICEC 2008, 7th International Conference Pittsburgh, PA, USA: Lecture Notes in Computer Science. https://miguelsicart.net/lectures/Newsgames_ICEC08.pdf

Valentim, Juliana.
2019. "LADO B: A Case Study on Critical Games for News Literacy in the Post-Truth Politics Era (in Portuguese)." Master Dissertation. Faculty of Engineering of the University of Porto, Portugal.

Wardle, Claire, and Hossein Derakhshan.
2017. Information Disorder: *Toward an Interdisciplinary Framework for Research and Policymaking*. Strasbourg-Cedex: Council of Europe.

Zuboff, Shoshana.
2019. The Age of Surveillance Capitalism: *The Fight for a Human Future at the New Frontier of Power*. New York: PublicAffairs.