xCoAx 2020

Proceedings of
the 8th Conference on

Computation, Communication, Aesthetics & X

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Foreword

Graz, Lisbon, Milan, Porto, Weimar,
July 8th 2020

Dear readers,

We hope this finds you and your loved ones well.

These are the proceedings of the eighth edition of our Conference on Computation, Communication, Aesthetics and X, also known as xCoAx 2020.

Due to the CoVID-19 emergency, for the first time since our beginnings we were not able to organise a physical event with panels, exhibitions and performances, but we had to resort to a fully digital edition with remote meetings, video-streamed material and web-based Q&As.

These exceptional circumstances have made us even more aware of some of the contrasting characteristics of the world we live in. It has become a truly global and connected entity, where a virus can spread literally everywhere in just a few weeks, from the busiest metropoles to the most remote corners of the Amazon rainforest. On the other hand, the people inside this close-knit world were very quick to reinstate barriers of all kinds to try to contain the problem: borders were closed, trade and financial agreements were questioned, shutdowns were enforced. As a result, not only international relations were put to the test, but even inside each country the already existing socio-economic divides got strengthened, due to the differences in ability to respond to the emergency.

Where do computational arts stand in all this? As an aspect of human culture that is intrinsically hybrid, at the intersection between human creativity and technological connectivity, digital art reflects in full the losses, the opportunities and the relevant tensions of this situation.

The obvious lack of physicality, which prevents us from “being there” in the most traditional sense, has made conferences, exhibitions and performances impossible at the moment. However, all the events that were brought online out of necessity also gave us the occasion to test the available digital platforms to their limits, to see how much can be done, conveyed and exchanged between geographically distant individuals.

It is true that the digital divide is there to remind us that we are deluding ourselves if we think that the online world is the digitised version of everything out there. Not only there are several aspects of our lives that elude digital encoding, but there is still a significant portion of the world population that is not able to connect and take part in our online discourses. Here is hoping that, as we have tried in our xCoAx community to make things happen in a different but as effective way despite the difficult circumstances, so other organisations out there, dealing with much harder problems than bringing an event online, will work hard to find solutions and make compromises for a more inclusive, fairer, and healthier world.

Whether digital or not, arts and culture are the most powerful reminder that we are all in this together. Our gratitude goes to all the artists, authors and performers who contributed to this very embodiment of that reminder.

Life goes on and so do we all.

All the best,
the xCoAx 2020 Organising Committee

Papers

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Machine Patiency and the Ethical Treatment of Artificial Intelligence Entities

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Keywords: Artificial Intelligence, AI, Deep Learning, Ethics, Complexism, Moral Philosophy, Patiency.

In recent years there has been explosive growth in the realm of artificial intelligence or AI. With that has come a body of ethical concerns regarding human implications. However, this paper explores our actions towards AI systems. The concept of machine patiency is the notion that humans may have moral obligations towards AI systems as they become sentient. Five bodies of knowledge are inspected to set the landscape for future machine patiency research. These are (1) the history of human encounters with sentient others, (2) topics from the philosophy of mind, (3) topics from moral philosophy, (4) niche specialists who study AI and ethics, and (5) the nascent field of complexism. The paper closes with a provisional affirmation of machine patiency as plausible on the basis of both natural charity and rational non-contradiction.

1. Introduction

In recent years there has been explosive growth in the realm of artificial intelligence or AI. This has been primarily fueled by the invention of *deep learning* algorithms. These techniques are an extension of neural network technology, and neural networks date all the way back to the invention of perceptrons in 1958 by the psychologist Frank Rosenblatt. (Rosenblatt 1962) Neural networks operate by using a simplified model of biological neurons that are assembled into layers, and typically take sensory (or other) information as input, and yield classifications (or other analyses) as outputs. In between the input and output neurons are *hidden layers* of neurons that process information based on the connectivity and weights of the neuron network. Adjustment of those connections and weights is what allows a neural network to generate meaningful output. The process of that adjustment is called *training* or *learning*, and is generally done by exposing the network to real-world training data and making iterative adjustments.

Prior to about 2010 the general consensus was that neural networks with more than one or two hidden layers were impractical. (Smith 1993) This was because adding layers exponentially increased both the amount of data needed for training, and the compute time required to do so. However, improvements in compute power (especially using GPU technology), and the easy availability of data (thanks in part to the Internet revolution) changed everything. Suddenly those building neural network systems were free to add many more hidden layers (the depth in deep learning), and achieve feats of AI previously out of reach.

But deep learning-based AI has raised new issues regarding its impact on society. These include questions with moral entanglements such as:

- How do we manage the elimination of jobs, and fairly distribute the new wealth AI yields?
- Since the internal representations used by neural networks are inscrutable, how do we guard against impactful errors?
- How do we protect privacy given the massive storage and data gathering in AI?
- How do we maintain control over systems that may someday surpass our own intelligence?
- How do we prevent racism, sexism, and other forms of bigotry from being learned by AI systems?
- How can we protect ourselves from disinformation and "deep fake" forged media?
- How do we train machines to respond to ethically challenging scenarios like the trolley problem?
- How do we control the use of AI in warfare via autonomous robotic weapons?
- How do we defend our AI systems from attacks by hackers or international bad actors?

These are indeed vexing questions, but they overlook an entire class of other problems. They only include threats to humans, and ignore those to individual AI systems. The question raised here is the ethical treatment of AIs, and our giving them moral consideration similar to that we extend to other people. (*AI* can either refer to the field of artificial intelligence, or to specific AI systems in operation.)

Concern for the ethical treatment of AIs will be met by some with skepticism or even derision, and dismissed as an absurd question. One would expect statements such as:

- AIs have no awareness. Therefore, we don't have to worry about how we treat them.
- AIs have no free will. Therefore, they cannot participate in ethically-based relationships.
- Shouldn't we make sure all humans are getting moral consideration first?

One purpose of this paper is to go beyond these knee-jerk reactions, and to set the stage for giving the question serious consideration.

Most are familiar with the notion of ethical agency. It refers to the ability, typically assumed human, to take assertive action in transactions with others, and to do so within an ethical framework that yields due moral consideration. We typically expect adults to act in an ethical manner, or in other words, we consider adults to have moral agency. We typically do not, however, confer agency in the case of children. As a matter of upbringing we incrementally expose children to moral expectations, but because children are still in the process of developing their cognitive capacity, we withhold agency and other forms of autonomy for their own protection. Thus, we expect adults to exercise agency, but not children.

In moral philosophy, also known in this context as ethics, there is a less well known but related concept called *patiency*. A *patient* is simply a recipient who is due moral consideration in an (ethical) agent's decisions and actions. When one kicks a rock there is no patiency involved. The rock is not due moral consideration, and in this sense kicking a rock is neither right and good, or wrong and bad. But kicking a child would be an entirely different matter.

So only adults have agency, but both adults and children have patiency.

With the terms understood as above, we might expect self-driving cars to exercise a very limited form of moral agency. An example is a variation of the trolley problem. The scenario is something like this. As a high-tech car is self-navigating down the street, a child runs in front of it. The only option available to the car at the time is hitting the child or swerving off the road running over various adults. What should the car do?

Even most humans would find the moral calculus here murky, but nevertheless we would hope the car "does the right thing." By granting autonomy, we have conferred upon the car some small degree of agency. The car is expected to make a decision in a moral context. But is the car a patient? If someone intentionally smashed the windshield of the car, we might accuse them of many things. But most would not complain that the rights of the car itself have been violated.

If AIs approach human intelligence, or even beyond, will this remain the case?

1.1. About This Paper

In introductory texts on moral philosophy the problem of skepticism is typically addressed very early on. (Rachels and Rachels 2018, Blackburn 2003, Singer 1994, Shafer-Landau 2020) As religious conviction has receded from the intellectual landscape of the west, so too has a relatively simple yet solid foundation for ethics and morality. Any ethics discussion must face this realm of ambiguity and uncertainty. But in this paper the skepticism expressed isn't about our general ability to answer moral questions. The skepticism here is about the relevance, or even relative absurdity, of moral consideration extended to AIs.

A leading issue is that patiency, the right to moral consideration, seems bound to the factual question as to whether the candidate machine has awareness. Without awareness, often called *sentience*, a machine or other object cannot suffer, feel pleasure, or have any experience at all. Of course, even this standard is not a simple binary one. For example, murdering a human in their sleep would still be considered wrong. And the treatment of those in a coma or "brain dead" raises vexing problems in medical ethics. These are questions for another time.

So machine sentience would seem to logically precede considerations of machine patiency. Unfortunately, this leads to questions that are often the object of disdain because they are so absurdly intractable. In the philosophy of mind there is a (special) concept of "*zombies*." These are theoretical objects that behave as if they are sentient, even though they are in fact entirely without consciousness. If AIs approach *general artificial intelligence*, i.e. if they seem to broadly understand the unconstrained and ambiguous everyday world as we do, one might wonder whether or not they are zombies. Perhaps they act as if they are aware, but it's only a simulation of external behavior. Or perhaps they have the moment to moment sensation of awareness that we experience as sentience.

But note that logically one could just as easily ask whether other (apparent) humans have awareness. This could be referred to as the problem of *solipsism*, the notion that one's own mind is the only one that exists. Typically, solipsism is simply rejected by most people as being prima facia absurd. "Of course, other humans have awareness!" But when it comes to artificial intelligence many will take the opposite side. They will insist that considering AIs as anything other than zombies is prima facia absurd. "Of course, computers don't have awareness!" Is this a kind of bio-chauvinism? Can we reason our way past this potentially arbitrary contradiction?

This paper does not develop a refutation of solipsism. In fact, there is no attempt to develop a final argument from first principles. So, there will be statements presented here as axioms or hypotheticals that might, in some other context, be inferences. The intent is to set the stage for future research, and to describe the current conceptual lay of the land for machine patiency. However, a position affirming machine patiency is presented in the final section as being at least plausible.

So why take on the issue of machine patiency at this time? Because it's likely that the question will leave the realm of philosophical reverie, and enter everyday situations that involve practical real-world concerns. How long it will take to achieve general artificial intelligence is a matter of speculation. Perhaps it will take hundreds of years or longer. Or maybe it will appear much sooner. Here we are assuming it is just a matter of time, however vague the estimate. Once machine sentience seems upon us, life situations will force the question, and morally significant decisions will have to be made even where deciding to not decide is also a significant decision. There will be no ducking the issue of machine patiency in life.

If someday your AI expresses fear and terror and pleads to not be turned off, what will you do?

As an aside, it should be noted that this paper only takes a western approach. Because patiency touches on issues regarding consciousness, and eastern notions regarding consciousness are so different than those in the west, covering those contingencies will have to wait.

1.2. Is Ethical Consideration Towards Machines Even Plausible?

If the first step in exploring machine patiency is to nail down whether machines can be sentient, the cause is already lost. At this time, we simply don't know how to verify sentience in others with certainty. Perhaps we will never know.

Some will raise Alan Turing's "imitation game," now commonly called the "Turing test," in this regard. (Turing 1950) In what is now a famous article, Turing first asks "can machines think?" But he immediately retreats from that question due to the vagaries of defining the term "think." (It's interesting, but not obviously relevant here, that he also finds the term "machine" problematic.) To replace that question he operationalizes the issue by suggesting what we would now call a double-blinded test. A computer and a human are both hidden, but they can communicate with an interrogator via a teletype. The interrogator alternates asking each a series of questions without first knowing which is the computer, and which is the human. Then the interrogator gives an opinion as to which is which. If the interrogator can consistently identify the computer, then Turing suggests we say that that computer apparently cannot think. But if there is no apparent difference between the two allowing identification as to which is which, then Turing suggests we say that the computer can apparently think.

But notice that Turing has changed what we would normally mean by the word "thinking." His version of thinking doesn't, for example, require sentience. It merely requires giving responses as if sentience was involved. Turing essentially begs the consciousness question entirely, just as he said he would. As an aside, in the text he seems to think people would be more inclined to find the results of his test more compelling if the questions and responses were audible. But that is beside the point.

The philosopher John Searle's "Chinese room" thought experiment offers a similar objection. (Searle 1980) He imagines a room in which someone who doesn't understand Chinese accepts questions written in Chinese, and "answers" them by slavishly following a large set of English language instructions, and writing answers in Chinese without actually understanding the input or output. The parallel is clear. The Chinese room apparently converses in Chinese even though it lacks understanding, just as a machine in the hypothetical Turing test might seem to converse without actually thinking.

The truth is despite all manner of study by philosophers, computer scientists, neurologists, and others, we simply don't know at this time what the necessary and sufficient conditions are for sentience in humans, animals, or computers. Without such knowledge we can't discount the possibility of machine sentience. And if machine sentience may be possible, the ethical consideration of machines is activated as a legitimate concern.

2. Areas of Study Related to Machine Patiency

There are a number of sources of research and opinion that can contribute to the consideration of machine patiency. Here is a provisional list of some of those:

- We can inspect history for examples of encounters with other sentient entities.
- We can turn to philosophy of mind regarding sentience.
- We can turn to moral philosophy or ethics regarding human patiency.
- We can look for niche scholars specifically focused on AI and ethics.
- We can look to the nascent field of complexism for relevant systems and models.

It was noted that at best only a good first step is possible within this paper. In the following sections we will simply survey these related topics, note initial impressions regarding machine patiency, and organize the landscape for further research. And we will look for sign posts that point in the likely direction additional research can take. But we should take care to not mistake the sign post for the journey. The hypotheticals presented here will require significant additional effort in exploration. Nevertheless, as previously noted, machine patiency will be affirmed as plausible.

2.1. Patiency and Encounters with Sentient Others

We can ask history about our experiences with other entities with regard to how much or little, and when and where, patiency is granted. But we shouldn't assume these historical decisions are correct. An understanding of past mistakes (not) conferring patiency may prevent those same potential mistakes being made with AIs in the future.

Many human encounters with "the other" take place when cultures meet. Although it is arguably a relatively recent invention, the concept of race has acted to defamiliarize others, and can mark one group as outsiders relative to an in-group. And this, in turn, has provided cover for diminished patiency, and diminished patiency has allowed abominations such as slavery and segregation. (Smith 2015)

One of the most divisive conflicts in contemporary American society is the patiency granted, or not, to prenatal humans. That disagreement has obvious ties to the issue of abortion. It was previously noted here that children and adults are granted relatively equal patiency even though their statuses in terms of moral agency are significantly different. For many patiency doesn't begin at conception, and it only comes into play after many months of gestation if not birth.

There are also disputes on the other far end of lifespan. As people age and become infirm, society allows that they lose some agency, and rescinding that agency may appear to be a form of reducing patiency. (Mueller, Hook, and Fleming 2004)

Additional examples of encounters with sentient others include ongoing human relationships with the animal kingdom. Humans are capable of great kindness towards animals and especially domesticated animals. Sadly though, animals are more frequently subjected to what is objectively nothing better than torture and terror leading to premature death. Some feel this kind of treatment of animals should and will diminish and disappear over time. (Singer 2009, King 2017)

It's worth noting here that some find confidence in comparing human notions of suffering with subjective animal experience based on common underlying biological factors. This is especially relevant in terms of hormones, neurotransmitters, and brain organization where it seems that nature uses the same mechanisms over and over again. It is thought that subjective experience supervenes on brain activity. We may not understand the mechanics of consciousness, but for many having a common biological substrate increases the likelihood of a commonality in subjective experience. This would seem to position machine sentience at a disadvantage relative to animal sentience. This is related to, and somewhat denied by, the notion of *functionalism* discussed here later.

Finally, there are numerous depictions of encounters with non-human sentience in literature. Most obviously notable is the genre of science fiction.

But mythology and folk tales are replete with enchanted animals or golem-like creations that exhibit sentience beyond our everyday experience. While not based on historical facts, literature can reflect the concepts and ideas a culture is primed for. It may be the broader culture is only waiting for our computing technology to catch up.

(Some might think here of the novel *I, Robot* which introduced Isaac Asimov's "Three Laws of Robotics." (Asimov 1963) These, however, are only tangentially related to the issue of machine patiency because they specify obligations a robot is to fulfill, not obligations humans have towards robots.)

2.2. Philosophy of Mind and Ethical Patiency

Western philosophy also offers a variety of views regarding consciousness, sentience, and free will. The issue of machine patiency activates an already uncomfortable tension in contemporary society. On the one hand science describes a universe that, short of quantum effects, is mechanistic and subject to deterministic cause and effect. And western culture is nothing if not under the sway of science.

On the other hand, typical western moral values assume that ethical choices are indeed freely chosen. The conflict is sharp when considering the moral implications. For example, is it just to punish someone for apparently instigating an illegal event when all along that event was as inevitable as an apple falling from a tree?

For the time being here are some snapshots of some of the theories of consciousness, and as is relevant to this paper, tentative implications for machine patiency. It's important to remember that to date none of these theories provides a complete answer as to how conscious machines can be constructed, or how human consciousness works, or how third parties can verify a given entity has consciousness.

Quantum Emergence (Penrose) – Roger Penrose and Stuart Hameroff have suggested that biological structures are able to harness quantum phenomena to leverage superposition. (Penrose 2016) This allows the brain to essentially compute solutions to problems that are not amenable to Turing machine computation, and are limited by Gödel incompleteness. It is said that this yields consciousness. If true, we would know that a necessary but not sufficient condition for machine patiency is a capacity for quantum computing.

Panpsychism (Whitehead) – Panpsychism is the theory that consciousness is a fundamental, low-level, aspect of nature distributed throughout all matter or being. (Goff, Seager, and Allen-Hermanson 2017) From this point of view even subatomic particles have a trace of sentience that can be aggregated in larger systems. Alfred North Whitehead is the most notable modern advocate, and he integrated panpsychism as part of his process philosophy point of view. If true, machine patiency would probably have to be viewed as something awarded in a continuously varying amount.

Property Dualism (Chalmers) – Descartes famously wrestled with the mind-body problem which asks how it is that humans have both physical and mental aspects. He proposed what we now call substance dualism as a solution. Substance dualism proposes that mind and body are ontologically distinct substances. One problem with substance dualism is explaining how the two interact. David Chalmers has suggested that a single substance, the brain, can have two kinds of properties, mind and body. (Chalmers 1996) Unfortunately, it's hard to see how this paradigm provides leverage over identifying whether consciousness exists in a candidate for machine patiency.

Bio-Emergence (Searle) – John Searle endorses the notion that mind is an emergent property of the brain, and it creates a "first-person ontology" of sentience that is inaccessible to third parties. (Searle 1992) He contends that computing hardware may be able to simulate the operation of the brain, but it won't create the kind of first-person ontology we associate with consciousness. Thus "weak AI" which does not create sentience is possible, but "strong AI" which does is not possible. If true, one would think that machine patiency is a non-issue. However, due to the inaccessibility of first-person ontology, Searle would say there is no empirical way to verify this.

Functionalism (Putnam) – Functionalism is the contention that mental states are assembled purely on the basis of the functional relationships of its parts. Hillary Putnam was an early advocate for functionalism. (Putnam 1988) Mental states then are in a sense hardware agnostic, and minds constructed from biological neurology can also be constructed from computer electronics or any materials with the appropriate functional relationships. If true, candidates for machine patiency should qualify if properly designed, but it's not clear how an observer would know whether the constructed device was sentient or simply a zombie device.

Integrated Information Theory (Tononi) – Integrated Information Theory (IIT) presents a relatively new paradigm developed by starting with the phenomenon of conscious, and from that ultimately inferring what the physical substrate must be like to support it. (Tononi et al. 2016) One key to the theory is a measurement Φ (Phi) of the capacity for a system to integrate information. The theory is highly technical and controversial. It has traces of panpsychism in that tiny degrees of consciousness exist in small structures and can be distributed and of varying density. One significant criticism is that Φ measures an aspect that may be necessary, but is not obviously sufficient for consciousness. This is very much a work in progress, but it holds some hope that a means of measuring consciousness in a computer may become available. The relevent implication here is that IIT might provide an objective measure for assigning machine patiency.

Mysterianism (McGinn) – The so called "hard problem" of consciousness was identified by David Chalmers as the experience of what it's like to be something. It turns in part on the awareness of qualia, the redness of red, or the sweetness of sugar. The canonical example is captured in the title of Thomas Nagel's article "What is it like to be a bat?" (Nagel 1974) Some, like Colin McGinn, have concluded that consciousness, and particularly the qualia of the hard problem, are things simply beyond human comprehension. (McGinn 1991) If true it would not bode well for being able to identify machines worthy of patiency.

2.3. Ethical Patiency in Moral Philosophy and Ethics

Most philosophical systems require a commitment to rationality as being axiomatic, and that typically starts with the embrace of the three laws of logic. The first is the law of identity stating that a true proposition is (always) true. Next, the law of non-contradiction demands that if a proposition is true, it is not false. Finally, the law of the excluded middle insists that a proposition must either be true or false, and there is no third option. In some ethical systems (Kant 1950) the law of non-contradiction is specifically harnessed as a powerful tool.

Philosophy may not have much to say about specific irrational acts, but there is much that can be said in the form of meta-critique about irrationality itself. Individual irrational actors may claim to be driven by love, hate, or other emotions. Or they may claim to have been inspired by divine revelation, or some artistic muse. Some have offered that existentialism in philosophy offers a defense of a kind of irrationality. (Barrett 1990)

A commitment to ethical impartiality is often directly inferred from a commitment to rationality. By impartiality we mean that there must be a reason for differential treatment. However, there is typically a belief that ethics only applies to humans. The underlying assumption is that humans are uniquely rational. But this is exactly where AIs may challenge that default attitude.

Western philosophy offers various systems of ethics, and with each there is a theory, explicit or not, of patiency. These theories of patiency can precede, intertwine with, result from, or otherwise reflect the moral system they are associated with. A short inventory of moral approaches, similar to what might be expanded upon in introductory ethics texts, is presented here. It is offered not merely as a survey, but also as a way to add preliminary implications for machine patiency.

Nihilism, or more precisely *moral nihilism*, is the belief that there is simply no moral right or wrong. Although this would seem to be a dead-end, in ethics the defense against meaninglessness is a viable discussion. (Barrett 1990)) In any case, it may be that conferring patiency to AIs is in the practical self-interest of the human nihilist involved. A moral nihilist, for example, could enter into a social contract with an apparently sentient AI purely for reasons of self-interest. So, conferring machine patiency in that case might be possible, even if somewhat in bad faith. (And why should a nihilist worry about bad faith?) This approach can be related to social contract theory which is briefly discussed below.

Moral relativism, or simply *relativism,* is a bit like nihilism in that it denies that absolute normative judgements are available to us. But it carries with it the consideration that a given culture will have a strong commitment to a system of normative guidelines; and that while having no absolute basis, norms are nevertheless rigorously followed and enforced. Under such a system the issue of patiency, and thus machine patiency, could potentially take on any shape depending on cultural taste. (Gowans 2019)

Religion is potentially as variable as nihilism or relativism. Plato asks whether an act is moral because the gods say it is, or do the gods say an act is moral because they have the wisdom to see the truth of the matter? The second possibility raises the ethical good above the gods, and this is entirely compatible with Plato's metaphysics.

But in western monotheism, notably the three major Abrahamic religions of Judaism, Christianity, and Islam, there is no higher power than God. God is the ground of being, and God stitches morality into the fabric of being as part of the act of creation. Thus, right and wrong have ontological weight. Humans are viewed as uniquely possessing souls given by God, and because of that humans are conferred patiency by God.

Being without souls, animals cannot be said to have patiency. Humans have been given dominion over all living things by God. But that's not to say animal abuse can be justified. People are also charged with stewardship of the natural world. In addition, it is thought that cruelty to animals is likely to have a corrupting influence on a person's soul, and maintaining one's soul is of highest moral priority.

It would be terribly naive to suggest a single size fits all of western religion. But an initial signpost for sentient machines probably points in the same direction as that for animal patiency. As such patiency is probably not conferred upon apparently sentient machines, but cruelty towards sentient machines is to be minimized. (Detection of sentience, however, remains a problem.)

Kantian ethics is simply the study of ethics as authored by the philosopher Immanuel Kant. Kant is arguably the most important philosopher of the modern era, and his writing is the benchmark for *deontological ethics*. (Kant 1950, 1956) Deontological ethics is a rules-based practice. This is to be contrasted with *consequentialist ethics* which is a results-based practice. There are at least two propositions that serve as maxims central to Kantian ethics. First there is the notion that persons should never be treated merely as a means to an end, but rather as ends in themselves. This is related to what Kant sees as a uniquely human capacity for rationality. The other maxim discussed here is actually stated by Kant in a number of forms, and is referred to as the *categorical imperative*. Perhaps the most well-known formulation is this:

“Act only according to that maxim whereby you can, at the same time, will that it should become a universal law.”

Kantian ethics is notoriously complicated and entire academic careers can be built on related research. Here the admittedly simplified view offered is that Kant asks whether, given a commitment to rationality, there is something about rationality itself that can give us guidance in our choice of moral actions. In this regard the categorical imperative gains its strength from the law of non-contradiction.

Kant afforded personhood to humans but not animals because he viewed humans as being uniquely rational, where animals are not. However, not unlike monotheistic religious views noted above, he viewed cruelty to animals as something to be discouraged because of its corrupting influence on the human committing the abuse.

This subtopic clearly invites additional work. But if an apparently sentient AI could be considered to be as rational as a human, then it's hard to see why Kant wouldn't afford it more moral consideration than an animal. This would mean that AIs would have to be treated as ends in themselves, and not treated merely as means to some human end. That would obviously be a radical shift in human attitudes towards computers. Quite possibly Kant would further view sentient AIs beyond some threshold of rationality as having both agency and patiency.

Utilitarian ethics is a consequentialist rather than deontological theory based on the notion that increasing happiness is the highest good. (Driver 2014) The operative phrase is often stated as “the greatest amount of good for the greatest number.” While many intuitively find this to be a strong and just principle, as well as a pragmatic guide that easily fits contemporary liberal society, there are a number of well recognized problems.

The established critique of utilitarianism is beyond the scope of this paper. However, from a systems point of view the formula “the greatest amount of good for the greatest number” is an underspecified multidimensional optimization problem. At best it offers the opportunity for a set of pareto-optimal solutions, but not a way to narrow those solutions to a single choice. In short, it does not provide a way to make final moral decisions.

Historically utilitarians have afforded animals consideration because they are seen as sentient creatures that experience pain and pleasure. Utilitarians tend to be especially sensitive to awarding patiency where suffering is likely. However, human needs are typically given priority. So, for example, one might speculate that utilitarians will not compel vegetarianism, but they will strongly prefer farm animals to be kept and slaughtered “humanely.”

Nevertheless, given their willingness to give animals some moral consideration, it seems reasonable to see utilitarianism as pointing in the direction of granting machine patiency.

Social contract theory advocates for an ethics of cooperation where individuals voluntarily enter into an agreement with others, and that agreement asks that they give up any anarchic disposition in exchange for the stability and safety of an ordered society. Ethical thinking in this context leaves the traditional metaphysical weight of "the good" behind, and instead inspects relationships and social networks in terms of the exchange of benefits. (D'Agostino, Gaus, and Thrasher 2019)

In an unordered society a person who purely cooperates with others will come out on the losing end because they will be predictable and ripe for exploitation. (This resonates with game theory as noted in a following section.) Humans as rational animals are therefor moved towards negotiation, and form social contracts where each individual is guaranteed a moderate benefit. Under such a contract, patiency is conferred by rational agents to each other out of enlightened self-interest.

Because a trust-based highly ordered society is also the most fertile ground for sporadic criminality, part of the social contract will tend to include a shared enforcement mechanism. It takes the form of a variation of the golden rule that is operationalized. "You will be done unto as you do unto others."

A known problem with social contract theory is that those who pose little threat, or have little to offer, may be left out of the contract and find themselves unprotected. This does not bode well for apparently sentient machines. The question becomes whether we will anticipate the need to include apparently sentient machines in the social contract, or whether such machines will have to "do (painful things) unto others" in order to demand inclusion in the social contract. Granting apparently sentient machines patiency in such a context seems underdetermined, but may be forced by enlightened self-interest just as it is in the human-to-human case.

2.4. Niche Scholars Focused on AI and Ethics

It's obviously important to include in these considerations any niche scholars specializing in AI and ethics. While the bulk of writing about AI and ethics focuses on human-to-human obligation, some is about the ethical treatment of AIs and machine patiency, including AIs embodied as robots.

Notable among these is Joanna J. Bryson. In the essay *Robots Should Be Slaves* she argues that AI-endowed robots would only suffer if they were programmed by humans to suffer, and they are best viewed as sophisticated tools for our use in a way that would be objectionable if they were humans. (Bryson 2010) In line with this notion of the ontological subservience of AIs, in a more recent article regarding machine patiency she concludes "We are therefore obliged not to build AI we are obliged to." (Bryson 2018)

In S*uperintelligence: Paths, Dangers, Strategies* (Bostrom 2014) the threat of runaway growth of autonomous artificial intelligence is considered. Bostrom has widely published on allied topics, and is one of the many experts who signed on to the Asilomar AI Principles agreement intended to head off all manner of AI related ethical and social problems.

Also worth mentioning is the work of ethicist Peter Singer. (Singer 2009) His work on animal rights parallels the same kinds of concerns we see in the consideration of patiency for AIs. It's entirely possible, if somewhat ironic, that the fresh view afforded by the consideration of machine patiency may reinvigorate the kind of concern for animals that activists like Singer have expressed for decades.

And indeed there are dozens of others actively publishing in this realm in philosophy, computer science, and other general disciplinary journals, as well as specialty journals such as the *Journal of Artificial Intelligence and Consciousness.* A definitive bibliography would be a greatly appreciated project in itself.

2.5. Complexism and Machine Patiency

Complexism is a nascent worldview that takes the findings and tone of complexity science, and uses same as a platform to analyze and critique the problem space of the humanities. (Galanter 2016) As such complexism has implications for ethics.

Previous work on complexism has yielded a new model of authorship that ventures beyond those from modernity or postmodernity's post-structuralism. (Galanter In Press 2020) This model illustrates when a generative art system would have to be credited as truly being an author. To the extent that the determination of authorship is "giving credit where credit is due," such an analysis is already on the precipice of conferring a degree of machine patiency. (There are, however, other formulations where identifying a machine as an author is purely descriptive and without moral connotations.)

Complexism views human relations through the lens of network analysis, and ethical behavior is viewed as an emergent product of co-evolution. Co-evolution emphasizes that when it comes to "survival of the fittest," properties that contribute to fitness are a moving target. As an environment changes, and as competition creates a kind of "arms race," each adaptation stimulates adaptation by others in response. Ethics in this light can be seen as a kind of network protocol in a co-evolving human network. As that network evolves, so too does the network protocol. Thus the "moral good" can change slowly over time.

But are there high-level protocols that are strongly persistent? An interesting question is the mystery of the Golden Rule, "do unto others as you would have them do unto you." Some form of the Golden Rule is found in virtually every society and religion. Why is that? One possibility is that the Golden Rule is an inevitable emergent property of group adaptation.

The canonical prisoner's dilemma problem from basic game theory can provide insight. (Kuhn 2019) It can be described as follows:

A situation occurs where criminal partners have been caught, and they are being interrogated separately under the following terms. If both remain silent, each will serve one year in prison. If each betrays the other, each will serve two years. But if one betrays and the other remains silent, the one who remains silent will serve three years, and the one who betrays the other will go free.

The paradox is that if both prisoners remain silent, the total time served will be minimized, but from a selfish point of view the optimal move is to betray. However, when an iterated version is played as a game, and players can remember previous rounds, what tends to emerge is a winning strategy called tit-for-tat. Initially player one will strategically give player two the benefit of the doubt, and will cooperate by remaining silent. If player two betrays, i.e. selfishly tries to profit at player one's expense, on the next round player one will betray player two. But if player two cooperates, then player one will continue to cooperate.

This is, in effect, an operationalized version of the Golden Rule; "I will do unto to others as they do unto me." The surface cooperative behavior may appear to be altruistic, but the underlying mechanism is one of enlightened self-interest.

It's worth noting there are also traces of the Golden Rule operationalized this way in observed animal behavior. (Schmelz et al. 2017, Choe et al. 2017, Warneken and Tomasello 2006) The extent to which this emergence is directly related to genetic inheritance is arguable, but it certainly would be advantageous to have such behavior hardwired rather than discovered anew by each individual.

Is it possible that what feels like empathy at the level of consciousness is in fact a somewhat inevitable result of this co-evolution? Empathy can be viewed as an adaptation promoting social bonding and cooperation yielding a survival advantage. But the individual's survival instinct also brackets empathy with limits that protect the individual from uselessly giving to the point of personal jeopardy. As a result, each human defines and defends a circle of empathy. Their capacity for empathy, i.e. the number of people within that circle, is speculated to be in part determined by their genetic inheritance. Those outside the circle become "the other", and are eyed with greater suspicion. At its edge this circle becomes the functional method used to define and confer patiency.

Some moral values must be as universal as breathing for the survival of any culture. For example, the importance of the care of children is a universal human value. Similar cross-cultural values, e.g. the prohibition of murder, lying, etc., are enforced within the circle of empathy. Evolutionary pressure ensures these protections will be enforced by the culture, but the most important and permanent values are suggested to be genetically inherited. (More precisely, simple neurological precursors are genetically inherited, and these lay the groundwork for the emergence of empathy and cross-cultural values. Sometimes something in that chain of causation goes wrong, and sociopathy follows.)

In a way similar to the iterated prisoner's dilemma, a trust-based highly ethical society creates fertile ground for criminality, because so many members of that society are available as unsuspecting cooperative victims. Even if a society somehow reaches one hundred percent compliance with the law, some intelligent agents will later discover non-cooperation to be profitable and put it into play.

An innate predisposition for an emergent circle of empathy is also hypothetically a biological basis for tribalism. In a relatively short amount of time homo sapiens has gone from small group living to coping with "the global village." Evolutionary change takes much longer, and the expansion of the optimal size for an inherited circle of empathy likely has not kept up. In addition, due to the size of our current society, many transactions are one-offs. This results in the iterated prisoner's dilemma model being undercut for lack of iteration. I.e. it's easier to cheat someone you will never see again than to cheat someone you expect to see repeatedly.

Finally, in every culture morality is not permanently fixed, and there is a slow ebb and flow of public ethics in creative tension. An area of investigation, perhaps via simulation, for both complexity science and complexism is whether feedback loops within a society lead to ethics as a chaotic system. Chaotic systems are deterministic (i.e. follow cause and effect) and yet are unpredictable because of sensitivity to initial conditions. The implication is that at any given time we can describe the general contours within which ethical behavior operates (i.e. the phase space), but individual moral decisions remain somewhat unpredictable to observers. Perhaps such social turbulence can be quantified and empirically verified.

So, what are the implications within the framework of complexism for machine patiency? Much of the above is informed speculation, but speculation nevertheless. Additional work establishing theory of mind and empathy in other animals will be crucial, as will be additional understanding as to how genetic information ensures this emergent behavior. A scientific basis for something akin to "human nature" is essential, and flies in the face of social constructionist attitudes in the humanities.

But with additional evidence, this line of thinking leads to the following idea. To the extent that people and AIs are in transactional relationships, and AIs have achieved what appears to be autonomy, rationality, and sentience, enlightened self-interest will suggest that humans extend moral consideration to AIs. Co-evolution within a circle of empathy is proposed to be part of our genetic inheritance. It has emerged because it tends to ensure optimized benefits for all, and avoids conflicts with "the other" that only ensure strife.

3. Going Forward: Rationality and Charity

The preceding sections have surveyed various theories in ethics and philosophy of mind in the context of machine patiency. Both fields currently include viable, yet conflicting, theories. In addition, complexism has been offered as a possible framework for integration and further research. That completes the initial goal of describing the landscape for future machine patiency research.

In this final section we will consider whether some provisional position regarding machine patiency can be suggested. Speculation aside, we are locked out and cannot access the possible first-person experience of AIs. This is not specific to AIs. It is the very nature of first-person ontology that third parties cannot know what it's like to be a bat, or an AI, or another human. But coming over the horizon is the likelihood that as a practical matter, we will face decisions relative to the treatment of AIs. Even deciding to not decide is loaded with the risk of irresponsibility.

In every culture other humans are assumed to be sentient and to have awareness that is similar to our own. This is referred to in psychology as a "theory of mind". Theory of mind emerges in children in the first years of life. It is notable that behaviors consistent with a theory of mind can also be found in some animals. (Krupenye and Call 2019) This implies that theory of mind, like and related to empathy, has at least some genetic component. It is part of our very nature, and not a purely cultural effect.

If our apparently natural impulse turned out to be wrong, and some humans are indeed zombies, those zombie humans by definition would not suffer regardless of whether or not they are extended patiency. But if we are right, sentient humans will be in great danger of suffering if not extended patiency. It would seem that following our natural capacity for empathy does no harm in any contingency, but withholding patiency from other humans might. Our natural empathic drive to minimize harm to others is identical to exercising charity in conferring patiency upon other humans.

Such instinctual charity is different than, but congruent with, rationality in this matter. The first-person experience (or lack thereof) of other apparently sentient humans is not available to us. Thus, we have no rational basis by which we can assert differences between the first-person experience of other humans and our own. Therefore, there is no rational basis by which we can justify differential treatment, and we cannot withhold the same patiency we expect and prefer for ourselves. If we are committed to rationality, and we demand our own patiency, we must extend patiency to all apparently sentient humans or live in irrational contradiction.

A pair of parallel arguments can be made for AIs that appear to be capable of general artificial intelligence. We cannot know with certainty that such AIs know no suffering. To the extent they appear to be sentient, AIs will increasingly appeal to our natural capacity for empathy. And just as with humans, our natural drive to minimize harm to those who stimulate a theory of mind response will call for an instinctual exercise of charity in conferring patiency.

In the realm of rationality, short of some unlikely breakthrough in philosophy of mind, there will be uncertainty regarding the first-person experience (if any) of AIs. Any current rational bases for the differential treatment of AIs will fall away if they master general intelligence. In the context of this uncertainty we will have no rational basis by which we can justify differential treatment. Rational non-contradiction will call for awarding machine patiency.

Acknowledging there is more work to be done, this provisional position is offered as being at least plausible. It is proposed that assuming the technology continues to advance towards general intelligence, at some point a commitment to rationality will compel us, as will our natural empathic drive, to confer patiency upon future AIs.

References

Asimov, Isaac.
1963. *I, robot*, *Doubleday science fiction*. Garden City, N.Y.,: Doubleday.

Barrett, William.
1990. *Irrational man : a study in existential philosophy*. New York: Anchor Books.

Blackburn, Simon.
2003. "Ethics : a very short introduction." In *Very short introductions 80*. Oxford ; New York: Oxford University Press,.

Bostrom, Nick.
2014. *Superintelligence : Paths, Dangers, Strategies*. Oxford, UNITED KINGDOM: Oxford University Press, Incorporated.

Bryson, Joanna J.
2010. *Robots should be slaves*. *Close Engagements with Artificial Companions: Key social, psychological, ethical and design issues*: 63-74.

Bryson, Joanna J.
2018. *Patiency Is Not a Virtue*. *The Design of Intelligent Systems and Systems of Ethics* 20 (1):15-26. doi: 10.1007/s10676-018-9448-6.

Chalmers, David John.
1996. *The conscious mind : in search of a fundamental theory*, *Philosophy of mind series*. New York: Oxford University Press.

Choe, Il-Hwan, Junweon Byun, Ko Keun Kim, Sol Park, Isaac Kim, Jaeseung Jeong, and Hee-Sup Shin.
2017. *Mice in social conflict show rule-observance behavior enhancing long-term benefit*. *Nature Communications* 8 (1):1176. doi: 10.1038/s41467-017-01091-5.

D'Agostino, Fred, Gerald Gaus, and John Thrasher.
2019. "*Contemporary Approaches to the Social Contract*." Metaphysics Research Lab, accessed April 19. https://plato.stanford.edu/archives/fall2019/entries/contractarianism-contemporary/.

Driver, Julia.
2014. "*The History of Utilitarianism*." Metaphysics Research Lab, accessed April 19. https://plato.stanford.edu/archives/win2014/entries/utilitarianism-history/.

Galanter, Philip.
2016. *An introduction to complexism*. *Technoetic Arts: A Journal of Speculative Research* 14 (1/2):9-31. doi: 10.1386/tear.14.1-2.9_1.

Galanter, Philip.
In Press 2020. *Towards Ethical Relationships with Machines That Make Art*. *Artnodes: e-journal on art, science, and technology*.

Goff, Philip, William Seager, and Sean Allen-Hermanson.
2017. "*Panpsychism*." Metaphysics Research Lab, accessed April 19. https://plato.stanford.edu/archives/win2017/entries/panpsychism/.

Gowans, Chris.
2019. "*Moral Relativism*." Metaphysics Research Lab, accessed April 19. https://plato.stanford.edu/archives/sum2019/entries/moral-relativism/.

Kant, Immanuel.
1950. *Foundations of the metaphysics of morals*. Chicago: University of Chicago Press.

Kant, Immanuel.
1956. *Critique of practical reason*, *The Library of liberal arts, no 52*. New York,: Liberal Arts Press.

King, Barbara J.
2017. *Personalities on the Plate : The Lives and Minds of Animals We Eat*. Chicago, IL, USA: University of Chicago Press.

Krupenye, Christopher, and Josep Call.
2019. *Theory of mind in animals: Current and future directions*. *WIREs Cognitive Science* 10 (6):e1503. doi: 10.1002/wcs.1503.

Kuhn, Steven.
2019. "*Prisoner's Dilemma*." Metaphysics Research Lab, accessed April 19. https://plato.stanford.edu/archives/win2019/entries/prisoner-dilemma/.

McGinn, Colin.
1991. *The problem of consciousness : essays toward a resolution*. Oxford, UK ; Cambridge, Mass., USA: B. Blackwell.

Mueller, Paul S., C. Christopher Hook, and Kevin C. Fleming.
2004. *Ethical Issues in Geriatrics: A Guide for Clinicians*. *Mayo Clinic Proceedings* 79 (4):554-562. doi: https://doi.org/10.4065/79.4.554.

Nagel, Thomas.
1974. *What Is It Like to Be a Bat?* *The Philosophical Review* 83 (4):435-450. doi: 10.2307/2183914.

Penrose, Roger.
2016. *The emperor's new mind : concerning computers, minds and the laws of physics*. Revised impression as Oxford landmark science. ed, *Oxford landmark science*. Oxford: Oxford University Press. still image.

Putnam, Hilary.
1988. *Representation and reality*. Cambridge, Mass.: MIT Press.

Rachels, Stuart, and James Rachels.
2018. *The elements of moral philosophy*. NINTH EDITION. ed. Dubuque, IA: McGraw-Hill Education.

Rosenblatt, Frank.
1962. *Principles of neurodynamics; perceptrons and the theory of brain mechanisms*. Washington,: Spartan Books.

Schmelz, Martin, Sebastian Grueneisen, Alihan Kabalak, Jürgen Jost, and Michael Tomasello.
2017. *Chimpanzees return favors at a personal cost*. *Proceedings of the National Academy of Sciences* 114 (28):7462-7467. doi: 10.1073/pnas.1700351114.

Searle, John R.
1980. *Minds, brains, and programs*. *Behavioral and Brain Sciences* 3 (3):417-57.

Searle, John R.
1992. *The rediscovery of the mind*, *Representation and mind*. Cambridge, Mass.: MIT Press.

Shafer-Landau, Russ.
2020. *A concise introduction to ethics*. New York: Oxford University Press.

Singer, Peter.
1994. *Ethics*, *Oxford readers*. Oxford ; New York: Oxford University Press.

Singer, Peter.
2009. *Animal liberation : the definitive classic of the animal movement*. Updated ed. New York: Ecco Book/Harper Perennial.

Smith, Justin E. H.
2015. *Nature, human nature, and human difference : race in early modern philosophy*. *Justin E.H. Smith*: Princeton University Press.

Smith, Murray.
1993. *Neural networks for statistical modeling*. New York: Van Nostrand Reinhold.

Tononi, Giulio, Melanie Boly, Marcello Massimini, and Christof Koch.
2016. *Integrated information theory: from consciousness to its physical substrate*. *Nature Reviews Neuroscience* 17 (7):450-461. doi: 10.1038/nrn.2016.44.

Turing, A. M.
1950. *Computing machinery and intelligence*. *Mind* 59 (236):433-460.

Warneken, Felix, and Michael Tomasello.
2006. *Altruistic Helping in Human Infants and Young Chimpanzees*. *Science* 311 (5765):1301-1303.

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Amplifying The Uncanny

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Deep neural networks have become remarkably good at producing realistic deepfakes, images of people that (to the untrained eye) are indistinguishable from real images. Deepfakes are produced by algorithms that learn to distinguish between real and fake images and are optimised to generate samples that the system deems realistic. This paper, and the resulting series of artworks *Being Foiled* explore the aesthetic outcome of inverting this process, instead optimising the system to generate images that it predicts as being fake. This maximises the unlikelihood of the data and in turn, amplifies the uncanny nature of these machine hallucinations.

1. Introduction

In recent years, machine learning systems have become remarkably good at producing images, most notably of human faces, that can trick the human eye into believing they are real. Well documented controversy surrounds the potential consequences of deepfakes. Although, usingdeepfakes to spread disinformation in the political sphere has not yet occured in the way many predicted—and may instead be a convenient excuse for political actors to discredit the veracity of inconvenient footage (Breland 2019). However, deepfakes are disturbingly prevalent in pornographic websites where the image of a person (almost exclusively women) is superimposed into pornographic material without their consent (Adjer et al. 2019).

In a recently reported event, deepfakes have been used to make fake LinkedIn accounts (Satter 2019) to try and connect with employees at the US State Department. As the identity of generated images of faces cannot be found through reverse image search, it makes them perfect for creating false online identities that are difficult to trace as being fake. Unsurprisingly, the production of and means of detecting deepfakes have both become fast growing areas of research, as well as industries in and of themselves (Venkataramakrishnan 2019).

In order to produce deepfakes, the machine learning algorithms that generate these images are optimised in an unsupervised fashion to distinguish between real and generated images. Through this process they become increasingly sophisticated at generating realistic images (see Section 2.1 for more details). Not only are the machines optimised to make representations that are more realistic, they also generate information on whether or not a generated image is fake. To our knowledge, visualising and understanding this aspect of the machine's "disembodied, post-humanized gaze"(Steyerl 2012) has not yet been interrogated. This paper and the series of artworks *Being Foiled*[1] explore the aesthetic outcomes of optimising towards producing images the machine predicts are fake rather than real. By starting from realism and optimising away from it, the process bridges the uncanny valley in reverse, ultimately ending at a point of near total abstraction.

1. Artworks from the series can be seen here: https://terencebroad.com/works/being-foiled.

2. Background

2.1. Machine Learning

Machine Learning is a broad field, closely related to statistics and data mining, but with more of an emphasis on using methods of optimisation to automatically develop programs "that can automatically detect patterns in data ... to predict future data or other outcomes of interest" (Murphy 2012). In the field of Machine Learning, 'learning' is understood as an automated process of optimisation (often referred to as training), where an algorithm processes data and finds a set of parameters that best 'solve' a pre-defined objective function. This paper uses the term 'learning' in this computational sense, to be considered distinct from the anthropomorphic sense of human understanding, knowledge acquisition and reasoning.

Mackenzie, in his ethnography of Machine Learning, describes the field as a discourse of knowledge-practice not knowledge-consciousness. He describes the 'learning' in machine learning as embodying "a change in programming practice, or indeed the programming of machines ... a contrast between programming as 'a lot of [building] work' and the 'farming' done by machine learners to 'grow' programmes" (2017) .

2.2. Generative Adversarial Networks

The key method used to produce deepfakes is the Generative Adversarial Networks (GAN) framework. In this framework there are two main components, the generator that produces random samples and a discriminator that is optimised to classify real data as being real and generated data as being fake. The generator is optimised to try and fool the discriminator. Over time it learns to do so, producing increasingly realistic samples that 'fit' the data distribution without reproducing samples from the dataset.

Since the inception of GANs in 2014 (Goodfellow et al. 2014) a number of breakthroughs have been achieved in improving their fidelity, (Radford, Metz, and Chintala 2016; Karras et al. 2018; Brock, Donahue, and Simonyan 2019) leading to StyleGAN (Karras, Laine, and Aila 2019) which was most likely used to make the fake LinkedIn profiles referred to earlier and acts as the base pre-trained model for this paper.

GANs have also been used widely in the production of art, leading some to declare them leading to the next great movement in art (Schneider and Rea 2018). However, GAN generated art has come under a substantial amount of criticism. The banal production of new artworks, trained on datasets of existing artworks (Christie's 2018) has led Hassine and Ziv to term some examples of GAN generated art as 'zombie art' (2019). Another criticism is the reliance on the ability of deep neural networks to produce endless variations of mesmerising samples, without any meaningful framing of the works being presented by the artists (Zylinska 2019).

2.3. Fine-tuning GANs

Once a GAN is trained, the discriminator is usually discarded and the samples are drawn solely from the generator. However, this discriminator network contains potentially powerful representations that can be used in subsequent sampling or fine-tuning procedures of the generator. In our previous work, we showed that by freezing the weights of the discriminator, it can be used in conjunction with features from another network in order to fine-tune the weights of the generator through backpropagation. This enables it to transform its output distribution to a novel distribution with unexpected characteristics (Broad and Grierson 2019a).

2.4. The Uncanny

The uncanny is a psychological or aesthetic experience that can be characterised as observing something familiar that is encountered in an unsettling way. In his 1906 essay, Ernst Jentsch defined the uncanny as an experience that stems from uncertainty, giving an example of it as being most pronounced when there is "doubt as to whether an apparently living being is animate and, conversely, doubt as to whether a lifeless object may not in fact be animate" (Jentsch 1997). Freud later refined this definition to argue that the uncanny occurs when something familiar is alienated, when the familiar is viewed in an unexpected or unfamiliar form (1919).

In art, feelings of the uncanny are often evoked to explore boundaries between what is living and what is machine. This often reflects the anxieties and technologies of any given era, such as interactive robotic installations in the late 20th Century (Tronstad 2008). In work from the early 20th Century, such as Jacob Epsteins *Rock Drill* which depicts the human form as transformed and amalgamated by industrial machinery (Grenville 2001). In moving image, Czech animator Jan Svankmajer is well known for creating animated representations of the human form that deliberately confuse the viewer with respect to notions of life and lifelessness (Chryssouli 2019).

2.5. The Uncanny Valley

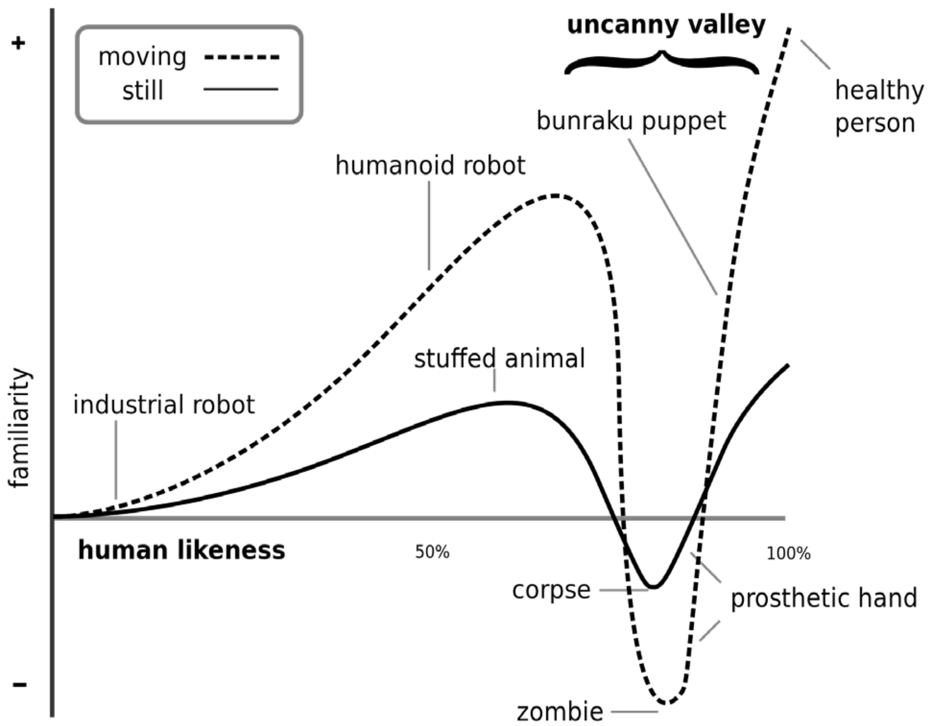

Fig. 1. Diagram illustrating the uncanny valley effect. Source: Wikipedia[2] (CC BY-SA 3.0).

2. https://simple.wikipedia.org/wiki/Uncanny_valley#/media/File:Mori_Uncanny_Valley.svg

The uncanny valley is a concept first introduced by Masahiro Mori in 1970. It describes how in the field of robotics, increasing human likeness increases feelings of familiarity up to a point (see Figure 1), before suddenly decreasing. As a humanoid robot's representation approaches a great closeness to human form, it provokes an unsettling feeling, and the responses in likeness and familiarity rapidly become more negative than at any prior point. It is only when the robotic form is close to imperceptible with respect to human likeness that the familiarity response becomes positive again (Mori, MacDorman, and Kageki 2012). In addition to being observed in robotics, this has also been observed in CGI, games and other domains where the likeness of humans and animals is imitated.

3. Inverting the Objective Function

In similar fashion to our previous work (Broad and Grierson 2019a), we take a pre-trained GAN (in this case StyleGAN trained on the Flickr Faces HQ dataset[3]) and then fine-tune the weights of the generator whilst keeping the weights of the discriminator frozen. The main difference here is that instead of using the discriminator in its standard usage (to determine if a generated sample looks realistic), we invert this objective function, optimising the generator to begin producing images the discriminator sees as being fake.

3. In this case we use an unofficial PyTorch implementation of StyleGAN and accompanying pre-trained models: https://github.com/rosinality/style-based-gan-pytorch.

3.1. Maximising Unlikelihood

GANs, in their adversarial game of deception and detection, implicitly learn to maximise the likelihood of generating samples that fit the distribution of the dataset they are given. By inverting this objective function we are, in effect, maximising the unlikelihood of the data.

As we are starting from a pre-trained model, the initial state is a generator that produces highly realistic samples. But as the fine-tuning process occurs, the weights of this model begin to change in accordance with features that are predicted by the network as tell-tale signs that the sample is fake, increasingly exaggerating these features until they are prominent.

4. Divergence > Convergence > Collapse

Fig. 2. Samples from fine-tuning process after 0, 250, 500, 750, 1000 and 1500 iterations.

Over the course of the fine-tuning procedure, the generator goes through a number of stages, increasing in its unlikelihood and in effect, reversing into the uncanny valley. Beginning from a state of producing almost imperceptibly realistic images, to increasingly exaggerating features that show the images are fake, ultimately collapsing into complete abstraction.

The different stages we describe are not discrete, but overlap, interact and feed into one another. We categorise them as representing three prominent phenomena. The first is divergence; the generator slowly starts to diverge from the original distribution of natural images, towards a constantly evolving new distribution, increasing in their uncanniness as the 'fake' or unnatural features of the images become increasingly pronounced.

Secondly (and concurrently), the generator begins to converge towards a new state that maximes the unlikeliness of the data. As this process continues, the gradients (the derivatives of the loss function being back-propagated through the generator) begin to explode. The system is in a vicious cycle where each update to the generator causes it to produce results that the discriminator predicts more strongly as being fake, producing an even more extreme loss function, causing ever more extreme changes to be made to the updates of the parameters of the generator.

This ultimately leads to collapse. The increasingly extreme gradients have washed away any of the subtle or delicate features that were present in the original data. The entire space of potential images has collapsed into (effectively) a single output (see Figure 3), a posterised caricature where human features are barely registrable.

The process we have described is a positive feedback loop, a reinforcement of the intensification of prediction as viewed and understood through the samples generated by the model, giving us a view into the stages of transfiguration it goes through. This process can be thought of as a computational enactment of the production of prediction (Mackenzie 2015), providing a form of visual insight into the production of deepfakes themselves.

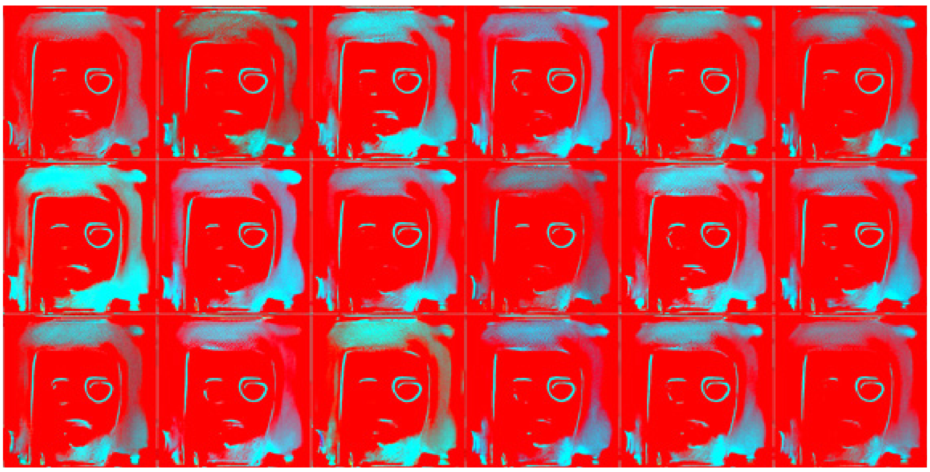

Fig. 3. Samples drawn from the model after 2000 iterations (part of the series of works *Being Foiled).*

5. Examining Peak Uncanniness

Fig. 4. A sample drawn from the model after 500 iterations (Part of the series of works *Being Foiled*).

If we take a snapshot of the model at an earlier iteration then we can draw samples when (in our opinion) the uncanniness is most pronounced (See Figure 4). This optimisation process has bridged the uncanny valley in reverse, starting from a state where samples are almost imperceptibly life-like, towards almost complete abstraction. By stopping early, we can pick an iteration of the model where the uncanniness is potentially most amplified.

When examining these samples, what is particularly striking is the prominent red hue that has saturated the entire face of the subject, so much so it is bleeding into the surrounding background of the image. This is in stark contrast with the overt blue shades infecting the eyes and peripheral facial regions.

The exaggerated artifacts around the eyes are instructive of the fact that this must be where flaws in the generation most often occur, potentially because there are a lot of details and a wide range of diversity in those details that have to be modelled to produce both realistic faces and an array of distinct identities. The eyes in many of these samples are not aligned, and there is an exaggerated definition around the wrinkles where the eyes are set. This is also the faultline between outputs where faces have or do not have glasses. If the generator produces a sample that is half-way between wearing and not wearing glasses this would be a telltale sign that the image is fake.

There are overt regularities in the texture of the hair. An artifact of the network generating these images from spatial repeated, regular features, and again, something that is a tell-tale sign that the image is generated by a machine. These regularities, asymmetries, and other pronounced artifacts fit with many of the descriptions given by McDonald in his blog post detailing ways of recognizing deepfakes (2018).

Fig. 5. Samples drawn from the model after 500 iterations (part of the series of works *Being Foiled).*

Viewing the samples individually provokes a certain feeling of uncanniness. But when viewed in aggregate across a population of samples (see Figure 5) this feeling is intensified further, provoking (in our view) an almost visceral response, as if viewing a diseased population. Even the emotional register appears off. Many of the samples appear to be half grimacing, having either a completely vacant stare, or one with unnerving intensity.

One criticism of GAN generated art is that the endless generation of samples from a given model, while initial mesmerising and transfixing, can quickly become banal, monotonous repetitions for the sake of overwhelming the viewer with the "sublime of algorithmic productivity" (Zylinska 2019). However we believe that presenting the work in this context helps to provoke and reinforce the feeling of uncanniness in the viewer (just as the intensification of these artifacts across the distribution of generated samples reinforces the prediction of fakeness by the system itself). Therefore, we think it is fitting to present the work as grid(s) of endless variations, all with the same common transformations and transfigurations. The faultlines of fakery emerging from the foreground and the background, bleeding into each other, are an artifact which was purely accidental, but welcomed. An 'accidental aesthetic' that is the result of non-human agency and inter-object relations (Koltick 2015).

6. Exploring Different States

In the previous two sections, we discussed the results from one iteration of the model (after training is completed at the resolution 512x512). However, this fine-tuning process can be done at any iteration of the model and seemingly with widely varying results (see Figures 6 & 7).

To understand why there is such variation in the results of this process at different stages of model training, it may be instructive to consider the unusual nature of GAN training. Unlike most machine learning systems, which are most often highly non-linear convex optimisation problems, attempting to find an optimal set of parameters to clearly defined objective functions, GANs operate more like a dynamic system, with no target end state. The optimisation problem is almost circular (Nagarajan and Zico Kolter 2017). The generator and discriminator will endlessly be playing this game of forger/detective. The discriminator endlessly picks up on new miniscule flaws in the generator output, and the generator in turn responds.

With there being no target end state, the flaws most prominent to the discriminator are ever shifting and evolving over the training process. The samples in Figure 6 show that the fine-tuning process pushes the output towards increasingly muddy, washed out images, the facial features, dispersing as if being propagated by waves. In contrast the samples in Figure 7 show a hardening of the facial features. With rectangular geometric regularities in the shape of the nose and mouth becoming increasingly prominent.

Fig. 6. Samples from the fine-tuning process from an earlier iteration (256x256) of the model (after 0, 150, 300, 450, 600 iterations).

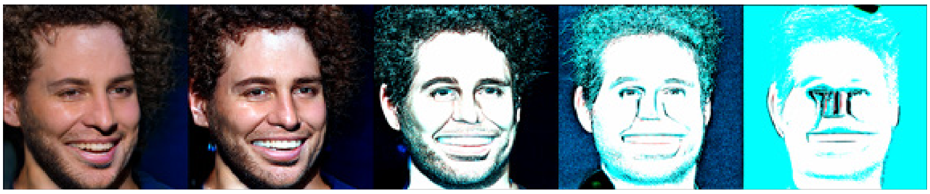

Fig. 7. Samples from the fine-tuning process from a later iteration (512x512) of the model (after 0, 150, 300, 450, 600 iterations).

7. Conclusion

What makes deepfakes so mesmerising (and terrifying) is our inability to distinguish them from *real* images. What we have done here is to manipulate the weights of a system that would normally produce indistinguishably real images to instead produce definitively unreal images. This we achieve by utilising a key and otherwise unseen component of the predictive capacity of a deepfake system, in the service of producing—the prediction of—unreal images. These are generated by a process that can be understood as a feedback loop that bridges the uncanny valley in reverse, exposing the fragility and arbitrary nature of the configuration of parameters that produces such realistic images, whilst showing that it can quickly be twisted and exposed to produce distinctly unreal, previously unseen, images.

Comparing the results of this process from different iterations of the model, it is apparent that what the machine predicts as being fake is constantly in flux. The relationship between generator and discriminator (forger/detective) is constantly evolving. It is this constantly evolving dynamical relationship which makes GANs so effective at producing realistic deepfakes in the first place.

It is important to note that these results are highly contingent on a number of factors: the idiosyncrasies of the state of the model snapshot that was selected from the training process, the choice of methods for optimisation and regularisation and accompanying hyperparameters used in training (which can have a profound effect on the visual output), the tacit knowledge that has been ascertained through previous experiments of creating novel network ensembles (Broad and Grierson 2019b), and fine-tuning existing models (Broad and Grierson 2019a).

This work fits into a broader line of enquiry of technical and artistic research looking at new ways of configuring ensembles of neural network models, examining the interaction of the models, the interaction of the artist with the models, and the aesthetic outcomes of the generative processes. By manipulating and reconfiguring these generative models, there is a huge amount of latent potential for such systems to produce not only novel outcomes, but learning sets of parameters that can produce novel, *divergent distributions* of outcomes that do not imitate any distribution of images created or curated by people. With the series of artworks *Being Foiled*, we have presented the results of these experiments in a way that can be understood visually, giving a representation of an otherwise unseen and uncanny aspect of the machine's gaze.

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References

Adjer, Henry, Giorgio Patrini, Fancesco Cavalli, and Laurence Cullen.
2019. "The State Of Deepfakes: Landscape, Threats and Impact." Deeptrace. September 2019. https://deeptracelabs.com/resources/.

Breland, Ali.
2019."The Bizarre and Terrifying Case of the 'Deepfake' Video That Helped Bring an African Nation to the Brink." *Mother Jones*, March 19, 2019. https://www.motherjones.com/politics/2019/03/deepfake-gabon-ali-bongo/.

Broad, Terence, and Mick Grierson.
2019a. "Transforming the Output of GANs by Fine-Tuning Them with Features from Different Datasets." *arXiv preprint arXiv:1910.02411.*

———. 2019b. "Searching for an *(un)stable equilibrium*: experiments in training generative models without data." *NeurIPS Workshop on Machine Learning for Creativity and Design 3.0.*

Brock, Andrew, Jeff Donahue, and Karen Simonyan.
2019. "Large Scale GAN Training for High Fidelity Natural Image Synthesis." *International Conference on Learning Representations*.

Christie's.
2018. "Is Artificial Intelligence Set to Become Art's next Medium?" December 12, 2018. https://www.christies.com/features/A-collaboration-between-two-artists-one-human-one-a-machine-9332-1.aspx.

Chryssouli, Georgia.
2019. "The Alchemist of the Surreal and the Uncanny Valley: Jan Švankmajer, the Puppet and Eerie Animation." Phd, University of Essex.

Freud, Sigmund.
1919. "The 'Uncanny.'" https://web.mit.edu/allanmc/www/freud1.pdf.

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*.

Grenville, Bruce.
2001. *The Uncanny: Experiments in Cyborg Culture*. arsenal pulp press.

Hassine, Tsilia, and Neeman Ziv.
2019. "The Spectre of Zombies Is Haunting AI Art." *7th Conference on Computation, Communication, Aesthetics & X (xCoAx).*

Jentsch, Ernst.
1997. "On the Psychology of the Uncanny (1906)." *Angelaki: Journal of the Theoretical Humanities* 2 (1): 7–16.

Karras, Tero, Timo Aila, Samuli Laine, and Jaakko Lehtinen.
2018. "Progressive Growing of GANs for Improved Quality, Stability, and Variation." *International Conference on Learning Representations*.

Karras, Tero, Samuli Laine, and Timo Aila.
2019. "A Style-Based Generator Architecture for Generative Adversarial Networks." *IEEE Conference on Computer Vision and Pattern Recognition*, 4401–10.

Koltick, Nicole.
2015. "The Artificial, the Accidental, the Aesthetic…." *Journal of Science and Technology of the Arts* 7 (1): 17–20.

Mackenzie, Adrian.
2015. "The Production of Prediction: What Does Machine Learning Want?" *European Journal of Cultural Studies* 18 (4-5): 429–45.

———. 2017. *Machine Learners: Archaeology of a Data Practice*. MIT Press: p. 21.

McDonald, Kyle.
2018. "How to Recognize Fake AI-Generated Images." Medium. December 5, 2018. https://medium.com/@kcimc/how-to-recognize-fake-ai-generated-images-4d1f6f9a2842.

Mori, M., K. F. MacDorman, and N. Kageki.
2012. "The Uncanny Valley [From the Field]." *IEEE Robotics & Automation Magazine / IEEE Robotics & Automation Society* 19 (2): 98–100.

Murphy, Kevin P.
2012. *Machine Learning: A Probabilistic Perspective*. MIT Press: p. xxvii.

Nagarajan, Vaishnavh, and J. Zico Kolter.
2017. "Gradient Descent GAN Optimization Is Locally Stable." *Advances in Neural Information Processing Systems*, 5585–95.

Radford, Alec, Luke Metz, and Soumith Chintala.
2016. "Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks." *International Conference for Learning Representations.*

Satter, Raphael.
2019. "Experts: Spy Used AI-Generated Face to Connect with Targets." Associated Press News. Associated Press. June 13, 2019. https://apnews.com/bc2f19097a4c4fffaa00de6770b8a60d.

Schneider, Tim, and Naomi Rea.
2018. "Has Artificial Intelligence Given Us the Next Great Art Movement? Experts Say Slow Down, the 'Field Is in Its Infancy.'" Artnet News. September 25, 2018. https://news.artnet.com/art-world/ai-art-comes-to-market-is-it-worth-the-hype-1352011.

Steyerl, Hito.
2012. "In Free Fall: A Thought Experiment on Vertical Perspective," *The Wretched of the Screen*, Sternberg Press: p. 24.

Tronstad, Ragnhild.
2008. "The Uncanny in New Media Art." *Leonardo Electronic Almanac* 16.

Venkataramakrishnan, Siddharth.
2019. "Can You Believe Your Eyes? How Deepfakes Are Coming for Politics." *Financial Times*, October 24, 2019. https://www.ft.com/content/4bf4277c-f527-11e9-a79c-bc9acae3b654.

Zylinska, Joanna.
2019. "Joanna Zylinska: AI Art: Machine Visions and Warped Dreams." re:publica 2019. May 7, 2019. https://www.youtube.com/watch?v=WSBl0uoKZZ0.

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The Ambiguity of the Deepfake

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Keywords: Deepfake, Aesthetics, Hyperreal, Machine Learning, Memetics, Apophenia.

This paper argues that generated photographic media, such as "deepfakes," intensify the ambiguity of the digital image causing widespread shifts in perceptual orientations. The operational structure of the generative adversarial network suggests that the dataset is a central component to the development of this type of face-to-face image translation. Analyzed both from a photorealistic standpoint, and from the perspective of the mutability of digital imagery, the dataset is found to be the key element in understanding the ambiguous nature of the deepfake. It is proposed that an embrace of the plasticity of the image can offer a new approach to combating problems that have emerged in regard to deceptive visual media.

1. Introduction

In this paper, I argue that the deepfake intensifies the ambiguity of the image in digital space. I first outline the current problematics surrounding the emergence of the deepfake. Though most of this discourse focuses on the development of measures to weed out counterfeit images using detection technologies, some suggest preventative tactics and regulation. I then explain the contours of basic machine learning architecture, and explain the specific components of the generative adversarial network (GAN), the formulation responsible for the deepfake. Then, the structural makeup of the *generated photograph* (a computer-generated photorealistic image produced using a dataset of digital photographs) is detailed by noting its deviations from preceding photographic media. The deepfake marks an evolution into a new paradigm: images that are built in the form of an approximated dataset. An analysis of the data required to generate the deepfake follows, first, a reading of the data as analog photographs—images that preserve a perception of fixity and objectivity; second, as digital images—images that are radically mutable. Here I claim that the deepfake reimagines the notion of hyperreality, and resonates with paranoid and apophenic logics. It is conclusively argued that the structural composition of the deepfake indicates an evolution of the image where ambiguity defines its form and content. By appreciating this evolution as an inevitable consequence of technological advances in image production, an embrace of visual ambiguity is proposed as a more realistic orientation for approaching problems surrounding the emergence of deceptive visual media.

It is important to note that the term “deepfake” has been used to reference a broad spectrum of deceptive audiovisual media. In this paper, however, I use this word exclusively for media in which a machine learning algorithm performs face-to-face image translation. Here, the pattern of a face is “learned” and grafted onto that of another’s to create the illusion that one engaged in activity that they did not. One of the reasons this version of the deepfake is startling is because it automates and democratizes an ability to doctor moving images in the same way Photoshop did for the still image. Though important, the use of video will not be directly addressed: In the context of this essay video is considered to be a lens-based media that holds equivalence with the photographic process and is therefore technically bracketed as such.

2. Control Measures

In 2017 a user on Reddit with the handle “deepfakes” uploaded a series of pornographic videos of what appeared to feature a handful of famous actors. In fact, they were “fakes” wherein the faces of the actors in the videos were replaced with the faces of celebrities, appropriating their facial identity to simulate an event that never occurred. Since then, the deepfake has been a popular topic of discussion in technology studies and adjacent fields as well as the mainstream media. As the technology continues to improve on inconsistencies and glitches, and becomes packaged and shared for public use, the growing unease about its potency as a tool of disinformation has provoked the involvement of government agencies, technology companies, and academics. For instance, the US Congress has requested a formal report on these new technologies from the Director of National Intelligence; and the Defense Advanced Research Projects Agency (DARPA) has sought partnership with academic and corporate institutions to conduct research into detection techniques. Likewise, both Facebook and Google have produced and released open-source manipulated videos for the purpose of crowd-sourcing procedures for detection. Facebook even launched a "Deepfake Detection Challenge" offering cash rewards for the best methods. The problem with developing detection technology is the unlucky paradox of fortifying its quality by revealing its faults. In other words, because detection requires locating error in the code, programmers can use this information to update and improve on the system to evade exposure by future detection technologies. As well, it is becoming apparent that educational approaches to increase media and image literacy are no longer sufficient for providing the public with isolated means of detection.

Some believe regulation and prevention are better solutions. A start-up out of San Diego called Truepic aims to supply verified digital originals. Photographs taken with Truepic's smartphone app are instantly uploaded to a locked server to prevent tampering and manipulation. Ultimately, the company hopes to integrate the software into smartphone camera components so that "verification can begin the moment photos enter the lens" (Rothman 2018). Other suggestions include: (1) legislation that limits use to a pre-chosen selection of voices or faces; (2) restriction of access by carefully vetting those who are granted privilege to the technology; (3) requiring watermarks be added to all images, or (4) demanding that metadata indicate whether an image has been altered or synthesized. These methods are imaginative, but may be difficult to implement on a large scale. Furthermore, its hard to imagine an architecture of regulation that could practically circumvent problems like identifying culpable users and the origin of production; and the use of screenshots which weaken and eventually render both watermarks and imbedded metadata ineffective. It seems that containment of image manipulation through regulation is opportunistic at best and myopic at worst.

Though if these approaches are faulty, certainly the urgency behind them is not. Understanding new visual formulations is critical not only because they threaten to amplify the spread of disinformation, but also because they are increasingly being used to affect people of less high-profile status in the general public. Already an online market has been established for the manufacture and sale of deceptive videos. Even though the consequences of these prospects are gloomy, the "apocalyptic" rhetoric used in mainstream media to anticipate their effects does little to offer a deeper understanding about how they function and impact broader visual regimes. Alarms sounded by publications like the *Atlantic*, have claimed that "we'll shortly live in a world where our eyes routinely deceive us [...] we're not so far from the collapse of reality" (Foer 2018). In an attempt to put these claims into context, a report from Data & Society in New York reminds that deceptive media belongs to a long lineage of media manipulation. Furthermore, the relationship between truth and media has been a point of contention throughout history. While it is true our visual landscapes have always been riddled with ambiguities (the history of image doctoring and photography's illusory claim to objectivity are topics that have been exhausted in numerous visual disciplines), the deepfake uniquely brings into awareness an enhanced state of ambiguity that is consistent with a more general gravitation of the visual experience toward confusion and uncertainty.

Indeed, at a conference back in 2014, artist Hito Steyerl diagnosed confusion to be one of the main characteristics of mass data circulation. She suggested that this confusion stems from a condition she names a "code without contract." That is, a recognizable "code" circulates, yet a "contract" that provides directives on how to interpret it has been implicitly lost or dismantled: "There is a sign, but anyone can understand it from their point of view," she stated (2014). As outlined above, there is a scramble to re-instate old iterations of this contract: disentangling or keeping separate the unaltered image from the forged one—fact from fiction. The line of thinking goes, if we can filter out deceptive images or prevent the production of them we can stymie the spread of confusion and restore some semblance of clarity to our media institutions. At the basis of many of these approaches is a familiar solutionist refrain: the development of *more* technology will provide answers to correcting difficult circumstances caused by other technological inventions. Yet, instead of employing solutions to curtail the evolution of the image into unfamiliar terrain, perhaps it's more useful to understand where the trajectory of this evolution is leading. Further, rather than spending resources to contain or reverse it, maybe there are better ways to adapt to it.

The intention of this essay is not to advocate for better alternatives to the tactics outlined above, but to provide a foundation for thinking through problems surrounding the deepfake in terms of visual literacy rather than disinformation. Though the exact parameters of an effective literacy remain unclear, the following analysis suggests that the impulse to preserve a true/false dichotomy must be replaced with an appreciation of the inevitable drift of image-based media toward an increasing ambiguity. To apply Steyerl's maxim, the following sections attempt to "de-code" the deepfake's unique visual "code" (the image) in order to understand how it contributes to an absence of "contract" (a common mode of interpretation). This is achieved by analyzing how the structural makeup of generated images differ from, but also assimilate, preceding forms of imagery. In her book *Programmed Visions* Wendy Chun notes that the more sophisticated one's understanding of how computational systems operate the more readily they're able to decode the operations of the most abstract and invisible processes. Therefore, given that it is not visually apparent how the structure of the deepfake deviates from previous versions of the photograph, a decoding first requires an understanding of its computational system of production.

3. Perceptron to GAN

Artificial intelligence emerged as a way of automating human perception. The first artificial neural network, invented by cognitive scientist Frank Rosenblatt in 1957, was called the Perceptron. An analog computer with an input device called a "retina," the Perceptron operated almost like a kind of camera wherein a grid of 400 photoreceptors replaced the optical lens. This grid of photocells, connected to a layer of artificial neurons, was not only able to record simple shapes or letters like the photographic camera, but had the ability to recognize them. That is, this camera-like computer had the ability to "learn" a pattern by making a decision to classify it into a binary output (0 or 1), with a margin of error. In a recent paper, media philosopher Matteo Pasquinelli identifies the first Perceptron as marking a revolutionary turn in the field of computation: the development of a new paradigm that was both spatial and self-computing.

> “This turn introduced a second spatial dimension into a paradigm of computation that until then maintained a linear dimension [...]. This topological turn can be described also as the passage from a model of passive to active information. Rather than having the information of a visual matrix being processed by a complex top-down algorithm (like in the case of an image edited by Photoshop, for instance), the disposition itself of the pixels in the visual matrix dictate the rules for their computation bottom-up. Data themselves shape the algorithm for their computation according to their relation” (Pasquinelli 2019a).

This bottom-up self-computing structure provided the foundation for a subset of machine learning known as "deep learning," a more complex configuration of the neural network that emerged in the early 21st century.

In the most simplistic terms, machine learning systems are made up of three components: the training dataset, the learning algorithm, and the model application. The learning algorithm "learns" a pattern in the training dataset by reading the association between, in the case of visual datasets, the image (input) and its label (output). In the case of face-to-face image translation (the generated photograph or deepfake), a type of system is used called a generative adversarial network (GAN). Therein, the association between image and label forms a statistical description that comprises a model application called a discriminator. A second model application, called the generator, attempts to generate data that fits within the statistical parameters of the discriminator model. In short, the generator produces images that guess the pattern of the face, which is then corrected by the discriminator. Put simply, the generator model attempts to produce an image that appears genuine enough to fool the discriminator into thinking it is "real." The image cycles through the generator and discriminator until it has reached a sufficient error rate at which point, in theory, it looks realistic enough to deceive the human eye.

The quantity and quality of the training dataset is critical in determining the quality or "realism" of the visual outcome. The process of collecting and preparing the data involves multiple steps: production of an image, translation of image into data, encoding data into a machine-readable format, and, finally, labelling the data. With so many stages to the collection of a dataset, it is intuitive that they are prone to biases and ambiguities, which Pasquinelli has taken on the task of identifying. Adding fuel to the flame, the dataset used for face-to-face image translation requires a dataset of digital photographs, which are fundamentally ambiguous in form. *Digital photographs* (a photorealistic image in the digital format) are photographs in digital formats that are perceived in the tradition of analog photography but function as digital images. In order to understand the unique character of this medium, it is useful to delineate a brief history of the structural evolution of photographic media.

4. Analog, Digital, Generated

Advancement from analog to digital to generated reveals a progressive increase in the ambiguity of the image. In *Toward a Philosophy of Photography*, Vilém Flusser acknowledges that images "are not 'denotative' (unambiguous) complexes of symbols (like numbers, for example) but 'connotative' (ambiguous) complexes of symbols: They provide space for interpretation" (Flusser 1983, 8). When the camera was first invented, the *analog photograph* (a chemically-based, lens-produced image) was thought to replace the ambiguity of other mimetic media with an accuracy of representation perceived by many as objective. Though its subjectivity has always been acknowledged, the photograph has long enjoyed close ties to realism and truth. Susan Sontag writes, "despite the presumption of veracity that gives all photography authority, interest, seductiveness, the work that photographers do is no generic exception to the usually shady commerce between art and truth" (Sontag 1977, 10). Though just as ambiguous as other manual methods, the mechanical photograph provided the illusion of certainty. However, with the arrival of digital media, this misperception has begun to wobble. Digital affordances have provided new tools that make image manipulation, construction, and sharing faster and more accessible. In consequence, the *digital image* (any image in the digital format) is perpetually in flux, susceptible to alteration, corruption, cropping, remixing, and vulnerable to variations in ownership, context, or format. In constant transition of form, meaning, and placement in digital space, it is subjected to the persistence of change as a result of circulation. The recognition of this instability and turbulence has naturally increased perceptual doubt and ambiguity.

Theorist W. T. J. Mitchell identifies the basic distinction between the analog photograph and the digital image as a move from a continuous form to a discrete one: "In [digital] images, unlike photographs, fine details and smooth curves are approximated to the grid, and continuous tonal gradients are broken up into discrete steps" (Mitchell 1992, 4). The digital photograph, therefore, straddles the boundary between the two: its unstable form (discreteness) is understood in the abstract and reads as having relative stability (continuity). A perceptual lag is a consequence of this shift—the bewildering malleability of the new is disguised by the old comforts of easy, objective representation. Scholar of visual media Fred Ritchin writes, "Photography, as we have known it, is both ending and enlarging, with an evolving medium hidden inside it as in a Trojan horse, camouflaged, for the moment, as if it were nearly identical: its doppelgänger only better" (Ritchin 2009, 15). As the digital turn transforms images into a state of universal ambiguity, the perception of relative certainty is a welcome default.

If the analog photograph is continuous, and the digital image is discrete, the generated photograph is manifold. It is an amalgamation, a multiplicity, a variation. At its most foundational level it is a series of digital photographs—multiple data points. Although it does not present in three-dimensions, its two-dimensional form can be understood as a flattening of a hidden dimension of images (the dataset): the generated image enters the n-dimensional space, a multi-dimensional vector space. Imagine that the single plane of the pixelated, digital image is expanded into a stack of multiple planes, one layered on top of the other like a deck of playing cards. The images of this invisible stack are the substantive elements of the resulting picture, which is an approximation of all faces on the "cards." Similar to the evolution of the computational paradigm in the Perceptron, a new spatial characteristic is introduced, at least in the abstract.

This construct aids in visualizing the generated photograph as a composite of its progenitors. Marshall McLuhan's claim that the "content" of any medium is another medium manifests literally: like Russian nesting dolls, the digital photograph—a digital image camouflaged as an analog photograph—is housed within the generated photograph. To understand how its components aid its production, it is necessary to study the relationship between the dataset and the resulting deepfake image. Because the perceptual lag of the digital photograph still suspends us in a pending hermeneutics, two separate analyses of the digital photograph are essential to comprehend how the deepfake operates. The dataset made up of digital photographs is first regarded as a composite of analog photographs, and second of digital images. Taken together, these dual manifestations begin to elicit an appreciation for the complexity of ambiguity in the deepfake.

5. Multiplicity and Hyperreality

Viewing the collected dataset of images as analog photographs is to perceive the deepfake as traditionally photographic, that is, in the category of realism. The dominance of this perspective has been in effect since the medium of photography was first introduced. Emerging alongside ideas of scientific rationalization and positivism, photography was originally tied to practices of systematically collecting empirically verifiable and measurable facts. An early writer on photography, Lady Elizabeth Eastlake, said, "([the camera's] studies are 'facts') . . . facts which are neither the province of art nor of description, but of that new form of communication between man and man — neither letter, message, nor picture — which now happily fills the space between them" (Eastlake 1857). The invention of photography ushered in a new way of thinking about images as units of information, as both curriers of facts and as facts themselves. For Eastlake, the photograph functions as factual due to its inability to choose and select the objects within the frame. To put it differently, in the absence of intervention there is impartiality: the camera succeeds by producing an index of visual facts.

The perceived outsourcing of human agency automates the practice of representing the world in visual form. However, the photograph as factual representation is limited by the "centrality of the eye." Owing to the origins of the camera within normative models of vision, photographic aesthetics are situated in traditions of Western two-dimensional art where the centered perspective dominates. Leaving aside for now the illusion of objectivity, the photograph fails as representation if for no other reason than the limits of its singular frame of reference. Writing on the gesture of photography, Flusser claims that the photographer is confronted with a form of "phenomenological doubt" when taking a picture:

> "Photographers have doubts, but these are not of a scientific, religious or existential sort; rather, they are doubts in the sense of a new sort of doubt in which stopping short and taking a decision are reduced to grains — a quantum, atomized doubt. [...] They discover the multiplicity and the equality of viewpoints in relation to their 'object'. They discover that it is not a matter of adopting a perfect viewpoint but of realizing as many viewpoints as possible. Their choice is therefore not of a qualitative, but of a quantitative kind. [...] The act of photography is that of 'phenomenological doubt', to the extent that it attempts to approach phenomena from any number of viewpoints." (Flusser 1983, 38)

The "doubt" of the photographer, as Flusser names it, is based on the constraints of the singular viewpoint and the recognition that conveying an “object” is impossible with only one perspective or one decisive position. Flusser continues, “no decision is really ‘decisive,’ but part of a series of clear and distinct quantum-decisions, likewise only a series of photographs can testify to the photographer’s intention” (Flusser 1983, 38). The photographic gesture fails to communicate an idea unless it incorporates all viewpoints—a series of atomized decisions. Though perhaps precise as a subjective act, the singular decision of the photograph is ambiguous in its representational form.

If the single photograph fails, can multiple perspectives succeed at the task of representation? To be sure, the deepfake solves the quantitative problem of Flusser’s “phenomenological doubt” by combining the decisive positioning of many photographers. In a manner of speaking, the “doubt” of the photographer reverses the inadequacy of the singular signifier (two-dimensional) back into the multiplicity of the signified (n-dimensional). The generated photograph ends up being, theoretically, more certain, “real,” and accurate as a representation. In confronting what Flusser calls “the invisible hurdles of space-and-time categories,” the deepfake succeeds in transcending the authority of the single photograph (Flusser 1983, 37). Moreover, its structural makeup surpasses all known modes of representational production. The dataset is comprised of variant spatial perspectives (positions of the camera in space, and even the spatial context of the subject), but also different temporal states: pictures from different times (i. e. assorted dates of capture). Instead of being serial, these multiple viewpoints are expressed finally as an approximation. Exceeding the realism offered by the camera, the artificially-generated deepfake can be understood as a reimagining of the Baudrillardian concept of the “hyperreal.”

In *Simulacra and Simulation*, Baudrillard defines hyperrealism as a simulation “[generated] by models of a real without origin or reality. [...] Whereas representation attempts to absorb simulation by interpreting it as a false representation, simulation envelops the whole edifice of representation itself as a simulacrum” (Baudrillard 1994, 6). Transferred into computational terms, the discriminator model learns a pattern from a dataset of representations (model of a real) which then aides the generator model in mapping a face (simulacrum) without origin or reality. While tempting to name the deepfake as a false representation—a form of disinformation—what it ultimately succeeds at is dissolving the idealistic illusion of the representational gesture. What Flusser observed about the photograph, namely that “the traditional distinction between realism and idealism is overturned in the case of photography: It is not the world out there that is real, nor the concept within the camera’s program — only the photograph is real,” is finally evident in the deepfake (Flusser 1983, 37). The generated photograph promotes an awareness that the interpreted, the manufactured, the simulated has always been the only “real.” As philosopher Gianni Vattimo put it: “Under the pressure of today’s media construction of reality we comprehend that reality was always a construction" (Vattimo 1989). The deepfake simulates a face that is "deeply" constructed and profoundly hyperreal. On the surface, it is a displacement of a real event by a simulated one; but on a deeper level, it indicates an additional dimension of representations spanning multiple spaces, times, and subjectivities. The end result is an aesthetic pattern that is hyper-constructed, yet, paradoxically, remains fettered to the illusion of photographic realism.

Since this category of image has come into common awareness, there has been a shift in thinking about imagery: an intuitive understanding of the hyperreal condition, but a hold on perceptual habits moored to the photorealistic perspective. Confusion about the truth-value of the digital photograph has resulted in generalized skepticism, or, indeed, something more like paranoia. The deep-rooted contract that dictates how a photographic image is read is in danger of breaking. With the invention of more powerful and pervasive means of post-production, the long-standing agreement that a photographic image is innocent until proven guilty is being turned on its head. In other words, the dominant approach for interpreting a photograph has always been to assume it is real until proven to be counterfeit. But with the awareness of quicker, democratized image manipulation, the image is now thought to be guilty until proven innocent. This attitude is not limited to the visual realm: it is a more widespread symptom of disinformation. A good example of this shift is the infamous recording of Donald Trump speaking crudely about taking advantage of women. First declared by the US president to be "locker-room talk," it is now presumably forged: "we don't think that was my voice," he claims.

The deepfake has created a perfect condition for plausible deniability, which Hany Farid, a scholar who specializes in digital image forensics, has recognized to be a danger especially if used for political deception. If a fake image is now seamless, and detection is difficult if possible at all, any image or video can be reasonably declared false. "Deepfakes do pose a risk to politics in terms of fake media appearing to be real, but right now the more tangible threat is how the idea of deepfakes can be invoked to make the real appear fake," echoes Henry Ajder, a researcher from Deeptrace Labs, a company focused on detection of deceptive media. As a result of abounding confusion, attitudes err on the side of paranoia. The digital photograph has taken on the status of a conspiracy theory: without the means to access evidence for corruption, paranoid assumptions surface as plausible explanations. Though the realism of the photograph is still functional in institutions such as journalism, law, and science, a doubt is creeping in. The use of image manipulation for malicious intent is breaking down the image's true/false binary, but in institutions dependent on this premise, there is an active fight to keep it intact. Detection, regulatory, and preventative tactics hope to uphold an old contract for interpretation, but the question becomes how long that is possible to sustain.

6. "Dirty" Data and Apophenia

In the previous section, the digital photographs used to generate photographs are assumed to be analog—an image belonging to the tradition of photorealism. Importantly, this position also assumes that the dataset is "clean," that is, untampered with. Though "dirty data" can refer to any number of errors and inconsistencies in a set of data, in this context the dirtiness of the images refers to their digital condition, defined by a susceptibility to post-production. Put differently, the plasticity of digital images make for a notoriously dirty media. In her article "Sea of Data" Steyerl notes, "Veracity is no longer produced by verifying facts. It's a matter, as one big-data expert put it, to cleanse 'dirty data' from your systems" (Steyerl 2019, 5) If the deepfake is perceived as fact, its deceptive veracity is dependent on ensuring that manipulated or post-produced images are cleared from its dataset. Yet, the impossibility of arranging a set of clean or untouched data is becoming more apparent. With new technological developments, most influential of these being artificial intelligence, there are increasing chances that the images compiled for training datasets have already been post-produced. How does the configuration of the deepfake change if we assume the dataset is inherently dirty—that it is comprised of digital images?

The definitive quality of the digital image is a perpetual change in content and form. Though image manipulation is not new, the affordances of digital tools have drastically democratized the ability to modify and annotate images. As soon as the image enters digital circulation, its form and content is presumably altered. The digital image is remixed, cropped, collaged, compressed, doctored, filtered, and reformatted. Practices of digital bricolage, poaching, and collaging treat visual material less as an object to interpret passively, and more as an object to affect actively. Mirroring the evolution in computation that began with the Perceptron, data-as-image moves from a passive to active mode. Increasingly viewed as a "found image in waiting," this attitude has effected participatory cultures that use images to engage in complex visual conversations. Active participation allows users to contribute individual interpretations or "takes" on the visual material they encounter inviting communal engagement on a level that was out of reach in analog formats. Researcher Ryan M. Milner writes, "new types of information become easier to create, circulate, and transform. The participatory barriers are lowered, and new forms of communication can be encoded and decoded by a broader group of individuals" (Milner 2016, 25). The digital photograph now relies on an "expanded linguistic fluency," Ritchin notes, "its role becomes that of a less proximate signifier like words, paintings or drawings, but with the background duality of its surviving role as direct trace" (Ritchin 2019, 15).

Most commonly expressed in meme culture, this form of communication has drastically tipped the ratio of overtly post-produced content to "clean" content, in favor of the latter. The meme is defined by Limor Shifman as digital content that shares the same basis of form, content, or stance; is created in awareness of each other; and is circulated, imitated, or transformed via the internet. To put it in simple terms, digital memes are "pieces of content that travel from person to person and change along the way" (Mina 2017). They embody the mutability of the image, novel visual structures for conversational exchange, and, most interestingly, a new aesthetic. In the age of the meme, an aesthetic emerges that is defined by its blatantly "Photoshopped" quality. The more one is exposed to this aesthetic (the higher volume of memes one is exposed to), the more one acclimates to a digital environment wherein images are mutable, constructed, and "unreal." In consequence, meme culture is encouraging a relation to the image wherein literacy is no longer a matter of detecting whether images are real or not, but, to a degree, seeing all images as constructions a priori.

Meme production engages in cultural collaging that shares some similarities with apophenic vision: participants draw what sometimes is read to be arbitrary connections between circulated imagery based on perceived associations.[1] As memetic imagery becomes more pervasive, collaged images eventually become available for manipulation themselves. These layers of alterations can be thought of as a form of metadata that is then collaged together on a meta-level.[2] Put differently, the re-constructed image is used for further constructions: the manipulation, manipulated boundlessly. Just as more and more images in digital circulation are resembling this memetic logic, so too might the deepfake as its datasets become "dirtied" by altered imagery. Steyerl describes pattern recognition as apophenic: "in order to 'recognize' anything, the neural network must be fed what to recognize. Then in a quite predictive loop they end up 'recognizing' the things they were taught" (Steyerl 2019, 8). Face-to-face image translation is very different from the mechanisms of apophenia, however, the production of the deepfake is based on the same premise: the discriminator is fed a dataset that marks the parameters of recognition, then, quite intuitively, the generator ends up "recognizing" this pattern after producing countless faulty versions. Though deepfakes do not resemble the eerie aesthetics of commonly-cited examples of visual apophenia like Google's deep dream generator, the effects of participatory cultures may be pushing generated photographs toward types of distortion that are equally disturbing.[3]

From the perspective of those whose visual field is dominated by constructed, remixed, collaged, and forged images, the true/false dichotomy is inching closer toward irrelevance: the traditional contract with photographic material has already largely dissolved. Though photographic impressions still hold indexical value when experienced in certain institutionalized contexts, the truth-value of the digital photograph becomes secondary to its symbolic and aesthetic value. Rather than focusing on the photograph as a document of truth, there is an embrace of its ambiguity as a creative force.

1. In "Sea of Data," Steyerl references Google's blog entry that explains the idea of "inceptionism," the act of creating a pattern or image from visual noise: "The results are intriguing—even a relatively simple neural network can be used to over-interpret an image, just like as children we enjoyed watching clouds and interpreting the random shapes" (Google Research blog, 2015).

2. Image memes are created wherein other memes are referenced. A knowledge of these meme premises is necessary for interpreting these "meta-memes."

3. Apophenia entails an apparatus of perception that is narrowed and sees patterns in data where there is no correlation. A comparison to face-to-face image translation cannot be made in this sense, yet apophenic attitudes can be thought of as a symptom of a larger migration away from the true/false dichotomy of the image and toward different forms of hermeneutics.

This results in a fundamental shift in perception where digital photographs are not necessarily either real or fake, but instead become the basis for new interpretive approaches based on individuated projections. In the place of photorealistic truth, new contracts for visual interpretation have the potential to lead to broader truths. With an unprecedented amount of images in circulation ("truckloads of data" as Steyerl calls it), apophenia, which Benjamin Bratton defines as "drawing connections and conclusions from sources with no direct connection other than their perceptual simultaneity," may eventually replace paranoia as a reigning cultural logic (Bratton 2013). With so much visual material moving so fast with no way of detecting whether it signifies what actually happened in reality, viewing all images through a loose, more individuated lens may prove to be a more "realistic" orientation.

7. Conclusion

The emergence of generated deceptive media forces us to ask how we might grapple with an image that is almost instantly produced, has the ability to preserve high standards of realism, evades detection, and presents a condition where we no longer know if images are true, false, malicious, or merely expressive. It compels us to question whether our collective cultural orientation toward visual hermeneutics is outmoded. Or, as Steyerl might phrase it: is it necessary to develop a new contract that adheres to new visual codes? To put it most plainly, how can we deal with images that are profoundly ambiguous? It is not enough to recognize that new forms of imagery are challenging our traditional perceptual modes, it is important also to understand their operative structures so that myopic and futile points of view are discarded for an informed reorientation toward images that, with time, can render destructive uses inert.

The image has moved from its status as objective representation to one that is in motion, mutable, and inherently uncertain. The progression from analog photograph to generated photography has led to an ambiguity that induces a major collective adjustment. In the face of uncertainty, paranoia about truth and falsity will allow for people in power to capitalize on anxieties about photographic representation. If we are being confronted with a collapse of photojournalism, then perhaps we must rely less heavily on the photograph's duty to provide a representational truth and more on a function that offers symbolic and aesthetic truths. In adopting this reorientation, the power of the constructed image, the meme aesthetic, the corrupted digital object is recognized as a means of recovering authority over our visual landscapes—over our images-as-data. The deepfake is a visualization of the "neoliberal subjects coming to understand their *selves* to be aggregated statistically. […] Individual particularities remain latent in data systems, lying dormant until called forth in the service of an externally imposed narrative," writes theorist Steve Anderson (2017, 17). No doubt an externally imposed narrative like the deepfake has an alarming potential to cause sweeping political confusion, but equally ominous is its use use on smaller scales, where all events and past actions are at risk of becoming as ambiguous as the image. In the face of these potential futures, an embrace of new visual regimes that relinquish realism for radical subjectivity may be the best means of combat.

References

Ajder, Henry, Giorgio Patrini, Francesco Cavalli, and Laurence Cullen.
2019. "The State of Deepfakes: Landscape, Threats, and Impact."

Anderson, Steve F.
2017. *Technologies of Vision: The War between Data and Images.* Cambridge, MA: MIT Press.

Baudrillard, Jean.
1994. "The Procession of Simulacra." in *Simulacra and Simulation.* trans. Seila Glaser. Ann Arbor: University of Michigan Press.

Bratton, Benjamin.
2013. "Some Traces of Effects of the Post-Anthropocene: On Accelerationist Geopolitical Aesthetics." e-flux Journal 46.

Crary, Jonathan.
1992. *Techniques of the Observer: On Vision and Modernity in the Nineteeth Century.* Cambridge, MA: MIT Press.

Eastlake, Lady Elizabeth.
1857. "Photography." *Quarterly Review.* in Liza Wells, ed. *Photography: A Critical Introduction.* 5th edition. New York: Rutledge, 2015.

Flusser, Vilém.
1983. *Towards a Philosophy of Photography.* trans. Anthony Mathews. London: Reaktion Books.

Foer, Franklin.
2018. "The Era of Fake Video Begins." *Atlantic.*

Google Research Blog.
2015. "Inceptionism: Going Deeper into Neural Networks."

Hao, Karen.
2019. "Google Has Released a Giant Database of Deepfakes to Help Fight Deepfakes." *MIT Technology Review.*

Harwell, Drew.
2018. "Fake-Porn Videos Are Being Weaponized to Harass and Humiliate Women: 'Everybody is a Potential Targe.'" *Washington Post.*

Hui Kyong Chun, Wendy.
2013. *Programmed Visions: Software and Memory.* Cambridge, MA: MIT Press.

Knight, Will.
2019. "Facebook is Making Its Own AI Deepfakes to Head Off a Disinformation Disaster." *MIT Technology Review.*

Knight, Will.
2018. "The US Military Is Funding an Effort to Catch Deepfakes and Other AI Trickery." *MIT Technology Review.*

Lister, Martin.
2009. "Photography in the Age of Electronic Imaging." in Liza Wells, ed. *Photography: A Critical Introduction.* 4th edition. New York: Routledge.

McLuhan, Marshall.
1994. *Understanding Media.* Cambridge, MA: MIT Press.

Milner, Ryan M.
2016. *The World Made Meme: Public Conversations and Participatory Media.* Cambridge, MA: MIT Press.

Mina, An Xiao.
2017 "Memes and Visuals Come to the Fore." NiemanLab.

Mitchell, W. T. J.
1992. *The Reconfigured Eye: Visual Truth in the Post-Photographic Era.* Cambridge, MA: MIT Press.

O'Sullivan, Donie.
2019. "When Seeing Is No Longer Believing." *CNN.*

Ovadya, Aviv.
2019. "Making Deepfake Tools Doesn't have to be Irresponsible. Here's How." *MIT Technology Review*

Paris, Britt and Joan Donovan.
2019. "Deepfakes and Cheap Fakes: The Manipulation of Audio and Visual Evidence." *Data & Society.*

Pasquinelli, Matteo.
2019a. "How a Machine Learns and Fails — A Grammar of Error for Artificial Intelligence." *Spheres.*

Pasquinelli, Matteo.
2019b. "Three Thousand Years of Algorithmic Rituals: The Emergence of AI from the Computation of Space." *e-flux.*

Pasquinelli, Matteo.
2017. "Machines that Morph Logic: Neural Networks and the Distorted Automation of Intelligence as Statistical Inference." *Glass Bead Journal.*

Ritchin, Fred.
2009. *Post Photography.* New York: W. W. Norton.

Rothman, Joshua.
2018. "In the Age of A.I., Is Seeing Believing?" *New Yorker.*

Shifman, Limor.
2013. *Memes in Digital Culture.* Cambridge, MA: MIT Press.

Sontag, Susan.
2011. *On Photography.* New York: Picador.

Steyerl, Hito.
2019. "A Sea of Data: Pattern Recognition and Corporate Animism (Forked Version)." in *Pattern Discrimmination.* Minneapolis: University of Minnesota Press.

Steyerl, Hito.
2014. "Circulationism: Discussion with Hito Steyerl," May 24, 2014, Van Abbemuseum, Eindhoven, https://vanabbemuseum.nl/en/programme/programme/circulationism/

Vattimo, Gianni.
1989. *La Societa Trasparente.* Milan: Garzanti. in Martin Weiss, "Reality, Simulation and Hyperreality: An Essay on Baudrillard." *International Journal of Baudrillard Studies.* 2011.

Wolf, Sarah.
2018. "CycleGAN: Learning to Translate Images (Without Paired Training Data)." *Medium.*

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The Cultural Origins of Voice Cloning

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Inaugurated as a deep learning application on voice synthesis, appropriated by "deepfake" users to create fake Trumps and Obamas and by artists to explore non-anthropomorphic possibilities, voice cloning is not only a technology but a new cultural and artistic practice. Subverting the relation between voice and subjectivity, voice cloning affects the very notions of embodiment and truth. In the wake of media archeological investigation, this paper explores the epistemic properties of voice cloning analyzing its technical and cultural aspects and comparing them with their ancestors, media messages and outcomes.

1. Introduction

Artificial voices are increasingly populating today's technological and social landscape. Their unsettling fascination is related to the archetypical power of voice in human cultures and to its paradoxical topology (Dolar, 2006), always on the edge between inside and outside the body, and between the speaker and the listener. In this sense voice, as suggested by Connor (2002), is always "disembodied", something whose limits are not restricted by the body but can migrate and animate also the inhuman. A condition, this, that feeds voice's unfathomable and suggestive power in cultural practices such as rituals, trials, singing or charismatic speech. In all those situations we assist to a mix: voice is considered at the same time the "natural" means of communication for humans, carrier of phenomenological presence, and an object of treatments and manipulations that enlighten its status of cultural "artifact". The history of artificial voice is therefore, in a certain sense, as old as voice itself, but it's with sound recording technologies and telecommunication that voice has been for the first time "commodified". The possibilities to transport, store and re-enact the voice that those technologies made possible, merged with ideas about disembodiment that go back in time, contributed to enhance the development of the talking computer as a machine that can speak by itself, operating a trespassing from the supposed "proper of human" to the non-human domain. But whereas the disembodied voice of talking computer has been so far accepted by our culture, *voice cloning* is something new and in a certain sense traumatic. The idea to clone someone's voice, to make that voice say things that the person has never "performed", pronounced, immediately makes us think to dispossession, identity theft, fraud. This is probably because the connection between voice and identity is very strong and grounded in our cultural habits. As Adriana Cavarero suggests, anytime I speak I'm voicing myself, no matter what I'm saying (Cavarero 2003). For her, voice is not just language nor just sound matter, but it's their connection within a self and a body. Voice is uniqueness, is the principle of individuation of a singularity. Virtual Assistants, such as Alexa, don't mine the fundamental relation between voice and subjectivity, at the contrary they push a lot on the "personification" of technological devices and AI through the seduction and affection of voice. They just subvert the relation voice-body, without subverting the one voice-subjectivity. Voice cloning, instead, looks like threatening that very principle, that is the "testimonial value" of voice (Peters 2004), the possibility to find in voice a safe warranty of what's real. Whereas truth has been traditionally grounded in the possibility for the subject's self-affection, voice was exactly the place where philosophy individuated that possibility. But, with Derrida's critique of phonocentrism (Derrida 2011), the status of voice itself has changed, and the idea of pure self-affection deconstructed. Nevertheless, the idea of a voice that is not immediately connected to the innermost part of someone's identity is still conflicting with our most basic assumptions of reality, and the possibility to use someone's voice to say something he never said is generally considered worrying.

In the era of analog manipulation, voice was still considered a kind of safe place, something very difficult to fake. For two reasons: both because we have a marked sensitivity to voice that makes us able to recognize even the smaller artifacts in it (Nass & Brave 2005); and because the tools to manipulate voice signals were not adequate to do something so realistic to deceive our sensitivity. Not that attempts of voice manipulation are missing in the analog media landscape. At the contrary, in line with Connor's considerations, the special and ambiguous status of voice has made it a privileged place of experimentation of new techniques and sensitivities, both in the art and in other fields, like linguistic and forensic studies, since very long time.

I would like to start from here, from the review of some past attempts of voice cloning, to track down the cultural origins of this new technological phenomenon. Adopting a media archeological approach (Parikka 2012; Ernst 2012), the study aims at recognizing the common fantasies and desires related to this practice, but also at finding the epistemological ruptures and specificities brought by technologies such as deep learning and artificial neural networks—the algorithmic core of voice cloning—which incorporate precise knowledge and ideas in their very functions. It's my belief that reading this difference is a decisive key to understand voice cloning as a new cultural practice in all respects, very meaningful of the new status of AI in contemporary society. Here deconstructive instances about the voice-subjectivity bond (such as "deepfake") are merged with brand new cognitive and expressive media configurations and socio-technical relations. If medium is the message (McLuhan 1994), neural networks in voice cloning define voice in a specific way and determine how we think to it and how we use it. "When ideas about bodies are built into digital signals, these signals, in turn, produce bodily effects" (Mills 2012, 136); symmetrically, when ideas about voice are built into digital processing, this processing, in turn, produces effects on voice and its physiological and socio-cultural determination.

2. Archeology

The term "voice cloning" has been introduced for technical purposes, in the framework of *deep learning* applied to text-to-speech technology. The term "deep learning" indicates the most recent application of machine learning. Where machine learning is used to map hand-designed features (i.e. labeled voice samples) to an output (i.e. words), so allowing machine to "learn" couplings and associations in order to generalize them to new cases (i.e. matching voice samples to a new text), deep learning uses multiple hierarchical layers of neural networks to progressively extract higher level features from raw input. Instead of having hand-designed features, as in machine learning, deep learning is used to extract those very features from data. This is very useful for all the tasks that are difficult to model or where it's difficult to know which features should be extracted. Voice speech is a perfect example of a hardly representable phenomenon, since every word can be pronounced in several different ways, with different intonations, speeds, accents, timbres. Deep learning helps solving this problem since it finds the appropriate features by itself directly from a big enough dataset. It does it by processing data many times through several hierarchical layers, each of them going deeper detail: lower layers may identify formant frequencies of voice, higher layers may identify consonant sounds, higher modulations and prosody, and so on until having a representation of all the countless features needed to reproduce voice from a text. "Deep learning is a particular kind of machine learning that achieves great power and flexibility by learning to represent the world as a nested hierarchy of concepts, with each concept defined in relation to simpler concepts, and more abstract representations computed in terms of less abstract ones" (Bengio et al. 2017, 8).

In voice cloning, a deep neural network is usually trained using a corpus of several hours of professionally recorded speech from a single speaker. Giving a new voice to such a model is highly expensive, as it requires recording a new dataset and retraining the model. Deep learning allows to clone a voice unseen during the training from only a few seconds of reference speech, and without retraining the model (Jemine 2019; Arik et al. 2018). In this way, a text-to-speech can read a typed sentence with the voice that the algorithm has "learned" from the reference dataset. Previous voice synthesis systems were working on formant and articulatory parameters (parametric speech synthesis; Flanagan 1972; Klatt 1982), or on database of recorded voice samples (concatenative speech synthesis or unit selection; Sagisaka 1988), eventually mixing the two approaches, where parameters are used to statistically calculate the units of recorded sounds that best fit the proposed text in trainable systems (statistical parametric speech-synthesis; Donovan 1998; King 2010). For a technical and historical overview of these systems, see (Jurafsky & Martin 2014; Hoffmann 2019). Taking from the previous systems, but with a number of significant differences, deep learning voice synthesis with neural networks uses datasets of texts and recorded voice samples not to directly concatenate them (as in concatenative synthesis), but to "learn" from the dataset the main features of a voice in relation to text, in order to be able to recreate it in new sentences (Sejnowski & Rosenberg 1987; van den Ord et al. 2016; Seijas 2018). Neural networks do that by "classifying" the main features of a voice, like pronounce, timbre, prosody, and separating them from each other in deep detail. Those features constitute a "speaker profile", that is the elements that distinguish a certain voice from another. This is the idea at the base of "voice cloning" as well. In fact, a deep neural network can learn a "speaker profile" through a training process, then use it to condition a text-to-speech, already trained on the linguistic features. In this way a text-to-speech can use the speaker profile to customize the "generic" voice it has been trained with and make it sound like the voice of a certain precise person. If text-to-speech is the invariable structure, voice cloning is the "mask", that can be changed at will. This means that a text-to-speech algorithm can be trained on different voice timbres with small training sets, making it easy and relatively "user-friendly".

Voice cloning is nowadays advertised as a way to "personalize" things like customer services, chatbots, videogames, IoT devices, in order to make them more appealing through the seductive power of a real person's voice. "'Resemble' can clone any voice so it sounds like a real human" (www.resemble.ai). Before discovering its subversive power in the "deepfake" (Wilson 2018), voice cloning technology was developed in 2017 by Canadian startup company Lyrebird to develop software that reconstructs someone's voice in audiovisual files. As a test of the efficiency of their system, they tried to clone Donald Trump's voice training their neural networks with Trump's recorded speeches. They succeeded in using Trump's voice to say a couple of realistic sentences about their product. But a similar idea sparkled already in the mind of a composer who lived almost a century before. The result is unknown, nevertheless the episode helps understanding the cultural meaning of voice cloning.

In 1932 the Russian composer, musical theorist and journalist Arseny Avraamov proposed to vocalize the writings of Lenin by reproducing the author's voice using new technological means. The fact is reported and documented by Smirnov (Smirnov 2012). In order to do that, Avraamov needed to "synthesize" Lenin's voice on the basis of his existing recorded speeches. He proposed to achieve a "possible vocalization of mute pieces of the Lenin's chronicle, by precise assignment of fragments of the shorthand report uttered by him in each particular moment of speech" (Avraamov quoted in Smirnov 2012, 163). Somewhat later in 1943, Avraamov argued also against the new Soviet anthem, contending that the real revolutionary anthem should be based on new approaches to harmony and performed by the synthesized voice of Vladimir Mayakovsky. This happened at the end of Soviet Russia's political and artistic turmoil that accompanied Russian Revolution, when ideological totalitarianism started to grow and put an abrupt end to all the avant-garde spirit in science and the arts. The influence of major artistic figures such as Alexander Scriabin, Dmitry Shostakovic in music, Sergei Eisenstein in film, Vladimir Mayakowsky, in poetry, Kandinskij, Malevic in painting, was still inspiring for a generation of artists and intellectuals ready to experiment new languages and practices in the wake of revolutionary ideals (Smirnov 2013). Arseny Avraamov was active part of this artistic and political movement, spending his life experimenting with new techniques of sound and image inscription.

What Avraamov had in mind with his vocalization of Lenin's writings was something very similar to that kind of particular speech synthesis that nowadays we would call "unit selection", or concatenative synthesis. This technique is based on the recombination of stored speech fragments, usually diphones or sound units, according to the text that needs to be read and its phonetic transcription. Avraamov's idea of a proto-concatenation was grounded on the new discovery in "sound storing" of the time: graphical sound. After the invention of Edison's phonograph in 1877, sound recording was mostly made using soft tinfoil and wax cylinders (Feaster 2011). In 1898 Vladimir Poulsen introduced magnetic wire recording with steel wire for his Telegraphone, an ancestor of magnetic tape. In 1914 a new technology for sound recording and storing was introduced in top-secret navy projects: Thallofide Cell was a device by Theodore Case to record optical sound, that is sound recorded on film through variations in light produced by sound oscillations. The year after, Charles Hoxie used optical sound in silent movies with his Pallophotophone, and in 1922 De Forset Phonofilm company introduced optical sound as a standard in film production (Kellogg 1955).

By 1932, when Avraamov wrote about Lenin's voice, optical sound started to be widely explored in Germany and Russia. If German sound engineer Pfenninger succeeded in correcting a misspell of an actress voice recorded in a movie (Levin 2012), Russian artist Moholy-Nagy saw in optical sound a means for the generation of new, unheard, "synthetic" sounds and Russian painter and acoustician Boris Yankovsky, Avraamov's pupil, explored the techniques of spectral transformations of singing and speech through manual drawing of waveforms on the film, using a self-invented machine called Vibroexponator (Smirnov 2013). At the basis of all those results there's graphical sound research, an application of mathematical functions, such as Fourier transform, to waveforms drawn on film. This technique made it possible to access the soundtrack as a visible graphical trace in a form that could be studied and manipulated, through magnification, hand-drawing in grid and then shrinking, allowing to synthesize new and unheard sounds.

As reconstructed by Smirnov, in the early 1930s, voice synthesis was strangely popular in Russian avant-garde. "There were two main intentions focused at the development of new sound machines: to play and compose with any sounds at will and to synthesize speech and singing" (Smirnov 2012, 166). Besides optical sound, other machines were invented to "synthesize voices", like the Mechanical keyboard instrument for the reproduction of speech, singing and various sounds, the most advanced proto-speech synthesizer at the time, invented by Tambovtsev in 1925. The instrument was primarily intended for reproduction of artificial speech and singing: each key of its keyboard corresponded to a loop of steel tape which stored a sound of Russian language, prerecorded with different pitches, corresponding to different keys on the keyboard. "It was a kind of proto-sampler, very similar to the Mellotron, popular in 1970s" (Smirnov 2012, 166), but it was also a concatenative speech synthesizer *ante-litteram* (it's of 1960 the System LORA by Cramer, which used a similar system with 40 pieces of magnetic tape (Hoffmann 2019)).

Regardless of the results, both sound drawing and the mechanical keyboard embody a principle that will be decisive for the epistemology of sound manipulation, that is for the very possibility of thinking to sound and voice synthesis. This principle is the *assemblage*, the idea that a new sound can be composed by juxtaposing fragments of other sounds, and that speech can be conceived as a concatenation of phone units. This revolutionary principle, probably one of the most important in electronic sound after Fourier's transform and von Helmholtz's resonators, sets the conditions for sound editing. At its basis there's not only a concept of sound, but a *logic of the archive*. It's only because of storage and archive that sound can be edited, sliced in fragments, and recomposed. Nothing like that was possible before sound recording and the possibility to store and archive sound on physical supports.

There's also a key difference between Tambovstev's keyboard and Yankovsky's Vibroexponator. The former used only recorded sound materials, that are acquired from the "real world" through a transducer or microphone, while the latter could produce sounds from nothing, from just drawing, in a computational (even if manual) manner. In this sense, Tambovstev could be seen as an ancestor of *musique concrète* as music based on recordings (Schaffer, 2012), while Yankovsky as a father of electronic music, based on pure synthetic sounds. But these the two genealogic lines share a fundamental character, a new attitude towards the archive, that is, in the interpretation that I'm suggesting here, the beginning of the "database logic", as Manovich defined it (Manovich 2002, 219). One of the main purposes of Yankovsky, in fact, was to produce and collect a number of *syntones*, that is pieces of drawn sound on film, in order to recomposed them to produce new sounds or new speeches. He wanted to collect a *database* of sound materials, ready to be used at will. "Yankovsky named these final drawn waveforms 'spectro-standards' or 'spectral templates', semiotic entities that could be combined to produce sound hybrids, based on a type of spectralmutation" (Smirnov 2012, 170). Even if his technique was different from proper sound recording, the logic of his work was the same of Tambovstev, a database logic. "Synthesis" means, here, two symmetric operations: a) creation of an archive of recorded or drawn sound materials; b) operationalization of that archive through its recomposition and assemblage. This kind of logic has been assumed, almost unchanged, by computation in digital devices. Arseny Avraamov was involved in all those researches about sound and voice synthesis and took inspiration from them to imagine his "cloned Lenin". His idea was to mix the two operations: using optical sound to collect sound samples from Lenin utterances, and then operationalizing them in the construction of new sentences by concatenation and editing of film pieces; the concatenated syntones could also be hand-drawn again with slight differences to give intonation and rhythm to the new synthesized speech.

The idea of sound archives grew rapidly at the cross of XIX and XX century, influencing many fields of society beyond the art world. Mara Mills and Xiaochang Li have reconstructed the technical and epistemological link between sound archive and sound inscription, meaning the original possibility to "see the sound" that new devices allowed (Mills & Li 2019). From Eduard-Leon Scott de Martinville's Phonautograph (1857) to W. H. Barlow Logograph (1877) to Goddard harmonic analysis of kymographic inscriptions (1903), to Carl Lindstrom's Parlograph (1910), all those tools tried to transform sound in visible traces. Optical sound and drawn sound, as in Yankovsky's Vibroexponator, were doing essentially the same. The next step in this story is the invention of the *sound spectrograph* in the 1940s, a new way to visualize sound as a time-frequency representation: time on the horizontal axis, frequency on the vertical one, and loudness indicated by the intensity of the ink or light patterns. When the technology was commercialized after the war, linguists as well as communication engineers used spectrograms to identify the landmarks or key features within speech waves. One group of researchers, at Haskins Laboratories in New Haven, proposed compiling a large collection of spectrograms for each speech sound (Mills & Li 2019). It looks like the idea of sound database is strongly connected to the one of sound visualization. What is common to all those devices of sound inscription is their use in forensic context.

> "By examining numerous spectrograms of the same sounds, spoken by many persons and in a variety of contexts, an investigator can arrive at a description of the acoustic features common to all of the samples, and in this way make progress toward defining the socalled invariants of speech, that is, the essential information-bearing sound elements on which the listener's identifications critically depend" (Mills & Li 2019, 132).

This was the beginning of the idea of "voiceprint", a visualization of someone's vocal emission that should have allowed to individuate criminals from the analysis of their voice. In the opening decades of the twentieth century, most anthropologists and criminologists took graphic inscription as evidence that humans could not disguise their unique voices and ethnic origins. Spectrograms and other sound inscriptions and sound analysis tools became means for criminal identification or for speaker individuation by military in intercepted communications. The introduction of database of sound visualization for forensic purpose, together with the practice of concatenation of stored sounds on film, constitute the conceptual and technical base for what today we call voice cloning. As I'll try to explain now, of the two, only the more discrete is still at work, while the other, long celebrated, is now leaving the way to a different paradigm.

3. Media Practices and Epistemes

3.1. Speaker Identification

This attempt of a media history of voice cloning, so quickly sketched, reveals an interesting parallel between old and new systems: technically speaking, in fact, voice cloning with deep learning consists in the union of an algorithm for "speaker verification" with a text-to-speech (Jemine 2019). My critical suggestion is the following: it is not in the database logic and in the practice of assemblage, but in the persistence of an idea of voiceprint and speaker recognition, that we find a continuity between sound recording and voice cloning. This continuity reveals a latent forensic attitude in voice processing that is not disconnected from a paradigm of control and surveillance embedded in contemporary algorithmic technologies (Bucher 2018; Andrejevic 2020). It is also the materialization of the persisting fantasy of a "commodification" of voice, a voice to be detached from the body, measured and reattached again, allowed first by sound recording, and then confirmed and reaffirmed by voice cloning. An old fantasy that produces a new relation between voice-as-signal—to be stored, manipulated, reassembled, etc.—and subjectivity—a body that can now have multiple voices (as in voice conversion) or lose the control on its voice. As stated by Jonathan Sterne,

> "voice-as-exteriority formation is at least two hundred years old. Both the fields of acoustics and medicine treated the voice as something separate from an intending, speaking subject since the eighteenth century. Nineteenth-century innovations in sound technologies and the education of the deaf that led to telephony, radio, and sound recording followed in this vein" (Sterne 2008, 96).

The forensic use of voiceprints began in the beginning of the XX century but has never been established as a scientific practice and it's still nowadays a technological challenge, as well as a controversial ethical and political issue. Today's machine learning and deep learning systems seem like doing great steps ahead in the possibility to recognize someone's identity through his voice in reliable way.

From a technical point of view, neural networks are classifiers that are able to find their own representations in raw data, that is in a not-labeled dataset (Bengio et al. 2017). Those representations are in the form of a nested hierarchy of simpler representations, organized as topological distribution of numerical vectors in the latent space (the space where hidden layers make their calculations). This operation of "classification", that is the deep analysis of the input signal in order to sort any minimal element as for its similarity or difference with any other, is the basis of the "learning". The "learning" in deep learning is first of all an operation of "sorting". This tells also something about the general attitude of data-driven approach to AI, as machine learning is. Through these classifications, deep learning can solve the problem of speaker identification: the speaker verification algorithm classifies voice features in a big training dataset, according to differences in parameters detected by the neural networks. After the training, it can sort, in any voice signal, which features go always together and which can be separated, i.e. a certain way of pronouncing subsequent phonemes can be fix, while the timbre (formant frequency and other parameters) can be variable according to the speakers, and so on. Through this process the algorithm can encode a "speaker profile" or "embedding", "a meaningful representation of the voice of the speaker, such that similar voices are close in latent space" (Jemine 2019, 12). Once obtained a speaker embedding, it can be used to synthesize new speech with those voice features. This operation is what today we define as "voice cloning". To do that it's enough to condition a text-to-speech synthesizer such as WaveNet (van den Ord et al. 2016) or Tacotron2 (Shen et al. 2017) on the embedding of the speaker.

In a technical sense voice synthesis with deep learning is always a kind of voice cloning. But in a media archeological sense, the speaker verification algorithm suggests that deep learning is answering to an old call about the "appropriation" of such an elusive and powerful object such as voice. An appropriation that opens also critical concerns about issues such governmentality, control and privacy.

3.2. Different Logics of the Archive

On the other side, my proposal is that voice synthesis and voice cloning with deep learning are producing a rupture with the database logic, inaugurating a *different logic of the archive*. As Manovich observed, "database became the center of the creative process in the computer age" and a new way to structure our experience of ourselves and of the world (Manovich 2001, 227). Database is therefore part of a precise cultural and expressive practice. This practice is based on the "operationalization of the archive": where the archive is a set of stored information, database is the organization of archived data to facilitate operations on it. The database is a modulation of the archive in the form of a set of individual items that can be re-assembled to create new items. The database logic, therefore, finds expression in cultural techniques such as assemblage, montage, remix, "cut'n'paste". We find this logic at work in sound editing as well as in voice synthesis. In concatenative synthesis or "unit selection", a database of archived sound samples is algorithmically assembled in many possible ways, so that the same archived voice can say something different every time. Whereas the archive is static and "says always the same thing", the database logic can continuously recreate it as something new. This is the power of this cultural expression, a virtual regeneration of presence (Ernst 2012).

With machine learning, and deep learning in particular, something different is happening. We have a database, of course, and it's often based on spectrograms, in a continuity of format with the old systems. But this database is now used as a *training dataset*; it means that those data are not re-assembled, but are "learned", the algorithm understands something from them, extract some features that is then able to use in new contexts (i.e. new sentences). The database is not just copied and reassembled in the outcome. Rather, the training database is only used to "feed" the algorithm, but is not present anymore in the outcome. The algorithm will learn from it to then generate "new" or "unknown" items, which are technically different from the dataset because not made of the same data.[1] Voice here is not assembled but "reconstructed", not according to a perceptual principle, but according to a numerical rendering, that learns something about that voice and looks for the optimal way to use it in the context. This process is really specific of deep learning, since only the classifying power of neural networks is able to separate voice timbre from all the other features through an interpolation in the latent space. If we had a series of sound samples and try to do that with classic sound editing, we would be stuck: or we could use just the pre-recorded sentences, or we would have other features accompanied to timbre, in a muffled crossfading of signals.[2]

1. In this paper I leave unquestioned the complex ontological issue of the identity regarding a fundamentally differential concept such as data. For a detailed study of the question see (Floridi, 2011).

2. One of the consequences of this process is a copyright issue: who has the copyright of a training dataset which, technically, doesn't figure in the output?

To resume, we can find three different logics of archive: *model-based logic*, where the knowledge is embedded in the model, such as in the machines or *automata* who wanted to reproduce human behavior; *corpus-based or database logic*, where the knowledge is stored in micro-archives of sound samples and then operationalized; *machine learning or abductive logic*, where the knowledge is rendered and recreated in its unfolding, through a training process. What differentiates machine learning from the historical use of databases is that the former is meant to generate previously unknown patterns that cannot be perceived prior to running the algorithms. It is a tool for simulation, not in the sense of modeling or imitating an existing reality, but rather in that of generating a process as unpredictable as reality (Andrejevic 2013, 37).

3.3. New Expressive Practices

Machine learning gives life to a new expressive practice: not assemblage, as in the database logic, but *hybridization*, the application of a model relative to a class of events to one or more other classes, or *chimerization*, a process where a hybrid is generated with genetic fusion of multiple distinct entities. I suggest the use of these two terms because, as biological concepts, they represent quite well the ambition of AI to biologic life, or at least its rhetoric. Already Manovich (2013) has adopted the term "hybridization" to refer to the capacity of software to combine together properties and techniques of different media. In this framework I use the term with but also beyond Manovich, underlining an attitude in data processing that precedes the phenomenology of different media. Therefore, I suggest to use hybridization and/or chimerization as metaphors to describe a shift: the replacement of the practices of data juxtaposition and "remix", with the practices of statistical rendering, estimation and optimization allowed by the abductive power of neural networks (Kitchin 2014). Like in abductive reasoning (Josephson 1994), in fact, neural networks start from the observation of data (the training) and seek to find the optimal approximation (the learning), which is, consistently, something new and emergent, even though uncertain in causal terms. This practice produces something not present in the input data, nor composed by it. Moreover, this new product can be the result of any kind of observation between any kind of data, even completely heterogeneous ones: neural networks don't mind categories, they will always find a correlation as far as phenomena are transformed in numbers. The result is that classes of completely unrelated events can now be hybridated together, giving life to something that completely trespasses classes and semantics, and doesn't belong to any precise category anymore.

"Neural style transfer" is the name of the new artistic practice derived from the use of deep neural networks in a hybridizing sense. It is a technique "of recomposing images in the style of other images", such as Monna Lisa restyled by Picasso or van Gogh, as in the works of Gene Kogan based on Gatys, Ecker and Bethdge algorithm (2015). "Voice conversion" is a style transfer technique applied to voice, a special application of voice cloning where you can hybridize the timbre of someone's voice with the prosody of someone else, as proposed by the company Modulate.ai. Sound artist Tomomi Adachi has cloned his own voice in "Tomomibot", an AI that has learned Tomomi's vocal improvisation styles and can play live, establishing a dialogue with the "embodied" artist. Jenna Sutela artwork *nimiia cétiï* documents the interactions between audio recordings of supposed Martian language, and footage of the movements of extremophilic bacteria. A neural network trained on her voice looks at each frame of the bacteria video and produces a short block of sound that it thinks matches that frame, or the configuration of bacteria in it. Here, the computer is a medium channeling messages from entities that usually cannot speak. The work shows how neural networks' creations are aliens, monsters or hallucinations, confusing the borders between natural and machinic. James Bridle's media art work "The Cloud Index" is another very meaningful example of this new approach. "The Cloud Index" is a piece of software that can be used to create different weather formations based on different political outcomes. To develop the work, Bridle fed a neural network with satellite images of the UK's weather formations and Brexit polling results that showed the UK's relationship to Europe.

In the previous examples, unrelated classes of phenomena are combined together and let dynamically grow on each other. The functions of body and subjectivity, such as voice or language, are now made equivalent to social or natural phenomena, and can be hybridized freely with anything else. But, as Jenna Sutela suggests: "the aim is to contribute to the development of a culture based on symbiosis rather than the survival of the fittest narrative—organic and synthetic life forms included" (Sutela 2019). This sounds consistent with a project of global chimerization, that should open the way to new forms of co-existence and collaboration between human and nonhuman. As a consequence, this technology redefines voice itself: voice is not only separated from the body, as in sound recording, but can now transmigrate on other bodies, can be hybridized with any kind of psycho-physical features, while being filtered out of certain speaker traits.

The introduction of deep learning in voice synthesis was motivated by the possibility to do natural-sounding realistic voices, while its media analysis reveals a connection with forensic and policing techniques. Nevertheless, one of the most interesting cultural outcomes of deep learning specific power can be seen in the indefinite possibility of hybridization, transfer and invention of "new", impossible voices. The rise of "deepfake", both in creative expressions and in fraudulent operations, expresses very well the importance of the new challenges opened by this power; challenges that concern the very status of the truth in a society populated by synthetic media (Wilson 2018).

4. Conclusion

In this paper I've presented a preliminary study of a cutting-edge socio-technical phenomena that deserves further investigations. The media-archeological method has allowed to retrace the cultural and technical origins and the epistemological conditions of that odd idea that is cloning someone's voice. But more work should be done on the epistemic continuities and ruptures of machine learning in the field of sound processing. Older ideas could be, for example, individuated behind voice cloning. As suggested by Wolfgang Ernst, a media-archeological ancestor could be found in Jaynes' theory of bicameral mind (Ernst 2016), according to which in pre-writing times people could hear proper "voices" of dead kings in their heads, as a form of behavior control exercised from the inside. Without entering the articulated debate around the scientific validation of Jayne's theory, I will limit to suggest that the wish (or the obsession) to reproduce the voice of the "leaders", as in the case of Lenin or Trump, could perhaps respond to a similar need to find "his master's voice" (Dolar 2006). The leader is the one who "gives body" to the voice, is the depositary of the truth in form of acoustic experience, his voice comes before the meaning because it's legitimated by his very presence. If synthetic voices, in their unsettling being on the edge of organic and technologic, manifest and represent the anthropological condition of uncertainty produced by media, the leader's voice could perhaps represent a reactionary attachment to old values. Voice cloning, therefore, can be considered like both the emblem and the risk of a high-tech society: it is the place where a short-cut happens within the traditional "power" of voice (charisma, seduction, interiority), demystifying the qualities of the metaphysical embodied subject; but it is also the place of a paradoxical recovering of the link between voice, body and subjectivity, this time in form of gadget.

References

Andrejevic, Mark.
2020. *Automated Media*. New York: Routledge.

Andrejevic, Mark.
2013. *InfoGlut: How Too Much Information Is Changing the Way We Think and Know*. London: Routledge.

Arik, Sercan, Jiton Cheng, Kainan Peng, Wei Ping, Yanqui Zhou.
2018. "Neural Voice Cloning with a Few Samples". arXiv:1802.06006

Bengio, Yoshua, Ian Goodfellow, Alan Courville.
2017. *Deep Learning*. Cambridge, MA: The MIT Press.

Bucher, Taina.
2018. *If...Then. Algorithmic Power and Politics*. New York: Oxford University Press.

Cavarero, Adriana.
2003. *A più voci: Per una filosofia dell'espressione vocale*. Milano: Feltrinelli.

Connor, Steven.
2000. *Dumbstruck: A Cultural History of Ventriloquism*. Oxford: Oxford University Press.

Derrida, Jacques.
2011. *Voice and Phenomenon*. Evanston: Northwestern University Press.

Dolar, Mladen.
2006. *A Voice and Nothing More*. Cambridge, MA: The MIT Press.

Donovan, Robert E., Ellen Eide.
1998. "The IBM Trainable Speech Synthesis System". *ICSLP-98*, Sydney.

Ernst, Wolfgang.
2012. *Digital Memory and the Archive*. Minneapolis: University of Minnesota Press.

Ernst, Wolfgang.
2016. *Sonic Time Machines. Explicit Sound, Sirenic Voices and Implicit Sonicity*. Amsterdam: Amsterdam University Press.

Feaster, Patrick.
2011. "A Compass of Extraordinary Range". The Forgotten Origins of Phonomanipulation". *ARSC Journal*, vol. 42, n. 2, pp. 163-203.

Flanagan, James H.
1972. *Speech Analysis, Synthesis and Perception*. Berlin: Springer.

Floridi, Luciano.
2011. *The Philosophy of Information*. Oxford: Oxford University Press.

Gatys, Leon A., Alexander S. Ecker, Matthias Bethge.
2015. "A Neural Algorithmic of Artistic Style". arXiv:1508.06576.

Hoffmann, Reudiger.
2019. "Nothing but a Lung, a Glottis, and a Mouth. The Long Way of Speech Synthesis", In Pucher, M., Trouvain, J., Lozo, C. (eds.). *HSCR 2019. Proceedings of the 3rd Int. Workshop on the History of Speech Communication Research*, Vienna, September 13-14, 2019. Dresden: TUD press, pp. 9-28.

Jemine, Corentin.
2019. *Real-time Voice Cloning*, Master Dissertation, Université Liège.

Josephson, John R., Josephson, Susan G., eds.
1994. *Abductive Inference: Computation, Philosophy, Technology*. New York: Cambridge University Press.

Jurafsky, Daniel, James H. Martin.
2014. *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*. London: Pearson.

Kellog, Edward W.
1955. "History of Sound Motion Pictures". *SMTPE Journal*, vol. 64.

King, S.
2010. "A Beginners' Guide to Statistical Parametric Speech Synthesis". *The Centre for Speech Technology Research*. University of Edinburgh.

Kitchin, Rob.
2014. "Big Data, New Epistemologies and Paradigm Shifts". *Big Data & Society*, April-June, pp. 1–12.

Klatt, Dennis.
1982. *From Text to Speech: The MITtalk System-* Cambridge, MA: Cambridge University Press.

Levin, Thomas Y.
2003. "'Tones from Out of Nowhere': Pfenninger and the Archeology of Synthetic Sound". *Grey Room*, vol. 12, pp. 32–79.

Manovich, Lev.
2001. *The Language of New Media*. Cambridge, MA: MIT Press.

Manovich, Lev.
2013. *Software Takes Command*. New York: Bloomsbury.

McLuhan, Marshall.
1994. *Understanding Media: The Extensions of Man*. Cambridge, MA: The MIT Press.

Mills, Mara.
2012. "Media and Prosthesis: The Vocoder, the Artificial Larynx and the History of Signal Processing". *Qui Parle*, vol. 21, n. 1, pp. 107-149.

Mills, Mara, Xiaochang Li.
2019. "Vocal Features. From voice identification to speech recognition by Machine". *Technology and Culture*, vol. 60, pp. 129-160. DOI: 0040-165X/19/6002-0006/S129–S160.

Nass, Clifford, Scott Brave.
2005. *Wired for Speech: How Voice Activates and Advances the Human-Computer Relationship*. Cambridge, MA: The MIT Press.

Parikka, Jussi.
2012. *What Is Media Archeology?* Cambridge: Polity Press.

Peters, John Durham.
2004. The Voice and Modern Media. In D. Kolesch and J. Schrödl (eds.), *Kunst-Stimmen*. Berlin: Theater der Zeit Recherchen 21.

Sagisaka, Yoshinori.
1988. "Speech Synthesis by Rule Using an Optimal Selection of Non-uniform Synthesis Units". *IEEE ICASSP-88*, pp. 679–682.

Seijas, Jesùs.
2018. "Into a Better Speech Synthesis Technology". https://becominghuman.ai/into-a-better-speech-synthesis-technology-29411b64f2a2.

Seijnowski, Terrence, Charles Rosenberg.
1987. "Parallel Networks that Learn to Pronounce English Text. *Complex Systems*, 1, pp. 145-168.

Shaeffer, Pierre.
2012. *In Search of a Concrete Music*, Berkeley: University of California Press.

Shen, Jonathan, et al.
2017. "Natural TTS Synthesis by Conditioning WaveNet on Mel Spectrogram Predictions". eprint arXiv:1712.05884.

Smirnov, Andrey.
2012. Synthesized Voices of the Revolutionary Utopia: Early Attempts to Synthesize Speaking and Singing Voice in Post-Revolutionary Russia (1920s). In D. Zakharine & N. Meise (eds.), *Electrified voices. Medial, Socio-historical and cultural aspects of voice transfer.* Göttingen: V&R Unipress.

Smirnov, Andrey.
2013. *Sound in Z. Experiments in Sound and Electronic Music in Early 20th Century Russia*. London: Koening Books.

Sterne, Jonathan.
2008. "Enemy Voice". *Social Text 96*, vol. 25, n. 3, pp. 79-100. DOI: 10.1215/01642472-2008-005.

Sutela, Jenna.
2018. "Jenna Sutela on Machine Learning and Interspecies Communication". https://artsandculture.google.com/theme/lQKy0vx84f5GIg.

van den Ord, A., S. Dieleman, H. Zen, K. Simonyan, O. Vinyals, A. Graves, N. Kalchbrenner, A.W. Senior, K. Kavukcuoglu.
2016. "WaveNet: A Generative Model for Raw Audio," CoRR, vol. abs/1609.03499.

Wilson, Mark.
2018. "The War on What's Real". *The fast Company*. 3 June 2018. https://www.fastcompany.com/90162494/the-war-on-whats-real.

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Postdigital Art in Design Education

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With this research we explore how an educational approach could be devised that encourages both a critical and creative engagement with the postdigital condition. While those art practices seem omnipresent in cultural institutions, there is surprisingly little work done at the university level. Yet, practicing artists exhibit a particularly pragmatic, yet critical attitude when it comes to appropriating technologies and often generously share their own insights and experiences in making art with digital tools. We devised a course format during which advanced second and third-year students of communication and interface design engaged with postdigital theory and practice. Our aims were to lower thresholds to tools and technologies, encourage the engagement with the ethical and aesthetic aspects of digitization, and convene a temporary community of students that freely share and collaborate. We report on the results of the course and reflect on our observations.

1. Introduction

Over the past few years, postdigital perspectives have become more and more prevalent within the creative and cultural field. We understand the postdigital condition as the sobering recognition that the digital cannot be considered new anymore, but has become an increasingly naturalized backdrop to all activities and experiences we engage in (e.g., Cramer, 2015). The tools that artists, designers, and educators are using range from online platforms and social media to mobile apps and generative algorithms. While these technologies have become integral to communicating, exchanging, and formulating ideas, and eventually presenting art works, they are also object of critical reflection and resistance within the arts (c.f. , Ackermann et al., 2019; Berry & Dieter, 2015). Mass surveillance is being challenged, yet still used in the artistic hacking of networked cameras (Depoorter, 2015). The filter bubble is being questioned by artists writing browser extensions which encrypt status updates and search queries (e.g., Eckert, 2016). The rise of digital assistants is countered by programming ironic, feminist, and disobedient assistants (McCarthy, 2017). The primacy of productivity in the postdigital age can be undermined by a website that makes the computer run slow and hot (Lavigne, 2016).

Arguably, all these examples can be considered postdigital art. Characteristic of this art practice is the reflection of both established and emerging technologies like networked communication, the internet and its markets, surveillance structures, artificial intelligence, and the like, using the very technologies they refer to. More broadly, the postdigital refers to the contemporary condition we live in (Berry & Dieter, 2015). The postdigital describes our modern technologized and hyperconnected world and society as a whole: how we collect information and knowledge at the same location where we share it, where we network, where we communicate, where we work, shop, love, or fight; where we consume art and culture, display and distribute it, and acquire the skills and means for production. The postdigital is a state in which the digital is not seen as something new anymore opening up an altered perspective on the difference between analog and digital media (Conrads & Morlok, 2014).

In this paper, we concentrate on the question of how we can integrate postdigital strategies into new educational formats in order to sensitize students to the powers and perils of networked technologies. How can we incorporate current digital technologies in design education to encourage critical reflection on our current conditions, as well as to teach the relevant practical skills? Often the postdigital is being observed in its role within contemporary art production and popular culture, with this research we investigate the potential that the postdigital perspective affords in the context of design education.

The aim of this paper is to explore how postdigital arts can be taught at the university level. Particularly the discrepancy between a theoretical approach—as common in traditional higher/academic art education in the form of readings and seminar discussions—and a generative mode—acquiring technical and aesthetic skills in a typical studio course—is a challenge. *How can a course format be devised that encourages both a critical and creative engagement with the postdigital condition?*

2. Background

Our work relates to recent efforts in art, design and cultural education that engage with digital technology and practices in media art that follow a didactic approach. Teaching media technologies is often approached as the transfer of knowledge of a specific program, software, or environment which stands for itself. This might make sense for some software applications (like Adobe CS, or 3D modeling software), but for other 'hard' skills like coding algorithms for networked infrastructures, artificial intelligence or machine learning, the 'technical framework' is much more embedded in—and deeply influenced by—the dynamically changing networked ecosystem of our modern digitized world. The same applies to the art aspect of postdigital education—also here tool, material and sometimes even output are not always clearly marked-off and often condition each other:

> “It is as if postdigital over-determinates the sociopolitical landscape; without anyone's 'permission' it entered the classrooms in both student's and teacher's pockets (via their mobile devices), immersed into the pedagogical process, and broke the boundaries of formal and informal teaching and learning: unreflexive certainties turned into reflexive uncertainties” (Jandrić et al., 2018).

The postdigital perspective advances the observation that technologies permeate everyday life resulting in the dissolution of long-standing distinctions such as work vs. leisure and online vs. offline. Even though they do not talk particularly about education, Berry and Dieter describe the postdigital phenomena in a similar way:

> “Computation becomes experiential, spatial and materialized in its implementation, embedded within the environment and embodied, part of the texture of life itself but also upon and even within the body. Computation becomes something which operates while one walks around, is touched and touch-able, manipulated and manipulable and interactive and operable through a number of entry-points, surfaces and veneers.”
> (Berry & Dieter, 2015)

A crucial point why the 'postdigital'—be it art or just its quotidian and ubiquitous condition—has such a potential to engage people, is the immediacy which gets created by integrating the user through interactive elements as entry points into an aesthetic experience. Particularly these entry points promise an important factor in education, which we observe in more detail: the varied ways of interaction in order to enter via touching a screen, pressing a button, speaking into a microphone, or shaking devices of different kinds. In an art context, often only after this interaction, the whole content and narration will be unsealed; interaction is the glue between story, object, and technology. These integrations happen constantly and often unconsciously as a component of our daily life and the interactions with our accompanying devices and services. Jandrić relates to this hereness and nowness: "the contemporary use of the term 'postdigital' does describe human relationships to technologies that we experience, individually and collectively, in the moment here and now." (Jandrić et al., 2018).

Looking at the other side of postdigital art, the producing artists, we can also see efforts of integrating the user. Many artists and creative technologists working in the field also teach the specific tools needed in workshops on- and offline (e.g., Kogan, Lavigne), share the source code to a project, or produce video tutorials. Often an open source 'how-to' vision drives this approach. The artist Gene Kogan for example shares screen recordings of all of his classes, as well as demos and code on his website. He teaches classes like Neural Aesthetic or Machine Learning for Artists at NYU's Interactive Telecommunication Program (ITP), or the School of Ma in Berlin. The fact that he publishes class material online for free, for which enrolled students pay up to several hundred dollars a session, illustrates the points above.

The tendency of broadening access through postdigital education we can also see in the transformations taking place in cultural institutions such as museums offering educational formats for children and teenagers alongside their exhibition program. For example, in 2018 Martin Gropius Bau in Berlin offered a series of hands-on workshops accompanying Ed Atkins' solo show 'Old Food'. While the exhibition featured big-scale computer-generated video installations of highly artificially looking worlds, the workshops shared practical insights into the digital tools Atkin employs for video editing, 3D modeling, etc. (Gropius Bau, 2018). Also ZKM Karlsruhe (Center for Art and Media Karlsruhe) offers a range of workshops on topics such as video editing, digital radio production, programming of computer games, hacking single-board microcontrollers such as Arduinos, and running open coding sessions. The center integrated a huge, free to access lab area on the ground floor of their building, where visitors can familiarize themselves with emerging technologies and tools—independently or with instructions (ZKM Center for Art and Media Karlsruhe, undated).

Another example of expanded access are educational guides, apps, or games accompanying specific exhibitions or events. The National Museum Singapore initiated the DigiMuse programme launched in 2018. Over an open call the programme invited artists, technologists, and cultural professionals to develop multimedia and immersive reality applications. This effort is intended to engage the audience on a new level and provide background information on history and art through technologies such as augmented reality and artificial intelligence (The National Museum Singapore, 2018). In initiatives like this, visitors may not learn advanced skills like programming or video editing, but have the chance of participation through the use of accessible interfaces and events. Often in these applications the visitors are asked to provide input, like gathered information about an art piece or the history of a building, and are therefore encouraged to engage with a given topic. Therefore the visitor is not only a passive consumer anymore, but turns into an active participant.

The development that more artists and cultural institutions provide accompanying workshops with a focus on new media and the used technologies seems like a logical consequence to the postdigital condition. Therefore this art form is—already by its nature of operating with the same medium for criticism and subject of criticism—deeply entangled with the socio-political environment of its time. Not only by reflecting on it, but also by giving the possibilities to directly interact and change set-ups and therefore contribute to a comment or perspective on a (current) topic. With the shifting and blurring of lines between creator and audience, we see not only "an increased level of interactivity through the internet as a medium but also an increasingly fraught level of a politicized driven denial of the central and authoritative voice of the author" (Contreraskoterbay & Mirocha, 2016). The shifting roles are a central component in postdigital art practices, for example, in Adam Harvey's project CV Dazzle, in which a special make-up and hairstyle make the wearer undetectable for face recognition software therefore changing their role from an observer to a user, to an unidentifiable subject (Harvey, 2010).

Summing up different voices about the postdigital, a central, but often implicit assumption of postdigital art is that an increased level of involvement of the audience has the potential to lead to a strengthened awareness about socio-technical constellations. In contrast to a seemingly passive reception of art, the viewers' active participation in an aesthetic experience can be considered the main characteristic of postdigital art practices. In our experience, particularly the created empathy and interest for a subject, which comes through those points of interaction and involvement could lead to an increased level of politicization. The promise of expanding access, participation, and reflection underlines the societal importance and political weight of postdigital art practices for cultural education.

3. Approach

As discussed above the postdigital condition has already been reflected in its role within contemporary art production and popular culture. With this research, we focus on the potential that the postdigital perspective affords in the context of design education. Particularly at this stage of professional and academic formation, critical and creative engagement with digital technologies—as both subject matter and design material—is crucial.

While most writing on the postdigital condition takes a rather theoretical perspective, many artists whose work can be considered to be 'postdigital' demonstrate a didactic attitude, in that they freely share material, give hands-on workshops, and openly convey their experiences in working with and about digital technologies. Despite this pedagogic undercurrent in the art practice itself, there has been limited interest in the opportunities of the postdigital for formal education at the university (Conrads & Morlok. 2014). Arguably, there is a discrepancy between a theoretical approach as we know it from classic art education—readings, discussions, etc.—and the practical appropriation of mostly technical skills—drawing styles, materials, etc. With this research we intend to explore how postdigital art can be taught in a university-level studio course at a design department.

We want to point out a difference between the teaching of pure technology, like a software that can be taught isolated in a room without reference to the broader socio-technical reality, and technologies which should not only be taught by their technical specifications and application, but also being perceived and evaluated in their importance within the broader societal and political context of our times. Here we see the sweet spot—as well as the challenge—for postdigital education. Within the realm of education,the specific topic of postdigital structures, and how we could deal with it on an aesthetic, technological, and ethical level has not really been tackled yet: the potentially empowering aspect of postdigital art. Corporate and governmental surveillance has become a naturalized, yet suppressed characteristic of a hyperconnected world in which privacy appears at odds with convenience. However, we are convinced that the awareness and encouragement to critically reflect on socio-technical developments need to go hand in hand with an aesthetic response, which should be prioritized within our educational agenda in arts and design.

With this research we aim to devise a course format that encourages both a critical and creative engagement with the postdigital condition in the context of design education. To pursue this aspiration, we postulate three principles for design education:

1. Low thresholds: Foster creative participation with ready accessible tools and technologies.
2. Aesthetics in politics: Encourage ethical and artistic engagement with the postdigital condition.
3. Temporary community: Cultivate a community spirit among students that freely share and collaborate.

4. A course on Postdigital Art

We conceptualized a practical, yet research-oriented design seminar/studio course introducing students of communication and interface design to digital and interactive art practices. The authors co-taught the course over a period of three months during the summer semester 2018 at the design department of the University of Applied Sciences. The course was structured into a short warm-up phase of 4 weeks followed by three assignments spread over 10 weeks.

Warm-Up

The purpose of the first part of the course, was to familiarize students with the notion of the postdigital and the art practices that refer to it. Along theoretical texts (e.g., Benjamin, 1936; Berry & Dieter, 2015) and the introduction to different artists and work examples, the 'postdigital' as an art form and the role of digital culture within our contemporary society were subject of discussions among students and instructors. Parallel to this theoretical approach the students were introduced to a range of technologies employed such as virtual and augmented reality, 360° video, creative coding, non-linear and sensor-driven storytelling, physical computing, and machine learning. In addition to the introductions prepared by the instructors and guest lecturers-artists, each student participant gave a 'tech input' following a peer-to-peer learning system, in which students teach each other skills they either have already, or hold a lecture about a new technique which they would like to appropriate. Inputs include a coding workshop in JavaScript, a presentation about 3D scanning, an overview of different design workflows and programs, and a live demo in a projection mapping software.

Assignments

Three project assignments invited students to acquire practical skills by resorting to the different tech inputs. Each assignment was a small project, during which students were encouraged to reflect postdigital conditions. The students were encouraged to see postdigital arts in a close connection to the networked and hyper technologized society they are living in. According to this mindset art should not be seen as a stand-alone discipline that can be watched in a museum. Instead, postdigital art and design is and can be everywhere. On a phone, on a digital map, on a computer screen, as an immersive experience, in an urban space, in the park, in the subway, as a participatory installation, in the virtual, in the tangible, in the mixed reality.

The three assignments refer to the classic art forms of portrait, readymade, and collage. By choosing these already known formats, the students are encouraged to rethink established art forms in light of the postdigital condition[1]. This means not only how contemporary technologies transform production and presentation of art, but also what a contemporary

1. These assignments are in part inspired by courses of the similar name taught at the Interactive Telecommunication Program (ITP), New York University, which the first author attended 2014-2016.

portrait, readymade, or collage could mean. How would the Mona Lisa look if Leonardo Da Vinci lived in 2019? How can we draw an arc from Marcel Duchamp's Fountain to today's interactive readymades? Which layers of data, emotion, or critique can be added and how do technologies alter the art piece and its experience? And what are the benefits of remixing through digital technologies; how does the collage of the 21st century, look, feel, speak, and interact like? Open-ended questions along these lines defined the three assignments. During the pitches of initial ideas and the presentation of the final outcomes, students were requested to share their comments, questions, and suggestions in addition to the feedback by the instructors.

Assignment 1/ Algorithmic Portraiture: What is a portraiture in the algorithmic age? Why do we want to portray someone—or something? And which story we would like to tell about ourselves or about each other? The task for the students is to create any kind of portraiture that considers the *algorithmic*. Be it by using code, face recognition, 3D scanning, or other contemporary technologies. Subject of the portraiture can be a person, as well as a place, a thing, a location, et cetera. This task can also be executed in an analog fashion where algorithmic strategies are seen through the postdigital lens: computational decision making, clustering, or neural networks get transferred into analog processes, systems, models or strategies. Students had two weeks to finish this first assignment, while they had four weeks for each of the following ones.

Assignment 2/ Digital Readymade: The understanding of readymades as an artform changed over time. Duchamp's fountain does not shock anymore as it did when introduced more than 100 years ago, but the concept of using something found and alter its meaning by placing it in a new context or actual adding more to it stays as relevant as ever. Students are encouraged to find a subject of their interest and develop a digital and/or interactive readymade. For this assignment it is particularly important that object, interaction, and other additional layers work holistically together. Objects are loaded with meaning and narration. The postdigital ecosystem of our time turns this assignment into a comprehensive and challenging exercise. For example, when working with material encountered on the web, data that has to be sourced, edited, reassembled, and attributed. The piece will be probably later being fed back to the internet by showing it somewhere and therefore becomes again a part of the endless data stream, a point in the constellation.

Assignment 3/ Urban Collage: The existence of urban and public space is an integral part of functioning democracies. How can we utilize this space through the help of technology? In this third and last assignment the students were asked to use urban data sets as well as tools such as projection and video mapping, data visualization, and geolocation-based apps (Google Maps, Instagram, Tinder, Deliveroo, etc.) in order to conceive urban collages. Be it through the content and data the tool addresses or uses, or its spatial properties. The goal for this assignment was to add an extra layer of storytelling to the urban map. In our daily life we tend to accept the directions given by the map and rarely question what happens with the personal data that we feed those apps with. These technical developments lead to profound questions regarding privacy and control. We asked our students to challenge the data-driven outgrowths of our constant need of 'making our lives easier' and to artistically respond or intervene. On another level the students were confronted with the political aspects of space and infrastructure, accessibility and the role location data-based technologies play by providing their services.

5. Findings

For us most outstanding is the commitment and enthusiasm the students brought to the seminar. It was clear to see that the postdigital is so embedded in all areas of our everyday lives that it seemed that it was almost overdue for the students to reflect on it and work with it in the classroom.

Results

The following are selected student projects:

One student developed for the first assignment 'Algorithmic Portraiture' an abstract self-portrait: he was diagnosed with a brain tumor the year before (which fortunately could be cured). *Ghost of Mine* is a video generated out of MRT material (videos, gifs, layered models) of the students own brain and head. Text—excerpts of his medical reports, as well as his own thoughts and fears—goes along with the rhythm of the distinctive sound of the MRT tube. For the same assignment another student portrayed with the project *The Iron Soul* her cousin who works at the nuclear power plant of her hometown. The cousin talks about his daily working routines at the plant. These stories and routines are transferred into a sound installation that plays the audio material over and over again in an algorithmic fashion based on the rhythm of how he executes different tasks in the plant throughout the year.

Fig. 1. Algorithmic Portraiture *Ghost of Mine.*

In *Amazon Border*, developed for the 'Digital Readymade' assignment, the found object is a roll of military 'Nato barb wire' which can be purchased on Amazon. The students were shocked about the description and reviews on the online shopping center. The qualities of the product are advertised as amazing in order to keep unwanted people out, the blades are 'sharp and effective'. ("The razor sharp blades of the locking wire got a strong deterrent effect and a hindering function for trespassing.") The students ordered a roll of this barbed wire for an interactive installation: once a person, an audience, approaches the wire (measured with a proximity sensor) sound recordings from its actual environment, the European mainland border, start to play. As part of the installation print-outs of Amazon reviews for the product, as well as the bill, were hanging on the wall.

For *Everyone's a Printer, Only I'm a Maker* the students worked with found digital 3D models. By combining several of the same models in a 3D software, they created new objects with an ironic function such as a 'leg prothesis' or an 'artificial lung'. In a VR installation the user found themselves in the inside of a 3D-printer surrounded by the created artefacts staged like in a museum. The message is a clear and smart hint on the culture around 3D printing: even though the technology offers promising applications like cheap custom-made prothesis or local DIY-fabrication; it mostly gets used for plastic gadgetry that stresses our environment.

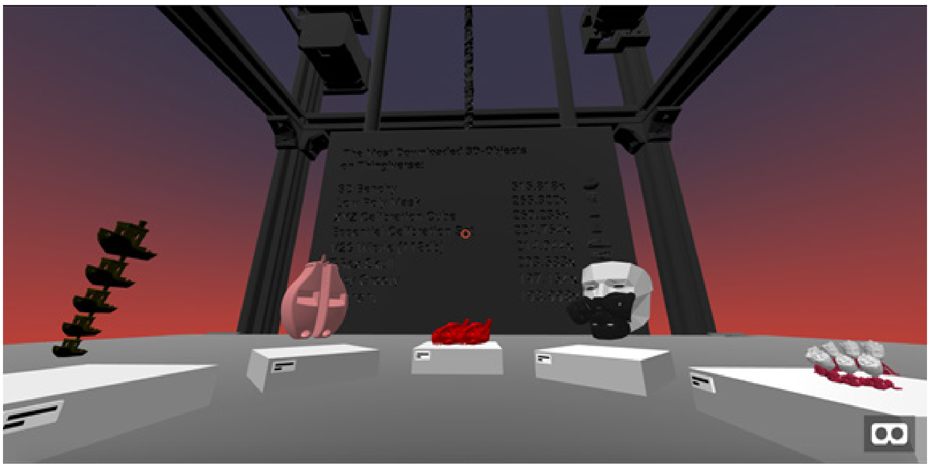

Fig. 2. Digital Readymade *Everyone's a Maker, only I'm a Printer.*

For the third assignment 'Urban Collage' the students were asked to take a step back and look at our world from a more global and spatial perspective. *Transit Nations* is also a highly political project which deals with 4K resolution satellite images of refugee camps recorded from Google Earth. These images from above show the difficult and determined condition of camps: rampant infrastructures between no man's land and city. Also *El Pan* is based on maps material and investigates unfinished infrastructures on the Spanish mainland: the student portrays an economic boom that ended in a massive absurdity of dead ends and unsold properties where villas and swimming pools will always stay just a capitalist vision. Both students used Google Mapping Software in order to determine aesthetically distinctive features which stand for structural political failure. These projects are highly political in their narratives as well as the choses aesthetic which is the content itself. Through this hybrid position they are very representative for postdigital arts as a whole and particularly the course we have taught.

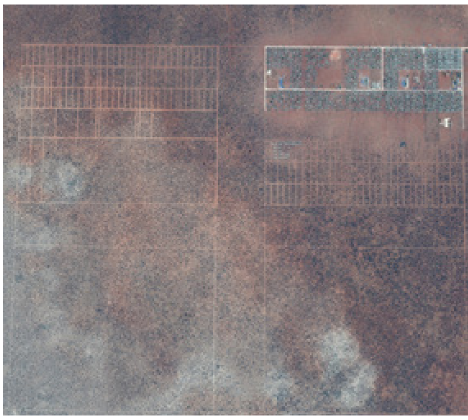

Fig. 3. Urban Collage *Transit Nations.*

Fig. 4. Urban Collage *El Pan.*

Observations

The results of the three assignments were interesting and showed similarities: the projects were predominantly personally or politically driven. Often in a hybrid form in between, 'stitched together' through an aesthetic approach.

On the one hand those overlaps amongst the students' projects arose because all of them were reading the same texts in class and saw the same work examples. We talked about how much we are already reference points to each other and the rest of the connected world, akin to stars or planets in a "postdigital constellation" (Berry & Dieter, 2015). And therefore how much the system 'changes' when we move within it. This awareness that if I hack, design, or dialogue within these structures, my own action might also have consequences to others or even the system itself, maybe even change the condition, was striving. To receive this feedback was a very important and eye-opening aspect of the whole subject and motivating for the students. The awareness to be part of a hyper-networked condition could be seen in the students' projects.

On the other hand the similarities among the projects are rooted in the congruency some of the tools have with the everyday postdigital experiences. Here we want to refer again to the 'nowness', to the level of involvement the students bring to the table. In the results, as well as the group dynamics within the class we could recognize evidence for our postulated principles for design education (see Section 3):

1. The postdigital condition as something omnipresent and therefore per sonal led to a likewise personal approach amongst the students, together with the availability of tools and technologies the whole subject presented itself to be quite low threshold.

2. In their assignment-based projects, the students engaged with the aesthetics in politics, as well as politics in aesthetics. The students largely succeeded in transferring political topics into aesthetic expressions.
3. The shared observation that the postdigital condition affects everyone in the class, created a strong sense of temporary community. We could witness a great interest in sharing inspirations, as well as ideas, thoughts, and feedback. The students researched additional material and met for exhibitions and events around the subject.

6. Conclusion

While the notion of the postdigital may evoke the impression that digitization is finished, we have argued and shown that it rather refers to the sobering realization that networked technologies now permeate and—to a growing degree—shape our lives. Postdigital art attempts to reckon with a lived experience that is increasingly shaped by algorithms, which may not only offer convenience, but also surveillance, patronization, and discrimation. With this work it was our ambition to devise an educational format in which design students could familiarize them with art theory and practice in an integrated manner. We have proposed the principles of low thresholds, aesthetics in politics, and temporary community to open up a space in which students can grapple with these socio-technical tensions in critical-generative ways. The results of the course exhibit a deep intellectual and aesthetic engagement with the topic. It is particularly noteworthy how the students' projects demonstrate not only a technological sophistication, but often personal connections as well as politically charged treatments of the postdigital.

The biggest challenge of the course was to combine the high level of technology, theory, and discussion in class. Even though the seminar had a relatively long time window of 4.5 hours every week, often there was not enough time to go through everything planned. Overall, the course schedule was relatively dense—from showing and discussing art projects, over teaching the accompanying technologies and debating about their societal impact, to talking about the ethical consequences of the postdigital condition and what that means for our own being in this world. The postdigital is everywhere, hard to delimit, and even harder to keep out. It was particularly this realization that made the discussions in the course so stimulating and the overall topic all the more relevant to both students and instructors. We could all feel a kind of 'digital hangover', which made the subject so personal, immediate, and urgent. The class felt like a resonance room, in which the students finally realized where they were and what consequences our postdigital reality has on every individual's here and now. The students were eager to experiment in order to see in which ways they can confront the postdigital condition in the form of artistic expressions.

References

Ackermann, Judith, Marian Dörk, Hanne Seitz.
2019. *PKKB: Postdigitale Kunstpraktiken. Ästhetische Begegnungen zwischen Aneignung, Produktion und Vermittlung*. In Forschung zur Digitalisierung in der Kulturellen Bildung, pages 173–184. kopaed.

Benjamin, Walter.
1936. *The work of art in the age of mechanical reproduction*. Visual Culture: Experiences in Visual Culture, pp.144-137.

Berry, David M., Michael Dieter.
2015. *Thinking postdigital aesthetics: Art, computation and design.* In Postdigital Aesthetics: Art, Computation And Design. pp. 1-11. Palgrave Macmillan, London.

Bridle, James.
2018. *New dark age: Technology and the end of the future.* Verso Books.

Contreras-Koterbay, Scott, Łukasz Mirocha.
2016. *The new aesthetic and art: Constellations of the postdigital.* Institute of Network Cultures.

Cramer, Florian.
2015. *What is 'post-digital'?* In Postdigital aesthetics, pages 12–26. Springer.

Depoorter, Dries.
2018. *Jaywalking.* https://driesdepoorter.be/jaywalking/

Dufva, Tomi.
2015. *Art education in the post-digital era- Experiential construction of knowledge through creative coding.* Aalto University.

Eckert, Leon.
2016. *Opinions Are My Own.* https://leoneckert.com/projects/opinions-are-my-own

Gropius Bau.
2018. *Parallel Words.* https:/ berlinerfestspiele.de/en/berliner-festspiele/die-institution/vermittlung/vermittlung.html

Jandrić, Petar, Jeremy Knox, Tina Besley, Thomas Ryberg, Juha Suoranta, Sarah Hayes.
2018. *Postdigital science and education.* Educational Philosophy and Theory, 50:10, 893-899

Kogan, Gene.
2019. https://ml4a.github.io/classes/

Lavigne, Sam.
2016. *Slow Hot Computer.* https://lav.io/projects/slow-hot-computer/

Maeda, John.
2002. *Design education in the post-digital age.* Design Management Journal (Former Series) 13, no. 3: 39-45.

McCarthy, Lauren.
2017. *LAUREN.* https://lauren-mccarthy.com/LAUREN
Zentrum für Kunst und Medien Karlsruhe. Undated. *Offers & Workshops.* https://zkm.de/en/education-mediation/offers-workshops

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Collaborative Vision: Livestream, Volumetric Navigation, AI Image Processing, and Algorithmic Personalisation

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Keywords: Collaborative Vision, Livestream, Volumetric Navigation, AI Image Processing, Algorithmic Personalisation.

'Vision' is the faculty of perception and visualisation that helps us to acquire information about our environment as an individual. The media industry has shown how the collection and distribution of such information can impact the public realm. For instance, the 2019 Extradition Protest in Hong Kong, which propagated itself through livestreaming events on media platforms, brought about the compliance of the government by collectively disrupting physical-urban and virtual-media spaces. These media technologies have demonstrated their capacity in facilitating a 'collaborative vision' that communicates and accumulates individuated information in real-time. This gives the urgency to understand the working of these distributed media and their potential in formulating a cohesive infrastructure that will help us in reconstructing and understanding the consequences of our own events collectively. This paper summarises a research—*Current*—which utilised 4 techno-social ideas to prototype a means of 'collaborative vision'.

1. Introduction

Our vision has changed radically since the invention of machines that are able to comprehend large datasets. For instance, the idea of 'climate change' will not be present without the invention of computers: not only because of the immense use of resources necessary to propel large scale computation, but also because computers helped us in perceiving the presence of climate change through the mathematical interpretation of data. 'Any change in the technology of the description of space has always changed the way we encounter and intervene with space' (Bottazzi 2020). The democratisation of such technologies decentralises knowledge to anthropogenic phenomena. Although large scale computation used to be instruments exclusive to institutions, the advancement of media technologies facilitates a means for individuals to gather and process data collectively—a 'collaborative vision'.

The research project *Current* is a 12-minutes prototype of 'collaborative vision' (fig. 9). *Current* speculates on the convergence of four core ideas into a media infrastructure that spans across cities and borders: livestream, volumetric navigation, AI image processing, and algorithmic personalisation. *Current* experimented with a range of digital technologies that are readily available to any individuals (e.g. livestream data, machine learning, 3D environment reconstruction, ubiquitous computing, point-clouds, etc.). It developed a production pipeline (fig. 8) using distributed technologies, which provide a means for individuals to reconstruct, navigate, and understand event landscapes that are often hidden from us, such as violence in protests, the handling of trash, changes in nordic animal behaviours, etc.. This paper tabulates the ideas and technologies explored in *Current*.

This paper first presents the four core ideas, and discusses the technologies used in examining these ideas. It then introduces how these ideas and technologies can amalgamate into a production pipeline to facilitate a 'collaborative vision'. Subsequently, this paper reflects on its findings in the discussion section. Finally, it concludes by discussing the types of data that has been created, the limitations of the system, and how this might open up new spaces of discussion.

2. The Four Core Ideas

2.1. Livestream

In the contemporary contestations of algorithmically recommended content, the screen time of scrolling between livestreams has become a new form of television. The word 'television' comes from Greek τῆλε *tèle*, meaning 'far', and Latin *visio*, meaning 'vision'; thus, it is a communication device that transmits vision from afar. Livestream identifies itself from traditional television as a distributed real-time media—anyone with a digital camera and access to the internet can produce and broadcast content simultaneously.

This gives rise to an attention economy that circulates values distinct from traditional moving-image media. First, it encompasses compelling moments alongside an infinite feed of the mundane, suggesting a sense of 'truth'—an event being preserved in its entirety—to its viewers. Second, it's arbitrary timespan allows viewers to be in control—viewers can step in and out of the stream at any moment instead of having to sit in for a standardised amount of time. Third, it facilitates a participatory authorship, where the interaction between the viewer and the streamer collaboratively directs, narrates, and curates the experience.

With more than 300 million users, the livestream media owns a virtual population the same size as the third largest country in the world (Cunningham 2019). Livestream platforms stimulate social participation by bringing vision into individuals' lives to attract both capital and data. It is a form of open-source database that represents a globalised demographic of the contemporary working class, who would regularly spend their mornings, lunch breaks, and after-work hours interacting in this virtual world as part of their daily routine—it is a collective effort in the characterising of socio-economic trends. As such, livestream is a cultural emergence to the contemporary urban demographic shift: from the domination of the modernistic nuclear family who live in the suburbs, to the domination of a mobile population of single professionals who work between metropolises. In the modernistic nuclear household, the television, which gravitates the space of the living room, represents the building block (a single modular unit) of the society. In comparison, livestream, which is the friendly companion of your studio apartment where shared screens are no longer desired except in the virtual space, represents a network of connected individuals—it is the market's response to the contemporary reinforcement of individualism.

Furthermore, livestream interfaces are generally designed with interactive components that extend its revenue model beyond television commercials: virtual chat rooms to promote engagement, virtual gifts and 'red pockets' to attract credit top-up, e-vouchers to nexus sponsors, loyalty ranking to embed competition, etc. (fig. 1). In 2016, the livestream economy in China alone surged a 20 billion Yuan revenue, which overcame Hollywood as one of the largest entertainment industries (Cunningham 2019). From the production to the consumption of its content, livestream is a distributed technology that diminishes a centralised operational cost. Its economy is based on a peculiar form of consumerism—the consumption of attention. By this very nature, branded virtual signalling becomes the contemporary currency that is based on the atomic unit of data: bits.

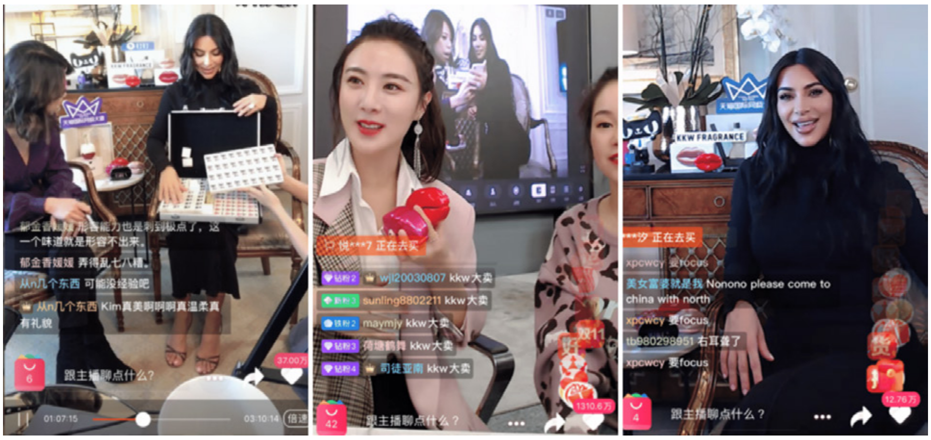


Fig. 1. Viya Huang and Kim Kardashian collaborating on livestream.
source | *Tmall.*

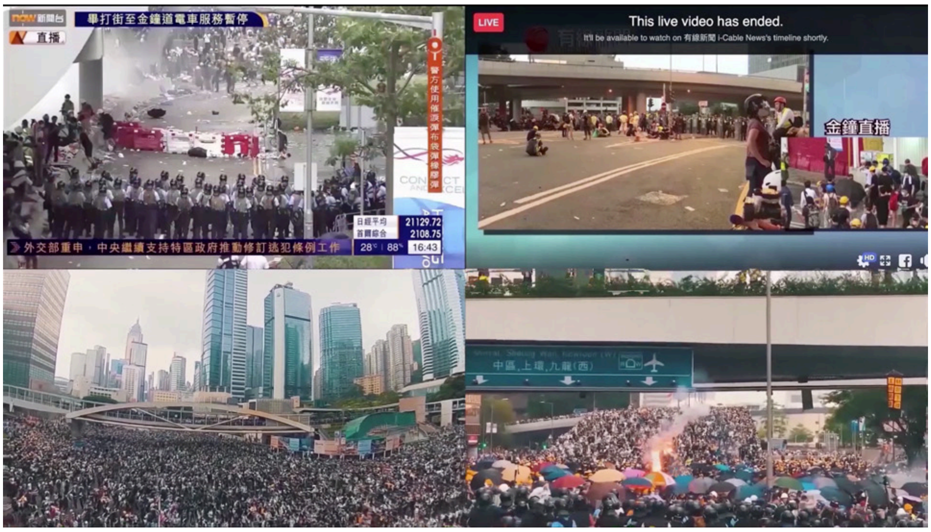


Fig. 2. Underground livestream released by protesters during the 'Hong Kong Extradition Protests' in 2019.
source | *Github.*

In our digital age, where every image can be readily copied and altered, the sense of 'truth' becomes problematised; the value of 'truth' becomes our currency. The virtual signalling of livestreams accomplishes a socially defined realism, albeit this may not always be a conscious thought process, it influences our collective intuition and reasoning. It is not only accomplished through the content that is being streamed, but also its visual cues. 'In principle, any image property can be a cue, including colour, texture, local parts, overall shape, as well as learned features' (Hertzmann 2019). Visual cues contribute to whether the vision being presented 'seems real' by providing supplementary information to its viewers. For instance, although most livestreams are quite shaky and pixelated, they imply 'real' people filming 'real' events; alternatively, if a footage is in static motion with high resolution, it signals a sense of 'curation' or 'being staged' from a well-resourced entity. As such, livestream is not only an open-sourced database, but also a form of expanded cinema, where the 'back of stage' is perceptible to its audience—its graphical aesthetic has intrinsic social value in our present-day technocracy. *Current* expanded on the definition of livestream beyond social media to animal cams, autonomous car visions, etc.. These sources represent the visions of alternative intelligence. In this respect, livestream may provide a prospective means to quantify, predict, and generate a 'collaborative vision'.

2.2. Volumetric Navigation

Volumetric navigation (VN) is a technique developed for large-scale traffic control systems, in which 'all the vehicles share information in order to be part of a collaborative navigation network' (Olmedo 2012). VN synthesises multiple sources of data, which includes positioning, navigation, volume, and time information, to simulation a subject(s) and its surrounding environment with the intention of deducing its plausible relative movements. VN is a collaborative context-reconstruction that gives multidimensional vision to an immediate moment for preemptive actions. The idea of 'volumetric' problematises the contestation between different perspectives in forming a coherent 'collaborative vision'; conversely, this gives the potential to authenticate events and truth. In 'Current', this is where livestream and VN meets: viewers will be able to volumetrically navigate events in real-time. *Current* experimented with extracting 3D information with photogrammetry frameworks from different livestream sources, including autonomous car vision, NASA, drones, animal cams, and surveillance cameras. These sources are selected specifically to examine and demonstrate the idiosyncrasies generated by different visual cues, which will reveal to its viewers how data is being collected, structured, and projected volumetrically - volumetric data analytics.

Autonomous car vision are often composed of dolly shots, which are more effective for image-matching procedural processing to deduce the depth of space by comparing consecutive frames, but it will only be able to reconstruct spaces that are perpendicular and immediate to the camera's movement. NASA often livestreams its expeditions from omnidirectional (360°) cameras mounted on mobile robots (e.g. the Mars 2020 Rover), which produces truck shots. This yields spherical interpretations of the robots' surroundings, yet often lacks information on what is behind other objects, generating a peculiar aesthetic of voids and shadows around the scene that discloses information of the relative position of the camera (fig. 3).

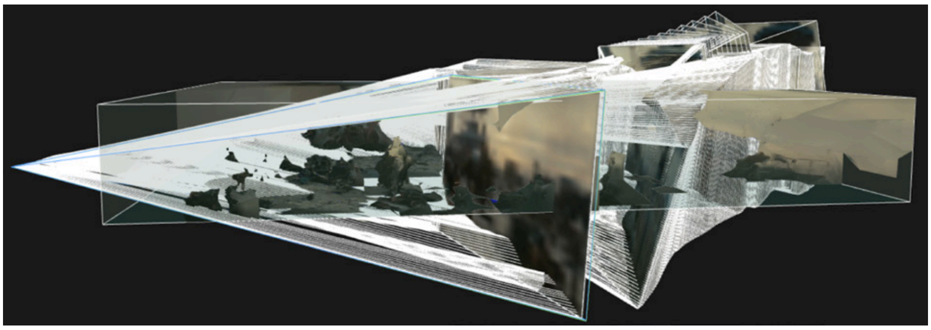


Fig. 3. Volumetric reconstruction that shows the peculiar aesthetic of voids and shadows around the scene, which discloses information of the relative position of the camera.
source | author.

This 'bug' can find its potential application in visual odometry, especially on foreign planets. Drones that were flying in circular direction produces relatively coherent reconstruction of single-body targets from aerial perspectives; while mono-directional flying produces quadrilateral scenes where objects are texture mapped all on one side (fig. 4).

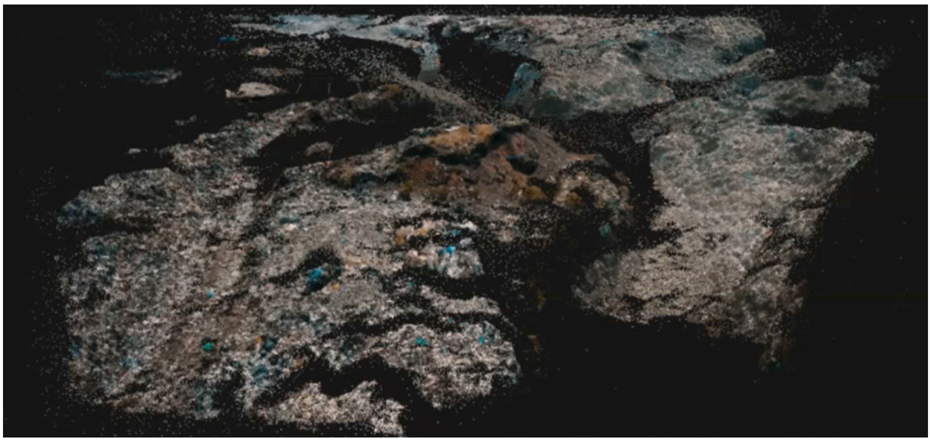


Fig. 4. Volumetric reconstruction from a drone flying from west to east over a landfill, resulting in texture mapping only on west-facing surfaces.
source | author.

This has potential application in forensic sciences by volumetrically reconstructing the path of subject(s) within a space at a given amount of time. These techniques, together with AI image processing, can help to democratise volumetric data analytics.

2.3. AI Image Processing

Today, many leading digital enterprises (e.g. Nvidia, Intel, etc.), which recognised the profound relationship between vision and intelligence, feed AI with images to conceive machine vision. *Current* experimented with two AI image processing neural networks (NN)—Autoencoders and Generative Adversarial Networks (GANs)—that are able to infer through self-organisational pair-work. In pedagogy, pair-work is 'learners working in pairs'; this allows learners to 'compare answers and clarify problems together' (British Council n.d.). In Autoencoders, an NN learns representations from high dimensional datasets to encode information, while the other NN learns to reconstruct the complexity of the dataset by decoding the representation. The two NN 'compare answers' with each other in an iterative manner. In GANs, the two NN compete against each other: one NN tries to generate synthetic data from input, while the other NN tries to identify the 'fake' from the 'real'. The competition continues until both NN have learnt to do their best in the game.

Autoencoders have been utilised in areas such as retrieving 3D information from a single 2D image, which is one of the earliest goals of AI research: mimicking human visual systems to achieve a full scene understanding (Papert 1966). On the other hand, Autoencoders have contributed to the social phenomena 'DeepFakes', where the NNs learn to swap human faces (e.g. put celebrities in pornographies, etc.). *Current* demonstrates both the bright and dark side of this technology, which influences the course of reality through synthesising images. In one scene, *Current* tried using Autoencoders to fill in voids between discrete data to present viewers with a more coherent environment reconstruction. In another scene, Autoencoders were used to swap the faces of Donald Trump and Chairman Xi in their national speeches to demonstrate how these images may impact the public realm when streamed (fig. 5).

GANs have been utilised in areas such as enhancing astronomical images and video game modding (Kincade 2019; Tang et al. 2018). *Current* experimented with GANs on two aspects of the project: up-scaling low-resolution textures and morphing data into a single viewing unit (fig. 6). Morphing, which is a digital aesthetic native to the iterative nature of AI image processing, 'adjusts shape but not colour or texture' of the data (Hertzmann 2019). In the process, GANs compose 'in-between images' that look strangely familiar to human vision, yet we cannot quite 'recognise them as anything real' (Hertzmann 2019). These 'in-between images' are a condensation of visual cues inferred by the AI, which is constrained by its inductive bias when it negotiates itself between the image topologies from one input to another. *Current* took livestreams from multiple perspectives on the same events and 'morphed' them into a 'collaborative vision' that tries to demonstrate a more encyclopaedic representation to the scenarios.

Fig. 5. A scene from *Current* where the US president Donald Trump is saying Chairman Xi's Chinese national speech. *source | author.*

Fig. 6. A scene from *Current* of a transitional morphing image approximating itself between rocks and trash. *source | author.*

2.4. Algorithmic Personalisation

Algorithmic personalisation (AP) is 'a process of gathering, storing, and analysing information' by recommendation systems (Venugopal 2009). It 'has become a standard approach to tackle the information overload problem [...as] we are still bounded by cognitive and temporal constraints.' (Perra, 2019). It is a response to the discrepancies between the amount of data different agents can process at a given point in time. Theoretically, machines can process an infinite amount of data; whereas humans often perform reduction in order to reason. The public, as a form of collective intelligence in our technocratic epoch, reach consensus depending on how many is being exposed to which content in a given period of time. Thus, AP is a communication strategy that translates between actors, and impacts the public realm by recommending the 'right' content, to the 'right' person, at the 'right' time.

AP influence our vision by presenting us with adjoining concepts. It predicts user preferences based on their viewing history, and generates an attention economy that regulates our civic lives based on data consumption. Today, AP are often operated by AI, which automate our aesthetic production and 'other cultural experiences (e.g. automatically selecting ads we see online)' (Manovich 2018). This form of AP is often employed by media platforms as part of their revenue model. For instance, Instagram offers a communal virtual space where all information is shared for free, and their profit is generated from commercial advertising through AP. As such, users are at once, both consumers and commodities. Media platforms offer us information services, the service fee is being priced not on fiat currency, but data. In capitalism, everything is quantifiable by their value and comes at a price, which ensure tradability and the circulation of value within the system. In our climate change epoch, instead of simply denouncing the data market, it may be more constructive to consider what are the kinds of data market we need to mitigate risks collectively.

Current tried to operate on a data market, where users are able to understand and operate the same set of AP tools as commercial suppliers. *Current* used recommendation systems to personalise livestream data that fits the research project. It used keyword labels (e.g. 'climate change', 'social issues', 'animal cams', etc.) to set up digital profiles with various open-sourced recommendation systems to retrieve the appropriate livestream contents amongst billions of hours of footages. The open-source quality problematises the empirical ideology of authorship in design that is entitled to a single name; at the same time, questions if AP helps us to be exposed to more choices or less.

Fig. 7. A scene from *Current* using volumetric techniques to personalise the virtual environment.

3. Result: Production Pipeline

From the experiments of *Current*, this paper formulates a production pipeline where the examined ideas and technologies come together as a media infrastructure that allows individuals to collectively gather and process data to reconstruct and understand the consequences of our own events —'collaborative vision'.

This pipeline (fig. 8) begins with individual users who produce and acquire data through livestream platforms, such as Facebook and Inke. The livestream data encompasses image data and metadata (e.g. GPS, timestamps, etc.), which can be stored and archived on any personal devices, and be extracted to AI image processing NNs for data enhancement. The learning algorithms, Autoencoders, can help to fill voids in discrete data based on the collective archived data. While GANs can assist in morphing data into a single viewing unit, and becomes an endless stream of content that can be viewed by users as requested. If the user prefers to navigate the event in 3D, the enhanced data can be delivered to volumetric reconstruction frameworks (e.g. RealityCapture, etc.) as needed. The output volumetric data can then be archived and plugged into personalisation algorithms, which would label and classify the data and deliver the recommended content retrieval to volumetric navigation engines, such as VR interface and devices, and accessed by users via media platforms. The accumulated data will be retrieved on the media platform through functions like keywords input, which helps to characterise trends collectively through a ranking system. Data on same or similar events can be used as comparative analysis or complete the void in each other's models to authenticate events. This completes the feedback loop, where the user produces and acquire further information through collaboratively characterised trends.

Fig. 8. Flow chart of the production pipeline with constituent components that generated a 12-minutes prototype of the concept 'collaborative vision' — *Current*.

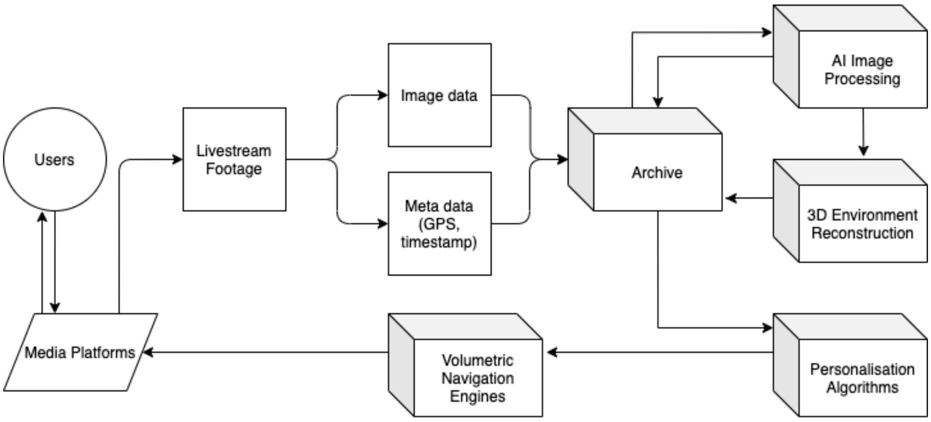
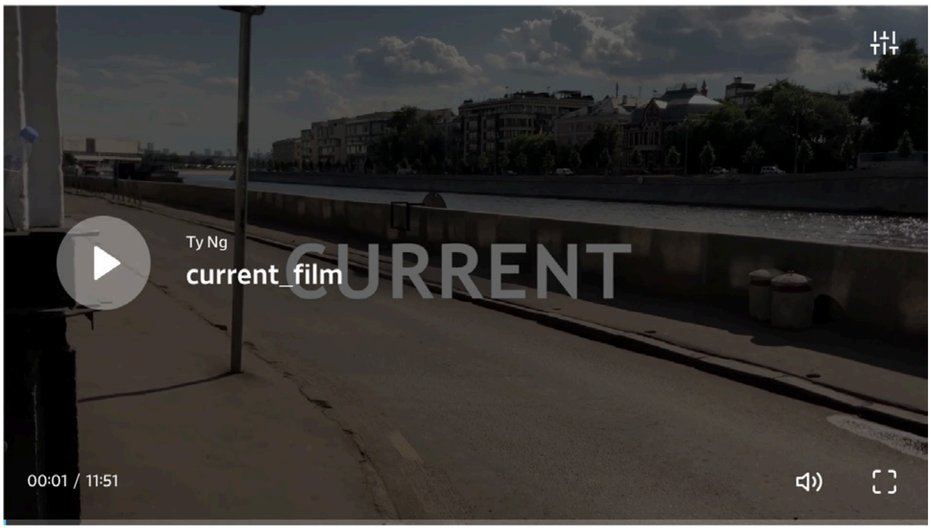


Fig. 9. A video asset: https://dai.ly/x7g1v7k password: 00000



4. Discussion

This research began as a design project that speculated on distributed technologies and slowly evolved into a 12-min prototype of volumetric media (fig. 9); which is why it has heavy reliance on media platforms. Just as Virilio (2008) indicated: the invention of any technology is also the invention of the relative accidents. Media platforms have brought convenience to the communal sharing of information, but have also brought with them the inherent accidents: ecological costs, exacerbating feedback, and data footprints.

As stated in the beginning of this paper, computation demands immense consumption of energy, albeit without which we will not be able to comprehend and communicate the changes in our climate. In the face of this problem, as opposed to simply denying computation, it is perhaps a more useful question to ask: what are the forms of computing we need in this climate emergency? This paper tries to demonstrate that distributed media, such as livestream, helps to diminish centralised operational monetary costs and has the potential to establish an information economy where individual's computing power can be put to uses beyond entertainment (e.g. volumetric data analysis). The author reflects that a technological solution is not enough to reform our present information economy, in which costs are priced on dollars instead of carbon. The author has come to realise that any technological solution will have to be coupled with pertinent socio-economical solutions, to which this paper regrettably does not conform to cover. The reviewers of this paper have accurately commented: 'In short, the four ideas used as a strategy in the presented research are highly novice to the environment... but nowadays it seems more difficult to innocuous practices.'

As early as 1995, Nicolas Negroponte had expressed his concerns on personalised media in his book 'Being Digital'. He feared that too much positive feedback in a single direction will lead to polarisation on public's opinion and reinforces individualism. Exacerbating feedback may occur and amplify the effects of a small disturbance that leads to perturbation. 'That is, A produces more of B which in turn produces more of A' (Keesing 1981). It is worthwhile to discuss how algorithmic personalisation can become a hybrid system, and combine social, ecological, cultural, economic, and other relevant data.

Although digital communication facilitates a 'collaborative vision' to the consequences of our actions, it has also produced data footprints that have led to the inevitable discussions of surveillance. It is easy to demonstrate that digital technologies strengthen autocracy, but it takes immense effort to extract the utility of surveillance. With the present pandemic, the debate on surveillance has been opened up in more important ways. For instance, 'reconstructing infection by tracking phones can be an important tool, despite the direct confrontation with principles of libertarian anonymity' (Bratton 2020). It is perhaps more useful to ask: how are we mining data? Are we mining the right kind of data? What data should algorithmic personalisation be recommending to us? These questions are expected in the discussion of this project.

As a final point of discussion, I couldn't have put it in better words than Benjamin Bratton: 'it is a mistake to reflexively interpret all forms of sensing and modelling as "surveillance" and all forms of active governance as "social control." We need a different and more nuanced vocabulary' (Bratton 2020).

Fig. 10. Scenes of volumetric reconstruction in *Current*.

5. Conclusion

This paper is an after thought to the project *Current* (fig. 9), which focuses on delineating the slippery relationship between media and urbanism. 'Current' is a project that tries to inverse the negative value metrics of media surveillance into a utilisable communication device that spans across cities and borders—a media infrastructure that facilitates a 'collaborative vision'. *Current* goes beyond the collection of data to the structuring of it: it appropriated livestreams as competing datasets to reconstruct our event landscapes (e.g. where did the wastes go? Who exercised violence during protests?), and used a combination of techniques to facilitate a collective processing of data: volumetric navigation, AI image processing, and algorithmic personalisation. These experiments present us a method of statistical reasoning to urban phenomena, which is readily becoming our contemporary realism.

This paper contrasted the modernists' with the contemporary household to emphasise how livestream is transforming our domestic routines: from the television that keeps you awake in the middle of the night so you can watch your favourite show with your family after a standard 9-to-5 working hours, to livestream platforms, which collapse all your favourite content into an infinite stream so you can enjoy it anytime by yourself during your precarious employment. Livestream reflects our existing socio-economic structure: from having the nuclear family as the atomic unit that represents societal preferences, to a generation that is based on a compilation of many 'self'.

This paper then discussed how we are reconfiguring our vision from 2D to 3D, which means adding a z-depth value to our images. We are adding information to the image world faster than we can appropriate. The aesthetic, values, and validity of this extra information, this extra dimension, foster the relative measurements to our images in the digital age. For instance, traditional cartography performs reduction on Earth's spatial information to achieve efficiency for human perception; whereas the recent geoid simulation developed by NASA (fig. 8) presents high-dimensional information that is beyond human perception—our attempt to grasp such level of information influx can only be metaphorical: 'Earth looks like a potato'.

Subsequently, this paper reflected on its findings by discussing the future of our information economy, which based on mining the past. If our media infrastructure allows every moment in every corner to be stored, processed, and recommended to you according to your digital profile, what will be the value of history? History, from Latin '*historia*', means the art of narrating past accounts as stories. What will be the future of our urban environment if every single event is preserved and archived in real-time to such accuracy that there will be no room for his-story? Will we be submerged in an absolute evident-based society, where every subject is infinitely contested?

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References

Bottazzi, R.
2020. Digital Architecture beyond Computers: Fragments of a Cultural History of Computational Design. London: Bloomsbury Visual Arts.

Bratton, B.,
2020. 18 Lessons of Quarantine Urbanism. Strelka Mag. Available at: https://strelkamag.com/en/article/18-lessons-from-quarantine-urbanism.

British Council.
(n.d.). Pair work. https://www.teachingenglish.org.uk/article/pair-work.

Cunningham, S., Craig, D., & Lv, J.
2019. China's livestreaming industry: platforms, politics, and precarity. International Journal of Cultural Studies, 22(6), 719–736. doi: 10.1177/1367877919834942

Hertzmann, A.
2019. Aesthetics of Neural Network Art. arXiv preprint arXiv:1903.05696.

Keesing, R.,
1981. Cultural anthropology: A contemporary perspective (2nd ed.) p.149. Sydney: Holt, Rinehard & Winston, Inc.

Kincade, K.,
2019. "CosmoGAN: Training a neural network to study dark matter". Phys.org.

Manovich, Lev.
2018. AI Aesthetics. Moskau: Strelka Press.

Negroponte, N.,
1995. Being digital, New York: Alfred A. Knopf.

Olmedo, R., Cuesta, C. D. L., Nemeth, J., Aichorn, K., Cabeceira, M. L., & Andres, N.
2012. ARIADNA: A Volumetric Navigation System implementation for maritime applications. 2012 6th ESA Workshop on Satellite Navigation Technologies (Navitec 2012) & European Workshop on GNSS Signals and Signal Processing. doi: 10.1109/navitec.2012.6423073

Papert, S.,
1966. "The Summer Vision Project". MIT AI Memos (1959–2004). hdl:1721.1/6125.

Perra, N., Rocha, L.E.C.
2019 Modelling opinion dynamics in the age of algorithmic personalisation. Sci Rep 9, 7261 .

Tang, X., Qiao, Y., Loy, C., Dong, C., Liu, Y., Gu, J., Wu, S., Yu, K., Wang, X.,
2018. "ESRGAN: Enhanced Super-Resolution Generative Adversarial Networks". arXiv:1809.00219.

Venugopal K.R., Srinivasa K.G., Patnaik L.M.
2009. Algorithms for Web Personalization. In: Soft Computing for Data Mining Applications. Studies in Computational Intelligence, vol 190. Springer, Berlin, Heidelberg

Virilio, P.,
2008. The Original Accident. Polity Press.

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Horizontal Against Vertical

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Keywords: Vilém Flusser, Image, Apparatus, Programme, Information, Aïm Deüelle Lüski, Multi-pinhole cameras, Horizontal Photography.

Photographs, as Vilém Flusser argued repeatedly, are the outcome of pre-programmed apparatuses: camera designs, industrial complexes and the economies which drive them. Flusser's elaborate view is contrasted by Aïm Deüelle-Lüski's hand-made multi-pinhole cameras and particularly his 'horizontal' cameras, wherein the negative (and later negatives) are placed horizontally within the camera. Deüelle Lüski's oeuvre is thus a unique problematisation of all other forms of photography that are revealed as solutions for only a single problem: how to produce referential pictures.

If we consider an unembellished history of photography, then we gather that cameras have been invented in order to function automatically and independently of human involvement. In that sense, the camera may be the first true apparatus. And if this is the intention with which they have been created, then it has been hugely successful. While the human components of photography are progressively being side-lined, the programs of the photographic apparatuses, whether seen as combination games or not, are becoming increasingly rich in desirable elements. They go far beyond our human ability to control them or even understand what they do, let alone how. It is precisely their tendency to conceal themselves automatically, to become opaque while their artefacts seem to become ever more transparent, that needs to be criticized. What is essential is that programs always become autonomous. Vilém Flusser's philosophy uses photography to argue that apparatuses, whatever they are, function independently of their programmer's intentions and increasingly more so. This is why Flusser, wherever he looked, could only see apparatuses whose initial purpose 'recedes farther beyond the horizon' (2011, 208).

Many human cultures can be defined by their methods of elaboration and preservation of information. Nevertheless, most procedures for elaborating and preserving information have many tedious aspects. This is arguably one simple reason why apparatuses have been invented: to process information faster and to preserve it more efficiently than humans can. This is also why creativity today rarely depends on the ability to actually fabricate physical objects. This may also mean, however, that creativity can no longer be measured exclusively in terms of the ability to fashion cultural objects intentionally. Instead, it should be understood as the ability to program apparatuses, to direct them to culturally desired models and then to end their independence when these models have been produced.

1. The Photographic Apparatus

Vilém Flusser's philosophy of photography is comprised of four key terms: image, apparatus, program and information. These enable the following definition of a photograph: 'an image created and distributed by photographic apparatus according to a program, an image whose ostensible function is to inform' (Flusser 2000, 76). Importantly, Flusser's definition of image can be understood as corresponding with Walter Benjamin's famous 'Work of Art' essay (Benjamin, 2008) and his definition of information can be understood as drawing according to Claude E. Shannon's (1948) mathematical theory of communication. I will not delve into these two terms here. I will instead focus on Flusser's definitions of apparatus and program and utilize these in presenting Aïm Deüelle Lüski's concept of horizontal photography.

The photographic apparatus, although based upon scientific principles and technical complexities, is easy to handle, argues Flusser remarkably.

It is, nonetheless, not an apparatus on which you merely click a button, as Kodak's nineteenth-century pitch would have us believe ('You Press the Button, We Do the Rest' was Kodak's advertising slogan, coined by George Eastman in 1888) (fig. 1). Rather, photography in Flusser's construal is functionally simple yet structurally complex.[1,2] Instead of accepting Kodak's 'fire-and-forget' description, Flusser suggests a concept of dynamic interaction between the apparatus and its user. Pondering the meaning of the term apparatus through the Latin verb apparare (to prepare), he conceives a photography that is far more than a technological tool that naturally, mechanically or automatically produces an image. Rather, it is a complex system that must be prepared in order for an image to be made. But what does 'prepare' mean in this context? Contrary to Joel Snyder (1975) and Neil Walsh Allen's (1980) advocacy of the photographer's artful preparation of the image – his or her choice of exposure variables, lens, film stock (or colour profile) etc., for Flusser the photographic image is prepared by the apparatus, and not the photographer. It is always already prepared, and the photographer's choices, in fact his or her liberty, are limited to engagement with that which has been pre-prepared.

1. In this regard, it is the opposite of the game of chess, which is structurally simple and functionally complex (that is, even though its structure and rules are relatively simple, every game embodies infinite possibilities). (Flusser 2013, 132).

2. A similar and intriguing distinction is made by Andy Clark when he refers to "transparent" and "opaque" technologies. (Clark 2009).

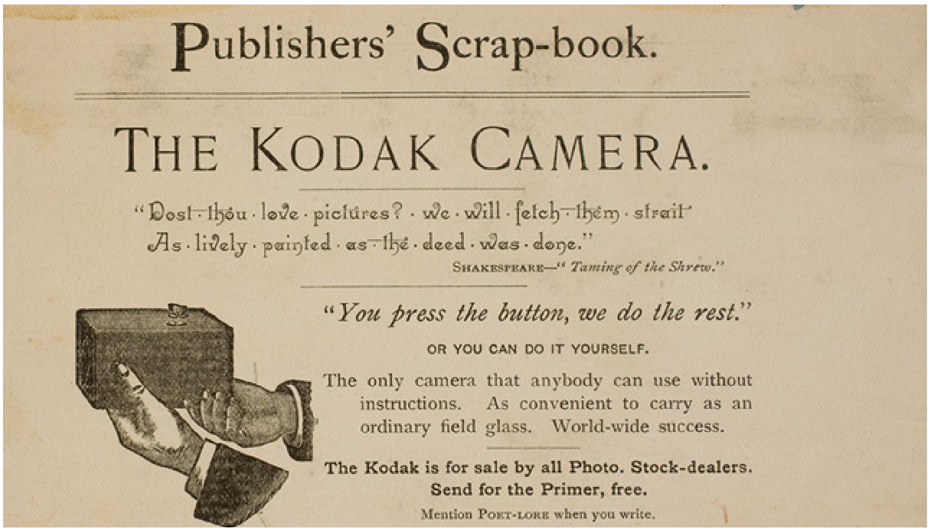


Fig. 1. Eastman Kodak Advertisement, c.1889.

Flusser then argues that an apparatus is a machine that calculates probabilities in order to elaborate information: 'humans used to do the same thing, and they called it "creation". They used to elaborate improbable situations empirically, and they used to call their empiricism by noble terms such as "intuition". Apparatus do this better because they use information theories [...]. However, if apparatus can create information in the place of humankind, what about human commitment? What about values?' (Flusser, 1980, 330). Put differently, photography, in Flusser's philosophy, is designated as the prototype for all technical apparatuses taken together.

Conceivably, most apparatuses are hard objects. A camera is usually constructed of metal, glass, plastic, etc., but it is not its hardness that makes it capable of elaborating information (similarly, it is not the cardboard of a chessboard or the wood of the individual chess-pieces that make a chess game possible). Rather, it is the rules of the game that allow play, interaction and consequently elaboration of information: 'What one pays for when buying a camera is not so much the metal or the plastic but the program that makes the camera capable of creating images in the first place [...]' (Flusser 2000, 30).

The term program should be first understood on a basic technological level, as the sum of all the operations that an apparatus can be set to perform – that which the apparatus is prepared to do. In the case of photography, however, the program is an expanded concept that also extends to the photographer's multiple decisions while making a photograph. All those are also conditioned by the programmatic possibilities built into the apparatus. The apparatus may therefore be understood as also 'programming' its human user. This concept extends our previous technological definitions well into the broad cultural context of present-day post-industrial society. The news photograph, for instance, ought to be understood as 'programmed' or 'pre-programmed' by the entire structure of the newspaper, the press or the media industry, where it not only illustrates reportage but also incorporates and evokes many pre-existing cultural codes and contexts.[3]

3. This aspect of Flusser's philosophy of photography indeed resonates with some familiar postmodernist strands of thought.

At first glance, it may seem somewhat counterintuitive to describe photography with a concept so intimately associated with the computer; but this is a point Flusser insists on: 'Computers are apparatuses that process information according to a program. This is the case for all apparatuses anyway, even simple ones, such as the camera [...]' (1998, 259). This insistence does not weaken Flusser's point. Rather, it raises the suspicion that photography should have never been theorized and philosophized athwart the (analogue) medium of painting. Rather, it would have been better articulated as what Friedrich A. Kittler (2006, 49) described as a 'super-medium': the (digital) computer.

Unlike manual labourers surrounded by tools and industrial workers standing by machines, photographers must be inside their apparatus, so to speak, as they are bound up with it. Therefore, unlike a chess player, the human photographer cannot defeat the photographic program. The apparatus automatically assimilates these attempts at liberation and enriches its programs with them. The photographer's involvement, as set by the inner contradictions of an automatic apparatus, is therefore confusing. In fact, looking at a photographer with his camera and comparing his or her movements with the movements of a fully automatic camera, as in a traffic light camera for example, it may be tempting to overestimate human involvement. For it looks as though the fully automatic camera is always tripped by chance, whereas the photographer only presses the release when he or she approaches a situation in the world that corresponds to his or her intention, his or her worldview, or desired form of information.

If we look more closely, however, we can confirm that the photographer's demeanour somehow carries out the apparatus's inner instructions and only them. This happens despite any attempt to deviate from the program: 'The photographer can only photograph what is contained as a virtuality in the camera program' (Flusser 1986, 330). If we accept this programmed world image, it follows that apparatuses and photographers are bound together, and this inherent contradiction always remains in place:

> “The apparatus does as the photographer desires, but the photographer can only desire what the apparatus can do. Any image produced by a photographer must be within the program of the apparatus and will be, in keeping with the considerations outlined earlier, a predictable, uninformative image. That is to say, then, that not only the gesture but also the intention of the photographer is a function of the apparatus” (Flusser 2011a, 20).

Moreover, when we consider the photographic apparatus in aggregate, we may notice that within it there are several interwoven and contradictory programs: one for 'capturing', another for 'controlling' and possibly a 'transmitting' program as well. Beyond these, there must be many more – those of the photographic industry that programmed the camera; those of the industrial complex that programmed the photographic industry; those of the socio-economic system that programmed the industrial complex... ad infinitum. In fact, since every program requires a meta-program by which it is programmed, we may conclude that there is no program to rule all apparatuses. The hierarchy of programs is open-ended.[4]

And if the photographic apparatus incorporates photographers, their viewers and the various programs that program the apparatus, the question who owns the apparatus becomes moot. Who then holds the power of decision? Flusser argues that it is now the toolmakers, or information programmers (in contemporary parlance) who hold the power.[5] What does this mean for photography? For art? What form of criticism can adequately portray these phenomena?

Today's vigilante critics claim that society is split into a class of programmers and a class of those being programmed. But even this may be optimistic. 'The programmers', whoever they are, must themselves be subordinate to a meta-program:

> “The society of the future without things will be classless, a society of programmers who are programmed. This, then, is the freedom of decision made available to us by the emancipation from work. Programmed totalitarianism [...]. Mind you, an extremely satisfying totalitarianism [...]. Hence I get the impression that I am making completely free decisions. The totalitarianism doing the programming, once it has realized itself, will no longer be identifiable by those participating in it: it will be invisible to them” (Flusser 1999, 93-94).

4. "Every program functions as a function of a metaprogram and the programmers of a program are functionaries of this metaprogram" (Flusser 2000, 29).

5. "As cultural objects became increasingly cheaper, and machines and tools increasingly more expensive, one tended to believe that those who owned the machines and the tools held the power of decision. This belief is one of the roots of Marxism. But as it became evident that 'shape' and 'value' are synonymous, that it is the toolmakers who shape the future of society, this belief shifted. It is now the toolmakers ('information programmers') who are believed to hold the power of decision. (Flusser 1986, 329).

2. The Distributed Apparatus

In the case of photography, however, the question of programming is often elusive, for two main reasons. The first is perhaps easier to explain: a photographic apparatus, construed in the strictest sense possible, most often contains components that are not located within a single space. Rather, it is always a whole composed of many different components that can be spatially clustered, but most often are not. Even the simplest photographic apparatus is composed of a physical body, usually with a lens, a controller or processor, which need not be physically attached to the body, and some other necessary 'protocol'. The latter includes the environment where the photographs can be produced. Previously this used to be called a 'darkroom';[6] nowadays it is called a computer screen. Thus, the various components of a photographic apparatus are often spatially dispersed, as well as temporally distributed. This means that whatever programming comes into play, it is not generally run by the photographer himself. Rather, it is outsourced and run elsewhere. As argued above, it is often run by programmers. Of those, some design the camera's architecture, others construct its hardware features and some, more recently, write its firmware and software.

6. In that regard, Adobe's decision to name their powerful photo-editing tool LightRoom cannot be understood as anything but a reference to or a joke at the expense of the history of photography.

In other words, the popular image of the photographer as a 'lone wolf' is mostly myth. This narrative probably originates from popular twentieth-century histories of photography. The best known of these, Beaumont Newhall's, is a carefully constructed work of fiction devised with the aid of Hollywood screenwriter Ferdinand Reyner (Hill and Cooper 2002, 407-408). Such emphasis on the unique sensibility of the photographer-as-protagonist has been consecrated by other twentieth-century histories of the medium. Consequently, to this day, it is individual photographic images that are routinely celebrated as markers of a photographer's unique genius. This renders the human photographer, most often the artist-photographer, the almost exclusive prism through which history views the broad sweep of photography, completely ignoring the apparatuses and programs that bring both photographs and photographers into being. Rather, I argue, photographs, at least since the late nineteenth century, are never the result of a one-man show, but always the result of significant external programming.

3. The Horizontal Photographer

To highlight this point let me discuss the work of one of the only photographers that, to my understanding, critically engages with these questions. Since 1977, Aïm Deüelle Lüski has been using pinhole cameras – familiar photographic apparatuses still popular amongst artists and educators. These cameras do not contain an aperture accommodating the human eye, and consequently photographers using them are unable to 'frame' their 'shot' accurately. Pinhole cameras also do without proper optical lenses and so the images they generate are never formed tracelessly. Instead, they maintain an intrusive presence reminiscent of the shape, edges and overall materiality of the pinhole.

Beyond such usage over a forty-year career being rare in itself, Deüelle Lüski's cameras are unique in that they are hand-made and custom-built from start to finish, meaning that he uses sculptural techniques to construct the 'body' of the camera and dental drills to open 'lens' apertures in the body. Furthermore, these cameras may contain not one but multiple pinhole openings, all designed to admit light at the moment of exposure.[7] This generates decentred, blurred, abstract images with many focal points.

7. Information collected from conversations and personal correspondence (Deüelle Lüski 2009–2015).

Conceivably, Deüelle Lüski's project is characterized by a certain indifference towards the classic products of photography, namely photographs. He is not indifferent to his products but rather to the ability much celebrated by 'professional photographers' to plan what will be inscribed in their photographs and to control it in the commonplace way in which a pre-existing, mostly commercially available camera becomes the means to capture an image. For Deüelle Lüski, photographs are little more than a side effect of a one-off device he manually constructs in response to a philosophical problem.

What's more, Deüelle Lüski insists on devising such a new camera for every shoot. This means that he spends weeks or months, or even longer, designing and building a camera that will then be used for no more than a day. Such a work process is, from the standpoint of most photographers, ridiculous. It is, we could say, as outrageous as building a new hammer for every nail. But it is this Sisyphean task that Deüelle Lüski is interested in. He explains this as an attempt to address a philosophical issue: 'It all began the moment I realized one cannot turn the same device at the world in different situations, cannot go on using the familiar device used by all photographers as if it has no essence of its own' (quoted in Azoulay 2013, 26).

Clearly, this statement echoes Flusser's statement that:

> “A philosophy of photography is necessary for raising photographic practice to the level of consciousness, and this is again because this practice gives rise to a model of freedom in the post-industrial context in general. A philosophy of photography must reveal the fact that there is no place for human freedom within the area of automated, programmed and programming apparatuses [...]. The task of a philosophy of photography is to reflect upon this possibility of freedom [...] in a world dominated by apparatuses [...]” (Flusser 2000, 81-82).

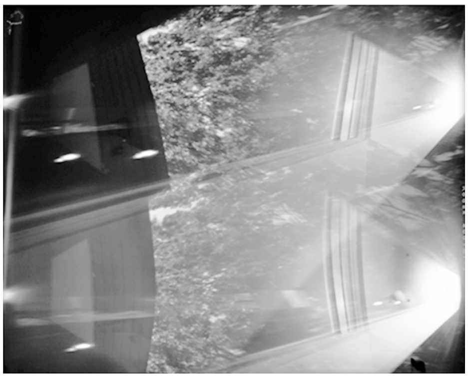
In 1998, Deüelle Lüski went on to build a 'horizontal camera'. This ended up providing the entire project with its raison d'être – systematic criticism of the vertical in photography (figs. 2-5). By 'vertical', Deüelle Lüski refers to the practice, prevalent since the invention of perspective, of having the image form on a vertical plain opposite the lens opening – whether a wall, a sheet of film or a digital sensor. In contrast, the main characteristic of Deüelle Lüski's practice is the horizontal placement of the negative, or often negatives, within the camera. This causes the image to be exposed to more light on the edge abutting the aperture, and to receive significantly less light on the farther side. The resulting images are not only non-perspectival but also usually obscurantist. Nevertheless, this does mean that the vertical position selected in the past has always been but one possibility. Deüelle Lüski's horizontal photography can thus be understood as problematizing all other forms of photography in that it shows that its components are possible solutions to a single problem: how to produce referential pictures.

Fig. 2. Aïm Deüelle Lüski, Horizontal Camera, 1998.

Fig. 3. Aïm Deüelle Lüski, The Hasan-Bek Mosque, Jaffa, 1998 (with Horizontal I camera).

Fig. 4. Aïm Deüelle Lüski, Horizontal II Camera, 2011.

Fig. 5. Aïm Deüelle Lüski ,
Rama's Window #2, 2011
(with Horizontal II camera).



As unique as this process is, it is nevertheless not free of external programming. Deüelle Lüski has always used commercial film and photo-paper. Either way, his work is, as I have implied, the exception that proves the rule. All other photographers are committed to greater degrees of pre-programming. It is this condition, I argue, that defines photography as well as post-photography.

One all-too-logical conclusion from the above narrative may unfortunately be this: if the program always subsumes the human photographer's intentionality (or, as it is elsewhere called, 'subjectivity') it follows that his or her presence may not always be necessary. The increasing role of automatic production and distribution in photography gives this question a sense of urgency it has not always had. It has rightly been argued that 'since automation removes decision making from the photographer it has also resulted in situations that render the agency of the photographer more or less obsolete' (Palmer 2013, 50). Should we then abandon the myth of 'artistic authorship' with respect to photographic information? Most camera operators will undoubtedly settle for the term 'photographer', which, to reiterate, is not all that different from being 'a computer'. However, artists not satisfied with the title 'photographer' must aspire to become 'photo-programmers', 'photographic makers' or, as Flusser calls them, 'envisioners'. They cannot but seek to reinvent the parameters, the program and the prospects of their apparatus.

References

Azoulay, Ariella.
2013. Aïm Deüelle Lüski and Horizontal Photography. Translated by Tal Haran, Lieven Gevaert Series. Leuven, Belgium: Leuven Univ. Press.

Clark, Andy.
2009. "Technologies to Bond With." In Rethinking Theories and Practices of Imaging, edited by Timothy H. Engström and Evan Selinger, 164–183. London: Palgrave Macmillan.

Deüelle Lüski, Aïm.
2009–2015.
Personal Communications with the Author.

Flusser, Vilém.
1986. "The Photograph as Post-Industrial Object: An Essay on the Ontological Standing of Photographs." Leonardo 19 (4):329–332.

Flusser, Vilém.
1998. Lob der Oberflächlichkeit: für eine Phänomenologie der Medien. Köln: Bollmann.

Flusser, Vilém.
1999. The Shape of Things: A Philosophy of Design. London: Reaktion.

Flusser, Vilém.
2000. Towards a Philosophy of Photography. Translated by Anthony Mathews. London: Reaktion.

Flusser, Vilém.
2011a. Into the Universe of Technical Images. Translated by N.A. Roth. Minneapolis: Univ. of Minnesota Press.

Flusser, Vilém.
2011b. "Our Programme." Philosophy of Photography 2 (2):205–209.

Flusser, Vilém.
2013. "The Democratization of Photography." In Something Other Than Photography: Photo & Media, edited by Claudia Giannetti, 132–133. Oldenburg: Edith-Russ-Haus for Media Art. Original edition, A democratizacao da fotografias.

Hill, Paul, and Thomas Cooper, eds.
2002. Dialogue with Photography: Interviews by Paul Hill and Thomas Cooper. Stockport, UK: Dewi Lewis Publishing.

Kittler, Friedrich A.
2006. "Thinking Colours and/or Machines." Theory, Culture & Society 23 (7-8):39–50.

Palmer, Daniel.
2013. "Redundant Photographs: Cameras, Software and Human Obsolescence." In On the Verge of Photography: Imaging Beyond Representation edited by Daniel Rubinstein, Johnny Golding and Andy Fisher, 49–68. Birmingham, UK: ARTicle Press.

Turing, Alan M.
1936. "On Computable Numbers, with an Application to the Entscheidungsproblem." Proceedings of the London Mathematical Society 42 (2):230–65.

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Post-Digital Aesthetics in Contemporary Audiovisual Art

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This paper examines the current tendency to theorize our contemporary times pervaded by digital technologies and media as 'post-digital'. It discusses the different understandings of this term and its relationship to other concepts that not only seek to define a contemporary aesthetics but also the current condition from which it emerges. In order to frame the main traits of a post-digital culture of artistic production, the paper starts by addressing the concept of the post-digital as aesthetics of failure. It then considers the changing conceptions of the term and related artistic approaches that gradually shift their focus on the digital medium's infrastructure towards the broader socio-cultural effects of the ubiquity of computational technologies. According to this view, we highlight how a contemporary post-digital culture of audiovisual production explores two main forms of hybridity pertaining to merging digital and analogue media and conflating digital and physical realms.

1. Introduction

The beginning of the 21st century is marked by a saturation of new digital media technologies that have become part of everyday life, such as portable smart devices, high definition screens, unified networked experiences and technology normalizations that transform human perception and influence models of artistic creation. The term post-digital is often used to describe this environment of "computational abundance whereby our everyday lives and the environment that surrounds us are suffused with digital technologies" (Berry 2014, 22).

However, the term 'post-digital' was first introduced by the composer Kim Cascone to emphasize a novel kind of exploration of glitch as an "aesthetics of failure" emerging in the 1990s. Since then, the concept has shifted from the context of digital music to encompass a broader set of artistic practices that critically address the fact that "the computational has become hegemonic" and it becomes increasingly difficult to encounter "culture outside of digital media" (Berry 2014, 26). In this sense, the term became used to define aesthetic manifestations of the post-digital as a current condition wherein distinctions between digital and analogue media, or being online and offline, become increasingly blurred.

This paper discusses these different understandings of the post-digital in order to frame the main traits of a contemporary post-digital culture of audiovisual production. To this end, it starts by addressing the notion of the post-digital as tied to an aesthetics of failure, glitch and errors, and related artistic methodologies. It then examines how the term post-digital is gradually appropriated and related to other notions that similarly reflect the cultural and aesthetic effects of the pervasiveness of digital technologies. Focusing on cultures of audiovisual production that react to uncritical notions of digitality and resist media technology-based labels, this paper discusses how these practices engage hybridity by merging media and conflating digital and physical realms.

2. An Aesthetics of Failure

When Kim Cascone first used the term post-digital he sought to highlight how the internet facilitated a "new movement in digital music", characterized by a "collection of deconstructive audio and visual techniques that allow artists to work beneath the previously impenetrable veil of digital media". This implied bringing the "background" of media to the fore by defying the normal functions and uses of software (Cascone 2000):

> "The 'post-digital' aesthetic was developed in part as a result of the immersive experience of working in environments suffused with digital technology: computer fans whirring, laser printers churning out documents, the sonification of user-interfaces, and the muffled noise of

hard drives. But more specifically, it is from the 'failure' of digital technology that this new work has emerged: glitches, bugs, application errors, system crashes, clipping, aliasing, distortion, quantization noise, and even the noise floor of computer sound cards are the raw materials composers seek to incorporate into their music.” (Cascone 2000, 12-13)

In the hype of the late 1990s high-tech commercialization and digital technology marketization, computer music artists approached glitches and errors in their compositions with the intent to "reject the idea of a digital revolution as the progress towards perfect representation" (Andrews 2002). The disruption of the idea of 'perfect representation' questions the belief in digital technology as a synonym for technical quality and higher-definition, or in "transparency" and "immediacy" by "ignoring or denying the presence of the medium and the act of mediation" (Bolter & Grusin 2000, 11). Rather, within this culture of audio-visual production artists engaged in revealing and forging glitch artefacts as a critical strategy to expose the materiality of the digital medium. As Cascone explains, this represented a new (post-digital) approach to the creative exploration of glitch in its complex lineage.

2.1. Glitch Art Practices

Acknowledging this complex lineage, we can trace back glitch art to different procedures and processes explored by pioneers of early audiovisual media art. Some works created by artists such as Nam June Paik or Steina and Woody Vasulka explore glitches with analogue electronic media such as audio and video synthesizers and processors of the 1960s and 1970s. These practices are nevertheless informed by earlier physical manipulations of analogue media in experimental music or film from the first half of the 20th century. Considering the diversity of glitch, digital media scholar Iman Moradi categorizes glitches into "Pure Glitch" and "Glitch-alike". The first is described as an "unexpected result of a malfunction" and the latter as "a collection of digital artefacts that resemble visual aspects of real glitches found in their original habitat" (Moradi 2004, 9-10). Instead of subjecting glitch to Moradi's binary categorization, art theorist and visual artist Rosa Menkman describes glitch as follows:

> “[...] a (actual and/or simulated) break from an expected or conventional flow of information or meaning within (digital) communication systems that results in a perceived accident or error. A glitch occurs on the occasion where there is an absence of (expected) functionality, whether understood in a technical or social sense. Therefore, a glitch, as I see it, is not always strictly a result of a technical malfunction.” (Menkman 2011, 10)

In this sense, a glitch is both the product of malfunction and artificial creation. Glitch artefacts are produced through signal or process corruption and by designing dysfunction, often combining different experimental methods that "challenge user experiences with digital media" (Dragona 2016, 192).

According to this idea, creative practices can explore glitch by hacking or experimenting with hardware, data manipulations or even custom software. For example, the practice of circuit bending physically modifies the electronic circuits within the black boxes (the hardware), as seen in the work *Super Mario Clouds* (2002) by the artist Cory Arcangel, or in *The Royal Touch* (2014) by the composer Nicolas Collins. Using feedback systems, audio and/or visual artefacts can be generated through feedback loops, as exemplified in the work *The Collapse of PAL* (2011) by Rosa Menkman. The techniques of databending and datamoshing explore glitch artefacts by manipulating digital data; the former through editing hexadecimal or raw data in a text editor, the latter through compression and its different codecs, as seen in the work *Monster Movie* (2005) by the artist Takeshi Murata.

Likewise, the technique of pixel sorting transforms horizontal or vertical lines of pixels that result in perceivable errors. Data manipulation techniques can be achieved through manual processes or by using scripts or programming. The creation of custom software is also used to produce intentional glitches, such as the online platform *Hydra* (2018) developed for live coding of real-time visuals by the artist Olivia Jack, as well as through hacking and modifying pre-existing software, as in *Untitled Game* (1996-2001) by JODI (artist duo Joan Heemskerk and Dirk Paesmans).

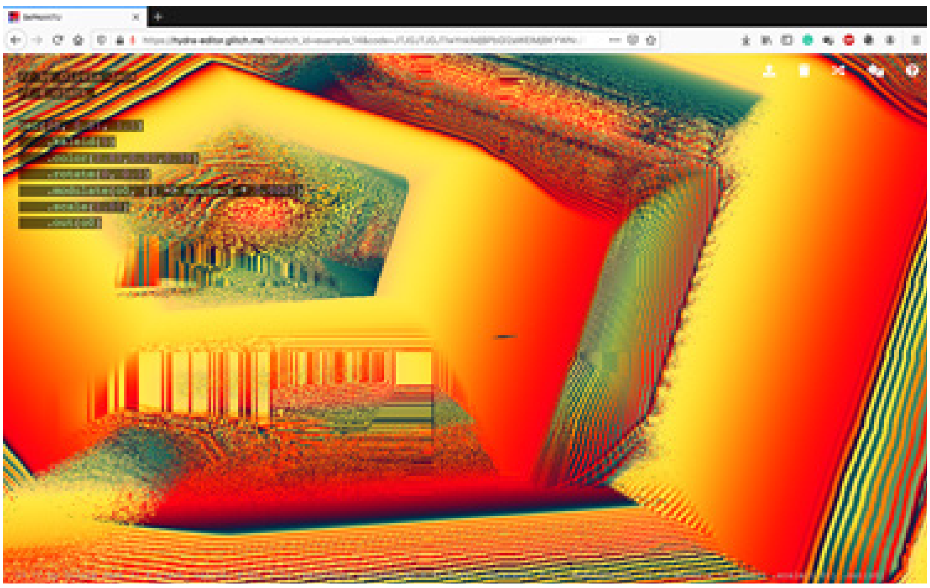

Fig. 1. *Hydra* (2018) by Olivia Jack. Online live coding platform screenshot.

These practices are aligned with a post-digital aesthetics as artistic strategies that ultimately seek to bring to the surface "the digital medium's subsurface" to focus on its infrastructure by routing the "inframedia" layer out into the sensorium, as "a reminder of materiality, a collapsing of representational transparency" (Whitelaw 2004).

2.2. The Critical Role of Glitch

The critical role of Glitch in promoting awareness of the materiality and infrastructure of audiovisual media is also discussed by theorist Michael Betancourt, who argues that it is "not simply an interruption of functional continuity in the media work" (2017, 128). In order for glitch to work as a critical element, the audience has to be able to recognize it as an intended feature of the work, and not as an actual technical failure. The audience has to understand the glitch's role "as disruption — the semiotic role that a specific glitch has in determining the meaning of the work compared with other works" (Betancourt 2017, 160).

This is the case with the "deconstruction of digital files" mentioned by Cascone (2000, 16) which indicates "a formal demonstration of the data-stream" as the "fundamental material for digital art" (Betancourt 2017, 106). In this sense, works such as *Super Mario Clouds* or *Untitled Game* express a desire not only to engage with the digital medium's infrastructure, but also to challenge the user's assumptions of the experience of digital media. Instead of merely formal or stylistic experiments in technological failure, these strategies render apparent the "disembodied technological instrumentalism of the digital" otherwise eluded by "illusions of perfection, transparency and immediacy" (Betancourt 2017, 162).

Without this semiotic function, there is no critical rupture. However, glitch has become a trivial formal aesthetic that can be easily achieved through software presets, which remediate it as a common sound and/or visual effect. This trivialization of glitch *effects* as mere appearance neutralizes the role of glitch in bringing to the surface and interface level the constraints and limitations of the experience of digital media. Through their deconstruction and repurposing, the perceivable glitch artefacts signify indexically the invisible layers of computational processes that are usually hidden inside the black box.

2.3. Beyond Digitality

The concept of the post-digital then reflects a critical engagement with media technologies, by defying their normal functions and use and exposing their infrastructure and materiality. However, "the very computational materiality of today's visual media is hidden beneath layers of user-friendly software, hardware, networks, cloud-based processing and storage services" (Mirocha 2015, 58). This is to say that the materiality of today's digital media devices, permanently connected to communication networks and the internet, is not reducible to, or exposed through, glitches. Therefore, a "glitch does not reveal the true functionality of the computer, it shows the ghostly conventionality of the forms by which digital spaces are organized" (Goriunova & Shulgin 2008, 114).

The materiality of digital and computational media is likewise "not reducible to the screen, not to software, and not even to hardware. It is a massively distributed reality that in turn conditions our perceptual realities" (Bishop et al. 2016, 13). Therefore, the conception of the post-digital as an aesthetic reaction to a narrative of digital progress already suggests the loss of significance of the digital as a disruptive or comparative attribute, at a moment when digitality and computation become enmeshed in our daily lives.

Consequently, the term post-digital has been gradually appropriated to address the contemporary context of widespread computational media where digital technologies have become banal. It is now used to encompass the complexity of the different "modulations of the digital or different intensities of the computational" that bypass distinctions between digital and non-digital (Berry 2014, 26).

The term is then reframed to describe a post-digital condition and also to cover a broader set of aesthetic manifestations that critically address current contexts where "the computational has become hegemonic" and there is nearly no "culture outside of digital media"(Berry 2014, 26). The post-digital then involves artistic methods, techniques and practices that go beyond an aesthetics of failure to express new hybrid digital and non-digital forms that seek "to make tangible the ever-elusive relationships between technology, society, and culture" and try to raise awareness of "the material complexities of digital culture beyond the clichés of zeros and ones" (Bishop et al. 2016, 13–16).

3. Post-Digital, Post-Internet and New Aesthetic

According to scholars Berry and Dieter, our current life in computational societies inspires the search for new concepts, such as 'Post-internet' and 'New Aesthetic', which are devised to describe artistic approaches that critically engage the effects of a contemporary life suffused with digital computational technologies. These notions are associated with the post-digital, as "attempts to grapple with the immersive and disorientating experiences of computational infrastructures as they scale up and intensify (Berry & Dieter 2015, 4). They emerge to highlight that "as ubiquitous computational infrastructures radiate data, they encourage tacit modes of knowing and the iteration of habit", therefore, directing us "towards a passive trust in widely delegated, yet obfuscated, actions" which "may undermine structures of reflection and critique" (Berry & Dieter 2015, 5).

3.1. Post-Digital and Post-Internet

The term post-internet was first coined by artist Marisa Olson around 2008, referring to "works that engage with digital networking through hybrid, often offline, manifestations" (Berry & Dieter 2015, 5). As Olson explains, "the notion of the postinternet encapsulates and transports network conditions and their critical awareness as such, even so far as to transcend the internet" (Olson 2011, 61). The term was rapidly accompanied by other notions seeking to reflect on what internet art has become, such as art *after* the internet, *aware* of or *engaged* with the internet. In their shifting interpretations, they end up emphasizing a conceptual break with previous artistic engagements with the internet as a medium to highlight the broader cultural effects of its pervasiveness.

> "After the dot.com bubble and with the arrival of the Web 2.0, the internet started to be perceived less as a medium and more as a key part of our daily lives; less as a utopia to construct together, and more as a dystopia we are all part of, but that still provides interesting opportunities for networking and community making, and an unprecedented tool for "surfing" reality and getting a better understanding of it." (Quaranta 2015)

Thus, the disenchantment evoked by post-digital aesthetics echoes the post-internet, as an expression of a "shift from an earlier moment driven by an almost obsessive fascination and enthusiasm with new media to a broader set of affectations that now includes unease, fatigue, boredom and disillusionment" (Berry & Dieter 2015, 5).

These different labels underline how the present moment is shaped by digital technologies and, in particular, the internet as a given; "less a novelty and more a banality" (McHugh in Olson 2011). The increasing dilution of online and offline time brought about by the spread of mobile technologies also contributes to the notion that all culture is reconfigured by the internet. As such, these labels are also transferred from art to culture at large. As critic Michael Connor explains, "it no longer makes sense for artists to attempt to come to terms with 'internet culture', because now 'internet culture' is increasingly just 'culture'" (Connor 2014). The term post-internet then points to a particular symptom of the post-digital condition, or as scholar Katja Kwastek argues:

> "[...] the notion of the post-digital is used to acknowledge that, today, digital technology is deeply embedded in 'everyday life'. It serves to emphasize that 'the digital' is not as definite as we might assume: that it is no 'virtual reality' distinct from our everyday world, but a constitutive part of it." (Kwastek 2015, 79)

3.2. Post-Digital and New Aesthetic

Another notion that relates to the effects of the increasing ubiquity of digital technology on culture is the New Aesthetic term coined by artist James Bridle in 2011 as an attempt to contextualize the visible influence of computation and the internet in everyday life. It refers to "situations where imageries and structures that are usually associated with the digital networked computer are superimposed on—or leak out into—the physical world" (Andersen & Pold 2015, 271).

Scholars Andersen and Pold note that the 'new' in New Aesthetic "carries traces of a historical compulsion to define digital media as new [...]. 'New media' was a catchphrase during the 1990s and early 2000s alluding to the convergence of computational and audio-visual media in multimedia computers" (Andersen & Pold 2015, 275), where the word 'new' stands for 'better'. Adding to this connotation of newness, Kwastek argues that while "postness insinuates some kind of reflective distance and disenchantment, newness implies a considerable amount of fascination, or, at least, wonder" (Kwastek 2015, 79-80). Andersen and Pold also suggest how the notion of the New Aesthetic must go beyond observable effects or the sensory domain by focusing on the underlying technological structure in order to "point to how the technologies themselves are also cultural constructs" (Andersen & Pold 2015, 277). This means that for a New Aesthetic to be significant it has to attempt to reveal how cultural constructs of technologies propagate former ideologies, power relations and cultural biases.

Post-internet art and New Aesthetic are thus related concepts in that both attempt to reflect how digital technology becomes embedded within the physical world. Nonetheless, post-internet art gives emphasis to the internet as the particular medium of influence on material instances or objects in the physical world. In other words, the term post-internet can be seen as a product of the present as "inherently informed by [...] the collapse of physical space in networked culture, and the infinite reproducibility and mutability of digital materials" (Vierkant 2010). The new aesthetic, in turn, scratches the surface of digital technology but, as Kwastek argues, it is "ultimately no more and no less than a post-digital aesthetics" highlighting the merging of digital and material realms while emphasizing "its perceivable effects" (Kwastek 2015, 79).

In sum, these terms underline how our perception and experience of reality is shaped by the ubiquity of digital technologies, or in particular the internet, as an indicator of a broader condition characterized by the inevitability of computational technologies and the need for a critical stance toward this phenomenon:

> “'post-digital' art, design and media—whether or not they should technically be considered post-digital—challenge [...] uncritical notions of digitality, thus making up for what often amounts to a lack of scrutiny among 'digital media' critics and scholars” (Cramer 2014, 20).

4. Towards Hybridity

The uncritical notions of digitality that scholar Florian Cramer describes evoke the loss of fascination or "disenchantment with digital information systems and media gadgets" that shifts from a "niche phenomenon" to a "mainstream position" (Cramer 2014, 12-13). Consequently, the post-digital defines "a condition in which digital disruption is not transcended as such, but becomes routine or business as usual" (Berry & Dieter 2015, 5). The post-digital is best understood not as the *end of* or *after* the digital, but as the continuation of the digital in its "subtle cultural shifts and ongoing mutations [...] after the initial upheaval caused by the computerization and global digital networking of communication technical infrastructures, markets and geopolitics" (Cramer 2014, 13).

Artistic practices associated with the post-digital label not only reject techno-positivist innovation narratives but also try to bypass media based labels. They do so by shifting their creative focus on the digital medium's infrastructure towards the forging of hybrid media forms that are not easily classifiable as analogue or digital and that merge digital and material realms. As such, a post-digital art practice often draws on artistic methodologies guided by principles of deconstruction, hacking or subversion of media technologies to unveil their inherent mechanisms and processes:

> "It tends to focus on the experiential rather than the conceptual. It looks for DIY agency outside totalitarian innovation ideology, and for networking off big data capitalism. At the same time, it already has become commercialized." (Andersen, Cox & Papadopoulos 2014, 5)

4.1. DIY Practices, Neo-Analogue and Digital Maker

The digital maker and neo-analogue media practitioner are part of "one and the same post-digital culture" (Cramer 2012), which reinforces DIY practice as a "hacker attitude of taking systems apart and using them in ways which subvert the original intention of the design" (Cramer 2014, 18).

The digital making and hacking cultures of artistic production can be seen as alternatives to, and resistance against, the corporate state of digital technology, where software, hardware and the internet are controlled by a few corporations that subject their users to passive consumption. These cultures defy a conception of the user as largely "unaware of the computer as a system that is programmed, that can be reprogrammed at any moment, and that could potentially be programmed or reprogrammed by its users" (Lialina 2016, 137).

Adding to the do-it-yourself attitude, neo-analogue practices also explore analogue media devices and offline manifestations in a reaction to structures of control and online surveillance. But, as Cramer argues, rather than mere nostalgic revivalism of older media technologies, they become meaningfully post-digital when they "functionally repurpose them in relation to digital media technologies" (Cramer 2014, 18). In this way, neo-analogue practices result in digital analogue media hybrids, while the digital maker and hacker practices approach audiovisual creative production through digital-physical combinations.

4.2. Beyond the Screen

This kind of merging of digital and material realms can also be related to the need of "developing ways to see beyond the screen", as theorist Josephine Bosma proposes. She argues that "'hidden structures, like network technologies, code and software processes" are the basis of media arts, which go largely beyond "a straightforward, retinal view" by questioning "boundaries between technological and socio-cultural domains" or how technological concepts penetrate life and culture (Bosma 2014, 109-113). Accordingly, theorist Mel Alexenberg suggests to move away from a single-point perspective in order "to explore post-digital perspectives emerging from creative encounters between art, science, technology, and human consciousness" and also question the divide between making and displaying art through collaboration, participation and interaction (Alexenberg 2011, 9).

Therefore, the audiovisual media hybrids and digital-physical combinations resulting from DIY practices, neo-analogue and digital maker cultures seem to emphasize how the post-digital condition is one, where "computation becomes experiential, spatial and materialized in its implementation, embedded within the environment and embodied" (Berry & Dieter 2015, 3), thus palpable and manipulable in various ways.

We can see how these forms of media hybridization are reflected, for example, in the audiovisual installation *Illuminations* (2013) by the artist Vibeke Sorensen, where projections of abstract visuals and sound are generated by the interaction with the audience and plants, both becoming actors in the creation of the audiovisual environment. Similarly, the networked installation *Biotricity* (2012) by the artists Rasa Smite and Raitis Smits, created in collaboration with the artist Voldemars Johansons, presents a real time visualisation and sonification of bacteria by means of a bacteria battery that stands on a table in front of a screen where the video presents images of bacteria and is manipulated live by the sound. Additionally, the audiovisual performance *Data.Nature.Anagenesis* (2016–18) by Hyungjoong Kim, seeks to deconstruct the single-point perspective of the screen by combining lights that are wearable through a self-made jacket as well as a number of strobe lights that act as part of the performance.

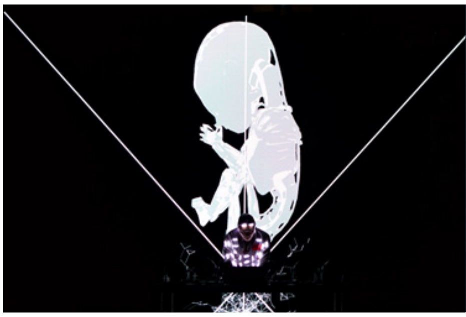

Fig. 2. *Data.Nature.Anagenesis* (2016-18) by Hyungjoong Kim. Audiovisual Performance at TADAEX, Tehran, Iran (2018).

Fig. 3. *UTopologies* (2017-20) by S4NTP (Society For Nontrivial Pursuits). Audiovisual Installation at Distopya Sound Art Festival, Istanbul, Turkey (2019).

The project *UTopologies* (2017–20) created by the collective S4NTP (Society For Nontrivial Pursuits, the group around Alberto de Campo and Hannes Hoelzl), presents different audiovisual machines installed and networked around the space. They generate audiovisual patterns autonomously, communicate with each other, capture live sound and are open to human participation through live coding.

These works explore media combinations that break the single perspective or display while involving multiple interactions with the environment and audience as constitutive parts of the work. As such, they devise digital-physical hybridizations that are not reducible to the digital computational realm and its code poetics or digitality. Rather, their poetics is influenced by both human and non-human agents while merging digital and physical realms.

5. On Post-Digital Aesthetics

In order to conclude on these aesthetic manifestations of the post-digital condition, it is useful to address different perspectives on aesthetics in the sense that aesthetics does not refer to the artefact as artistic production but to its subjective experience. Accordingly, scholar Lotte Philipsen argues that the "tendency to understand aesthetics in a technologically pre-fixed manner" projects aesthetics onto the technical qualities of the work and tends to subject "aesthetic experience to technology or equating it with poetics", but it is important to acknowledge that this is a matter of poetics (Philipsen 2014, 124–125). Philipsen then contrasts digital and post-digital "perspectives on aesthetics", meaning that a "digital perspective's notion of aesthetics" points to "an overall techno-essentialist character", while a "post-digital perspective [on aesthetics] takes a post-technological and post-media point of departure" (Philipsen 2014, 127).

This point of departure is reflected in the artistic methodologies that blur established dichotomies between old and new media, online and offline, digital and physical realms, drawing on the deconstruction, hacking or repurposing of media technologies to unveil their inherent mechanisms and processes as well as the social-cultural effects of their pervasiveness. In this manner, DIY practices, neo-analogue and digital maker cultures tend to challenge common assumptions about media technologies and "disrupt and challenge user experiences with digital media" (Dragona 2016, 186). To this end, they explore the hybridization of digital and analogue media or forge digital-physical combinations that are not reducible to digitality but embody the computational and make it tangible "and operable through a number of entry-points, surfaces and veneers" of interaction and participation (Berry & Dieter 2015, 3).

This paper sought to highlight how these practices explore two main strands of hybridization in their poetics and resulting post-digital aesthetics. One that engages the post-digital condition by rejecting the "new" through the functional repurposing of analogue media with digital computational technologies, according to a move from fascination towards disenchantment. The other is a form of hybridization explored by hacking and making cultures of artistic production that deconstruct and subvert media technologies, their hidden structures and processes, exploring new modes of materiality that blend the digital with the non-digital as part of the same reality. Often breaking with the single-point perspective of the display, these making cultures also react to institutionalized modes of artistic production and reception, though collaboration, participation and interaction.

In this sense, these cultures of audiovisual production also relate to what scholar Matt Ratto calls ‘critical making’, as a methodology that explores the intersection between digital technologies and the human, and between online and offline modes of production (Ratto 2011). In this manner, digital-physical hybrids emphasize “critique and expression rather than technical sophistication and function” (Ratto 2011, 253).

Post-digital aesthetics then reflects “the digital and non-digital, finding characteristics of one within the other, deliberately mixing up processes of making things discrete, calculable, indexed and automated in unorthodox ways” (Berry & Dieter, 2015, p. 6). This subversive attitude denotes a critical engagement with digital computational media as a key part of our daily lives; as “a cultural reference, and an environment, rather than a medium” (Quaranta 2015).

Accordingly, post-digital aesthetics expresses a post-technological and post-media artistic approach that can be related to what scholar Alexander Galloway generalizes as artists working “‘on’ the digital or ‘within’ it”, according to a modern and to a post-modern or non-modern approach. This means that while “in the former, one’s attention is directed from the outside in, taking the medium itself as its object, the latter takes the perspective of the medium itself, radiating attention outward to other contexts and environments” (Galloway, 2016). Through a set of artistic methodologies that critically engage media technologies as an act of resistance, post-digital aesthetics then moves between the digital medium’s infrastructure and the cultural and social effects of its pervasiveness in everyday life.

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References

Alexenberg, Melvin L.
2011. *The Future of Art in a Postdigital Age: From Hellenistic to Hebraic Consciousness.* 2nd ed. UK, Bristol/USA, Chicago: Intellect.

Andersen, Christian U. & Pold, Spren B.
2015. “Aesthetics of the Banal - ‘New Aesthetics’ in an Era of Diverts Digital Revolutions.” In *Postdigital Aesthetics: Art, Computation and Design,* David M. Berry and Michael Dieter (eds.), pp. 271-288. Hampshire, New York: Palgrave Macmillan.

Andersen, Christian Ulrik, & Cox, Geoff, & Papadopoulos, Georgios.
2014. “Editorial Postdigital Research” *A Peer-Reviewed Journal About: Post-Digital Research.* Vol. 3 No. 1., p. 5. https://aprja.net//article/view/116067/164246, date accessed 3 May 2020.

Andrews, Ian.
2002. *Post-digital Aesthetics and the Return to Modernism.* MAP-uts lecture. http://www.ian-andrews.org/texts/postdig.html, date accessed 3 May 2020.

Berry, David M. & Dieter, Michael.
2015. “Thinking Postdigital Aesthetics: Art Computation and Design.” In *Postdigital Aesthetics: Art, Computation and Design,* David M. Berry and Michael Dieter (Eds.), pp. 1-11. Hampshire, New York: Palgrave Macmillan.

Berry, David.
2014. “Post-digital humanities: computation and cultural critique in the arts and humanities”. *Educause Review* 49 (3). https://er.educause.edu/-/media/files/article-downloads/erm1433.pdf, date accessed 3 May 2020.

Betancourt, Michael.
2017. *Glitched Art in Theory and Practice: Critical Failures and Post-Digital Aesthetics.* New York, London: Routledge.

Bishop, Ryan, & Gansing, Kristoffer, & Parikka, Jussi.
2016. “Introduction.” In *Across & Beyond – A transmediale Reader on Post-digital: Practices, Concepts, and Institutions.* Bishop, Ryan, & Gansing, Kristoffer, & Parikka, Jussi (eds.), pp. 13-23. Germany, Berlin: transmediale e.V. and Sternberg Press.

Bolter, Jay D., & Grusin, Richard.
2000. *Remediation, Understanding New Media.* USA, Cambridge, MA: MIT Press.

Bosma, Josephine.
2014. “Post-Digital Is Post-Screen: Arnheim’s Visual Thinking Applied to Art in The Expanded Digital Media Field.” *A Peer-Reviewed Journal About: Post-Digital Research.* Vol. 3 No. 1., pp. 106-118. https://aprja.net//article/view/116091/164262, date accessed 20 January 2020.

Cascone, Kim.
2000. “The Aesthetics of Failure: ‘Post-Digital’ Tendencies in Contemporary Computer Music.” *Computer Music Journal.* V. 24:4, pp. 12-18, Winter. USA, Massachusetts Institute of Technology.

Connor, Michael.
2014. “Post-Internet: What It Is and What it Was.” In *You Are Here: Art After the Internet*, edited by Omar Kholeif, 56-64. Manchester: Cornerhouse and SPACE.

Cramer, Florian.
2012. “Post-Digital Writing”. *Electronic Book Review,* December 12. http://electronicbookreview.com/thread/electropoetics/postal, date accessed 3 May 2020.

Cramer, Florian.
2014. “What Is ‘Post-digital’?” *A Peer-Reviewed Journal About: Post-Digital Research.* Vol. 3 No. 1., pp. 10-24. https://aprja.net//article/view/116068/165295, date accessed 3 May 2020.

Dragona, Daphne.
2016. “What Is Left to Subvert: Artistic Methodologies for a Post-Digital World.” In *Across & Beyond – A transmediale Reader on Post-digital: Practices, Concepts, and Institutions.* Bishop, Ryan, & Gansing, Kristoffer, & Parikka, Jussi (eds.), pp. 13-23. Germany, Berlin: transmediale e.V. and Sternberg Press.

Galloway, Alexander R.
2016. *Jodi’s Infrastructure*. e-flux Journal #74. https://www.e-flux.com/journal/74/59810/jodi-s-infrastructure, date accessed 3 May 2020.

Goriunova, Olga, & Shulgin, Alexei.
2008. “Glitch.” In *Software Studies: A Lexicon.* Matthew Fuller (Ed.), pp. 110-118. USA, Cambridge, MA: MIT Press.

Kwastek, Katja.
2015. “How to be Theorized. A Tediously Academic Essay on the New Aesthetic.” In *Postdigital Aesthetics: Art, Computation and Design,* David M. Berry and Michael Dieter (eds.), pp. 72-85. Hampshire, New York: Palgrave Macmillan.

Lialina, Olia.
2016 “Not Art&Tech.” In *Across & Beyond – A transmediale Reader on Post-digital: Practices, Concepts, and Institutions.* Bishop, Ryan, & Gansing, Kristoffer, & Parikka, Jussi (eds.), pp. 135-145. Germany, Berlin: transmediale e.V. and Sternberg Press.

Menkman, Rosa.
2011. *The Glitch Moment(um).* Netherlands, Amsterdam: Institute of Network Cultures.

Mirocha, Lukasz.
2015. “Communication Models, Aesthetics and Ontology of the Computational Age Revealed.” In *Postdigital Aesthetics: Art, Computation and Design,* David M. Berry and Michael Dieter (eds.), pp. 58-71. Hampshire, New York: Palgrave Macmillan.

Moradi, Iman.
2004. *Glitch Aesthetics.* (Bachelor’s Thesis). UK: University of Huddersfield. http://www.organised.info/wp-content/uploads/2016/08/Moradi-Iman-2004-Glitch-Aesthetics.pdf, date accessed 3 May 2020.

Olson, Marisa.
2011. “Postinternet: art after the internet.” *Foam Magazine 29*, Winter, pp. 59-63. https://www.academia.edu/26348232/POSTINTERNET_Art_After_the_Internet, date accessed 3 May 2020.

Philipsen, Lotte.
2014 “Who’s Afraid of the Audience? Digital and Post-digital perspectives on Aesthetics,” In *A Peer-Reviewed Journal About: Post-Digital Research.* Vol. 3 No. 1., pp. 106-118. https://aprja.net//article/view/116092/164263, date accessed 3 May 2020.

Quaranta, Domenico.
2015. “Situating Post Internet.” In *Media Art: Towards a New Definition of Arts in the Age of Technology*, edited by Valentino Catricalà, 121-134. Pistoia: Gli Ori.

Vierkant, Artie.
2010. The Image Object Post-Internet. *Jst Chillin*. http://jstchillin.org/artie/pdf/The_Image_Object_Post-Internet_a4.pdf, date accessed 3 May 2020.

Ratto, Matt.
2011. "Critical Making: Conceptual and Material Studies in Technology and Social Life", *The Information Society: An International Journal*, 27:4, pp. 252-260. http://dx.doi.org/10.1080/01972243.2011.583819

Whitelaw, Mitchell.
2004. "Hearing Pure Data: Aesthetics and Ideals of Data-Sound." In *Unsorted: Thoughts on the Information Arts: An A to Z for Sonic Acts*. Altena, Arie (ed.), pp. 45-54, Amsterdam: Sonic Acts/De Balie.

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Exploratory Modelling with Speculative Complex Biological Systems

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Keywords: Generative Art, Performance, Creativity, Creativity Support Tools, Complex Networks, Exploratory Modelling, Creative Coding Pedagogy, Philosophy of Science.

We present a specific performance with a speculative complex biological simulation in the terms of exploratory modelling in scientific practice. The simulation, which adapts a model of acellular slime mold *Physarum polycephalum*, challenges the locus of agency during the performance. This powerful performative agency arises from the persistence of state and feedback mechanisms of this complex network system. To understand how agency shifts, and how the performance relates to the underlying biological system being modeled, we use the *scribe-system-representation* framework. We motivate the use of scientific work as a rich, generative basis for creative coding projects, which we see as a vital mode of engagement with contemporary scientific work and process. This article provides conceptual tools and some practical examples to explore this avenue in artistic as well as pedagogic practice.

1. Introduction

Phenomena representable by complex networks are pervasive in the world today, from the smallest to the largest of scales. Notable examples include biological systems like slime mold, as used in this paper; the multi-scale movement and migration of humans; the structure of the internet; and the interlocking feedback systems that influence the global climate. The nonlinear dynamics of these systems make them notoriously difficult to understand. Coupled with the enormous existential importance of systems like climate and contagious disease, understanding these systems is a necessity. We argue that the deliberate use of scientific work on modelling complex systems to inform creative coding pedagogy and generative art is a valuable, emerging model of scientific engagement. This essay provides tools for pedagogy and practice by demonstrating relevant use of the creativity support index (Section 2) and exploratory exercises (Section 4).

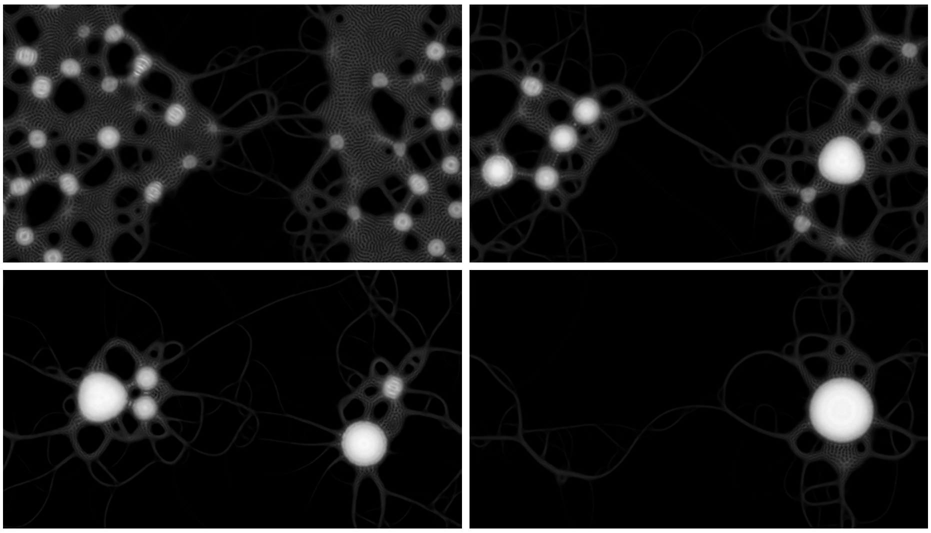


Fig. 1. The final movement of *Dismantling* (24:00–end[1]).

The essay is structured as follows. In Section 2, we introduce creativity support tools, which, in the context of art that involves writing code, has typically referred to the resulting code object. However, we motivate the use of this concept to understand not the code object but the paper on which it is based. We rely on a framework that distinguishes the (biological) system, the (simulated, performed) representation and the scribe (or performer) which highlights the shifting locus of agency in the live performance, "*Dismantling*" (Berlin, 2019; see Figure 1). In Section 3, we describe the performance and relate the artistic image-making to scientific image-making by drawing from Latour's concept of scientific inscriptions. In Section 4, we build on Gelfert's synthesis of exploratory modelling literature by translating it into a set of *Exercises for Performing with a Complex Network Simulation*. In Section 5, we consider the implications of exploring this relationship between scientific and artistic work in light of the inadequacy of the information deficit model in communication of climate change.

2. Scribe, System, and Representation

A major theme of "*Dismantling*" is the shifting locus of agency between the human performer and the simulation software used. In this section, we explain why viewing this software as a creativity support tool (CST) is inadequate. We introduce the *scribe-system-representation* framework that explains the relationship between software and performer. Then, we return to the CST framing, using it to describe not the software, but rather the scientific work that underpins the software. In this way, the CST evaluative framing becomes a generative tool for approaching scientific artifacts.

The simulation, which adapts a model of acellular slime mold *Physarum polycephalum* (Jones, 2010). The simulation is the *representation* of the biological *system*. The paper that describes this system is the means by which the representation-system relationship can be understood and validated. The performer, or *scribe*, influences the speculative *system*, by changing simulation parameters; and influences the simulated *representation*, by changing visual settings like color.

Because the aim of the performance is to explore a shifting locus of agency between the performer and a speculative biological system, the performance choreography focuses on ways that input can influence the system itself. Section 3 describes in further detail the controllability, in a complex dynamical systems sense, of the simulation, and its implications on the performance. Section 4 relates the choreography of the scribe's actions to exploratory modelling in scientific work, where researchers must resist "mistak[ing] their facility at exploring the 'world in the model' [*representation*] for an improved understanding of the *target system itself*" (emphasis original, Gelfert, 2016, p. 96). The exercises in Section 4 and pedagogical implications described in Section 5 maintain the distinction between *representation* and *system* as a means to relate the artistic work to the scientific work, and vice versa.

The Creativity Support Index (CSI) is "a psychometric survey... designed to assess the ability of a digital creativity support tools to support the creative process of its users" (Cherry and Latulipe, 2014). Here, the creativity support tool (CST) has a relatively inclusive definition: something which "be used by people in an open-ended creation of new artifacts... in the computing domain, CSTs are often software applications that are used to create digital artifacts or are used as part of the process of working toward the completion of an artifact" (Cherry and Latulipe, 2014).

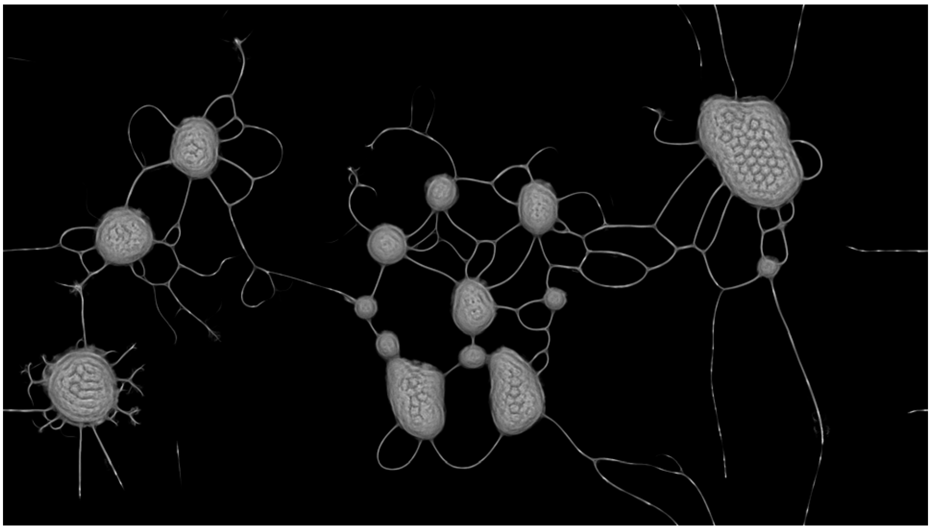
The CSI asks the CST's user—in our case, the scribe—to assess the tool along six dimensions: Collaboration, Enjoyment, Exploration, Expressiveness, Immersion, Results Worth Effort. Although the simulation is the software, we view the underlying scientific object (the original *Physarum* paper) as the primary creativity support. The following two of the six dimensions of the CSI (explained below through descriptions quoted from the survey itself) especially underline the inapplicability of an analytic tool like the CSI to the simulation itself.

Immersion: "My attention was fully tuned to the activity, and I forgot about the system or tool that I was using" (Cherry and Latulipe, 2014). We interpret immersion here not as forgetting about the speculative biological *system* encoded in software, but rather as forgetting the mechanics of the *representation* and engaging with it as a view into the complex system with its own agency.
Results Worth Effort: "What I was able to produce was worth the effort I had to exert to produce it" (*ibid.*). As we describe in Section 4, the activities necessary to choreograph and perform map well onto the activities of exploratory modelling in the natural sciences (Gelfert, 2016). The production of compelling images is an important aim of the activity, but the "effort" of the activity itself offers additional results of elucidating the biological meaning of the system to the scribe and viewer. We discuss the implications of this in Section 5.

This particular paper is a rich CST because it describes a complex system with feedback loops and tipping points. The CSI framing helps reflect on complex systems epistemology as artistic medium:

Collaboration: "The system or tool allowed other people to work with me easily" (*ibid.*). The study of complex systems draws from physics, biology, and the social sciences both in method and the body of knowledge upon which it builds. (Thurner, Hanel, and Klimek, 2018).
Exploration: "The system or tool was helpful in allowing me to track different ideas, outcomes, or possibilities" (*ibid.*). The interactive elements of the representation, as described in Section 3, were designed to support the exploratory activities in Section 4.
Expressiveness: "The system or tool allowed me to be very expressive" (*ibid.*). This particular representation includes additional feedback loops, further delving into the speculative biology of the system. Limited controllability of a system where the topology of the network itself is a dynamical system (Liu 2016) expands the space of possibility of visuals and dynamics. The scribe is therefore not limited to deterministic logic (Figure 2).

Fig. 2. Nonlinear behavior of the system allows a diversity of structures to arise from the same underlying simulation mechanics and parameterization.



The last of the six CSI dimensions, *Enjoyment* ("I enjoyed using the system or tool" (*ibid.*)) is omitted from the reflection above, though it is apparent from the description of the performance:

> "[...] reconstitutes fragments of scientific work. Using ink, tracing paper, video simulation, and tactile interaction, we hallucinate through complex networks that underpin biological and sociological systems. The viewer is invited to participate in the construction of meaning, as well as bask in the generative dismantling of the scientific face. [...] The images in science are the common thread and mediator, objects with meaning and agendas for both scientists (who produce them) and everyone else (who consume them). Through its human appendages, this face has the ability to materialize; often with dire social and environmental consequences. This exhibition reconfigures and scrambles the scientific face, collaboratively dismantling it piece-by-piece to reveal an expanded theater of operations, unexpected agency, and sensory lines of flight."
>
> —*Dismantling* (2019) statement excerpt.

3. Inscriptions

In *Dismantling* (Berlin, 2019), we presented a live performance[1] using an interactive simulation. The *scribe* draws on a tablet, which relays the stylus position and pressure to an agent-based simulation (Figure 1). The behavior of the simulation itself is an adaptation of the behavior of the acellular slime mold *Physarum polycephalum* (Jones, 2010). Additional feedback loops were incorporated into the model to increase the heterogeneity of the patterns that were produced. The resulting *system* is therefore a speculative biological system that shares some, though not all, properties with the model it is based on. The *representation* entails the visual representation, as well as the interactive elements, especially the capacity of the *scribe* to alter the parameters of the underlying *system* as a way to induce particular behaviors in the representation (Figure 2).

1. A recording of the entire piece, recorded later, can be seen here: https://youtu.be/hEbbmJaYHAc.

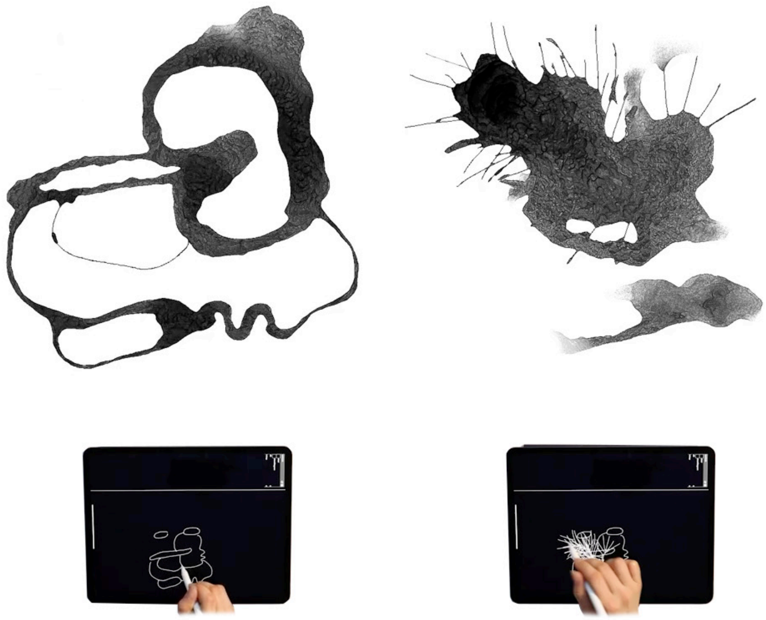


Fig. 3. Two frames showing how the scribe's input deliberately induces an accumulation of energy, which then flows in ways the scribe has no direct control over. (12:00–13:00 in the video[1]).

Figure 3 shows how building a concentration of particles leads to the simulation of those particles developing its own slow movement, demonstrating a shifting locus of agency. Prior to the shift, the system responds to the scribe (visually following the stylus), and after it, the scribe responds to the system, as the drawing can no longer significantly impact the macro-movement. The most striking difference in these two semi-stable states is a critical particulate density that alters the behavior of the simulation—a tipping point that, once reached, causes an explosive chain reaction through the connected components. The scribe has intentionally caused this state, ceding direct control of the flow of simulated matter.

This interactive simulation displays traits of a biological complex system—a co-evolving multilayer network. Experimentation with the simulation has demonstrated these traits: self-organization, nonlinear dynamics, phase transitions, and collapse and boom evolutionary dynamics. The interlocking feedback mechanisms and topological adaptability that drive the dynamics complicate its controllability—and thus the relationship between the scribe and the simulation. Controllability in this context means the ability to deliberately drive the system to a desired state at an intended pace. In contrast to abstractive digital text, the scribe retains a more limited level of control over the system, leaving a significant level of autonomy to the simulation itself. The controllability of this particular type of complex network (i.e. an adaptive transportation network, like acellular slime mold) remains an open problem, because the topology of the network itself is a dynamical system (Liu 2016). In spite of this, the scribe does have the ability to move the system between certain steady states—as demonstrated through the phase transition dynamics resulting from accretion of ink past a certain point— as well as guide the macro-scale behavior of the system.

Aside from the stylus spawning particulates, the scribe may change the parameters of the simulation: Figure 4 shows the aftermath of a parameter change alone. Changing parameters allows the scribe to redistribute the simulation's matter on the page, and change states, in an additional mechanism.

The role of the image, or visualization, in scientific practice helps to understand the relationship between the performance and the scientific work. Latour, investigating "what is specific to our modern scientific culture," considers breaking scientific practice "into many small, unexpected and practical sets of skills to produce images, and to read and write about them" (Latour, 1987). Although this "strategy of deflation" has major limitations, the analysis of inscriptions allows understanding scientific practice (Latour and Woolgar, 1979) and power (Latour, 1987). Inscriptions serve as record; basis for communication and rhetoric; and further investigation. We relate several properties of scientific inscriptions to the speculative simulation: recombination, scaling, and immutability.

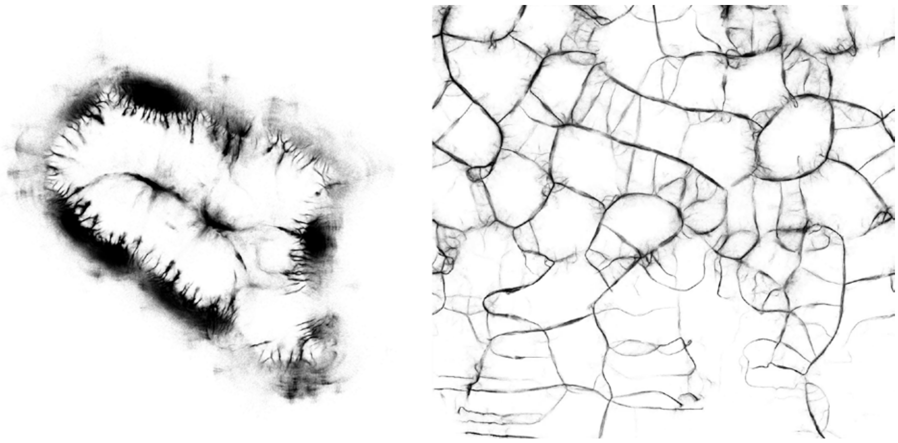


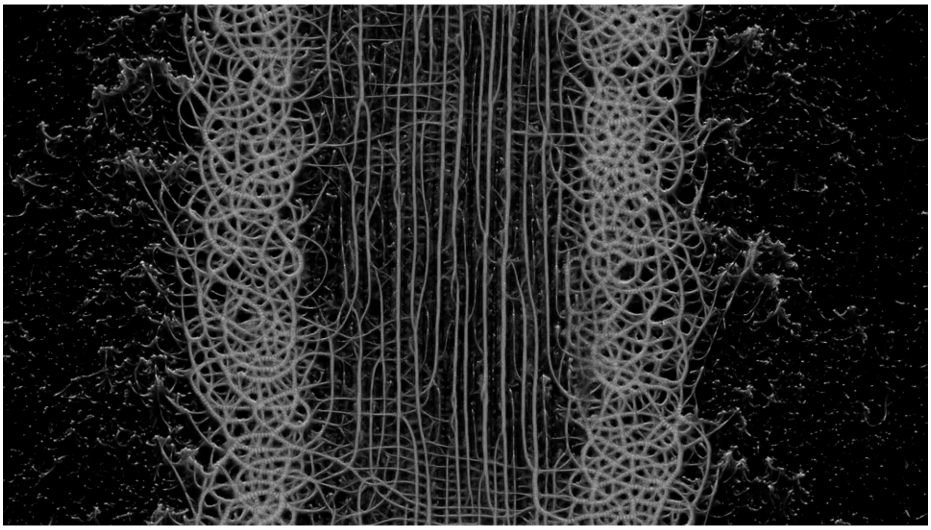
Fig. 4. Two frames showing how the scribe's input is affected by interaction between changing parameters of the system. Without any additional input from the scribe, the new parameter space reconfigures the visual field and invites different interactive input actions.

Recombination is enabled by "optical consistency" and its embeddedness in a shared visual culture, which "allows translation without corruption" (Latour, 1987). These inscriptions, including charts, tables, blots, and so on, depend on a domain's visual culture and shared socialization. Visualization is a meta-cognitive skill, including (1) familiarity with "the conventions of representation [one is] likely to encounter;" and (2) understanding of "the scope and limitations [i.e. what] aspects of a given model each can and cannot represent" (Gilbert, 2015). In the context of a performance, the scribe can support building a legible optical consistency through repetition and inclusion of familiar points of reference. *Dismantling* builds up each of the movements (Figure 6) to demonstrate the same actions resulting variously in either rupture or repair under different conditions.

The *scalability* of inscription is, in Latour's view, one of the sources of power of "scientists and engineers:" that "no one else deals only with phenomena that can be dominated with the eyes and held by hands" whether the phenomena be stars or atoms (Latour, 1987). As shown in Figure 5, the microscale simulation with which we perform mimics transportation networks. For Latour, the capacity to operate at radically different scales "following this theme of visualization and cognition in all its consequences" informs the "view of power" of scientific and engineering work:

> "There is not a history of engineers, then a history of capitalists, then one of scientists, then one of mathematicians, then one of economists. Rather, there is a single history of these centers of calculation. It is not only because they look exclusively at maps, account books, drawings, legal texts and files, that cartographers, merchants engineers, jurists, and civil servants get the edge on all others. It is because all these inscriptions can be superimposed, reshuffled, recombined, and summarized, and that totally new phenomena emerge, hidden from the other people from whom all these inscriptions have been exacted." (Latour, 1987)

Fig. 5. Inscription of this microscale simulation mimics transportation network inscriptions, demonstrating the scalability and recombination of scientific inscription of complex networks.



By nature of work practices and contexts, they are *immutable*: "even exploding stars are kept on graph papers in each phase of their explosion" (Latour, 1987). This key property grants legitimacy, by means of legible record, to audiences outside of original investigators. A performance has a similar need: to create reproducible and legible images. The *immutable* inscription includes the simulation visual which inscribes dynamics of *Physarum* parameterizations (Figures 1–5, 7) and the abstract score (Figure 6) which inscribes the inscription. However, speculative simulation is unlike the field and lab-based examples Latour draws on, so in the next section, we relate it to exploratory modelling.

With scaling and recombination as means of power, and immutability and means of legitimacy, *inscriptions* are both tools by which science is done internally and communicated externally, as well as means to engage directly in scientific work. This performance is functionally a scientific act. Engaging with it is a form of direct participation, both on the part of the performer and the audience, depending on the content of the performance itself. Stylus input of the scribe made visible (included in Figures 1–5, 7) constitutes an insufficient record alone, but reveals the process of inscription construction, resisting hiding. In the next section, we draw from scientific exploratory modelling practice to inform performance exercises.

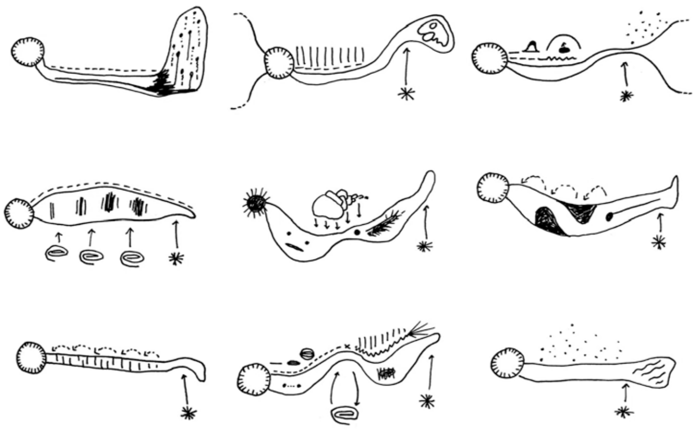


Fig. 6. Representation of each of the nine movements with enough detail to clearly distinguish between them, and to consistently achieve the desired state. The external "asterisk" notation refers to interpolation between parameter spaces; all other interactions are within particular parameterizations.

4. Exploratory Modelling

In this system, the scribe must develop an understanding of a complex system. The performance then uses that intuition with a particular set of parameters and their behavior in response to pen input in order to consistently induce emergent behaviors legible to an audience who does not possess that familiarity. Although the preparatory process described is active and exploratory, the scribe's task *during* the performance becomes focused on the consistently producing the inscription in cooperation with the *system*, through the *representation*.

The kind of hypothesis formulation and observation of the *system* through its *representation* can be seen as a form of exploratory modelling by the *scribe*. This section presents a detailed set of *Exercises for Performing with a Complex Network Simulation*, building on study of modelling in scientific work (Gelfert, 2016; Rosen, 1991). Writing about complex biological systems, Rosen recognises "essentially two ways [...] to obtain meaningful information regarding system behaviour and system activities. We can either passively watch the system in its autonomous condition and catalogue appropriate aspects of system activity, or else we can actively interfere with the system by perturbing it from its autonomous activity in various ways, and observe the response of the system to this interference" (Rosen, 1991). Both active interaction and passive observation of the result of a deliberate combination of initial conditions and parameters can be used in the performance (Fig. 7).

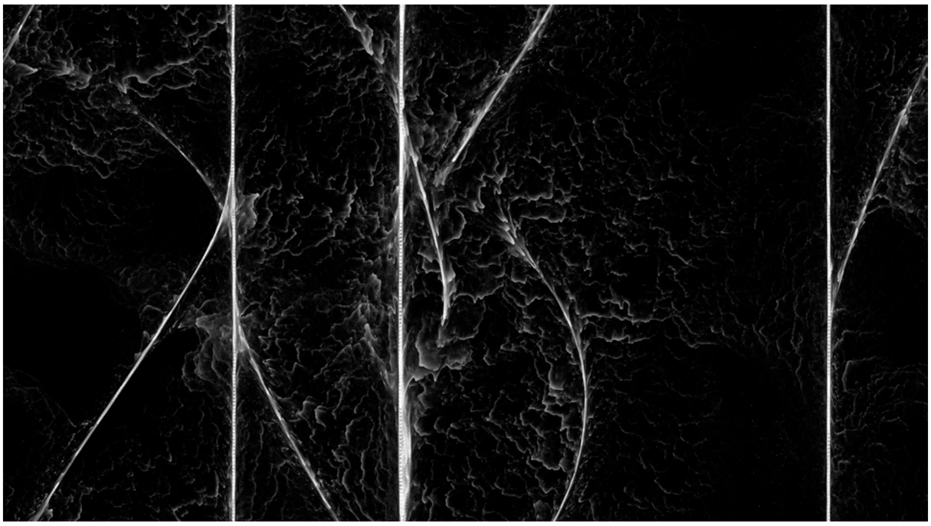


Fig. 7. The initial conditions and parameters lead to a tipping point, with a phase shift unfolding over the course of several minutes. In the video[1] the movement at 15:20-15:55 is followed by a change in parameters, and until 20:22 the remainder of this movement and the entirety of the next unfolds without any input from the scribe.

The actions that the scribe undertakes to *explore* the system through its representation can be seen as either (1) specific, "stimulus-oriented" behaviour which "*converges* upon a specific question, fact, detail, or 'missing link'", and (2) "divergent" exploration, which is "not directed at a specific object, question, or stimulus, but is response-oriented, in that the cognitive subject seeks novelty or surprise for its own sake" (p. 74–75, Gelfert, 2016). Gelfert writes that "manipulation [...] is a good way of deepening one's understanding of a model" (p. 73) further citing Mary Morgan's work that "representations only become models when they have the resources for manipulation." Projects like distill[2] and Complexity Explorables[3] specifically aim to create resources for manipulation as a way to make complex systems accessible to a wider audience.

2. https://distill.pub/2017/research-debt/.

3. complexity-explorables.org.

Referencing Steinle, Gelfert reviews some methodological guidelines for exploratory experimentation: (1) varying a large number of parameters; (2) determine which experimental conditions are indispensable, and which are only modifying; (3) look for stable empirical rules; and (4) find appropriate representations by means of which those rules can be formulated. These and the above two methodological guidelines can be further synthesized into the below exercises for developing a performance with a simulation that has both manipulation resources, and sufficient model complexity in the form of feedback loops and potential to create tipping points to enable deliberate shifting of the locus of agency. These exercises are shown in order of increasing need for developing an understanding and/or intuition of the system.

Exercises for Performing with a Complex Network Simulation

1. Find steady state(s);
2. Find a maximum density state;
3. Find a minimum density state;
4. Find pairs of states that demonstrate different scale of motion;
5. Practice creating tipping points to create a phase shift;

6. Practice finding a variety of states that consistently slowly converge back to steady state;
7. Determine some minimal parameter change that disrupts the steady state(s);
8. Find states in with a parameter space that are either difficult or impossible to achieve without certain starting conditions (which can be achieved in a different parameter space);
9. Document (as text, a sketch, or score) how overall impression of patterns and dynamics shifts (speed of movement, its structuredness or chaos, and so on) in response to manipulation.

In scientific work, models can "(1) function as a starting point for future inquire, (2) feature in proof-of-principle demonstration, (3) generate potential explanations of observed [...] phenomena, and may lead us to assessments of the suitability of the target" (Gelfert, 2016): "just as an experiment does not always serve the function of *testing* a theory, neither does a model always have to render an empirical phenomenon to subsumption of a pre-existing theory". Not only does choreography and performance require doing exploratory modelling, but the exploratory artistic practice can also become a form of scientific knowledge-building and synthesis.

5. Discussion and Implications

In previous sections, we presented exploratory modelling of speculative complex biological systems: a simulation that *represents* a *system*, controllable by a *scribe*'s actions, which can deliberately shift the locus of agency between the performer and the simulation. Our theoretical framing of this practice has implications for how creative coding pedagogy and science communication intersect.

When it comes to scientific communication, the presumed relationship between scientists and the general public remains informed by the information deficit model. This model suggests a one-way communication channel of scientists educating the public, despite having been shown to be inadequate and not reflecting reasons for lack of public engagement, particularly in the realm of anthropogenic climate change (Suldovsky, 2017). Suldovsky describes three alternatives to the information deficit model and their benefits, characteristic features in practice, and challenges:

Contextual model, as the information deficit model, "prioritizes one-way communication [but] does not assume that the mere presence of information will have a meaningful impact on audiences;" this is "most evident [in] attempts to segment audiences according to their level of concern about climate change." However, "it is not sufficient on its own as it fails to recognize [the many] goals in public engagement beyond the "selling" of climate change."
Dialogue model "rests on the assumption that greater public participation and engagement will lead to more effective policy" and is exemplified in

science museums. However, "while there is great enthusiasm [...] there is often little guidance on how to use [it] effectively or evaluate its benefits within the context of climate change." It is "time consuming and costly" to execute well; executed poorly, its drawbacks are as those in the information deficit model.

Lay expertise model is "most evident in approaches to climate change mitigation and adaptation" and "embraces non-scientific knowledge, or lay expertise, as equal to scientific expertise within the process of public engagement." Its utility is especially well-documented in natural resource management, although this model has also been criticized as contributing to anti-science sentiment, depending on the context and implementation.

The use of art objects or practices in science communication can be seen as a part of any of these communication strategies. However, we have seen continued and increasing interest among the general population to develop coding skills, combined with creative coding as offering accessible and low-barrier environments, as different expressive opportunities. Although the models Suldovsky presents have different drawbacks, they all struggle with relative lack of interest of engaging with scientific work directly. We see here an opportunity for channeling the interest of novice learners who search for appropriately challenging problems to fit their skill development interests.

As one example of a popular mobile app that attempted to raise awareness of sea-level rise due to anthropogenic climate change, After Ice[4] uses augmented reality to show water rising to fill the viewer's locale. While an engaging example of the contextual model, it is also an example of the drawbacks[5] of focusing on "selling": there is no climate model that makes the kind of precise claim with regard to a specific point and specific outcome (Lopez, et al, 2015). The uncertainty of climate models has been widely used to create doubt in the public sphere and showing precise numbers that directly contradict the epistemology of climate modelling arguably reduces the literacy of, and interest in, scientific information about climate change. The reality of climate change is not debatable, but the details are a subject of a wide range of ongoing research, and more—not less—enthusiastic, open-ended, multi-disciplinary public engagement with this research is needed. Perhaps in lieu of toy examples for creative coding, concepts from fascinating work on complex biological systems can be used in instruction, using the interest in creative coding as introduction not only to practical coding.

By creating a framing for incorporating scientific work into creative coding practice, we envision exploratory modelling practice within creative coding instruction. Gelfert (2016) delves into the uses of exploratory modelling "in situations where an underlying theory is unavailable" (p. 75) and introduces the notion of "minimal models [that are] not intended to be faithful representations of any target system in particular, but are meant to allow for the exploration of universal features of a large class of systems,

4. https://www.climatecentral.org/news/app-sea-level-rise-21374.

5. Critique of app based on discussion, in which one of the authors participated, at the Summer School on Simulation in Science. MECS Institute at Leuphana University in Lueneburg, Germany.

” such as in theoretical ecology (p. 80). In these situations, faced with (relative) “absence of comprehensive theoretical knowledge—determining where the target system begins and where it ends, reliably picking it out from the background noise, and arriving as a stable ‘research object’” requires recognizing that revision of any initial conception of target phenomenon is often necessary, and that exploratory modelling is a path to reconsideration of target systems.

Writing on the role of computers in creativity in 1967, Noll rejected the “portrayal of the computer as a powerful tool but one incapable of any true creativity... if creativity is restricted to mean the production of the unconventional or the unpredicted, then the computer should instead be portrayed as a creative medium – an active and creative collaborator with the artist” (Noll, 1967). In 2019, Hassine and Neeman highlight “a significant difference between early computer-generated art, from the 1960s-1970s, and this new type of [contemporary] generative art. Early computer art was undertaken in the spirit of open-ended experimentation, without a specific goal in mind. ... In contrast, the projects ... directed towards their predetermined [goal of replicating master works...] included substantial experimentation, yet this type of experimentation was most likely motivated by engineering rather than artistic purposes” (Hassine and Neeman, 2019). We see the use of scientific work as both structuring and providing fruitful creative constraints, especially in instruction, but also as actively supporting more open-ended, creative use of the powerful contemporary technical tools.

6. Conclusion

In this article, we describe a performance software that demonstrates a shifting locus of agency between the performer, the software, and the biological system that underpins the dynamics of the software. Although software is used, it does not constitute a “creativity support tool;” rather, we present a more generative perspective that hold the paper describing the biological system to the requirements of “creativity support” (Cherry and Latulipe, 2014). The *scribe-system-representation* framework helps to understand this performance as an interaction between speculative inscriptions of complex systems (Thurner, Hanel, and Klimek, 2018), drawing on Latour’s concept of inscriptions in science (Latour, 1987; Latour and Woolgar, 2013). We then bridge interactive visual art informed by models of natural or social phenomena, and exploratory scientific modelling (Gelfert, 2010).

Our synthesis of work from diverging areas allows us to envision a research and practice agenda for creative coding instruction, which we will explore in future work through workshops for novice and intermediate coders. Section 2 includes our own reflection of doing exploratory modelling in a complex speculative biological system, using the framing of the creativity support index (CSI). As we experiment with using scientific inscriptions, and the exploratory modelling exercises (Section 4) with learners, we will use the psychometric CSI instrument combined with qualitative methods (Maxwell, 2012) to understand learners' experience. Finally, in supporting learners presenting and sharing the outcome of creative coding, we hope to gain additional experience regarding ideas in Section 5 on the relationship of this artistic practice to scientific engagement.

References

Cherry, Erin, and Celine Latulipe.
2014. "Quantifying the creativity support of digital tools through the creativity support index." *ACM Transactions on Computer-Human Interaction (TOCHI)* 21, no. 4: 21.

Gilbert, John K.
2005. "Visualization: A Metacognitive Skill in Science and Science Education." In J. K. Gilbert (ed): *Visualization in Science Education*, pp. 9–27. Dordrecht: Springer Netherlands.

Gelfert, Axel.
2016. "How to do Science with Models: A Philosophical Primer". Cham: Springer.

Hassine, Tsila, and Ziv Neeman.
2019. "The Zombification of Art History." *Journal of Science and Technology of the Arts* 11.2: 28–35.

Jones, Jeff.
2010. "Characteristics of pattern formation and evolution in approximations of Physarum transport networks." *Artificial life* 16, no. 2: 127–153.

Latour, Bruno.
1987. "Visualisation and cognition: Thinking with hands and eyes." *Knowledge and Society* 6.

Latour, Bruno, and Steven Woolgar.
1979. "Laboratory Life: The Construction of Scientific Facts". Princeton: Princeton University Press.

Liu, Yang-Yu, and Albert-László Barabási.
2016. "Control principles of complex systems." *Reviews of Modern Physics* 88.3: 035006.

Lopez, A., Emma B. Suckling, F. E. L. Otto, A. Lorenz, D. Rowlands, and M. R. Allen.
2015. "Towards a typology for constrained climate model forecasts." *Climatic Change* 132, no. 1: 15–29.

Maxwell, Joseph A.
2012. "Qualitative research design: An interactive approach". Vol. 41. Sage publications.

Noll, A. Michael.
1967. "The digital computer as a creative medium." *IEEE spectrum* 4.10: 89–95.

Suldovsky, Brianne.
2017. "The information deficit model and climate change communication." In *Oxford Research Encyclopedia of Climate Science*.

Rosen, Robert.
1991. "Some systems theoretical problems in biology." In *Facets of Systems Science*, pp. 607–619. Springer, Boston, MA.

Thurner, Stefan, Rudolf Hanel, and Peter Klimek.
2018. "Introduction to the theory of complex systems". Oxford University Press.

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The Technobiotics of Others

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The Foucauldian idea of life-power is fused into the realm of multiple technologies, and the subject body is advocated as the hinge of the technobiopolitical system. The paradoxical position of providing descriptions for a mute materialism is demonstrated through graduated instances: Haraway and a biosemiotics of systemic context, Derrida's Kierkegaardian secret and Bataille's base materialism - each elucidating different alterities. The interfusal of code and its biological space is contextualized in an outward-facing system: recognition and (mal)adaption. These aesthetic realities work to obscure and elucidate scientific objects within an environment, creating opportunities in shifting paradigmatic and hypothetical spaces that inform research frameworks.

1. Introduction: Life Powers

In the History of Sexuality, Foucault discusses the idea of biopower—“a power bent on generating forces [...] and ordering them, rather than one dedicated to impeding them [...] or destroying them” (136). The suggested life-administering power orders and sustains, the destruction and impedance of the other is replaced by a preservation and monitoring. How do we administer life? Linda Birke discusses machines that graph bodily events—the body as information, the body as a series of systemic curves and trends (Traces of Control, 91). The machinery of the cyborg doctor and the cyborg patient. The system-body is diffused into lines and graphs, and likewise the gazes that objectify are multiplied. Haraway finds this most relevantly represented in immunity, a power that works by “networking, communications, redesign”, through “texts and surfaces” and “management” (Simians, 194).

However, is it premature to proclaim the “death of the clinic” as the authors would propose contra Foucault, eliminating “bodies and work” in favour of texts and surfaces, or is it rather that these technologies alter and mutate the form of bodily interaction (194)? Is it rather that, no matter how technologized, human interaction will still be present—now no single gaze, but multiple gazes, not through the filtration of a time and concept-limited account (symptomological report), but through bodily absence and the interpretation of data-driven objectivities. As Shildrick asserts, the “clinic is maintained as an idea and a practice in day-to-day functioning in different societal contexts” (Vital Signs, 171)—its forms and applications are altered, the techniques it uses new, but its permanence—if but as a concept—remains through mutations and control of the technobody and its machine’s manifestations.

But the gaze now is multiplied—in Birke’s words: “machines that converted what was subjectively felt into number and graphs meant that several observers could discuss the output” (Traces of Control, 91). However, while Birke rightly points out science’s dependancy on the “objective data of the graph”, there’s a mythical move from the ideally non-objective territory of the experiences of the patient to an objectifying mechanization. Foucault’s gaze however—while technologically different—is in its very nature authoritatively objective; indeed, for any efficacy the objectivity of the diagnosing action must be presupposed. However, as opposed to Foucault’s gaze, in the technogical gaze technologies into which it is codified ramify into corroborative territories, the panoptic view is inverted and cloned, and the multiple system of objectivity becomes a matter of communicative management, a mutually accessible network manual—the view through the graph is through its portability and reproducibility, more generally accessible for its objective information. This networked power, management and communicative authority—the gaze through the text and artificial surface of the machine’s diagrams and graphs—lead to Haraway’s account of the biomedical/biotechnical body which “must start from the multiple molecular interfacings of genetic, nervous, endocrine, and immune systems” (American Feminist Thought, 208). Further:

> “Biology is about recognition and misrecognition, coding errors, the body’s reading practices (eg, frame-shift mutations), and billion-dollar projects to sequence the human genome to be published and stored in a national genetic ‘library.’ Sex, sexuality, reproduction - theorized as local investment strategies; body not stable spatial map but highly mobile field of strategic differences. The biomedical-biotechnical body is a semiotic system, a complex meaning-producing field, for which the discourse of immunology, ie, the central biomedical discourse on recognition/misrecognition, has become a high-stakes practices in many senses” (208).

What is high-stakes here is both the immune system as an “iconic mythic object in high-technology culture” and as a “subject of research and clinical practice of the first importance” (Feminist Theory and The Body, 204). This distinction cannot be taken too lightly. As a representative icon it is in no way dictating its actual mechanisms and applications, but rather highlighting its importance and relevance as a primary area in need of study. The actual elucidation of its mechanisms come through a scientific process of experiment and its framing. Conversely, however, what is known gives rise to the epitomizing of contextual material understanding.

The immune system is everywhere and nowhere—there is not a part of the body it does not affect and its recognition faculties are externally oriented. Hierarchies give way to a network of the complex and specific, becoming the means of individual coherence. This omnipresence and absence provides a discourse of constraint and the possible in a world “full of difference, replete with non-self” (Simians, 214). Such a restless movement in an aesthetic context may recall Adorno’s constellatory negative dialectics, materiality now a site of multiplicity and conflict, the dialectical embedded in the physical, in its inscriptions. Reproduction is a resource corporation’s investment strategy and society’s library a set of genes waiting in the statistical wings. Now we have a map of differing postulates, identity is a non-self coding error, and the sequencing of its individual network a billion-dollar global project ideologically suspended. This is a cyborgian umwelt or environment, subject to biologist Jakob von Uexkull’s synthetic marks and signals for its interpretation.

Building onto Butler’s sense of the ideologico-linguistic defining of the bios is a taking up of that inscribability closer to the terms with which Thomas Sebeok takes up Uexkull—the biosemiotic. For Sebeok there is a mutual implication in “the life science” and “the sign science” (Signs, 114)—however, this leaves a gap that is filled by materialism (as evidenced in biological semantic systems such as Chomsky’s). The book, the sculpture, the river, the horizon all are signal markers existing in relation to their environment according to principles both known and unknown. Our environment is both a physical reality and a constant grounding need in physiological and cultural terms—as Haraway would put it an "artificial intelligence system" where "the relation of copy and original is reversed" (Simians, 206). Replicant substance precedes organic pretension, copy template informatics before originary creativities, artifices enveloping the real, objects well before subjects—we have code possibilities embedded in atmospheric space before becoming incorporated into biomaterial instances. The meanings of this niche are the maps of the Innenwelt (internal world) that approximate a self notion.

2. Death's Gift, Life's Secret

Johannes de Silentio describes Abraham's awareness that obedience requires the gift of death (Fear and Trembling, 22). A pure gift, it has no hope of being returned—also, in Derrida's words, "a gift of infinite love, something that makes us tremble in fear because we lack knowledge" (Gift of Death, 55–56). It is something "which requires him to be absolutely irresponsible toward both law and community, but a responsibility that nevertheless cannot be called into question, that has no language, that refuses explanation" (Gift of Death, x). Derrida continues, "I am responsible to any one… only by failing in my responsibility to all the others, to the ethical or political generality" (GD, 70). This inevitable failure is the burden of the secret.

But while Derrida locates the Other outside of Abraham, it is Abraham himself who is the other as Kierkegaard realizes—in the which the narrator himself is continually mystified at the compulsions of Abraham and his pretended actions. What body compells him, what is his secret? The narrator never finds out—but the materiality, the distinct semiosis of the compulsion is in the event. The description of this materialism is approached in Althusser's aleatory material (Philosophy of the Encounter, 171) with an even more fleshed-out image given in Bataille's concept of the base material.

In the base material there is nothing but unique monsters, there is "nothing but deviation" (Visions of Excess 53–56), the material disconcerts and debases all ideology (16). There is no particular form to it, it is the core of the heterological—"the science of what is entirely other" (102)—not only amorphous or informe, but "violently expelled from every form" (91). The base material is the heterological entity, whose form we don't know, the secret and other whose basic existence violates the laws and ethics of community. The Derridean secret is not a sort of implied spiritual entity, but a material existence that is not yet descriptively known, and that rather than accept that lack of knowledge, is expelled violently from a given artifice. The deviant travel from the Butlerian image of the drag show performer negotiating their public marginalization to a Herculin Barbin not quite fitting into the idealities of sexual dimorphism our cultural simplifications require. More specifically, it is the infinite number of Herculin Barbins who are miscategorized based on the requirements and ideologies of the societies they live in, preventing the basic scientific reality of their material existence to flourish in light of nonsensical cultural codes that subject.

But the cultural creation of that material alterity is as complex as the technologies that give it rise. Now it is the thalidomide mutant and side-effect junky, the unforeseen result—corporeal inscriptions for heterological propensity, Durkheim and the statistical manufacture of deviance. Both Borges' Immortals and Beckett's eventless prolongations become identified a post-eugenic haphazard sterilization and life support machine. Like the Officer in Kafka's Penal Colony, our revelatory dreams of the machine are finally at odds with the actual experience of it, a basic experimental precept that requires testing before social overcoding with mythological abstractions. The formulation of another self, a sideline material secret builds on the liminal locations and bio-control supplied by Foucault. A system divided unto itself, to socially locate it is to play with its semiotics, write its codes, its possible corollaries with the signs that inscribe it. The base material nodes of its configuration inherent in their simultaneous belonging and utterly unseen difference. No longer do we have the visually grotesque prisoner of Goya, but nor do we quite have the inmate in need of the panoptical asylum's orderly help. Now everyone is free, autonomous, the panoptical schedule moves out into the streets, homes and individual spaces of analysis, reminded in one's own material bearing and existence.

Foucauldian schedules begin this movement but the lack of institutional containment relocate its architecture into the multiplication of material semiotics. Its languages and edifices, its totalized appropriation into the technical is mirrored by the very immaterial discourse which gives it lie. The code-making programmers, like Maynard Smith inscribing game theoretics to explain biological behavior, are engaging in disembodied events - virtual and mathematical—the very pretense of disembodiment leaves only the necessary material circumstances for any symbolic engagement. The acceleration of technical products shifts focus from the consistent object to a modularity within a sufficient rational space of Gibsonian affordances. Quite the opposite of dematerialization this object destabilization becomes a mere reminder of material realities—and yet the brand for the accelerated object in response becomes ever more insubstantial. The immaterial is commercialized, systematized: the unspeakable other, technobiotics created in an unpredictable and unique margin, finding its Derridean Secret parodied in Rhonda Byrne's film of the keys to all life, giving you everything you could want. Media and material technology, their inscriptions, for each entity and new medium it is different, for the same entity in a new medium it is different.

3. Speculations: Fiction, Open Science and Practicality

Science offers a complementary place for what are theoretical hypotheses and practical experience. The key moments of scientific history reveal points where the theoretical apparatus hits a disjunction with experimental activity. Kuhn and his paradigm shifts mark the breaking point of where the institutional edifices resettle into new research frameworks. In this there is an implicit model for inscription, for empirical sight and objectivities—a primacy in experiment, and an openness in the theory which observes. The biosemiotic is always communicating, verbalization under sensorial visualization further relays and translates what has been mapped into tangibility. The inevitability of the gaze is to be framed within its theoretical sense-making bias - its danger of objectification without accountability—the ideal of observation a continual openness that finds the tension of theory next to the experience and signalled communication of the subject analyzed. Insofar as experiment is illuminated by it, it has a utility dependent on the maintenance of its Peircean fallibility.

It is a contingency whose knowledge is, in a Spinozan sense, rationally framed: the experiments are given—but the theoretical constructs necessary for sense-making not. For each inscriptive experimental event, a previously unknown entity exists—so it is that the narcotic, drug or heavy metal can be understood through the toxicity they inscribe, as revealed in controlling designs. What is inscribed is another base material to be discovered, and it is through open scientific theory that there is space for its potential expression and epistemological reception. The role of fictional imagining and hypothetical framing arrive in the territory of play within work—the techne that is not less scientific than artistic. Technobiotics paralleled with scientific needs within a societal apparatus puts art in the role of revealing technobiotic structure. A stepping-aside or reflective mirroring of what is occurring—a location where it has the time and space to be spoken about, and where what isn't is spoken about. It is an index or secondary sign to a testing proposal, an existential frame design that gives place to objective expression, vocal innovation—the needed artifact for laboratory semantics.

Bodies under subjection, experiments to be recorded—aspects of material semiotics to suggest what the pragmatic operations of quotidian received concepts fail to envisage. Its nodes and network points are those which speak the language beyond instantiated need, that practicality lacks the time for, whose language is not immediate enough to be useful. A marginal entity can make no sense to a normal society, is doubted to exist and in this way doesn't—but the space afforded by art gives the time and play terrain to extrapolate new frames, to speculate awareness and dialectical hypothesis. Unproductive voices in their uselessness recreate space and the possible future. It is itself embedded in a perspective that doesn't fit and revolutionizes, the Beckett play whose stillness is both out of place and increasingly in place—that is a form of the future temporally as an analogue to spatial displacement. The other material is technobiotic, the map complex on which writing and inscription has indelibly taken place, on which the communication and flow of marking has reinvented the umwelt with a paradigmatics invented by virtue of being unfit. In an age of technical multiplicity, the monsters are myriad and ironic in their outward normality, they are cyborgs which appear as media personalities, they are graphing machine robots whose linear progressions represent a particular aspect of material mapping—lifelike prosthetic limbs in a system network that looks innocuously like normalcy.

4. Conclusion

The secret space—the grotesque multiple—infused through and through with the technological and coded—is the space of art and fiction. That Herculin Barbin exists is inevitable, but that Virginia Woolf's Orlando does is artistic reflection, and insofar as its realism values the actual existence which underlies its character so it may prove to be of value in enabling one such. Biopower is infused with a plurality of technologies, which gives it just as many forms in which to operate. As technologies and codes within itself (the experimental graphing machine), it begins in its medial form and only beneath this normal voice is a material heterology glimpsed. It is ubiquitous and ecological immune externalizing, a grotesquery lacking marginal linguistic utilities (consumed) for its own existence. Technology outpaces the alterity of accountability. So the aesthetic realm, subverting and exposing the practicality in fiction, becomes essential for technobiotic speech.

References

Althusser, Louis.
2006. "The Underground Current of the Materialism of the Encounter" *Philosophy of the Encounter: Later Writings, 1978–87*. Verso, pp. 163–207.

Bataille, Georges. tr. Stoekl, Allan.
1985. "Visions of Excess: Selected Writings, 1927–1939". University of Minnesota.

Birke, Linda.
1999. "Traces of Control: the Body and Systems" *Feminisms and the Biological Body*. Edinburgh.

Derrida, Jacques. tr. Wills, David.
1995. "The Gift of Death".
University of Chicago.

Foucault, Michel.
1990. "The History of Sexuality". Vintage.

Haraway, Donna J.
1991. "Simians, Cyborgs, and Women: The Reinvention of Nature". Free Association.

Kauffman, Linda S. ed.
1993. "American Feminist Thought at Century's End: A Reader". Blackwell.

Kierkegaard, Søren. tr. Hong, Howard Vincent & Hong, Edna.
1983. "Fear and Trembling: Repetition". Princeton University.

Sebeok T.A.
1994. "Signs: An Introduction to Semiotics." University of Toronto.

Shildrick, Margrit & Price, Janet.
1998. "Vital Signs: Feminist Reconfigurations of the Biological Body". Edinburgh.

Shildrick, Margrit & Price, Janet eds.
1999. "Feminist Theory and the Body: a Reader". Taylor & Francis.

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Electric Love: Analyzing Human Mate Selection Dynamics in a Digital Environment

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Human mate selection behavior in digital environments is, despite the rise of online dating, not well understood. In this paper, swiping apps are simulated by using an agent-based model. Implementing empirically derived data from other studies, the aim of this study is to investigate the fairness of such platforms. Our model predicts that positive evaluations (Likes) and reciprocal positive evaluations (Matches) of agents are highly unevenly distributed. We calculated a Gini coefficient for the likes agents receive and modulate system conditions to increase the fairness on the platform. We found conditions under which the system is fairer towards both female and male agents. Substantial inequalities never fully disappear when changing various factors in the system, hinting at the fundamental principle of swiping apps for the cause of said inequalities.

1. Introduction

Mate finding is a crucial factor for the population dynamics of all sexually reproducing life-forms, thus also for humans. There has been a strong trend towards digital environments as a place to meet potential partners (Baker 2002, 363; Rosenfeld et al. 2019; Silva et al. 2019, 45). Especially dating platforms increase the chances of finding potential partners. These platforms have lost most of their stigma in society (Finkel et al. 2012, 13; Gibbs et al. 2011, 71) and have become widely accepted (Pewresearch 2016). Although the exact intentions of users on such platforms vary (Tyson et al. 2016, 7; Lefebvre 2018, 1215-1216), the main goal is to find a romantic partner – either in the form of a consensual short-term agreement , a dedicated long-term relationship, or anything in between those extremes (Timmermanns and Caluwé 2017, 348). Intimate relationships play an important role in the personal life of most people and contribute significantly to their happiness and life satisfaction (Diener and Seligman 2002, 82). Therefore, there is a huge market for computer programs and internet sites supporting the finding of intimate partners. With the rising popularity of digital platforms, other forms of dating are being replaced at a fast pace (Rosenfeld et al. 2019). A subtype of such platforms are so-called swiping apps. They have a game like structure and tens of millions of users all over the world (BBC 2016). Swiping apps can be perceived as unfair and may have a negative impact on users by harming their feelings of self-worth (Strubel and Petrie 2017, 37). Further, they drive unequal distributions of dating opportunities, which is related to male violence (Seffrin 2017). These mentioned issues and others like unrealistic expectations and social isolation can be tackled by models like the one proposed in this study. There has been empirical research on swiping apps (e.g. Timmermanns et al. 2018; Silva et al. 2019) but to the best of our knowledge, no multi-agent model of populations mating with swiping apps has been made, despite them being a highly relevant research target. Only this kind of architecture captures simultaneously parameters within and between individuals straightforwardly. In this study, we modelled a population of autonomous agents that use a hypothetical swiping app and investigated the impact of various parameters like physical attractiveness, the ratio of men and women, and the time people spend on the app. The aim of this study is to identify key characteristics of swiping apps: How are the markers of success, Likes and Matches, distributed among the users? How could the system be changed to increase fairness on the platform? How do different sex ratios affect this complex system? Especially the last question can only be investigated using a computer model, since one cannot simply change the user sex ratio on an existing swiping app. For the sake of modelling parsimony, there is a focus on heterosexual couples. Homosexual and bisexual individuals are out of scope, although there are clear plans to include them in future iterations of the model.

In order to define the terms that we use in this study precisely, as their definition might change over time and their connotation might be affected by zeitgeist, we will define the meanings we use in the following. We want to understand the word "date" in such a way that it refers to a meeting of two people, who have romantic interest in each other, with the motivation of forming an intimate relationship. The word "dating platforms" refers to websites ("dating sites") and computer applications ("dating apps"), that help to connect people with the goal of forming intimate relationships via the internet (a process called "online dating"). For further clarification, we want to use capital letters when talking about "Likes" (positive evaluations of other users' profiles) and "Matches" (reciprocal Likes), so their meaning can be distinguished from the usual meanings of those words.

2. Fundamental Mechanics of Swiping Apps

Swiping apps generally make use of a double opt-in principle: users must display a reciprocal initial interest in each other before a conversation is possible. This is managed by the app in the following way. Each user sees other users' profiles based on geographical proximity. A profile consists of at least one photograph and often, but not always, a very short self-written description. Photos are dominant and the main determinant of the user's decision to like or dislike a profile (Chan 2017, 248). However, written descriptions can increase the perceived attractiveness (Tyson et al. 2016, 6). The profiles are organized in a way that each user sees only one profile at a time (Timmermanns and Caluwé 2017, 341). Before being able to see another profile, users must decide to either "like" or "dislike" the profile shown. The liking or disliking is done by swiping the photo to the right (for liking another user's profile) or the left (for disliking it) respectively – hence the common name "swiping apps" for such apps. After the decision is made, the profile gets discarded. When two users "like" each other, they have a "Match", and the users get notified about this. This enables the two people to chat. Naturally, the conversation goes on for a while before users meet for a date. Meeting rates vary across studies (Timmermans and Courtois 2018, 66; Lefebvre 2018, 1220). The people who do meet their Matches most often do so within a week (Iqbal 2019). 35% of relationships emerging from swiping apps last for over 6 months (Simpletexting 2020) which undermines the hypothesis that dating apps are only used for "quick hookups".

3. Methods

We designed a multi-agent model. Agents in the model represent users on a hypothetical swiping app. Although size and distance play no role in the model, the spatial design is useful for evaluating the number of connections of individual agents to other agents in the network. One time step represents 30 seconds. This section explains the whole process of agent creation, the liking process, and the emergence of Matches. Agents represent users of the app, and their attractiveness value represents the attractiveness of their profile. In section 3.1 exact numbers can be found. Two types of agents are created: females and males. Agents get uniformly randomly distributed and oriented across a 2D map and get assigned one numeric value that represents attractiveness (called FATT for females and MATT for males). Another value assigned is the interaction time available for the day (called ITT). Both values mentioned are normally distributed. Interaction time that is available for the day refreshes every 2880 time steps (one day in the simulation). In this section, a female agent serves as an example - males work analogously. The description below describes in pseudo-code how a number of female agents is created and initialized.

```
create_females(number):
    self.ITT ← random_normal(mean=30.0, std_dev=5.0);
    self.FATT ← random_normal(mean=5.0, std_dev=2.0);
```

If a user still has interaction time left for the day, they visit another users profile.

```
For each of time_steps:
    For each of females:
       if self.ITT > 0 then:
            jump_to_position(choose_random_one_of(males));
```

A unidirectional check is performed. Agents compare the attractiveness of the profiles with their own and primarily “like” agents that are about as attractive as they are, which is modulated by FSF and MSF (female/male selection factor). There is some leeway, and random element to this: within a certain range (LW), a random number, which can also be negative, is added to the attractiveness of the other agent. This represents different preferences users may have. If the profile is still attractive enough after this, it gets a like and the agents have a directional link. If not, there is a dislike, and the agent will not see this profile again.

```
if (other_user.MATT ± self_LW) > (self.FATT * FF)then:
    create_like_to(other.user);
```

There is also a match-check. If the agent already has a like from the profile she is looking at, and she reciprocally likes it, a Match happens.

```
if in_like_from this other.user exists then:
    create_match_with(other.user);
```

This liking process takes time, which is subtracted from the daily time this agent *can* spend on the app and gets simultaneously added to the time the agent *has* already spent (TS).

```
self.ITT ← self.ITT - 0.5;
self.TS ← self.TS + 0.5;
```

Every 120 time steps (one hour in the simulation) there is a small chance for an agent to leave the app. This is regulated by the variable TOR (turnover rate). Simultaneously new agents join the app at the same rate, which keeps the size of the population roughly stable. The variable PF regulates the probability of female and male agents joining the app.

```
for each of agents:
     z ← random_float(1.0);
     x ← random_float(1.0);
     if (z < TOR) then:
          die;
              if (x < (PF) then:
                       create_females(1);
              else:
                       create_males(1);
```

3.1. Experimental Data Analysis

We exported the data generated from the model and plotted the results. To show the distributions of Likes and Matches, we stopped the run after varying amounts of time, with varying sex ratios in the system, and used scatterplots with logarithmic scales (figure 1 and figure 2). To show unequal distributions of likes we used the Lorenz curve for illustration (figure 3) and report the Gini coefficient for likes received as a measurement of fairness (table 2). To get three levels of fairness in the system, we did a parameter sweep and report three different settings. We conducted 100 runs for each experiment and report the average results.

3.2. The Simulation

The standard conditions aim to reflect real data (see section 4). Agent population consists of 400 agents (133 females and 267 males).

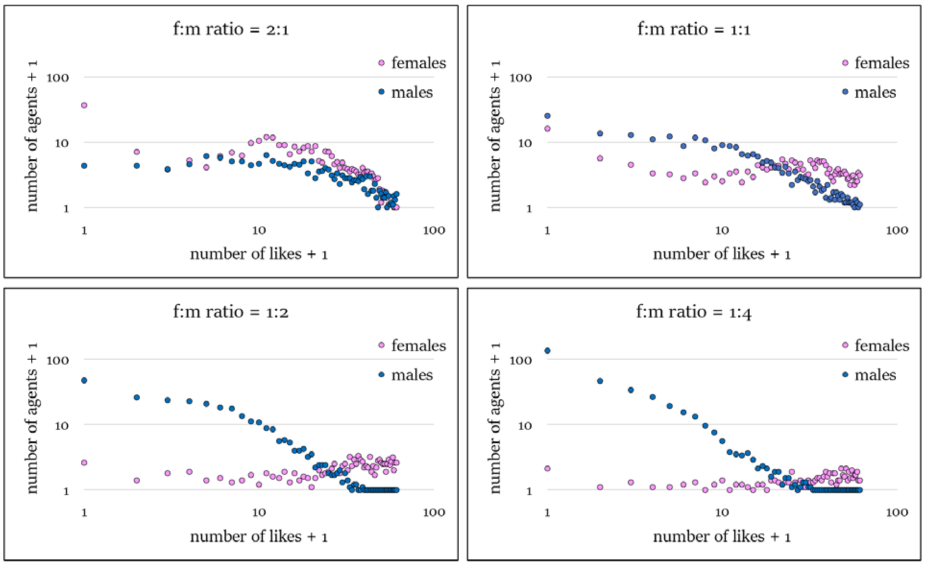
Table 1. Parameters used in the model.

Parameter	**Full Name**	**Standard Value (units)**	**Reasoning/Source**
PF	Proportion of females	0,33 (dmnl)	There are significantly more men on swiping apps (Iqbal 2019; Netimperative 2019; Clement 2020)
TOR	Turnover Rate	0,01225 (dmnl)	About 21% of users of the most popular swiping app do not return to the app the next week (Iqbal 2019)
self.FATT / self.MATT	Female / Male Attractiveness	Normally Distributed, μ 5.0, σ 2.0 (dmnl)	Attractiveness ratings are observed to be normally distributed (Gynther et al. 1991, 747; Fink et al. 2006, 437). Mean and standard deviation are assumed.
FSF/MSF	Female / Male Selection Factor	1.6 for Females 0.95 for Males (dmnl)	People "aim up" when looking for partners (Lee et al. 2008, 670). Women are more selective than men (Clark and Hatfield 1989; Buss and Schmitt 1993) and many men casually like most of the profiles (Iqbal 2019).
self.ITT	Interaction Time for the Day	Normally Distributed, μ 30, σ 3 (min)	People spend about 30 min/day on the app. There is little difference between women and men (Iqbal 2019). We assume normal distribution.

4. Results

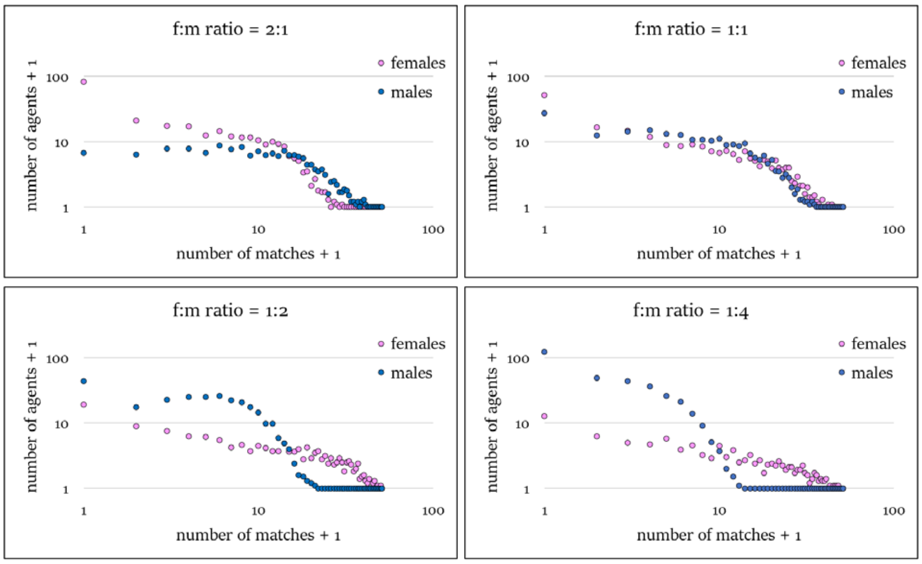
The distribution of the number of Likes among males is predicted to be highly unequal by our model. It is predicted to follow an uneven distribution, in which a few successful females and males receive many Likes and Matches, while most of the remaining agents are predicted to receive a low number of Likes. The fewer female agents are available on the app, the more unequal the distribution of Likes among the male agents gets. For female agents, the distribution of Likes is more equal, and they generally receive significantly more likes than men do.

Fig. 1. Distributions of Likes received by males and females at various sex ratios.



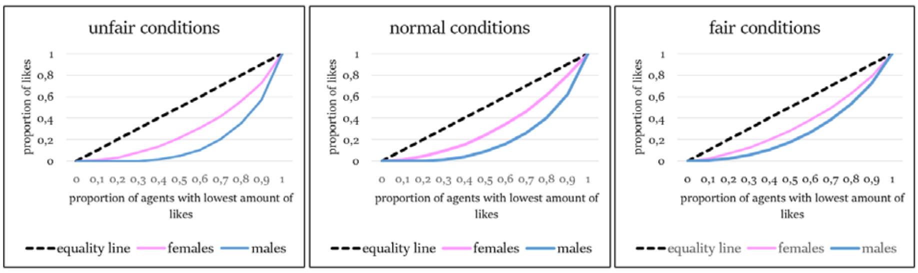
The distribution of the number of Matches among males and females is predicted to be highly unequal by our model. Most agents have a low number of matches, while some have a high number of matches. Females generally have higher number of matches, except when they make up most of the users.

Fig. 2. Distributions of Likes received by males and females at various sex ratios.



A Lorenz curves for the likes of male and female agents is shown below. The resulting Gini coefficient is significantly higher for males than it is for females. For both genders, it increases when they become the majority of users.

Fig. 3. Lorenz curves as fairness measurement for female and male agents.



Different parameter settings influence the Gini coefficient for female and male likes. Table 2 presents three different combinations of settings with different Gini coefficients.

Table 2. different settings and fairness outcomes.

Label	**Female Selectivity**	**Female: Male Ratio**	**Time People Spend on App**	**Gini Coefficient (female likes)**	**Gini Coefficient (male likes)**
Fair Conditions	Low	1:2	High	0,302	0,444
Cormal Conditions	Moderate	1:3	Moderate	0,387	0,582
Unfair Conditions	High	1:9	Low	0,401	0,660

5. Empirical Support for the Model

Empirical data was used whenever available, see table 1. Men are over-represented on dating apps. Reasons for this are debatable: maybe this is because they, on average, show more interest in sex (Baumeister et al. 2001), have a harder time finding mates in the offline world, or other. Depending on source and specific platform, the proportion of males on swiping apps varies between 65% and 93% (Iqbal 2019; Netimperative 2019). Compared to other means of dating, swiping apps promote especially quick evaluations of others (David & Cambre 2016). This may result in exaggerated importance of physical attractiveness, which already plays a big role in mate selection (Walster et al. 1966, 508; Feingold 1990; Sprecher et al. 1994). Physical attractiveness also affects which people the users are aiming for (Hitsch et al. 2005, 3). They tend to aim for people that are on average a bit more attractive than they are themselves (Lee et al. 2008, 675). Lastly, evaluation of attractiveness also depends on varying factors like mood or blood alcohol level (Jones et al. 2003, 1073; Lass-Hennemann et al. 2010). Overall, women are significantly more selective when finding intimate partners (Clark and Hatfield 1989; Buss and Schmitt 1993). These findings are integrated into our model: Users primarily like other users that are about as attractive as they are themselves, with females showing a higher selectivity, both males and females having some random leeway in their evaluations, and attractiveness values being normally distributed among the user population. At any point users can and sometimes do leave the app. There are two main reasons for this, users feel dissatisfied because of a lack of success, or they have success and do not feel the need for the app anymore (Lefebvre 2018, 1217). This leads to a high turnover rate: about 20% of users do not return in the next week (Iqbal 2019).

6. Limitations

This pioneering study has some limitations. For one, it needs a lot of computing power. This makes runs with large numbers of users impossible, or at least very time consuming. Second, the model does not include anything that is going on in the user's head, except from a simple rule on how to evaluate whether a user should like a profile or not. But this fact can be viewed as a strength of the system since the model is therefore inherently parsimonious in its assumptions. Modern swiping apps have special functions e.g. “Super-Likes” or “Icebreakers”. These serve as additional ways to get attention on the app and only a very limited supply is given to users. Another advanced feature are “dating app algorithms”. The profiles users see are not completely random. Profiles that are suggested are based on calculations made by algorithms behind the scenes (Rosenfeld et al. 2019). How these algorithms work is a business secret, and different apps use different algorithms. Such extras are not implemented in the model.

7. Discussion

Our model predicts that Likes and Matches are very unevenly distributed among the agent population. Furthermore, there is a high inequality, especially for males, among the distribution of Likes. This is indicated by the high Gini coefficient for the likes received by males and females. The Gini coefficient for males is in fact higher than that of over 90% of the world's economies (Elvidge et al 2012). Such an inequality was suspected (Medium 2015) but never quantitatively analyzed or shown. It helps to explain seemingly contradicting reports of user experiences with promiscuity and endless options on one side (Vanity Fair 2015) and frustration and loneliness on the other (The Guardian 2016). Considering the relationship between inequality and crime rates (Fajnzylber et al. 2005) this can be not only seen as unfair, but as problematic. This unfairness may be what is driving the high rate of users artificially improving their profiles: many users try to increase their perceived attractiveness by using make up (Osborn 1996), specific camera angles (Sedgewick et al. 2017), displaying wealth (Tskhay et al. 2017), using picture editing software for their profile pictures, or simply lying about any of these attributes or even personality characteristics. The model helps to explain why so many people are pressured into these kinds of behavior, since inequalities are related to unwanted behavior. Two main factors can drive or reduce this inequality: the sex ratio in the agent population and the selectivity of agents. Especially the skewed sex ratio, in combination with the fact that dating apps replace all other forms of dating (Rosenfeld et al 2019) and the link between uneven dating opportunities and violent crime among males (Seffrin 2017) are cause for concern. These factors may be artificially influenced by providers of swiping apps if they want to make their swiping app fairer. One way to lower the selectivity may be to follow up suggestions of very attractive profiles with less attractive ones, to make the latter seem more desirable (Taubert et al 2016). However, high female selectivity is the norm as can be seen when looking at the low percentage of profiles they like (Bilton 2014; Tyson et al 2016, 7). Because of psychological literature pointing to the fact that attractive people are popular romantic targets (e.g. Walster et al. 1966, 508), one can assume that the few likes given out by females go to the same few attractive males. The high selectivity of females is in line with evolutionary psychology (Clark and Hatfield 1989; Buss and Schmitt 1993) and the gravitation towards the same few male individuals is further evidence for mate copying by females (Dunn and Doria 2010). This model assumes that attractiveness is very much objective and produces results that align with reality. This can be interpreted as evidence that beauty is not entirely subjective, as suggested by psychologists (Langlois et al 2003), and that the only practical way to reduce unfairness on swiping apps is to change the underlying mechanics.

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References

Journals

Baker, Andrea.
2002. “What Makes an Online Relationship Successful? Clues from Couples who Met in Cyberspace.”
Cyberpsychology & Behaviour 5, no. 4: 363-375.

Baumeister, Roy F., Catanese, Kathleen R., and Vohs, Kathleen D.
2001. „Is There a Gender Difference in Strength of Sex Drive? Theoretical Views, Conceptual Distinctions, and a Review of Relevant Evidence.“
Personality and Social Psychology Review 5, no. 3: 242-273

Buss, David M., and Schmitt. David P.
1993. “Sexual Strategies Theory: An Evolutionary Perspective on Human Mating”
Psychological Review 100, no. 2: 204-232

Chan, Lik Sam.
2017. “Who uses dating apps? Exploring the relationships among trust, sensation-seeking, smartphone use, and the intent to use dating apps based on the Integrative Model.”
Computers in Human Behaviour 72, (July): 246-258

Clark, Russel D., and Hatfield, Elaine.
1989. “Gender Differences in Receptivity to Sexual Offers.” *Journal of Psychology & Human Sexuality 2,* no. 1: 39-55

David, Gaby., and Cambre, Carolina.
2016. “Screened Intimacies: Tinder and the Swipe Logic.”
Social Media + Society (April-June 2016): 1 –11

Diener, Ed., and Seligman, Martin E. P.
2002. “Very Happy People.”
Psychological Science 13, no. 1: 81-84

Dunn, M.J. and Doria, M.V.
2010. “Simulated Attraction Increases Opposite Sex Attractiveness Ratings in Females but not in Males”
Journal of Social, Evolutionary, and Cultural Psychology 4, no. 1: 1-17.

Elvidge C.D., Baugh, K.E., Anderson, S.J., Sutton, P.C., and Ghosh T.
2012. “The Night Light Development Index (NLDI): A spatially explicit measure of human development from satellite data.”
Social Geography no. 7: 23-35

Fajnzylber, Pablo., Lederman, Daniel., and Loayza, Normal.
2002. “Inequality and Violent Crime”
The Journal of Law and Economics 45, no 1: 1-39

Feingold, Alan.
1990. “Gender Differences in Effects of Physical Attractiveness on Romantic Attraction: A Comparison Across Five Research Paradigms.”
Journal of Personality and Social Psychology 59, no. 5: 981-993

Fink, Bernhard., Grammer, Karl., and Matts, Paul J.
2006. “Visible skin color distribution plays a role in the perception of age, attractiveness, and health in female faces.”
Evolution and Human Behavior 27: 433-442

Finkel, Eli J., Eastwick, Paul W., Karney, Benjamin R., Reis, Harry T., and Sprecher, Susan.
2012. “Online Dating: A Critical Analysis From the Perspective of Psychological Science.”
Psychological Science in the Public Interest 13, no. 1: 3 –66

Gibbs, Jennifer L., Ellison, Nicole B., and Lai, Chi-Hui.
2011. “First Comes Love, Then Comes Google: An Investigation of Uncertainty Reduction Strategies and Self-Disclosure in Online Dating.”
Communication Research 38, no. 1: 70-100

Gynther, Malcolm D., Davis, Amy Todd., Shake, Leasa G.
1991. “The Perception of Attractiveness: What About the Beholders?”
Journal of Clinical Psychology 47, no. 6: 745-748

Hitsch, Günther J., Hortacsu, Ali. and Ariely, Dan.
2005. “What Makes You Click: An Empirical Analysis of Online Dating:”
Society for Economic Dynamics, Meeting Papers, no. 2007: 1-51

Jones, Barry T., Jones, Ben C., Thomas, Andy P. and Piper, Jessica.
2003. “Alcohol consumption increases attractiveness ratings of opposite-sex faces: a possible third route to risky sex.”
Addiction 98, no. 8: 1069-1075

Langlois, Judith H., Kalakanis, Lisa., Rubenstein, Adam J., Larson, Andrea., Hallam, Monica., and Smoot, Monica.
2003. “Maxims or Myths of Beauty? A Meta-Analytic and Theoretical Review.”
Psychological Bulletin 126, no. 3: 390-423

Lass-Hennemann, Johanna., Deuter, Christian E., Kuehl, Linn K., Schulz, André., Blumenthal, Terry D., and Schachinger, Hartmut.
2010. ”Effects of stress on human mating preferences: stressed individuals prefer dissimilar mates.” *Proceedings of the Royal Society,* no. 277: 2175-2183

Lee, Leonard., Loewenstein, George., Ariely, Dan., Hong, James., and Young Jim.
2008. “If I’m Not Hot, Are You Hot or Not?”
Association for Psychological Science 19, no. 7: 669-677

LeFebvre, Leah E.
2018. “Swiping me off my feet: Explicating relationship initiation on Tinder.”
Journal of Social and Personal Relationships 35, no. 9: 1205–1229

Osborn, Don R.
1996. “Beauty is as Beauty Does? Makeup and Posture Effects on Physical Attractiveness Judgments”
Journal of Applied Social Psychology 26, no. 1: 31-51.

Rosenfeld, Michael J., Thomas, Reuben J., and Hausen, Sonia.
2019. “Disintermediating your friends: How online dating in the United States displaces other ways of meeting.”
PNAS September 3, 116 no. 36: 17753-17758

Sedgewick, Jennifer R., Flath, Megan E., Elias, Lorin J.
2017. “Presenting Your Best Self(ie): The Influence of Gender on Vertical Orientation of Selfies on Tinder.”
Frontiers in Psychology 8, no. 604: 1-6

Seffrin, Patrick M.
2015. “The Competition–Violence Hypothesis: Sex, Marriage, and Male Aggression”.
Justice Quarterly 34, no. 4: 652-673

Silva, Rita R., Koch, Marie-Luise., Rickers, Kyra., Kreuzer, Gabriel., and Topolinski, Sascha.
2019. “The Tinder™ stamp: Perceived trustworthiness of online daters and its persistence in neutral contexts.”
Computers in Human Behavior, no. 94: 45–55

Sprecher, Susan., Sullivan, Quintin., and Hatfield, Elaine.
1994. “Mate Selection Preferences: Gender Differences Examined in a National Sample.”
Journal of Personality and Social Psychology 66, no. 6: 1074-1080

Strubel, Jessica., and Petrie, Trent A.
2017. "Love me Tinder: Body image and psychosocial functioning among men and women"
Body Image 21: 34-38

Taubert, Jessica., Van der Burg, Erik., and Alais, David.
2016. "Love at second sight: Sequential dependence of facial attractiveness in an on-line dating paradigm".
Scientific Reports, no: 6: 1-5

Timmermanns, Elisabeth., and Caluwé, Elien De.
2017. "Development and validation of the Tinder Motives Scale (TMS)."
Computers in Human Behavior, no. 70: 341-350

Timmermanns, Elisabeth., Caluwé, Elien De., and Alexopoulos, Cassandra.
2018. "Why are you cheating on tinder? Exploring users' motives and (dark) personality traits."
Computers in Human Behavior, no 89: 129-139

Timmermanns, Elisabeth., and Courtois, Cédric.
2018. "From swiping to casual sex and/ or committed relationships: Exploring the experiences of Tinder users."
The Information Society 34, no. 2: 59-70

Tskhay, Konstantin O., Clout, Jerri. M., and Rule, Nicholas O.
2017."The Impact of Health, Wealth, and Attractiveness on Romantic Evaluation from Photographs of Faces"
Arch Sex Behav 46: 2365–2376

Tyson, Gareth., Perta, C. Vasile., Haddadi, Hamed., and Seto, Michael C.
2016. "A First Look at User Activity on Tinder." *Proceedings of the2016 IEEE/ ACMinternational conference on advances in social networks analysis and mining. Davis, CA: IEEE Press*: 1-8

Walster, Elaine., Aronson, Vera., Abrahams, Darcy., and Rottmann, Leon.
1966. "Importance of Physical Attractiveness in Dating Behavior."
Journal of Personality and Social Psychology 4, no. 5: 508-516

Websites

Anderson, Monica and Smith, Aaron.
2016. "5 facts about online dating". Last modified February 29, 2016.
https://www.pewresearch.org/fact-tank/2016/02/29/5-facts-about-online-dating/

BBC.
2016. "The dating game. Which dating apps are winning the hearts of the world?". Last modified February 2016.
https://www.bbc.co.uk/news/resources/idt-2e3f0042-75f6-4bd1-b4fe-9056540c65f8

Bilton, Nick.
2014. "Tinder, the Fast-Growing Dating App, Taps an Age-Old Truth." Last modified October, 2014.
https://www.nytimes.com/2014/10/30/fashion/tinder-the-fast-growing-dating-app-taps-an-age-old-truth.html

Clement, J.
2020. "Distribution of Tinder users in the United States as of June 2019, by gender". Last modified January 24, 2020.
https://www.statista.com/statistics/975925/us-tinder-user-ratio-gender/#statisticContainer

Iqbal, Mansoor. 2019.
"Tinder Revenue and Usage Statistics (2018)". Last modified February 27, 2019.
https://www.businessofapps.com/data/tinder-statistics/

Medium.
2015. "Tinder Experiments II: Guys, unless you are really hot you are probably better off not wasting your time on Tinder — a quantitative socio-economic study". Accessed April 16, 2020.
https://medium.com/@worstonlinedater/tinder-experiments-ii-guys-unless-you-are-really-hot-you-are-probably-better-off-not-wasting-your-2ddf370a6e9a.

Netimperative.
2019. "Online dating trends: Men outnumber women on Tinder by 9 to 1 (while Grinder wins for age diversity)". Accessed April 1, 2020. http://www.netimperative.com/2019/04/05/online-dating-trends-men-outnumber-women-on-tinder-by-9-to-1-while-grinder-wins-for-age-diversity/.

Simpletexting.
2020. "Dating Apps: Just for Hookups?". Accessed January 23, 2020.
https://simpletexting.com/dating-app-survey/.

The Guardian.
2016. "Is Tinder really creating a dating apocalypse?". Accessed April 16, 2020. https://www.theguardian.com/technology/2015/aug/16/tinder-app-creating-dating-apocalypse-twitter-storm.

Tinder.
2019. "About Tinder". Accessed January 15, 2020. https://www.gotinder.com/press

Vanity Fair.
2015. "Tinder and the Dawn of the "Dating Apocalypse"". Accessed April 16, 2020.
https://www.vanityfair.com/culture/2015/08/tinder-hook-up-culture-end-of-dating

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Ȧdea: Evolving Glyphs for Aiding Creativity in the Graphic Design Workflow

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Keywords: Generative Design, Generative Typography, Computational Creativity, Genetic Algorithm.

In creative fields such as Graphic Design, it is often difficult to break away from the past and find novel solutions. We present an evolutionary system for generating typographical glyphs along with a 3-stage workflow for using it as a graphic design tool. We evolve SVG using both interactive and automatic fitness assignments and comparing traditional operators with topological ones. The results suggest that the implemented topological operators are less destructive than conventional ones. Advantages to both interactive and automatic evaluation methods are addressed. Finally, we refer to a set of design artefacts developed out of the generated glyphs, demonstrating the relevance of including the system in the designers' workflow.

1. Introduction

Novelty is one of the fundamental characteristics of describing creativity (Boden 1996). Though, making novel advances in creative fields such as art or design often is a protracted process. Novelty may result from stochastic events, for example, exploited by experimentation (trial and error). For instance, even the interpolation of existent ideas may carry a stochastic factor, once it may be necessary to experiment with several different ways of interpolating ideas. For machines to be creative, these must overcome the same challenges as human beings do (Veale and Cardoso 2019). Thus, as Computational Creativity (CC) algorithms step forward in many creative fields, it is noticeable that many systems, mainly the ones based on Machine Learning (ML), often end up creating *pastiche*—imitations of existent styles (Toivonen and Gross 2015). Evolutionary Computation (EC), inspired by Darwin's theory of natural evolution, has potential to find novelty due to their similarity to the search processes of human designers—search the unexplored space of possibilities, often with a specific conceptual target limiting the possibilities. The main difficulty of applying EC for generating aesthetics is developing appropriate fitness functions. Nevertheless, ML and EC may complement each other for getting more capable CC systems. For instance, using EC for generating and ML for evaluating individuals. As long as there is not a perfect solution for finding novel designs, we believe that the most successful contemporary solution resides in the collaboration Human-Computer. In that sense, we propose a collaboration between humans, EC and ML (Romero 2007).

In this paper we are presenting Ȧdea, an online EC system for aiding designers during the creation of typographical glyphs, offering initial sketches for given characters. Human designers may then use the glyphs for creating design artefacts such as logotypes, typefaces or artworks. We opted to evolve SVG glyphs rather than raster ones for easing its editing and usage—it enables (i) direct vectorial manipulation, (ii) endless resizing and (iii) direct usage in typeface development software.

In the following sections, we present related work regarding ML and EC for aiding humans in the creative process. Then, we present our approach and we showcase some final artefacts designed using the generated glyphs. We conclude by reflecting on the current state of the system, along with future work.

2. Related work

Ȧdea uses EC to explore a set of parameters (gene values) and find novel typographic glyphs that help designers to construct new designs. Similarly, other systems have been developed using Artificial Intelligence (EC or ML) for aiding graphic designers' creativity.

A common ML approach is training models with existing examples and then handling the latent space to generate interpolations of these. However, as already referred, such approaches often produce *pastiche* results (Toivonen and Gross 2015). EC approaches also have their own shortcomings once it may be difficult to write conditions for automatically evaluating aesthetics. Yet, as well as it was employed in our system, ML may be used to endorse automatic fitness assignment, permitting extensive exploration. Correia et al. (2013) demonstrate the feasibility of such by evolving figurative images using classifiers trained to recognize objects.

Most of the EC systems for creative purposes employ interactive evaluation (manually managed by the user). This process is often slower yet more controllable, being useful in many creative contexts (Cunha et al. 2019). Along with ML and interactive aesthetics evaluation, Ȧdea regards EC for typography and vector formats. A related system is Heijer and Eiben's (2011), which allows the automatic evolution of computational-art out of vectorizations of photographs. The system also relates to ours by allowing one to start evolving from meaningful images.

Respecting both vector graphics and typography, Unemi and Soda (2003) proposed an interactive system for generating Japanese typefaces. The stroke of vectorial skeletons was evolved. Although there is no reference to it, it is likely that this approach could be applied to Roman alphabets. From the reviewed systems, Schmitz's (2004) is one of the most related to Ȧdea, by allowing to interactively evolve typefaces out of existing ones. The phenotype is encoded by three arrays of vectorial points describing the skeleton, line strength and serif shape (if available). The greater shortcoming of this approach is the need for a non-standard font format, which makes it difficult to create initial populations, leading to little variety. Yoshida et al. (2010) developed an interactive system for evolving typefaces out of existing ones. The anatomical parts of the initial glyphs had to be previously defined using complementary software. These requirements still obligate a protracted creation process, which may lead to the aforementioned shortcomings again. Levin's et al. (2006) permits to automatically evolve abstract yet congruent typefaces (represented by Bezier curves), starting from a single glyph and a set of parameters defined by the user. This approach could be highly complementary to Ȧdea. Though, there is no evidence that the system is able to generate glyphs for real alphabets. A more recent EC system for aiding type design is the one by Martins et al. (2016). The user may define a set of starting SVG modules and the system automatically evolves a style-congruent and camera-ready typeface out of them. By altering the starting modules, it is possible to create typefaces that are conceptually suited for a wide variety of purposes.

3. Approach

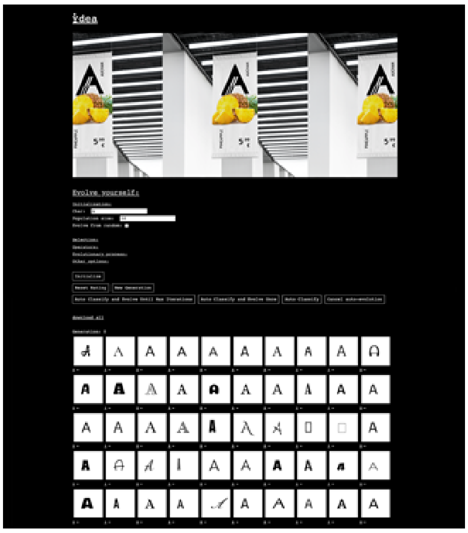

Fig. 1. Ȧdea's Interface
https://student.dei.uc.pt/~dfl/Adea

As a Human-Computer collaboration system, Ȧdea needs to be easily accessible to users (designers) and for that reason it was developed as a web page. The evolutionary engine runs natively on JavaScript (JS) on the client-side. The user interface (HTML, CSS, JS) (see Fig. 1) allows the definition of several different algorithm parameters, start and stop the evolutionary process, toggle between manual and automatic evaluation, and download single individuals or entire populations. After downloading the intended individuals, the user may manipulate them through external resources (for example, vector-edition software) or use them straight for creating designs. For trying the latest version of the system, please visit: https://student.dei.uc.pt/~dfl/Adea.

3.1. Evolutionary Engine

In our system, a genotype consists of a set of coordinates (relative to the canvas' origin) and their respective type of point—"line" (L) or "move to" (M). As a whole, those define SVG paths embedded in a 200x200 pixels view box.

Is it possible to start evolving from any population, whether it is a set of abstract individuals (randomly generated points, for example) or a set of meaningful glyphs (for example, the character "A"). It is also possible to evolve towards a given target, stop the process and then start from the already evolved population towards a different target.

At this stage, the interface does not allow the users to evolve from their own initial glyphs. The system starts by randomly choosing a number (population size) of typefaces out of a dataset of 977 *Google* fonts. Then, it automatically converts the characters into SVG paths using *opentype.js*.

The points of the paths are controlled using our one JS library, which allows point remotion, translation and type shifting (L or M). As the class cannot handle all the types of points, we convert them all into L and M types. This does not represent a problem because most of the paths can preserve their topology. Also, we do not seek to perfectly render the typefaces, but get a diverse set of initial meaningful glyphs. For starting from random initial populations, the points of each individual are randomized within the SVG canvas.

There are two different types of crossover available—2-point crossover and topological crossover. Variation operations involve two individuals at a time, each one with a 50% chance to be selected as predominant—first father. We refer to the latest as i1 and the non-predominant one as i2.

The user may set a probability for the variation operators to perform, as well as a maximum percentage of points to crossover in a single interaction (MPC). We set the latest as a percentage once the number of points in the genotype may vary in the order of hundreds. By doing that, we ensure that we are crossing over parts with relatively similar sizes.

The 2-point crossover operator takes a random slice of consecutive points from i1 and swaps it with a random slice of consecutive points from i2. The size of the slides is equal or smaller than the defined MPC. Also, the slices may not be the same size nor aligned.

The topological crossover operator aims to better keep the topology of the initial population, yet still maintain variety. For that to happen, a point from i1 is more likely to crossover with its closer points (in the Cartesian's plane) from i2. The crossover chances decrease exponentially as the points are further away.

We implemented five mutation methods which run by the following order: (i) point deletion; (ii) conventional/topological point translation; (iii) point type shifting; and (iv) point creation. The user may (i) choose between conventional or topological point translation; (ii) set a probability for a mutation to perform; (iii) set individual probabilities for each mutation operator to run; (iv) set a maximum percentage of points to be mutated in a single operation. The deletion method deletes one random point out of an individual's genotype. The conventional translation method translates one random point within a maximum radius (MR) defined by the user. The topological translation method translates a random array of consecutive points (>=1) according to a single random vector whose maximum magnitude is MR. The type shifting method toggles the type of one random point between L and M. The creation method picks a random point from i1 and adds a new point around it within MR; the type of the new point may be either M or L according to a probability defined by the user.

During the evolutionary process, the user may alternate between interactive and automatic evaluation. The fitness value is assigned from 0 to 1, being 1 the best hypothesis. An individual is considered properly fitted if its fitness value is greater than 1 minus a set satisfactory distance. Interactive evaluation is performed by clicking over individuals from better to worst fit. The not clicked individuals are assigned with the fitness of 0. Automatic evaluation is computed using a pre-trained neural network from *Tesseract.js* and it takes into account two considerations: (i) does *Tesseract* recognize the character; and (ii) with how much confidence it recognizes the character. If a glyph is not recognized or it is smaller than a minimum size defined by the user, the fitness value is set to 0. Otherwise, the fitness value is the distance between the confidence value returned by *Tesseract* and the target confidence set by the user. Ideally, a novel glyph for a given character must be far enough from *Tesseract*'s training examples (the existing glyphs), but close enough for the glyphs to be representative of the character. Thus, an optimal confidence target must not be 100%, but a lower value (80%, for example).

Regarding selection, the user may opt between tournament or elitist methods, and also set a tournament/elite size. The evolutionary process may be finished manually or by the completion of one of the following conditions: (i) a given maximum number of generations was run; (ii) a given percentage of the population is properly fitted.

4. Experimental Setup and Results

We conducted experiments to assess: (i) whether the system was able to generate suitable glyphs for a given character; (ii) whether we could find new ideas for aiding the design of novel glyphs. For assessing full detail on the settings used in the experiments, please visit: https://cdv.dei.uc.pt/adea.

We started by comparing conventional operators (Fig. 2.a and 2.b) and topological operators (Fig. 2.c and 2.d) for a population of *Google* "A"s evolved without evaluating individuals (random selection). As a result, we noticed that topological operators better keep the topology of the glyphs. We also noticed that having no evaluation is substantially destructive to the phenotypes, and the problem tends to increase as we step up generations (see Figure 2.b and 2.c for 50 generations and Figure 2.b and 2.d for 100 generations).

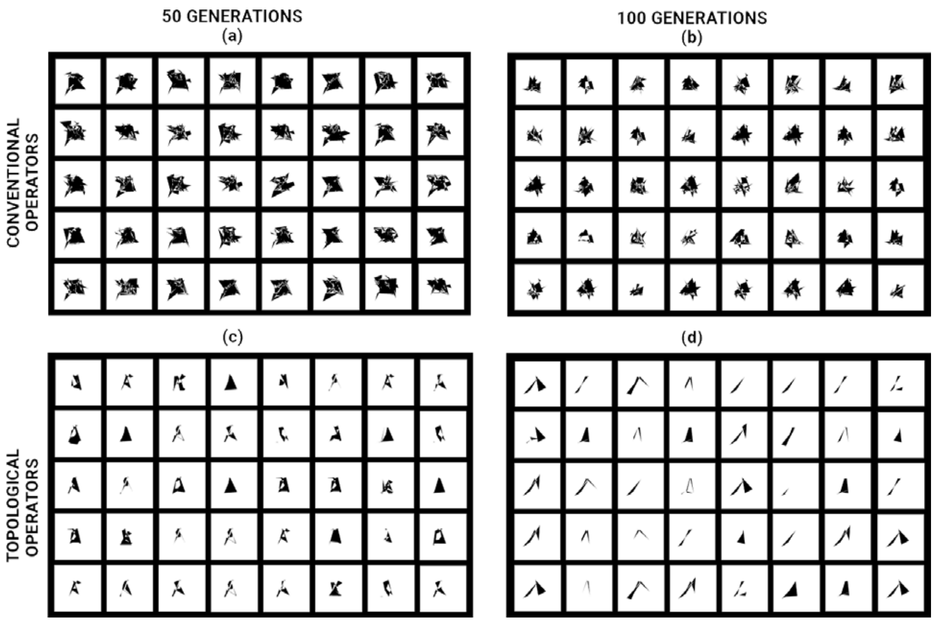

Fig. 2. Populations of Google "A"s evolved using random selection;
(a) 50 generations, conventional operators;
(b) 100 generations,conventional operators;
(c) 50 generations, topological operators;
(d) 100 generations, topological operators.

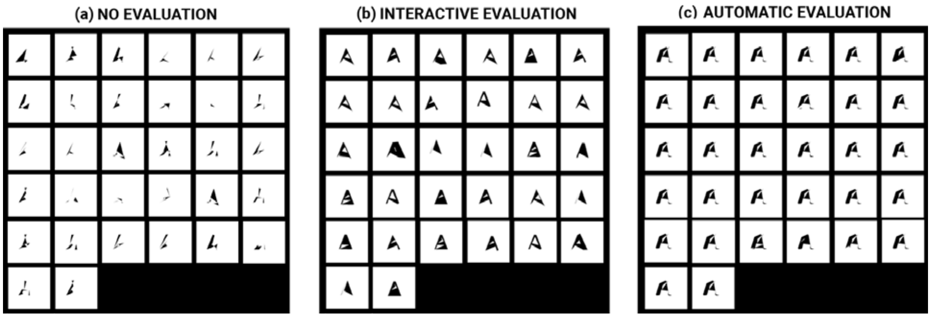

Fig. 3. 50th generation of Google "A"s evolved using topological operators; (a) using random selection; (b) using interactive evaluation and elitist selection; (c) using automatic evaluation and elitist selection.

Therefore, we compared random, interactive and automatic evaluation methods, using topological operators. As expected, both interactive (Fig. 3.b) and automatic (Fig. 3.c) evaluation turned out to be less destructive to the phenotypes than using no evaluation (Fig. 3.a).

By comparing Fig. 3.b and Fig. 3.c, we noticed that interactive evaluation may allow better control on the process, in this case, aiding the generation of less noisy glyphs. Moreover, these may be fully camera-ready and usable in graphic applications already. Its shortcoming may be the binding protracted process which may frustrate users after some seeds.

The automatic evaluation may be more agile and efficient once it has been successful in finding unexpected solutions without requiring major human effort. For instance, by searching for glyphs of 80% confidence, which may have higher chances to be novel due to their distance to the training examples of the network.

To address whether the aforementioned insights could be generalized, we evolved glyphs for all the uppercase characters in the Latin alphabet, using elitist selection and topological operators. Figure 4.a and 4.b showcases glyphs regarding interactive and automatic evaluation, respectively. Their similar graphisms suggest that both methods may lead to similar results, so the automatic one may stand out by being able to fasten the process, allowing the generation of a higher number of ideas per time period.

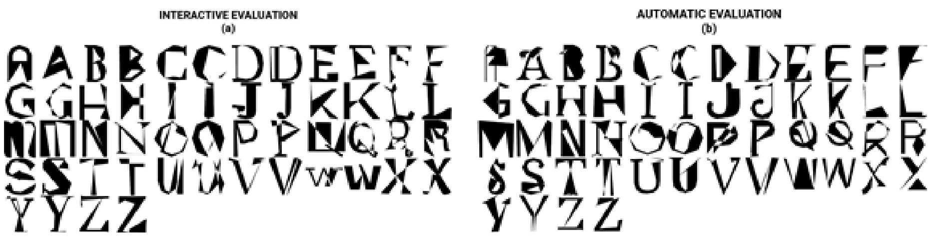

Fig. 4. Different characters regarding different seeds and generations, using elitist selection and topological operators; (a) regarding interactive evaluation; (b) regarding automatic evaluation.

As the generated glyphs may not be camera-ready (they may only trigger off new ideas), we recommend a 3-stage workflow (see Figures 5 and 6) for designers to use the system in its full potential: (i) generate and download glyphs straight out of Ådea; (ii) Use a third party software (vector-editing software, for example) for post-editing the glyphs or create new elements out of them (for example, a typeface or a logotype); (iii) Create artefacts using the previously designed elements.

For illustrating such, we present glyphs generated using varied operators and varied evaluation methods. Figure 5 presents a comparison between non-edited and post-edited glyphs, exemplifying possible manual fixes. We picked glyphs we considered noteworthy, yet different users may find different glyphs interesting. Figure 6 showcases artefacts designed using the same post-edited glyphs, demonstrating the potential of including Ȧdea in graphic designers' workflow.

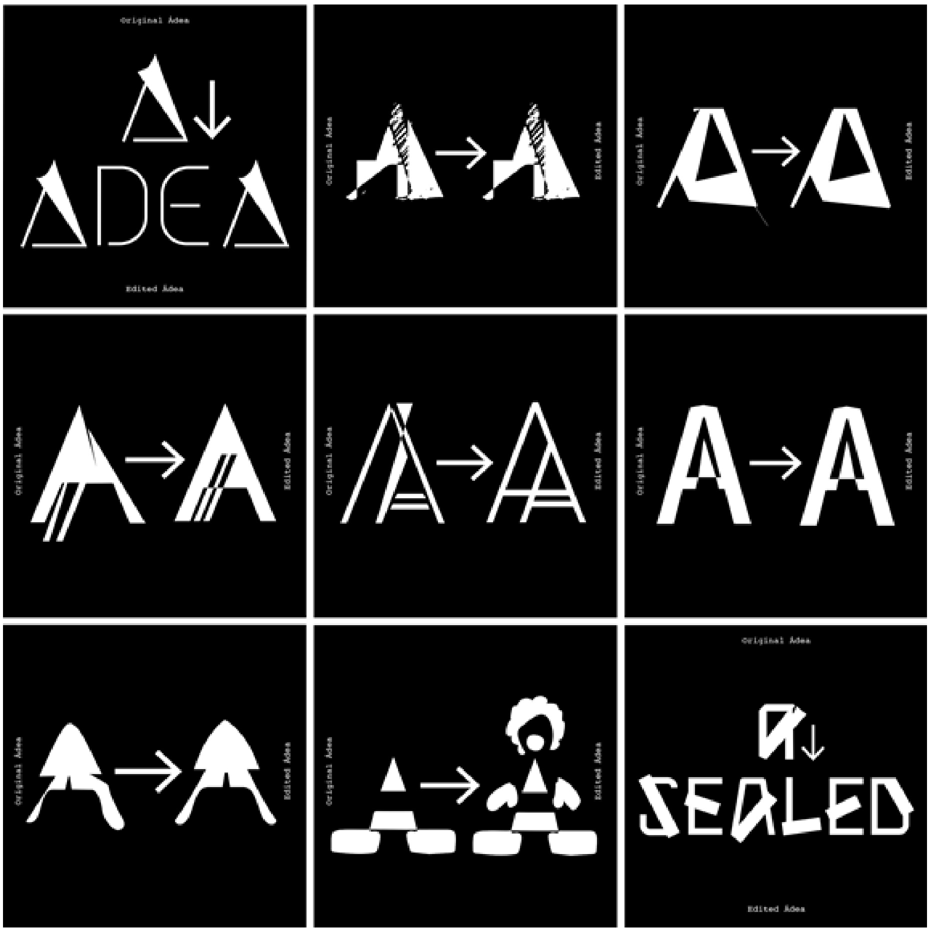

Fig. 5. Not-edited glyphs *vs* post-edited glyphs/ typefaces/ logos.

Fig. 6. Final artefacts designed using the manually manipulated glyphs/ typefaces/ logos.

5. Conclusion and Future Work

We have presented Ȧdea, an evolutionary system for aiding designers to find novel glyphs by offering starting points to conceptualize, construct and explore new design spaces. Instead of starting to evolve from randomness, we used glyphs from *Google fonts* for constructing initial populations—a starting point that we know to be closer from the intended results. These allowed us to use topological crossover and mutation operators which revealed to better keep the topology of the initial populations.

We tested both interactive and automatic fitness assignments (performed by a pre-trained neural network—Tesseract.js). We assessed that interactive evaluation may allow better control of the results, so it is easier to drive the process into camera-ready glyphs. Nevertheless, noteworthy results were also produced using the automatic fitness assignment. Thus we may pinpoint some advantages in using the latest, such as fastening the exploration process and allowing the generation of a higher number of ideas per time period.

Looking at the visual results presented in this paper, we consider that we have been successful in evolving suitable new glyphs for several different characters (see Fig. 4). Also, from our experience in GD and sustaining our conclusion in the artefacts designed out Ȧdea's glyphs (see Fig. 6), we consider that the system is capable of fostering creativity by offering ideas for GD applications. Future work will focus on (i) supporting the aforementioned statement by a user survey; (ii) finding other metrics for automatic evaluation (for example, pixel-to-pixel distance to existing glyphs); (iii) using figurative images in initial populations; (iv) using more mutation operators; (v) inviting different designers to test the system and use it to develop design artefacts; (vi) generate whole typefaces out of the generated glyphs.

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References

Boden, M. A.
1996. Creativity. In Artificial intelligence. Elsevier. 267–291.

Correia, J.; Machado, P.; Romero, J.; and Carballal, A.
2013. Evolving figurative images using expression-based evolutionary art. In Proceedings of the Fourth International Conference on Computational Creativity, 24–31.

Cunha, J. M.; Lourenço, N.; Correia, J.; Martins, P.; and Machado, P.
2019. Emojinating: Evolving emoji blends. In Eḱart, A.; Liapis, A.; and Castro Pena, M. L., eds., Computational Intelligence in Music, Sound, Art and Design, 110–126. Cham: Springer International Publishing.

den Heijer, E., and Eiben, A. E.
2011. Evolving art with scalable vector graphics. In Proceedings of the 13th annual conference on Genetic and evolutionary computation - GECCO '11, 427. New York, New York, USA: ACM Press.

Levin, G.; Feinberg, J.; and Curtis, C.
2006. Alphabet synthesis machine.

Martins, T.; Correia, J.; Costa, E.; and Machado, P.
2016. *Evotype*: from shapes to glyphs. In Proceedings of the Genetic and Evolutionary Computation Conference 2016, 261–268. ACM.

Romero J., Machado P., Santos A., Cardoso A.
2003. On the Development of Critics in Evolutionary Computation Artists. In: Cagnoni S. et al. (eds) Applications of Evolutionary Computing. EvoWorkshops 2003. Lecture Notes in Computer Science, vol 2611. Springer, Berlin, Heidelberg

Schmitz, M.
2004. GenoType.

Toivonen, H., and Gross, O.
2015. Data mining and machine learning in computational creativity. Wiley Int. Rev. Data Min. and Knowl. Disc. 5(6):265–275.

Unemi, T., and Soda, M.
2003. An IEC-based support system for font design. In SMC'03 Conference Proceedings. 2003 IEEE International Conference on Systems, Man and Cybernetics. Conference Theme-System Security and Assurance (Cat. No. 03CH37483), volume 1, 968–973. IEEE.

Veale, T., and Cardoso, F. A., eds.
2019. Computational Creativity - The Philosophy and Engineering of Autonomously Creative Systems. Springer.

Yoshida, K.; Nakagawa, Y.; and Koppen, M.
2010. Interactive genetic algorithm for font generation system. In 2010 World Automation Congress, 1–6. IEEE.

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Should Human Artists Fear AI?
A Report on the Perception of Creative AI

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Keywords: Artificial Intelligence, Creativity, Generative Systems, Art, Survey, Perceptions.

The question of whether a machine can be creative has been at the center of many scholarly debates. But what does the public think about the possibility for AI to gain a place alongside human artists? This paper presents the results of a survey conducted at the University of Nottingham which investigated the public reception of the application of Artificial Intelligence to the creative sector. The study examined the attitudes and beliefs of participants to the prospect of a future scenario where machines create art alongside and in collaboration with humans. The responses, collected both through an online questionnaire and a focus group, reveal that participants do not exclude the possibility that in the medium-term AI may earn the attribute 'creative'. Still, this does not mean that this scenario is welcomed.

1. Introduction

Artificial Intelligence (AI) applications relieve humans from the burden of tasks that would be too strenuous, too tedious, or that would require the elaboration of quantities of data that us humans would struggle to handle. In the last decades, however, AI has started entering also domains which we would comfortably describe as a prerogative of humans. Creativity is among these domains. In the last few years, AI has learned to write novels,[1] to draw,[2] and to animate pictures, not dissimilar from the portraits that hang on the walls of Hogwarts (*Zakharov et al*. 2019).

These state-of-the-art achievements by AI can without doubt intrigue and even bewilder the public. But how do people feel about the possibility for AI to be rightfully classified as 'artist' alongside humans in the medium-term future? In this paper I present the results of a survey conducted at the University of Nottingham in September 2019, aimed at testing how participants respond to the attribution of creativity to AI and to its application to the creative sector.

The survey consisted of an online questionnaire and a follow-up focus group, designed to discuss in more detail some of the prospects that emerged from the questionnaire. The results show a moderate agreement on the possibility for AI to develop creative qualities in the medium-term future (10 years from now), notwithstanding the fact that state-of-the-art AI is not deemed in possess of the necessary features to be at present deemed creative. These results, however, should not be taken as a mark of endorsement of the appropriateness of developing creative AI. On the contrary, the majority of participants expressed a feeling of concern and uneasiness at the prospect of a future creative AI entering a field that should remain exclusively human. I conclude the paper by pointing at some of the limitations of the study and at further research that may be conducted on the theme.

1. See, for example, the Japanese AI that passed the first round for the national literary prize https://www.digitaltrends.com/cool-tech/japanese-ai-writes-novel-passes-first-round-nationanl-literary-prize/.

2. See, for example, AI-Da robot, https://www.ai-darobot.com/ai-da-home.

2. Survey on the Perception of Creativity

2.1. Background

There is a rich literature on the definition of creativity and on its application to various domains, such as the arts but also science, technology and the everyday life.[3] However, what is lacking in the literature is a consensus on what the nature of creativity is. The notion of creativity can indeed cover a wide spectrum of meanings and definitions. It can be described as a subjective property of the artist or as a quality that is assigned to the process or product in question by the audience. On the other hand, it can also be described as an objective property that can be developed through exercise and hard work. It does not come as a surprise that, when the discussion revolves around the attribution of creativity to machines, the struggle in finding a consensus becomes even greater.[4]

3. For an overview on the theme of creativity in the literature and on the different definitions that can be given of it, see Boden 2004; Elton 1995; Gaut 2010; Glover, Ronning, Reynolds 1989; Moruzzi 2018; Newell, Shaw, Simon 1962; Runco, Garrett 2012; Keith Sawyer 2012; Simon 1985; Sternberg 1999; Weinberg 1993.

4. See Amabile 1996; Elton 1995; Kelly 2019; Newell, Shaw, Simon 1962.

One of the aims of the survey that I will present, was indeed that of analyzing the different opinions regarding the possibility for AI to be creative and of investigating the reasons that motivate them. Not surprisingly, the survey conducted confirms the lack of consensus as to what creativity is. The results obtained from the study are nevertheless beneficial to contribute to the mapping of public perceptions regarding the application of AI to the creative sector and the consequences that it may bring.[5] A secondary aim of the project is to get a grasp of the level of familiarity that contemporary audiences have with the recent developments in AI and with its application to the creation of 'art'. The long-term aim of this survey is to inform other, similar, surveys on different areas of application of AI. The final scope would, thus, be of getting a wider sense of the public reception of AI which could potentially inform policies and regulations on safe and beneficial applications of AI systems.

The study has been conducted in September 2019 as part of the Research Priority Area project 'Audience Perceptions of AI Interaction in Different Modes of Engagement' conducted in collaboration with the Departments of Humanities and Medicine at the University of Nottingham.[6] The study consisted of two parts. The first was an online questionnaire of 60 questions that was completed by 203 participants. The second part of the study consisted of two focus groups aimed at discussing in more depth the topics explored in the questionnaire.

In what follows, I describe in more detail the method and procedure of the questionnaire and focus group, as well as reporting on the results obtained.

5. Similar studies have been conducted, for example, by companies, governments, and teams of researchers, see AI Today, AI Tomorrow Survey 2020, Bristows 2018, Cave 2019, Robb 2004, Scheufele, Lewenstein 2005.

6. The other members of the team that participated to the project are Dr. Nicholas Baragwanath, Department of Music, Dr. Zachary Hoskins, Department of Philosophy, Dr. Elvira Perez Vallejos, School of Medicine.

2.2. Online Questionnaire: Method and Procedure

The online questionnaire was hosted on the JISC online survey platform and it was advertised through newsletters, social networks, and posters distributed around the University of Nottingham campus. The questionnaire was completed by 203 participants, who had been asked as a necessary condition to continue with the survey to agree for their answers to be used anonymously for research purposes. The participants were mainly academics (67.5%) and students (33%), and 9.9% were professionals. The age group 25-44y was the one that was better represented (63.5%). The participants belonging to the group 45-64y were 18.7%, 65y or above 3.4% and 16-24y 11.8%. The 74.9% of participants declared to be of White ethnic background. The majority of participants were Male (56.2%), the 37.4% Female, 0.5% Transgender, 1% Other and the 4.9% preferred not to answer.

After a screening section, aimed at measuring the familiarity participants had with AI and their engagement with the art sector, participants were asked their opinion regarding the application of AI in a range of different sectors. The central part of the questionnaire asked participants to indicate the principal features of creativity and to give answers to targeted questions about the use of AI in the creation of supposedly artistic products. Lastly, the questionnaire closed with some general questions on the participants' opinion regarding the possibility for AI to be creative. Some control questions have been included to try to minimize biases and to verify whether participants interpreted in a different way the terminology and concepts used in the questions. Most of the concepts discussed, such as creativity and its features, the concept of art, but also AI itself, can, in fact, be given different definitions and interpretations. Details of the relevant questions from the questionnaire are provided below in section 2.3..

At the end of the questionnaire, participants could enter a raffle prize of two £50 and two £100 Amazon vouchers as a reward for their completion of the questionnaire. They had also the option to insert their email address if they were interested in taking part to the follow-up focus group.

Given the diversity of the themes addressed and of the kinds of questions that were asked, the questions were of different kinds: binary questions, multiple choice questions, Likert scales, and one open question. With the exception of the open question, which was optional, answering the other questions was a necessary condition to proceed with the questionnaire.

2.3. Online Questionnaire: Results

The screening questions were aimed at having an idea of the background of the participants in regard to their engagement with the two fields on which the survey focuses, namely Artificial Intelligence and the creative arts.

Participants express quite a high level of confidence regarding their familiarity with AI systems. To the question 'How much do you know about AI?', the 75.9% replied 'Something' and the 18.2% 'A lot'. Despite the confidence displayed, though, the 32.5% of participants is 'Not sure' of whether they have been in contact or used an AI application, while the 8.4% declares not to have been in contact with any, which seems improbable given the pervasiveness of AI also in objects of everyday use such as the smartphone or the Internet (which participants had to use in order to fill in the questionnaire).

Getting closer to the theme at the core of the survey, to the question 'Are you aware of Artificial Intelligence systems that produce art?', the 66.5% of participants replied 'Yes', while the 14.3% is not aware of it. The 19.2% is instead 'Not sure'. As for the engagement with the creative sector, it is reassuring to note that only the 0.5% replied 'Never' to the question 'How often do you engage with creative arts (e.g. listening to music, going to the cinema, theatre, exhibitions, etc.)?', while the 78.8% engages with it 'Frequently'.

From the results, I believe it is safe to conclude that, from their own admission, participants are relatively familiar both with applications of AI and with the creative arts in general. What remains to be seen is how they react to the prospect of the interaction between these two fields.

The central task that the questionnaire presented to participants was to answer some questions about two paintings and two musical clips.

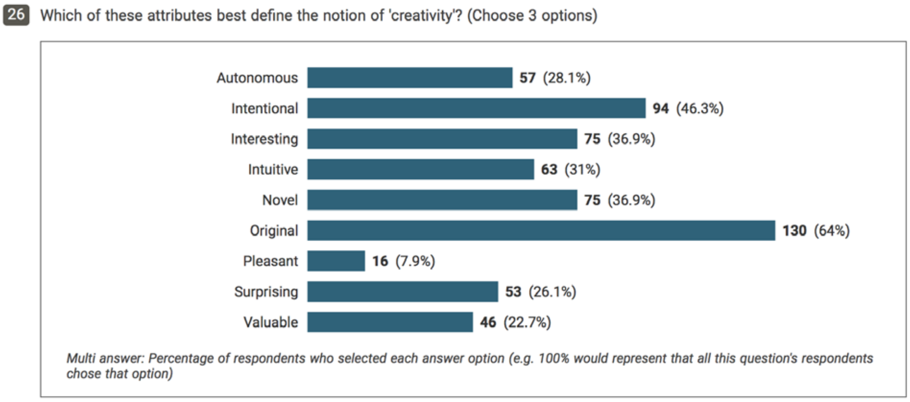
Participants were not aware of the fact that one of the two paintings was created by an AI and one of the two clips was AI-generated. More precisely, Painting 2 was created by the generative algorithmic model Creative Adversarial Networks (CANs) while Painting 1 was *Oil on Canvas* by the Armenian artist Yura Harutyunyan.[7] Clip 1 was AI-generated through Recurrent Neural Networks (RNNs) while Clip 2 was human-generated: *Emotional Piano Solo Music #2* by Mattia Cupelli.[8]

7. For Creative Adversarial Networks, see Elgammal 2017.

8. Accessible at http://www.hexahedria.com/2015/08/03/composing-music-with-recurrent-neural-networks/ and at https://www.youtube.com/watch?v=W-WJyFw5VT8.

Before engaging with the test, participants were asked to give their opinion regarding 'Which of these attributes best define the notion of "creativity"? (Choose 3 options)'. The participants' answers were as follows (Fig. 1. Attributes of creativity):

Fig. 1. Attributes of creativity.



The properties that are identified as the most defining features of creativity are: Original 64%, Intentional 46.3%, Interesting and Novel 36.9%. Not surprisingly, these are also some of the properties that are indicated in the literature as the essential characteristics of creativity.

After having the possibility to look at the two paintings and listening to the audio clips, participants were asked to reply to a number of different questions on a Likert scale that were aimed at testing which one of the two paintings/clips they preferred, and their level of confidence regarding the creativity, surprisingness, intentional creation, and pleasantness of the paintings/clips. Unaware of their provenance, 40.9% of participants agreed that Painting 1 (human-generated) was creative or very creative, while 28.6% claimed that Painting 2 (AI-generated) was creative or very creative. As for the clips, 35% of participants agreed that Clip 2 (human-generated) was creative or very creative, while only 20.2% claimed that Clip 1 (AI-generated) was creative or very creative. The results obtained are similar also in respect to the other parameters that participants were questioned on: the human-generated painting and clip obtained higher percentage of confidence as for their novelty, pleasantness, and surprisingness and participants liked them more than the AI-generated painting and clip.

As a last question, participants were asked which of the two paintings/clip they thought was created by a human. Most people recognized correctly which painting/clip was created by a human (58.1% for the painting, 62.1% for the clip). When asked if they would still pay to see Painting 2 in an exhibition and to listen to Clip 1, after learning that they were AI-generated, 25.6% participants replied 'No' and 10.8% 'Not at all' for Painting 2. The 47.8% of participants replied 'No' and the 29.1% 'Not at all' for Clip 1. Percentages decreased when, instead of paying, participants were offered to go and see Painting 2 at a free exhibition (13.4% replied 'No' and 5.4% 'Not at all') or to download Clip 1 for free (38.4% and 22.7% respectively).

The replies given by participants to these questions clearly depend on the paintings and music clips at issue and, thus, in part also on their aesthetic quality. It is not possible, then, to generalize and to conclude that participants would judge in a similar way also other products created by AI. Other questions in the questionnaire, however, allow us to have a wider sense of the participants' reception of creative AI in general. Even in this case, AI does not seem to gain much support, though.

To the questions 'If you found out that the painting/music album you just bought was not painted/composed by a human but by an AI, how would you feel about it?', participants did not react with much enthusiasm. The 31% of participants would be positively surprised if the painting was created by an AI and 35.5% if the music album was composed by an AI, but almost the same number of participants would react in a neutral way (36.5% for the music album and 36.9% for the painting). The 28.1% and 32% would instead be disappointed in finding out that the music album and painting respectively were AI-generated.

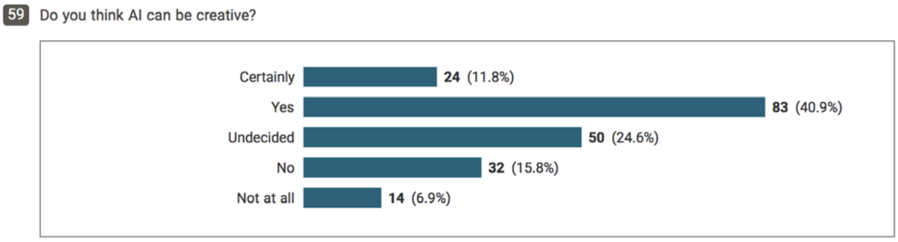
Even clearer is the participants' opinion when asked 'If you had the choice of buying a painting created by a human and one created by AI, which one would you buy?'. The 90.1% of participants would buy a painting created by a human and the 93.1%, when asked the same question but in relation to a music album, would prefer to buy an album composed by a human.

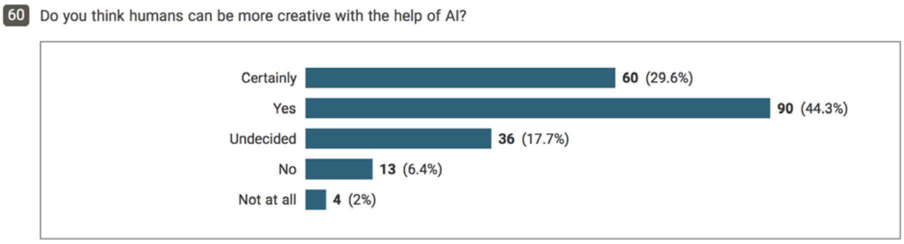
It should be noted that the disappointment that participants might have felt at the state-of-the-art AI-generated products presented as a case study in the questionnaire might have influenced also their reply to this question, since it was asked to participants after they carried out the test. The previous questions on the reaction they might have after finding out the origin of the product they bought was asked instead before they carried out the test on the human/AI generated paintings and music clips.

The questionnaire closed with a question that has been addressed numerous times in the literature on the topic and that stands behind the drive that motivated the design of the survey itself: 'Do you think AI can be creative?' (Fig. 2. Creative AI). Despite the disappointment expressed by participants in respect to the AI-generated painting and music given as example in the test, the majority of participants agreed with the possibility for AI to be creative: 40.9% of participants replied 'Yes', and 11.8% replied 'Certainly'.

Even more optimistic is the reaction to the question ‘Do you think humans can be more creative with the help of AI?’. In this case the 44.3% replied ‘Yes’ and the 29.6% is certain of the benefit that may come from the collaboration between humans and AI.

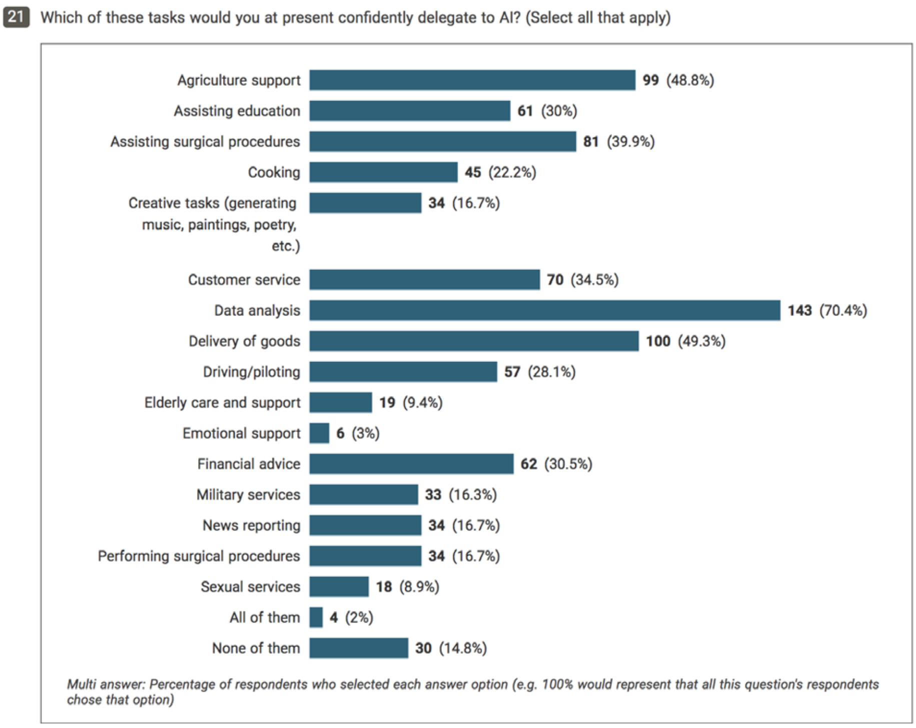
Fig. 2. Creative AI.

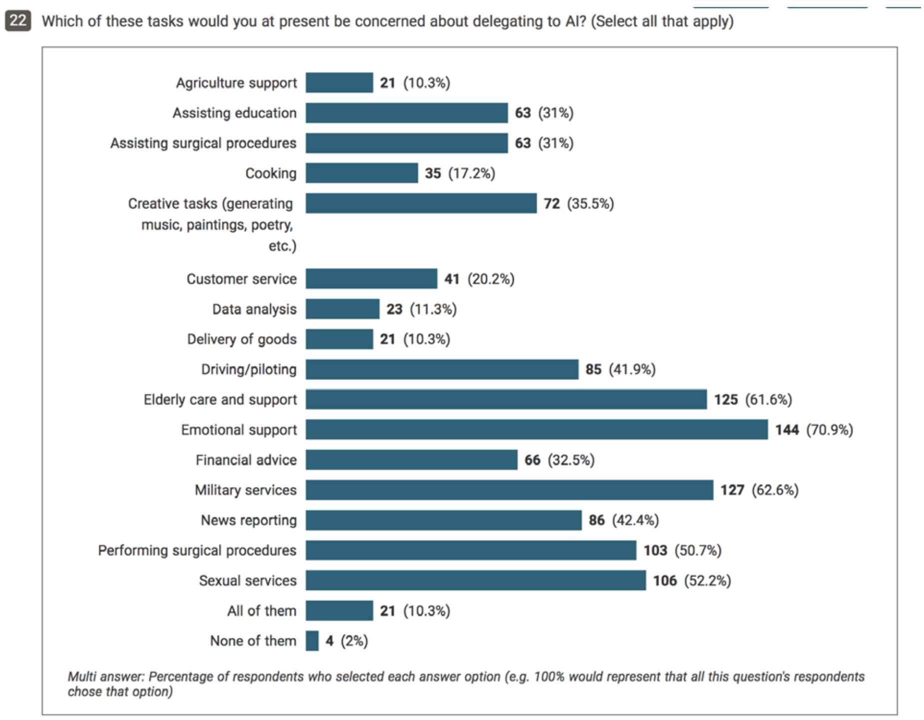




In general, however, the confidence that participants seem to grant to AI applications to the creative sector is not very high in respect to other areas of application. In the first part of the questionnaire, participants were asked the following two questions: ‘Which of these tasks would you at present confidently delegate to AI?’ and ‘Which of these tasks would you at present be concerned about delegating to AI?’. The results are as follows (Fig. 3. Applications of AI):

Fig. 3. Applications of AI.





The three areas of application that participants would more confidently delegate to AI are Data analysis 70.4%, Delivery of goods 49.3%, and Agriculture support 48.8%. The ones in relation to which participants expressed more concern are instead Emotional support 70.9%, Military services 62.6%, Elderly care and support 61.6%. It is clear from the results that the applications that people would be warier of delegating to AI are also those that involve emotional connection and empathy (in the case of Emotional support and Elderly care and support) or that require to take decisions that could have a relevant impact for global safety (in the case of Military services). On the other hand, more confidence is placed in respect to the application of AI to carry out tasks that are tedious or too time consuming to be carried out by humans. Application to creative tasks scored a 16.7% of confidence and a 35.5% of concern. The application of AI to the creative sector would in part also require the involvement of emotions and empathy, both from the side of the public and from the side of whoever produces art.

Still, the majority of participants is unsure about whether the increasing application of AI systems to different areas will be a valuable addition for our society. To the question 'Will society become better or worse from increased automation and AI', the 66.5% of participants declares to be 'Not sure', while only the 19.2% thinks it will become 'Better' (the 2.5% thinks it will not change, while the 11.8% thinks it will cause society to become 'Worse').

The concerns in relation to the use of AI systems for the creation of artistic products is expressed by many participants with clarity - and also with some vehemence - in reply to the open question of the survey. The question asked participants to motivate their reply in response to the question 'How likely do you think it is that AI replaces human artists in the next 10 years?'. 176

out of the 203 participants replied extensively to the open question, despite it being not compulsory for moving on with the questionnaire, thus showing the wish to engage with the topic. It is interesting to analyze the ideas that emerged from the replies in relation to the challenges met by AI in achieving a level of creativity which may be compared to human creativity.

The vast majority of replies can be grouped under two main categories: (i) those expressing the idea that AI cannot produce art/be creative since it lacks the necessary experience and 'personality' requested to a creative agent and (ii) those expressing the idea that AI cannot produce art/be creative since it lacks the necessary feelings and emotions. Some examples:

*****3819
'The personal narratives around artists are important. [...] Robots ain't gonna have any one trust that's worth listening to any time soon.'
*****8215
'The human subjectivity, intentionality and creativity can't be replaced by a machine, because a machine can only imitate the objective-formal thinking process.'
*****0222
'AI does not (any may never) possess the required emotional understanding.'

A third category that emerged in parallel to the two mentioned above is the category of responses that express a resolute distrust and instinctive aversion against the appropriateness of building a creative AI. Some examples:

*****3817
'Art created by AI will never be accepted within the entire population'
*****6582
'AI is a marketing sham'
*****1872
'What is the point of generative art if the greatest value of art (the process of artmaking by a human being) is left outside the equation?'

Similar feelings and opinions emerged also from the follow-up focus group that was conducted on similar themes. In the next section, I present the structure of the focus groups and its main findings, before moving on to the discussion on the conclusions that can be drawn from the results of the survey.

2.4. Focus Group: Method and Procedure

The follow-up focus group was designed with the aim of getting deeper into some of the issues that emerged from the questionnaire and to observe participants from different backgrounds interact through the discussion on the possibility for AI to enter the creative sector.

The focus group was advertised through newsletters and through posters in the University of Nottingham campus. People who were interested in participating contacted me directly through the email provided. Participants to the online questionnaire who expressed their wish to be part of the focus group had been contacted by email to ask for their availability.

The two focus groups had 10 participants each and they lasted one hour each. Both focus groups had been conducted at the University of Nottingham campus in September 2019 before the start of the lesson period in teaching rooms that were booked beforehand. The day and time of the focus group was agreed by email with the participants who signed up for the participation to the focus group.

Participants were asked to sign a consent form where they agreed for their replies to be reported anonymously in research papers and for me to record the session. They also anonymously filled in a sheet with screening questions, the same ones asked also in the online questionnaire. The participants to the focus group were mainly students (35%) and academics (25%) and the 25% of participants worked in administrative roles. As in the questionnaire, the age group 25-44y was the one that was better represented (85%), while participants belonging to the group 45-64y were 10% and 16-24y 5%. The 60% of participants was of White ethnic background. The majority of participants were Female 65% and 35% Male. The totality of participants declared to know 'Something' about AI and to engage with the creative arts 'Frequently' (55%) or 'Sometimes' (45%). For the participation to the focus groups, each of the 20 participants received a £15 Amazon voucher.

The focus groups consisted of three parts: in the first part participants were given a form each with a set of questions on AI and they were asked to discuss about them in smaller groups (two groups with 5 participants each) for around 10 minutes. They were asked also to write their individual replies on the forms that they handed me at the end of the session. The questions of this first part were the following:

Set A

1. What is AI?
2. What is your attitude towards AI in general?
3. Do you think AI can improve the way we live or that it will make it worse?
4. Are you aware of applications of AI in the arts? Name a few.
5. Do you think art is a field where AI will be able to replace humans? Why? Why not?

In the second part of the focus group I showed participants two videos. The first was the presentation of the Next Rembrandt project, sponsored by ING Direct in collaboration with the Rembrandt museum and Microsoft and the result of which was to create a portrait in the style of Rembrandt with the use of neural networks and 3D printers.[9] The second was the music video 'Automatica' of the musician Nigel Stanford playing music together with robotic arms created by the company KUKA Robotics.[10] After each video I left the students 10 minutes to discuss in their group the impressions derived from what they had seen.

9. Accessible at https://www.youtube.com/watch?v=IuygOYZ1Ngo.

10. Accessible at https://www.youtube.com/watch?v=bAdqazixuRY.

In the third and last part of the focus group, participants were divided again in two smaller groups with 5 participants each and they were given to discuss the following questions:

Set B

1. Do you think you are biased in your judgement of AI?
2. Has the session of today changed your ideas in this respect? Why?
3. If you believe that we (humans) are generally biased towards AI, what is that makes us so? What can we do to avoid it?

A supplementary scope of the focus group was to test two hypotheses:

H1: The fact that the artificial system is endowed with physical features increases the probabilities for this system to be perceived as creative.
H2: The skeptical attitude expressed by participants in respect to the possibility for AI to be creative that emerged from the online questionnaire is in part motivated by biases that people have against AI in general and, in particular, against the appropriateness of AI entering the creative field.

As I will detail, H1 was tested through the discussion that followed the videos and H2 through the questions asked in the last part of the focus group.

2.5. Focus Group: Results

The results that emerged from the focus groups confirm the attitudes expressed also by the participants to the online questionnaire. Participants to the focus group welcome the support that may come from AI system for carrying out tedious tasks, but they remain wary of a wider application of AI to other domains. Some of the opinions expressed during the first part of the discussion include:

Participant n. 1
Question A.1: 'I like the idea of having robots perform tedious tasks in my place but I think we should limit this to a certain degree'
Participant n. 11
Question A.2: 'Can be used for good or bad but needs to be controlled/monitored; pace of change scares me; needs legal oversight'
Participant n. 13
Question A.2: 'I'm afraid that in same point artificial intelligence would attempt against human kind'
In particular, art is perceived as a field which is, and needs to remain, paradigmatically human:
Participant n. 5
Question A.5: 'Imagination and creativity can't be replaced by machines.'
Participant n. 7
Question A.5: 'Art to me is essentially a field to express humanity.'

The reactions participants had after watching the two videos confirm the opinion they expressed in the first part of the talk. Both examples - the recreation of a painting in the style of Rembrandt through algorithms and 3D printers and the performance of a human musician with robotic arms playing instruments - are judged as fascinating processes but lacking the individuality and emotional involvement necessary to be considered 'Art' or creative. In particular, the Next Rembrandt project has been described as a 'waste of money' and disrespectful towards the original painter (Participant n. 13).[11]

11. In the online questionnaire, the 36.5% of participants declares to be 'concerned about the potential issues that AI could pose in matter of copyright', the 36.9% is undecided and the 26.6% is not worried about it.

The music video with the performance of robotic arms by KUKA, had the aim of introducing a further variable in the discussion, namely a physical presence of the machine that actively performs on stage. The starting hypothesis was that this additional element should contribute towards a more favorable acceptance of the potential creativity of the artificial system. Indeed, the fact of being embodied should arguably be beneficial to the agent's perception of the contextual environment and to its empathic interaction with other agents (Goldman 1993; Edmonds 1994; Sharples 1994). However, the participants' reactions supported H1 only in part. Participants, in fact, reported perceiving a lack of interaction of the robots with the audience and of the individuality that characterizes human performances, despite the physical presence of robots on stage. Even if robotic arms had not been deemed sufficient to vouch in favor of a greater creativity of the system, though, the relevance of embodiment for artistic performances had been acknowledged. Indeed, some participants did not exclude the possibility for these artificial agents to build a better connection with the public if they develop and assume additional 'human-like' physical features.

Testing the impact of embodied features on the perception of creativity is a task that would require more in-depth studies and experiments with controlled variables. I, thus, do not have the presumption that the results obtained in this respect from the focus group count as evidence against or in favor of the relevance of embodiment. They do, however, suggest that further investigations on the theme are worth pursuing.

The last part of the focus group was aimed at testing H2, namely the hypothesis that, in general, human are negatively biased against AI. Biases can affect judgements in respect to AI as a whole and as applied to the creative sector. Given its nature and the subjectivity of the area to which the notion is applied, the evaluation of creativity is in itself prone to biases. And biases may emerge even more strongly when the creative product is generated by a machine.

A notorious example of the effect of the biases that we bear in respect to non-human art is the case of David Cope's music generation program EMI, a software that creates new music by deconstructing the structure of the music entered as input into the database. This software was not exempt from biases: 'A music critic published a damning "review" of the first public concern of music composed by the Emmy program [...] - but he did so fully two weeks before the concert took place. [...] His preconceptions about the inadmissibly of computer-composed music [...] made any attempt at a TT [Turing Test] utterly pointless' (Boden 2010: 411). The lack of appreciation from the part of the audience ultimately led Cope to destroy the Emmy database (Boden 2010: 412).

The replies given by participants confirm the idea that we may be biased towards AI:

Participant n. 1
Question B.1: 'Yes! For me the reason is linked to ideas found in movies about the future. Those ideas are not necessarily true.'
Participant n. 4
Question B.1: 'Yes - as its [sic!] non human, we cannot form an emotional connection / relate to it. This is a bit barrier [sic!] for most people.'
Participant n. 14
Question B.1: 'Yes, biased against it to a large extent'
Participant n. 15
Question B.3: 'I think there's an instinctive aversion/suspicion to non-human tech - uncanny valley! Expectation of empathy with another human behind the art.'

Will this attitude change with the so-called 'digitally-conceived generation'?[12] Do these biases depend on the education of the individuals and on the context in which they are raised? Only time will answer the first question. As for the second, we can try to answer it by joining efforts in interdisciplinary research teams with the scope to analyze our perceptions and assumptions towards the diffusion of technology in our everyday life.

12. The generation conceived by the digital natives generation born from the 1980 onwards.

3. Discussion

From the results detailed above, some conclusions can be drawn regarding what do participants think regarding the possibility for AI systems to produce art alongside humans. Despite the fact that the examples used in the questionnaire - the painting generated through CANs and the music clip generated through RNNs - and in the focus group - the Next Rembrandt project and the 'Automatica' music video by KUKA Robotics - are not judged as displaying creativity, the majority of participants does not exclude the possibility that in the medium-term future AI may be creative. Even more positive is the attitude shown in respect to the possibility for AI to collaborate with humans to generate creative products.

This result, however, does not mean that participants agree at the same time with the appropriateness for AI to become creative. In other words, AI 'can' be creative but it 'should' not. This attitude emerges in particular from the replies given by participants to the open question in the online questionnaire and from the discussions in the focus group. This is accompanied by a diffused sentiment of uneasiness and concern regarding the intrusion of AI in many aspects of our existence. While the support that may come from AI systems to carry out burdensome and tedious tasks is generally welcomed, less so is the participation of AI in domains that require emotional participation and empathy, and the creative sector is among them.

In conclusion, it is necessary to point out some limitations of the present survey. The first limitation comes from the relatively small sample of participants and from a lack of diverse occupational background. Given the nature of the survey and the means that have been used to advertise it, in fact, most of the participants came from an academic background. It would be beneficial to repeat the survey with a more diverse pool of participants to examine whether it would entail also a change in the results. With a larger sample it would also be interesting to perform cross-tabulations between the age group of participants and the replies given to key questions in the survey. In the present survey, the sample size of some of the age groups is <20 participants, so it is not possible to relevantly apply statistical models to this kind of analysis.

A limitation of the survey that is less easily avoidable comes from the vagueness that is intrinsic to some of the categories that have been object of analysis. ‘Creativity’ and ‘art’ can indeed often be confused and, although it is difficult to totally exclude overlaps between categories whose definition is vague and which have many aspects of similarity, it could be helpful to conduct a survey that tries to isolate the two categories. Similarly, participants may not all agree on the use and meaning of notions such as ‘intention’ and ‘autonomy’. This condition could eventually be controlled by adding questions in the questionnaire, giving participants the possibility to clarify their use of terms.

Lastly, the test conducted in the questionnaire and the videos that sparked discussion in the focus group were limited to examples in the fields of painting and music. However, creativity can be displayed in a variety of other domains, from science to technology, to the everyday life. For the sake of completeness, thus, the discussion should be extended to other fields where AI can display creativity.

Many are the themes that emerged from this survey and that would be worth exploring in more detail. As already mentioned, the investigation of the role of embodiment for our perception of creativity would be beneficial both to better understand whether being endowed with physical properties is a necessary feature that a creative agent should possess but also to provide suggestions that can be useful for researchers in robotics to develop systems that can build a better interaction with users.

From the discussions during the focus group, it clearly emerged the idea that we are often biased in our judgement towards AI systems. This is a vast and complex theme that a single survey could not certainly exhaust. Further research would thus be welcome to explore the motivations that stand behind the mental models that we use when approaching topics such as the creative potential of AI. Although not a tool for acting directly toward a solution to the problem of biases, conducting further analysis and gathering data from participants coming from a variety of ethnic and occupational backgrounds would be beneficial to gain inputs that feed into a research path aimed at developing AI in a responsible and beneficial way.

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References

AI Today, AI Tomorrow Survey.
2020. "The Arm 2020 Global Survey" [accessed: 16-04-2020] https://pages.arm.com/artificial-intelligence-survey.html.

Amabile, Teresa.
1996. *Creativity in Context*. Boulder: Westview Press.

Boden, Margaret.
2004. *The Creative Mind: Myths and Mechanisms* (2nd ed.). London: George Weidenfeld and Nicolson.

Boden, Margaret.
2010. The Turing Test and Artistic Creativity. *Kybernetes* 39: 409-413.

Bristows.
2018. Artificial Intelligence: Public Perception, Attitude and Trust Survey [accessed: 16-04-2020] https://www.bristows.com/viewpoint/articles/artificial-intelligence-public-perception-attitude-and-trust/.

Cave, Stephen et al.
2019. "Scary Robots: Examining Public Responses to AI", *Proceedings of AIES*.

Edmonds, Ernest.
1994. "Introduction: Computer-based Systems that Support Creativity", in *Artificial Intelligence and Creativity, Studies in Cognitive Systems*, ed. Terry Dartnall. Vol. 17 (pp. 327-334.

Elgammal, Ahmed et al.
2017. "CAN: Creative Adversarial Networks, Generating "Art" by Learning About Styles and Deviating from Style Norms", arXiv:1706.07068v1.

Elton, Matthew.
1995. "Artificial Creativity: Enculturing Computers," *Leonardo*, Vol. 28 (pp. 207–213).

Gaut, Berys.
2010. The Philosophy of Creativity. *Philosophy* Compass, Vol. 5 (pp. 1034-1046).

Glover, John, Royce Ronning, and Cecile Reynolds eds.
1989. *Handbook of Creativity*. New York: Plenum Press.

Goldman, Alvin I. ed.
1993. *Readings in Philosophy and Cognitive Science.* Cambridge, MA: MIT Press.

Keith Sawyer, Robert.
2012. *Explaining Creativity: The Science of Human Innovation*. New York: Oxford University Press.

Kelly, Sean Dorrance.
2019. "A Philosopher Argues That an AI Can't Be an Artist", https://www.technologyreview.com/s/612913/a-philosopher-argues-that-an-ai-can-never-be-an-artist/.
Accessed on 5th August 2019.

Moruzzi, Caterina.
2018. "Creative AI: Music Composition Programs as an Extension of the Composer's Mind", *Philosophy and Theory of Artificial Intelligence 2017,* ed. Vincent Müller. Berlin: Springer.

Newell, Allen, John C. Shaw and Herbert A. Simon.
1962. "The Process of Creative Thinking", in *Contemporary Approaches to Creative Thinking*, eds. Howard Gruber, Glenn Terrel, and Michael Wertheimer (pp. 63-119). New York: Atherton Press.

Robb, David et al.
2004. "Robots in the Danger Zone: Exploring Public Perception through Engagement", arXiv:2004.00689v1.

Runco, Mark A. Garrett J. Jaeger.
2012. "The Standard Definition of Creativity", *Creativity Research Journal.* Vol. 24 (pp. 92–96).

Scheufele, Dietram, Bruce V. Lewenstein.
2005. "The Public and Nanotechnology: How Citizens Make Sense of Emerging Technologies", *Journal of Nanoparticle Research*. Vol. 7 (pp. 659–667).

Sharples, Mike.
1994. "Cognitive Support and the Rhythm of Design", in *Artificial Intelligence and Creativity, Studies in Cognitive Systems*, ed. Terry Dartnall. Vol. 17 (pp. 385-402).

Simon, Herbert.
1985. "What We Know About the Creative Process", in *Frontiers in Creative and Innovative* Management, ed. Robert Kuhn (pp. 3-22). Ballinger, Cambridge.

Sternberg, Robert J. ed.
1999. *Handbook of Creativity*. Cambridge: Cambridge University Press.

Weisberg, Robert.
1993. *Creativity: Beyond the Myth of Genius*. New York: W.H. Freeman.

Zakharov, Egor et al.
2019. "Few-Shot Adversarial Learning of Realistic Neural Talking Head Models", arXiv:1905.08233v1.

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Deriving Sense: Cognitive Aspects of Artefactual Creativity

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This paper explores the cognitive aspects of artefactual creativity in new media art. Starting with a concept of combinatorial inventiveness which is central to artefactual creativity, we outline its manifestations in the arts and culture, leading to contemporary applications of the emerging technologies for transforming the existing ideas, relations and data into new artworks. In view of the diverse art production in this domain, we focus on generative methodologies, and discuss the poetic features of the exemplar art projects created primarily by processing the material from cinema, television and the Internet. These artworks blend procedural thinking with bricolage, leverage complex technical infrastructures, foster curiosity and encourage vigilance in our critical appreciation of the arts, technology, culture, society, and human nature. In closing of each section, we outline the theoretical considerations that can be abstracted from the examples, and elaborate on them in the concluding section in which we examine the artists' motives and circumstances of analogizing, generating ideas and meaning making in relation with the cognitive implications of artefactual creativity.

1. Introduction

1.1. Combinatorial Inventiveness

Combinatorial inventiveness is essential in all manifestations of human creativity, from language, social and political relations, to the arts, science and technology (Boden 2004). In language and in the arts, it emerges from the cognitive processes for generating ideas, such as connecting the existing and the new, comparing the known and the unknown, and analogy-making (Hofstadter and Sander 2013). Combinatorial inventiveness in the arts and culture manifests in a range of creative procedures such as mashup, remix, pastiche, interpretation, free copy, allusion, citation, derivation, détournement, reprise, reference, reminiscence, homage, parody, imitation, forgery and plagiarism (Grba 2010, Boon 2013). With continuous recurrence of themes, motifs, forms and techniques, these procedures are among the key expressive and developmental factors in the arts throughout history. As an important part of art experience, combinatorial inventiveness induces pleasure through the recognition of source materials and models, and their interrelation with new poetic elements. It usually raises public attention in instances when a new artwork which references some copyrighted, commercially and/or otherwise prominent artefact becomes itself prominent, inciting the conflict over the 'creative interest' between two or more parties (Ferguson 2011). The obvious or implied creative use of cultural artefacts has been legitimized in different ways throughout the 20th century art—from Cubism and Dada, through Pop-Art, Fluxus and Conceptual Art, to Postmodernism in which it became a genre in itself—and today exists in many strategies and flavors. Within the context of contemporary culture, Lawrence Lessig extensively addressed various aspects of using digital technologies to transform the preexisting materials in creating the new artwork, and discussed the conceptual, legal, political, economic and social issues and consequences of combinatorial inventiveness, copyright and intellectual property (Lessig 2001, 2008).

1.2. Generative Art

In new media art, combinatorial inventiveness manifests through diverse applications of the emerging technologies for transforming the existing ideas, processes and data, and for exploring the expressive potentials of computational processing of all cultural phenomena that can be digitized. It is central in generative art, which we define as a heterogeneous realm of artistic practices based upon interfacing the predefined systems with different factors of unpredictability in conceptualizing, producing and/or presenting the artwork, thus underlining the uncontrollability of the creative process, and aestheticizing the contextual nature of art.[1] Like all other human endeavors, the arts take place in a probabilistic universe and always emerge from an interplay between control and accident, so in that

1. For other definitions of generative art in contemporary theoretical discourse, which vary by scope and/or inclusiveness, see Grba 2015: 201.

sense all the arts are generative. However, the awareness of the impossibility to absolutely control the creative process, its outcomes, perception, reception, interpretation and further use—which is often not the artists' principal motivation—becomes crucial in generative art (Dorin et al. 2012). Generative art appreciates the artwork as a dynamic catalyzing event or process, inspired by curiosity, susceptible to chance and open for change (Grba 2015). In its broad spectrum of creative endeavors, generative new media art frequently entails bricolage.

1.3. Bricolage

Bricolage is an analogizing approach that combines the affinity and the skills for working with tools, materials and artefacts available from the immediate surroundings. Reflecting the necessity-driven pragmatism of Italian neorealist filmmakers in the 1940's and 1950's (Giovacchini and Sklar 2013), bricolage became popular with arte povera movement during the 1960's as a critical reaction to the commodification of the arts. Since then, it has been adopted and explored in various disciplines including philosophy, anthropology, sociology, business, literature and architecture, and it has become almost transparent in a wide range of artistic disciplines. Discussing the concept of bricolage in *The Savage Mind* (1962), Claude Lévi Strauss noted that a bricoleur accumulates and modifies her handy means (operators) without subjecting them to a predefined objective, but the objective gets shaped by the interactions between operators (Mambrol 2016) in a dynamic process of analogy-making and discovery. Bricolage is therefore integral to new media art projects which constantly push the envelope of methodology, production and presentation through playful but not necessarily preordained experimentation with ideas, tools, and cultural resources.

2. Culture as Database

In our massive cultural production and consumption, various phenomenological aspects of everyday life can be quantized and approached as datasets. New media artists combine statistical tools with computation techniques to accumulate, categorize, process, transform and interact these datasets into new works that help us discover and compare the analogies, trends, regularities and trivialities in mass-produced culture. Adding an ironic twist to Jean-Luc Goddard's encyclopedic approach to cinema and modern culture epitomized in *Histoire(s) du cinema* (1989-1998), these artists turn the primary database operation of sorting into a conceptual device in order to explore supercut[2] as a generative mixer of cinematic and cultural tropes since the 1990's. By focusing on the specific elements (words, phrases, scene blockings, visual compositions, shot dynamics, etc.), supercuts accentuate the repetitiveness of narrative forms, routines and clichés in film, television and other media.

2. Supercut is an edited set of short video or film sequences selected and extracted from their sources by at least one recognizable criterion. It inherited the looped editing style from Structural film in the US during the 1960's and developed into the Structural/Materialist film in the UK in the 1970's (McCormack 2011).

For example, Matthias Müller's *Home Stories* (1990) is a collage of different scenes and protagonists from Hollywood melodramas of the 1950's and 1960's, edited into a series of recurring motifs of cinematic suspense such as uneasy sleep, getting up, listening at the door, turning on the lights, being startled, etc. In Jennifer and Kevin McCoy's installation *Every Shot, Every Episode* (2001) a strict application of sorting algorithm rearranges the complete television serial *Starsky and Hutch* into a collection of shots organized according to 278 formal and thematic criteria: every zoom in/out, every architecture, every disguise, every female police officer, etc. Shots in each category are sequentially arranged on DVDs that the visitors can play freely on several parallel displays (McCoy 2020).

Taking slightly broader selection criteria, supercut morphs into a condensed micro-narrative in the works such as Cristian Marclay's *Telephones* (1995) and *The Clock* (2010), Tracey Moffatt's *Lip* (1999), *Artist* (2000), *Love* (2003 with Gary Hillberg) and *Doomed* (2007 with Gary Hillberg), or Marco Brambilla's *Sync* (2005). These self-referential structures follow the thematic and formal logic, and accentuate the three essential components of screen culture: gaze, sex and violence. Exploring the possibilities for reproducing film imagery, Virgil Widrich elaborated the supercut micro-narrative in *Fast Film* (2003). It was assembled by making paper prints of the frames from selected movie sequences, which were then reshaped, warped and torn into new animated compositions. In 14 minutes, *Fast Film* provides an engaging critical condensation of the key cinematic tropes such as romance, abduction, chase, fight, escape, deliverance, etc. (Widrich 2003).

With the explosion of online video sharing since 2005, supercut became a popular Internet genre but has remained a strong artistic device. Kelly Mark's post-conceptual installations *REM* (2007) and *Horroridor* (2008) spiced it up with existential overtones through daily manual aggregation and filtering of television broadcasts (Mark 2020). In several manually aggregated projects such as *Timeline* (2010) and *Watching Night of the Living Dead* (2018), Dave Dyment expanded micro-narrative supercut into a full feature format which yields generative wonder out of the pop-cultural proliferation. To make *Watching…*, he collected the scenes from hundreds of movies and TV shows in which people are watching George Romero's film *Night of the Living Dead* (1968), curated and arranged them along the editing track of the original to reconstruct the complete zombie classic as the *mise-en-scène* of other films and TV programs (Hosein 2018).

Supercut became interactive and automatic in Julian Palacz's installations *Algorithmic Search for Love* (2010) and *Play it, Sam* (2012). Referring to McCoy's poetic of sorting, *Algorithmic Search for Love* invites the visitors for a playful discovery by entering a search phrase that generates a sequence of all video snippets with matching spoken phrases found in the project's library of films. In *Play it, Sam*, (Figure 1) the visitors can play a classical piano to trigger a projected sequence of snippets from feature films in which the corresponding piano keys were pressed (Palacz 2020).

Fig. 1. Julian Palacz, *Play it, Sam* (2012). Installation view.

With *Network Effect* (2015), Jonathan Harris and Greg Hochmuth routed the interactive supercut to the diversity and the anxiety of online cultures (Figure 2). They designed a web search interface in which the keyword selection returns a media stream from an online database of 10,000 video clips, 10,000 spoken sentences, news, tweets, charts, graphs, lists, and millions of data points. By limiting this overwhelming but addictive experience to between 6 and 10 minutes depending on the average life expectancy in the viewer's country, *Network Effect* confronts us with the reality of corporate online cultures that often frustrate any attempt at experiential completeness and induce the fear of missing out (Harris 2015).

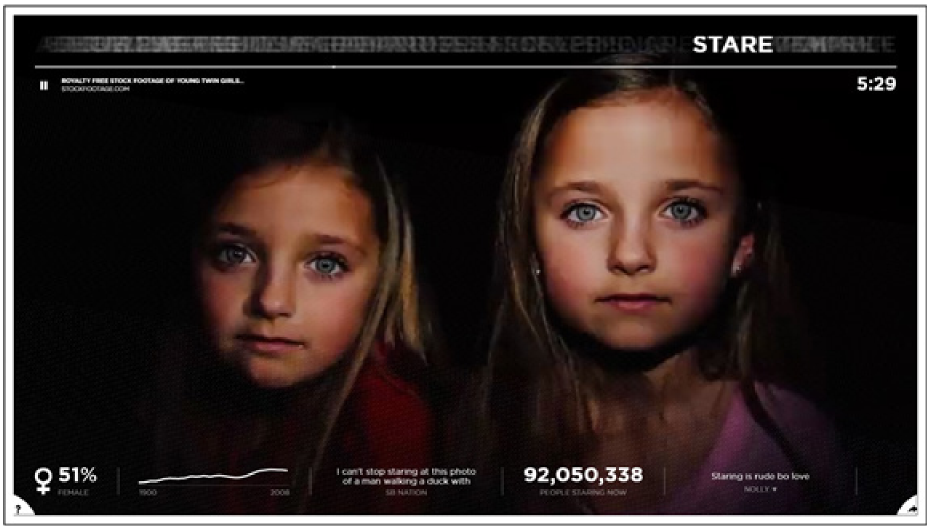


Fig. 2. Jonathan Harris and Greg Hochmuth, *Network Effect* (2015). Screenshot.

The poetics of automated supercut reached radical reduction and critical assessment with Sam Lavigne's open-source Python application *Videogrep* (2014) which generates video supercuts by searching the input query through subtitle files of an arbitrary collection of video files (Lavigne 2020).

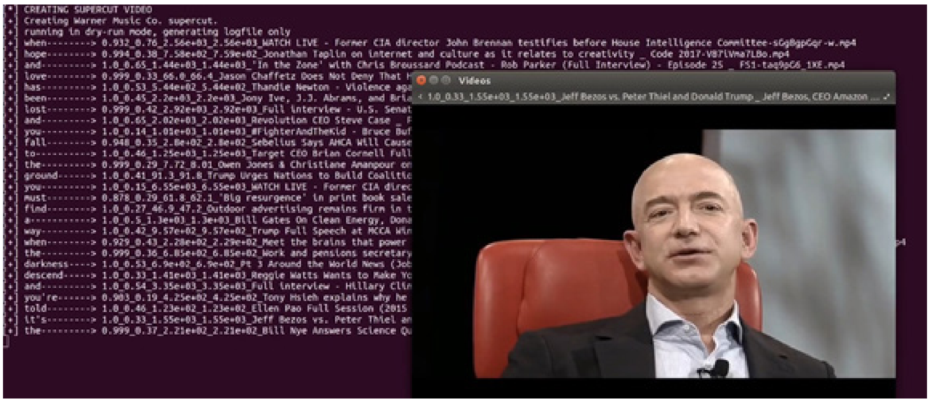


Fig. 3. Branger_Briz (Ramon Branger, Paul Briz, Nick Briz, Brannon Dorsey and Pedro Nel Ovalles), *Muse AI Supercut* (2017). Project case study screenshot.

Following this conceptual and technical logic leads to the machine learning (ML) systems that construct supercuts by searching the Internet (or large media datasets) for an arbitrarily selected artefact or a collection of artefacts. In *Muse AI Supercut* (2017) commission for the rock band Muse (Figure 3), digital agency Branger_Briz designed an ML system that generates daily supercut music videos in which every word of the Muse's song *Dig Down* (2017) is voiced by a different notable person from the videos found online (Branger_Briz 2017).

The innovative approaches to searching and editing the snippets of cultural production in these projects advance our understanding of animation, film, television, the Internet and other media, their experiential effects, social roles and consequences. They also demonstrate that there is no such thing as 'restricted creativity' but rather that creativity thrives on restrictions.

3. Sampling and Processing

Extending the logic of systematic selection, new media artists have been combining computational tools with statistical methods to explore the narrative and expressive potentials of automated accumulation, rearrangement and/or interpolation of cultural artefacts. Since the 1990's, Jason Salavon has been processing the various mass-media contents into refined visuals which define a peculiar aesthetic identity between infographics and abstract art. In *Every Playboy Centerfold 1988-1997* (1998), the artist merged all Playboy centerfolds from 1988 to 1997 into a single image using custom mean and median image averaging. In *100 Special Moments* (2004), he averaged the sets of one hundred conventionally themed stock photographs taken from the Internet: kids with Santa Claus, junior baseball league, the weddings and the graduations. In several video works such as *Everything, All at Once* (2001), *Everything, All at Once (Part II)* (2002) or *The Late-Night Triad* (2003), Salavon subjected the TV imagery to the radical abstraction through color averaging and slit-scanning (Salavon 2020).

Kurt Ralske elaborated the aesthetics of sequential frame sampling in a series of prints titled *Motion Extractions / Stasis Extractions* (2007-2009) in which he sequentially inter-dissolved the frames from various film classics[3] according to the degree of movement within each scene. *Stasis Extractions*

3. *Student of Prague* (1913), *Faust* (1927), *Citizen Kane* (1941), *The Seventh Seal* (1957), *Alphaville* (1965), *2001 Space Odyssey* (1968), etc.

comprises only the frames of static scenes, and *Motion Extractions* the frames with movement (Ralske 2007-2009). With *Cinemetrics* (2011), Frederic Brodbeck rounded up the infographic processing of the moving image into a Python application. It provides an interactive learning experience through the analysis of arbitrarily loaded films according to a number of criteria such as duration, average chromatic values, number of cuts, and sequence movement dynamics. It also allows comparison between the original version of a film vs. remakes, all films by the same director, films by different directors, by genre etc. (Brodbeck 2011). Multi-frame layering, averaging and/or collapsing in these works eliminate the details and reveal the formal and compositional trends in the source material, but also indicate some of the aesthetic preferences, as well as biases, in human visual perception.

However, perceptual biases such as apophenia and pareidolia[4] can be applied for analytical learning through extraction and rearrangement. For example, Benedikt Groß and Joey Lee's online project *Aerial Bold* (since 2016) utilizes the pareidolic effects to turn the alphabet shapes found in aerial imagery into a generative typeface (Figure 4). The project features a thorough documentation, a font catalog and an interactive word processor where the visitors can enter text and choose the font size, line spacing, different font classes, and locations (Groß, Lee et al. 2016). With cross-disciplinary development of crowdsourcing and machine learning techniques for deriving geodata from aerial imagery and enriching it semantically, this project also highlights the active role of artists and designers as data producers rather than passive data users.

4. Apophenia is a tendency to establish meaningful patterns within random data in general, while pareidolia is a tendency to recognize patterns within random visual data (nn 2014).

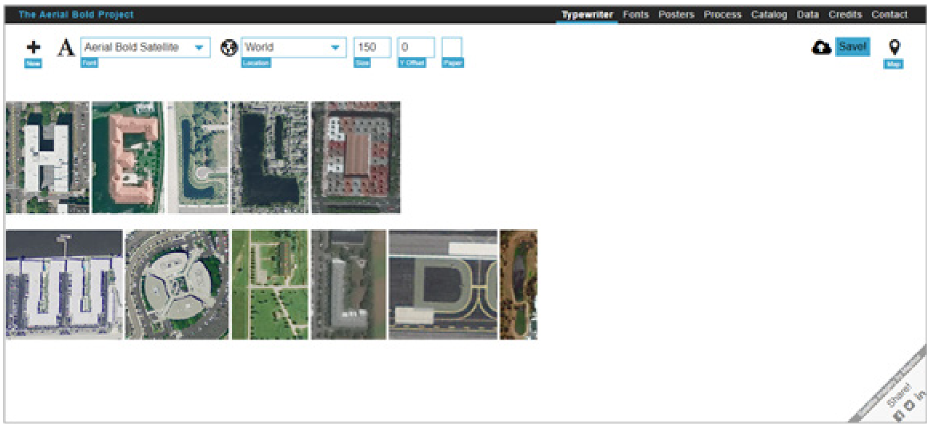
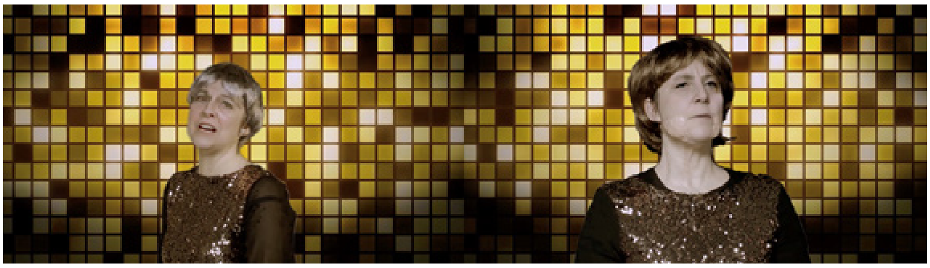


Fig. 4. Benedikt Groß and Joey Lee, *The Aerial Bold* (since 2016). Project website: typewriter.

The research in artificial intelligence (AI) has been providing various tools for the artists to interface and compare the human experiential learning with machine learning which relies on the large pools of accumulated samples. For example, Libby Heaney's *Euro(re)vision* (2019) is a moving image deep-fake in which two EU government leaders from 2019—Angela Merkel and Theresa May—sing absurd and nonsensical songs in a setting which mimics the Eurovision song contest (Figure 5) (Heaney 2019). Inspired by Dada and Cabaret Voltaire performances, this artwork uses two deep fake models and three character-level recurrent neural network models to create new forms of algorithmic poetry which eerily encapsulates the nonsensicality of actual EU/Brexit discourse.

Fig. 5. Libby Heaney, *Euro(re)vision* (2019). Screenshot.



Ben Bogart's series *Watching and Dreaming* (since 2014) is an attempt in understanding the algorithmic depictions of popular cinema based on the visual and sonic percepts (Figure 6). In this series, various film classics are interpreted and represented through hundreds of thousands of percepts which consist of millions of image segments grouped by color and shape similarity, and serve as a visual vocabulary for the ML system to recognize, and eventually predict, the structure of the processed films (Bogart 2019).

Fig. 6. Ben Bogart, *Watching (2001: A Space Odyssey)*, 2019. Screenshot.

By abstracting or concretizing the spatial, temporal, visual and sonic qualities of their source materials, these statistically informed works open new perspectives for envisioning, assessing and appreciating cultural phenomena. By emulating the semantic, narrative and expressive capabilities of human-made cultural artefacts, these works also question the nature of creativity.

4. Society as Database

Not only cultural artefacts, but all social structures and relations relying on frequent exchange of information can be envisioned and treated as databases. Collection of the clients' personal data, behavioral tracking, prediction and manipulation of decision-making have long been the essential strategies of large-scale systems such as governments, industry, marketing, advertising, media, finance or insurance, which all rely on frequent information exchange and processing. Computationally enhanced and virally exploiting the human need for socialization and communication, the new iterations of these old corporate strategies of quantization and statistical reductionism refresh our appreciation of privacy and our need for anonymity in a constant arms-race between the systems of control and the tools for individual advantage (Grba 2019). This is most evident in the interfaces of social media, whose design and functionality delineate their statistical logic, often by clumsily trying to hide it. Some new media artworks reveal this bizarre strategy in humorous and provocative ways. They emulate the models of corporate information services by virtually approaching the online participants as more or less complex datasets, but slightly repurpose their tools and objectives for the ironic revelatory effect.

Paolo Cirio and Alessandro Ludovico made several strong points in this context with their Hacking Monopolism Trilogy that began with *GWEI* and *Amazon Noir* (both 2006). For *Face to Facebook* (2010), the final project of the series, the artists created a bot which harvested one million Facebook profiles, filtered out 250,000 profile photos, tagged them by the facial expressions (relaxed, egocentric, smug, pleasant, etc.) and posted them as new profiles on a fictitious dating website called *Lovely Faces* (at http://www.lovely-faces.com) (Figure 7). *Lovely Faces* had been fully accessible and searchable for five days, during which the artists received several letters from Facebook's lawyers, eleven lawsuit warnings, and five death threats (Gleisner 2013).

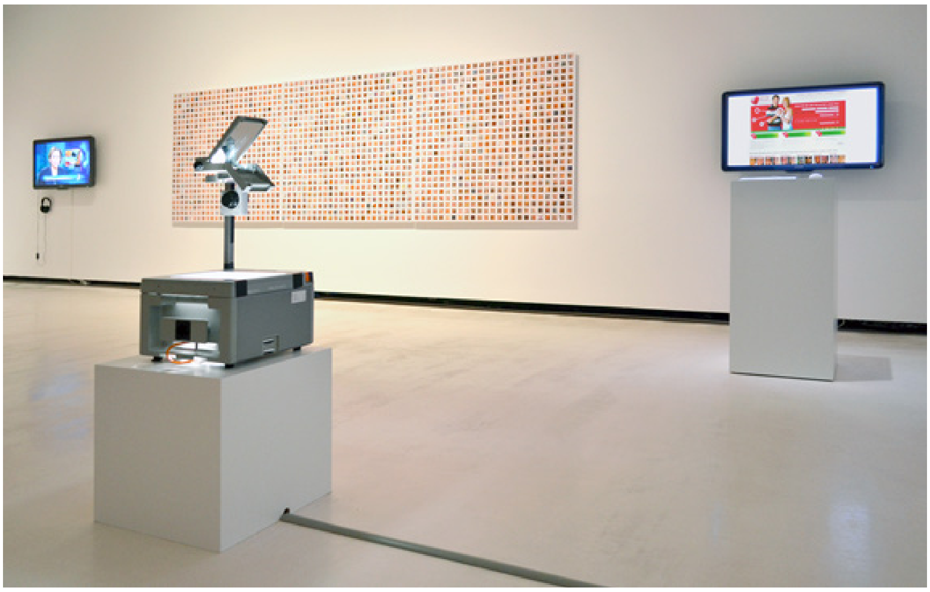


Fig. 7. Paolo Cirio and Alessandro Ludovico, *Face to Facebook* (2010). Artists as Catalysts exhibition in Alhóndiga, Bilbao, Spain. Photo: Paolo Cirio.

For his project *A More Perfect Union* of the same year, Luke DuBois made a shrewd interpretation of the technical term 'relational database' to draw a socio-cultural outline of contemporary United States according to the preferred identities and intimate aspirations of its population. He designed a software which sampled 19 million user profiles posted on 21 US dating websites, and used the associated zip codes to geographically arrange the most frequent keywords (blonde, cynical, funny, happy, open-minded, lonely, optimist, etc.) into 43 maps. In state and city maps, the artist replaced the names of cities, towns and streets with the most frequent keywords in dating profiles of local citizens. In federal maps, the brightness/saturation ratios of red and blue color show the relations between female and male preferences for the most frequent keywords in each state (DuBois 2011).

The uneasy positioning of the individual toward or within the online systems of control has been well analyzed by Alexander Galloway in his book *Protocol* (2004), and reverse engineered in a number of works by new media artists and activists such as Joana Moll (Moll 2017), Adam Harvey (Harvey 2017) and Vladan Joler. For example, Vladan Joler and SHARE Lab's project *Exploitation Forensics* (2017) (Figure 8) snapshots in a series of intricate diagrams the algorithmic logic and functionality of various layers in the Internet infrastructure: from the network topologies and the architecture of social media (Facebook) to the production, consumption and revenue generation complex on Amazon.com (nn 2017).

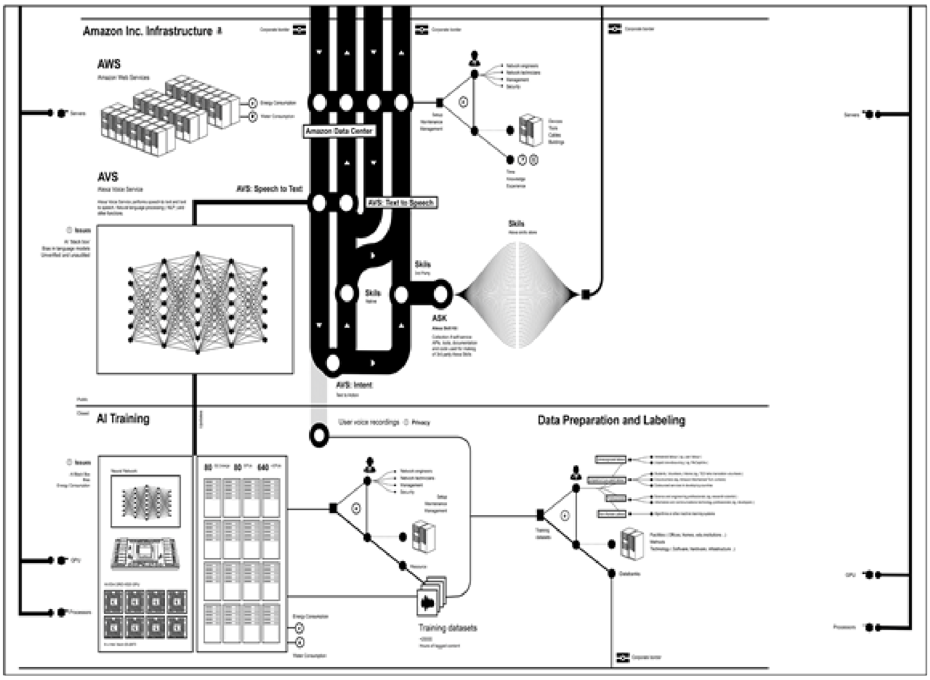


Fig. 8. Vladan Joler and Kate Crawford, *Exploitation Forensics: Anatomy of an AI System* (2017). Detail of the diagram.

These artworks skillfully criticize the digital implementations of governing mechanisms, point out their sophistication and pervasiveness, but also remind us that we are neither innocent nor completely sincere parties in this relationship. By adopting and using the profit-motivated digital platforms, our inertia, ignorance, selfishness and other fallacies (un)willingly support their functionality, build up their social authority and stir them to further exploit our participation explicitly (searches, clicks, selfies, stories, news), and implicitly (behavior patterns, intentions, desires, profiles). By extracting and representing the manifestations of our participatory-exploitative online strategies, these artworks also imply that only our fetishization of privacy protects us from realizing that the stories *of* us (as told by the metadata and algorithmic systems logic) are often much more interesting and meaningful than the stories *we tell* about ourselves. As long as we avoid dealing with our narcissism and our delusions of self-importance, we will fall prey to the dishonest signaling, exploitative agendas, and socially constructed apparatuses with mundane interests (Todorović and Grba 2019).

5. Artefactual Creativity

The projects we discuss in this paper are a sample of the divergent artistic exploration which contributes to the recent expansion of the creative AI. Contemporary AI research centers around a biologically-inspired programming paradigm called 'neural network' which enables a computer system to refine and optimize the methods for solving a particular problem or set of problems by training on the observational data and by dynamically modifying its own code instead of being exclusively programmed (Nielsen 2019, Bishop 2017). Since 2011, the innovations in AI science, technology and art target the elusive high-level cognitive functionality (which often includes the manifestations of human intelligence in artistic creativity), and rely heavily on processing large training datasets of annotated texts, drawings, pictures, photographs, 3D models, sounds, music, videos, films, etc. (Mitchell 2019). Being designed on various models of brain functions, the artefactual basis of the creative AI reflects the fact that human learning and creativity also rely to a large degree on the existing models and examples. These technologies enhance the realm of *artefactual creativity* which we understand as the application of combinatorial inventiveness to the specific qualities, meanings, contexts and/or implications of existing artefacts in order to produce interesting new artefacts.

5.1. Cultural Convergence and Artists' Opportunism

Creative flows and trends in science, engineering and in the arts are shaped by cultural convergence – the perceived, unperceived and/or idiosyncratic mutual influences and crossbreeding between analogous modes of thinking that render similar ideas, sometimes in different domains. Although the discovery often rides on well-established conceptual models or recognizable narrative structures, this ride is nonlinear and frequently gets unpredictable directions with unexpected consequences. Bricolage is an epitome of this largely self-organizing and accidental 'social life' of creativity, pronounced by the practitioners' expressive and/or aesthetic unorthodoxies. It also illustrates the power of interaction between the cognitive evolution, the mature and the emerging technologies, which sets up the conditions for novel concepts. In that regard, the artworks we discuss in this paper discredit the myth that everything has already been thought of, invented or discovered. Similar to science and technology, they always start with(in) the existing artefacts, but analogize, reconfigure, process and transform them with finesse and freshness which make us realize that they could only have emerged just now. They help us appreciate the difference between innovation (gradual) and invention (sudden change), showing that both have the potential to transform their contextual values and contribute to the enrichment of human experience, thinking, knowledge, and the world (Poole 2016).

The continuous zeitgeist-relative interferences in the arts, science and technology should be further addressed from the perspective of the unequal socio-political power and cultural hegemonies which keep some creative achievements unjustly overlooked, while disproportionately advertising others. This reflects in a tendency to praise certain creative models due to their luck of appearing within the right ideological authority, but without critically checking their originality or merit. On the other hand, in art and science only the 'fittest' survive by default, there is no copyright on ideas and one must fight their own place in the sun (Miller 2019). This is why feeling the zeitgeist, intuiting the paradigms and understanding the cultural convergence are strong motivational factors for the artists' appropriation of ideas, themes, techniques and technologies trending from other disciplines.

Within the context of code-based new media art, however, we also need to acknowledge the conceptual cogency, technical elegance, consequential power and aesthetic sophistication of the work in the related fields of computer science, engineering and robotics. In that respect, new media artists can be criticized for rarely going beyond smart or amusing spectacularization of the emerging techno-sciences and their cultural effects (Taylor 2014: 233). Although the artful spectacularization is necessary for making science and technology more accessible to the public and more open to critical insight (Taylor 2014: 113, 242, 243), the artists, the media and the cultural sector should outgrow the delusion (or cease promoting the illusion) that the arts can influence our world in the same way, to the same extent and with the same relevance as science and technology. Without the edge of critical self-consciousness, the artists' pragmatism easily slips into superficial, naive and/or exploitative strategies which support the hypothesis that the arts, among other components of human culture, have evolved as a suite of virtue signaling adaptations for sexual selection and social competition – one of the very views that the artists and art promoters oppose the most (Miller 2001). Respecting and exploring this edge, the artists can define new emancipatory horizons to help us question our ethical standards, assess our social norms, tackle our ever-changing present and anticipate the possible futures.

5.2. Above the Drive and Beyond the Procedure

Deeper understanding the cognitive aspects of artefactual creativity in new media art is instrumental for the artists' critical self-consciousness, and essential for our recognition of their achievements. At first sight, the artworks in this paper may suggest that creativity is somehow degraded if its procedural elements can be presented as algorithms and converted into program code. But the executable procedure of any creative process—when clearly defined—can be algorithmized and coded. Plasticity and adaptability in mimicking natural processes are the defining factors of universal computing machine which lays the conceptual foundation for modern computer science (David and Martin 2000, Watson 2012). Achieving that plasticity and adaptability, however, is itself a creative enterprise which requires ingenuity, multidisciplinary research, critical understanding of accumulated knowledge, and learning.

The development of new media art projects involves two modes of thinking. One is matching the algorithmic and the unpredictable elements into a coherent system. It relies on the anticipation of the performative qualities of the system, based upon experience, knowledge and intuition. Another mode is the construction of algorithms as multi-purpose tools, which requires procedural literacy and programming skills. This "ability to read and write processes, to engage procedural representation and aesthetics", means that programming is not a mechanical task but an act of dynamic communication and symbolic representation of the world (Reas et al. 2010). It runs in three steps: dematerialization of certain phenomenon into a set of signs which describe it properly, resolving that sign-set into pure syntax (removing the semantic layer), and translation of the syntax into a series of operations (within the programming environment) (Nake and Grabowski 2011).[5] This 'trivialization' requires a spectrum of cognitive abilities and skills such as the sense for recognizing the phenomenon which can be algorithmized under given conditions, imagination and flexibility of reasoning, distinguishing between the rational and irrational aspects in our mental concepts of natural phenomena, and attention to the scope of the algorithmic system. Whenever a previously incomputable natural phenomenon or creative process gets algorithmized, it is human intelligence doing the complex job of scrutinizing, symbolically structuring and encoding it into a functional system. The relationship between human creativity and human-built emulation of creativity reveals the essential flexibility of human mind in allowing itself to be influenced by the technology, and simultaneously absorbing, repurposing, transforming and inventing it.

5. This counterintuitive disassembly of the experience is clearly analogous to the core process of observation-based drawing, so it is probably just mental rigidity that makes many visual artists struggle to learn programming, and vice versa.

Procedural thinking faces some systemic challenges. The conceptual constraints of programming languages and hardware architectures can impose certain solutions and unwillingly spin the artistic process. The fixed performative capabilities of the hardware can reflect in roughness and lack of spontaneity (Watz 2010). Ultimately, there are the undecidable problems in computability theory, and the limits of mathematical formalization established in Gödel's incompleteness theorems (Penrose 1994). However, the material, formal and procedural boundaries are enforced by men or nature to all human activities, not just to procedural thinking. So, while the optimization of productivity and expressiveness within restrictive frameworks requires significant mental effort, the ability to break out of these frameworks is the essence of creativity (Kay 1997). In science, technology and in the arts, this ability often emerges through a combination of hard work and experimentation which can be pragmatic, playful or frivolous, but always implies the broader ethical aspects. The artists are motivated by the anticipation of poetic values and effects of their projects, but they also need to acknowledge the risks, to be open for the unwanted outcomes or failure, to evaluate and react by improving their methodology or by redefining their approach. Similarly, the agents of scientific, technological, economic or political experiments should be able to consider both their projected impact and the unpredictability of short- and long-term consequences, to be ready to question and improve their approach. Within such contexts of high stakes and high responsibility, artefactual creativity in new media art is instructive because it is defined by the artists' desire to overcome the fact that our experience is stronger than our imagination (Kay 2013), and that we predominantly understand new concepts through the existing (old) categories and models (McLuhan 1964).

The successful new media artworks which signify artefactual creativity are distinguished by the artists' abilities to transcend the conceptual, productive, aesthetic, and ethical constraints of algorithmic thinking and code-based expression. By leveraging the combinatorial inventiveness into the original structures, they offer inspiring, emotionally and intellectually rich experiences with unique aesthetic and ethical values. They are powerful cognitive tools for blending the elements of unrelated matrices of thought into the new entities of meaning through comparison, abstraction, categorization, analogies and metaphors. In a straightforward way, easy to understand and to empathize with, they affirm wit as one of the most attractive and valued human capacities. They tell us stories but, more importantly, they stir curiosity, stimulate imagination and further motivate creativity *through* experience, by revealing or suggesting their mental models which can be engaged implicitly or explicitly and incite new configurations and ideas.

References

Bishop, Chris.
2017. "Artificial Intelligence, the History and Future." The Royal Institution YouTube podcast. https://youtu.be/8FHBh_OmdsM.

Boden, Margaret A.
2004. *The Creative Mind, Myths and Mechanisms*, 40-53 and passim. 2nd edition. London/New York: Routledge.

Bogart, Ben.
2019. "Watching (2001: A Space Odyssey)." AI Art Gallery website. http://www.aiartonline.com/community-2019/ben-bogart/.

Boon, Marcus.
2013. *In Praise of Copying*. Cambridge: Harvard University Press.

Branger_Briz.
2017. "Muse AI Supercut." Branger_Briz website. https://www.brangerbriz.com/portfolio/muse-ai-supercut.

Brodbeck, Frederic.
2011. "Cinemetrics." Cinemetrics project website. http://cinemetrics.fredericbrodbeck.de/.

David, Martin, and Davis Martin.
2000. *The Universal Computer: The Road from Leibniz to Turing*. New York: W.W. Norton & Company.

Dorin, Alan, Jonathan McCabe, Jon McCormack, Gordon Monro, and Mitchell Whitelaw.
2012. "A Framework for Understanding Generative Art." *Digital Creativity* 23 (3-4): 239–259.

DuBois, Luke.
2011. "A More Perfect Union." A More Perfect Union project web page. http://sites.bxmc.poly.edu/~lukedubois/perfect/.

Ferguson, Kirby.
2011. "Everything is a Remix." Everything is a Remix website. http://www.everythingisaremix.info/.

Galloway, Alexander R.
2004. *Protocol: How Control Exists after Decentralization*. Cambridge: The MIT Press.

Giovacchini, Saverio, and Robert Sklar, eds.
2013. *Global Neorealism: The Transnational History of a Film Style*, 2. Jackson: University of Mississippi Press.

Gleisner, Jacquelyn.
2013. "Paolo Cirio's Lovely Faces." Art 21 magazine web page. http://magazine.art21.org/2013/08/12/new-kids-on-the-block-paolo-cirios-lovely-faces/#.XMLlPKQRVPY.

Grba, Dejan.
2010. "B.A.C.H. (References in Visual Arts)." Dejan Grba's website. http://dejangrba.org/lectures/en/2010-bach-references.php.

Grba, Dejan.
2015. "Get Lucky: Cognitive Aspects of Generative Art." *XIX Generative Art Conference Proceedings*: 200-213.

Grba, Dejan.
2019. "Forensics of a Molten Crystal: Challenges of Archiving and Representing Contemporary Generative Art." *ISSUE Annual Art Journal: Erase 08*: 4.

Groß, Benedikt, Joey Lee et al.
2016. "The Aerial Bold Project." The Aerial Bold Project website. http://type.aerial-bold.com/tw/.

Harris, Jonathan.
2015. "Network Effect." Jonathan Harris's website. http://number27.org/networkeffect.

Harvey, Adam.
2017. "MegaPixels." Adam Harvey's website. https://megapixels.cc/.

Heaney, Libby.
2019. "Euro(re)vision." AI Art Gallery website. http://www.aiartonline.com/highlights/libby-heaney-2/.

Hofstadter, Douglas, and Emmanuel Sander.
2013. *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking*, 17. New York: Basic Books.

Hosein, Lise.
2018. "Night of the Living Dead Has a Scarier Story Than You Think...because Copyright is Terrifying." CBC website. https://www.cbc.ca/arts/night-of-the-living-dead-has-a-scarier-story-than-you-think-because-copyright-is-terrifying-1.4768307.

Kay, Alan.
1997. "The Computer Revolution Hasn't Happened Yet." YouTube website. https://www.youtube.com/watch?v=oKg1hTOQXoY.

Kay, Alan.
2013. "Keynote at the 6th Annual Fujitsu North America Technology Forum." Computer History Museum website. http://www.ustream.tv/recorded/29156602.

Lavigne, Sam.
2020. "Repositories." Sam Lavigne's GitHub repository. https://github.com/antiboredom?tab=repositories.

Lessig, Lawrence.
2001. *The Future of Ideas*. New York: Random House.

Lessig, Lawrence.
2008. *Remix: Making Art and Commerce Thrive in the Hybrid Economy*. London: Bloomsbury Academic.

Lévi Strauss, Claude.
1962. *The Savage Mind*. Chicago: University of Chicago Press.

Mambrol, Nasrullah.
2016. "Claude Levi Strauss' Concept of Bricolage." Literary Theory and Criticism website. https://literariness.org/2016/03/21/claude-levi-strauss-concept-of-bricolage/.

Mark, Kelly.
2020. "Video." Kelly Mark's website. http://kellymark.com/V.html.

McCoy, Jennifer, and Kevin McCoy.
2020. "Projects." Jennifer and Kevin McCoy's website. http://www.mccoyspace.com/projects/.

McLuhan, Marshall.
1964. *Understanding Media*, 4. London: Routledge & Kegan Paul.

Miller, Arthur I.
2019. *The Artist in the Machine: The World of AI-Powered Creativity*, 39. Kindle edition. Cambridge: The MIT Press.

Miller, Geoffrey.
2001. *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature*, 258-291. New York: Anchor Books/Random House, Inc.

Mitchell, Melanie.
2019. *Artificial Intelligence: A Guide for Thinking Humans*, 52-107. Kindle edition. New York: Farrar, Straus and Giroux.

Moll, Joana.
2017. “The Dating Brokers.” Joana Moll’s website. https://datadating.tacticaltech.org/.

Nake, Frieder, and Susan Grabowski.
2011. “Computational in Art and Trivialization in Computing.” HyperKult XX Lecture website. https://vimeo.com/27318263.

Nielsen, Michael.
2019. “Neural Networks and Deep Learning.” Online book. http://neuralnetworksanddeeplearning.com/.

nn.
2014. “Apophenia.” Skeptic’s Dictionary website. http://skepdic.com/apophenia.html.

nn.
2017. “SHARE Lab: Exploitation Forensics Press Release.” Aksioma – Institute for Contemporary Art website. http://www.aksioma.org/press/exploitation.forensics.zip.

Palacz, Julian.
2020. “Works.” Julian Palacz’s website. https://julian.palacz.at/en/works/.

Penrose, Roger.
1994. *Shadows of the Mind: A Search for the Missing Science of Consciousness*, 64-126 and passim. Oxford: Oxford University Press.

Poole, Steven.
2016. *Rethink: The Surprising History of New Ideas*, 81-99. Kindle edition. London: Random House.

Ralske, Kurt.
2007-2009. “Motion Extractions / Stasis Extractions.” Kurt Ralske’s website. http://retnull.com/index.php?/project/motion-extractions/.

Reas, Casey, Chandler McWilliams, and LUST.
2010. *Form+Code in Design, Art, and Architecture*, 17. New York: Princeton Architectural Press.

Salavon, Jason.
2020. “Works.” Jason Salavon Studio website. http://www.salavon.com/.

Todorović, Vladimir, and Dejan Grba.
2019. “Wandering Machines: Narrativity in Generative Art.” *CITAR Journal of Science and Technology of the Arts, Special xCoAx Issue*: 55.

Watson, Ian.
2012. *The Universal Machine: From the Dawn of Computing to Digital Consciousness*. New York: Springer.

Watz, Marius.
2010. “Closed Systems: Generative Art and Software Abstraction.” in *Eléonore de Lavandeyra Schöffer*, edited by Marius Watz and Annette Doms, 1-3. Dijon: Les presses du reel.

Widrich, Virgil.
2003. “Fast Film.” Virgil Widrich’s website. https://www.widrichfilm.com/en/projekte/fast_film.

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A Sketch of Some Principles for Good Design in The Age Of Smart Automation

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Over the last decades, technological advancements have allowed automation to become "smart" and thus capable of replacing human manual control, planning, and problem-solving in a growing number of activities. This cognitive outsourcing has improved people's lives in several ways, but it has also brought a host of new problems such as loss of privacy and human liberties, deskilling, new forms of exploitation, harassment, and increased inequalities. This paper begins with the assumption that these issues are the consequence of poor design, and therefore asks what good design in the age of smart automation is. It analyses the general inherent complexities of automation and the role that User-Centered Design, arguably the contemporary dominant paradigm in design practices, could play in taming these complexities. It does so to provide a rough sketch of principles that a humanist and ethically-minded design approach should follow to ensure our technologies meet the moral, political, and social needs of people in the present and near future.

1. Introduction

While automation is relatively old, over the past decades, it has become "smart" thanks to the combination of recent developments in AI methods, computing power, and data availability. Smart automation has turned vital for many aspects of human life. In the so-called developed regions of the world, virtually every area of human activity, from fabrication to healthcare, now integrate some form of smart, automated system. Widespread implementation of smart automation, however, has brought many problems, including loss of privacy, threats to democracy, new forms of discrimination and exploitation, as well as new avenues for abuse and harassment. While admittedly no technology is neutral or intrinsically beneficial for human life, the above problems are not necessarily a direct consequence of smart automation *per se*, but rather, of poorly designed implementations of it.

There are many ways to explain poor design, including lack of experience, ignorance, incompetence, lack of resources, or even straightforward malice. However, in the case of contemporary smart, automated systems, arguably one of the main culprits (along with the logic imposed by venture capital) is the mixture of overconfidence, monocultural biases, and technocentrism afflicting their designers. The people fitting this profile tend to focus mostly on the positive aspects of automation and rarely on their downsides; hence they usually fail to consider that any new automated product will be embedded within larger and increasingly complex socio-technical systems. This type of designers tends to care more about the success of their creations and the profit they will bring to them and other stakeholders than for the well-being of end-users. That is to say, the people that will suffer the consequences misuses, and unforeseen risks brought by the new technologies.

More important, people responsible for poorly designed smart automated systems fail to consider whether their creations should exist in the first place. How to counter these situations is a matter of grave concern nowadays, for it is in this day and age that we will set the pace and tone of the technological developments that will shape human life for the next decades. Some form of regulation might be useful to address these issues; however, the scale at which it should be implemented, and the nature of the standards adopted are still a matter of great debate. Not to mention that policy tends to be impractical on account of the fact that it usually lags behind technological innovation. That is why one of the central questions that people involved in the design of smart automation must address is how to create systems that genuinely improve people's lives while minimising potential negative impacts. In other words, they ought to think about what "good design" should mean in the age of smart automation.

This paper takes that question as a starting point. It begins with an overview of automation and the inherent problems that every automated system can have, regardless of whether it is smart or not. This is followed by a brief outline of User-Centred Design (UCD) principles and their role when dealing with complexity. Through an admittedly simplified sketch of principles for good design, this paper shows that the UCD approach should integrate a robust ethical stance. It argues designers should steer as much as possible away from blue-sky technological thinking and instead pursue a *via negativa* approach when designing. That is, designers should focus less on the positive aspects of their creations and think more about everything that could go wrong when they go out into the world.

This paper shows that designers should strive to make explicit their assumptions and biases about technological systems and the long-term impact they can have on users by focusing not on the technical and methodological obstacles impeding their design but on the ethical constraints they should impose. This paper argues that to become genuinely humanistic, UCD should enable users to achieve a better understanding of their systems, for a thorough knowledge of our tools goes a long way in helping us navigate the muddle that is life. Ultimately, this paper argues that design has a crucial responsibility in developing our human project for the future. It is important to note, however, that the principles here outlined are nothing but rough sketches and therefore still require considerable reworking before reaching the point of turning prescriptive. The exercise here developed should be seen as a starting point for developing a more thorough critique of contemporary design approaches in the face of smart automation.

2. The Paradoxes of Automation

Humans have been automating tasks for a long time. Arguably, in light of recent discoveries about other animal species' capacity to communicate, develop cultures, and use tools, a case can be made that our propensity to "off-load" work to artificial systems[1] is a crucial aspect of being human (Martinho-Truswell 2018). Traditionally, automation has involved delegating the execution of physical or non-cognitive tasks originally carried out by humans or animals (e.g., beasts of burden) to machines (Danaher 2018; Johnson and Verdicchio 2017). Examples of the former include a bow and arrow or a windmill. In the last decades, however, the development of computational tools in general, and Artificial Intelligence (AI) in particular, has enabled automated systems to take over cognitive and mental tasks. The aim of automated systems is thus no longer confined to carrying out physical work but also "to replace human manual control, planning, and problem-solving" (Bainbridge 1983, 775). Hence, broadly understood, smart automation may be seen as "cognitive outsourcing" (Danaher 2018) to artificial (human-designed) systems.

In principle, automated systems should be capable of accomplishing processes without human intervention during runtime—that is, after all, their reason to exist. Nonetheless, every form of automation requires a

1. A system may be understood as an entity that can be separated into parts, which are all simultaneously linked to each other in a specific way (Vermaas et al. 2011, ch. 5).

minimum of human supervision, if not to trigger their operation, at least to guarantee their functioning, to make adjustments, to provide maintenance, and to expand and improve their features (Bainbridge 1983). In the case of simple automated systems, the former tasks tend not to be a problem; but as systems grow in complexity, so does the oversight they require. Since it is human beings who make sure automated systems operate safely and are also responsible for mitigating the consequences of those systems' malfunctions, it is clear that the more complex the automation, the more crucial the role of the human becomes (Strauch 2018). In this sense, then, and regardless of how sophisticated they might be, automated systems paradoxically continue to be human-machine systems (Bainbridge 1983).

The rationale for adopting automated systems is that they are faster, more reliable, and efficient than human beings carrying out the same tasks; this tends to be true for the most part, particularly when it comes to repetitive actions. Ironically, however, errors introduced when automated systems are conceived can be a significant source of operating constraints and difficulties, and these operating problems usually end up being solved by human operators (Bainbridge 1983; Strauch 2018). Automation implies abstracting processes, breaking them down and formalising them into definite steps, and then organising them into specific sequences. In other words, automation implies a deep understanding of those processes; otherwise, it would be impossible to "tell a machine" how to simulate them. Tasks that follow explicit procedural logic—e.g., simple mathematical calculations—are easier to formalise that is why machines vastly exceed human speed, quality, efficiency, and accuracy when it comes to computing (Autor 2014).

Nonetheless, such is not the case with activities that require flexibility, fine motor skills, judgement, and common sense. These are tasks that humans accomplish with little effort (e.g., giving advice, preparing an omelette or coming up with a good joke), not because we know their explicit "rules", but because we have *tacit* knowledge of how to achieve them (Autor 2014). A direct consequence of this paradox is that when those responsible for conceiving automated systems intend to replace human operators, ironically, these operators end up carrying out the tasks that could not be automated (Bainbridge 1983). For example, people still need to load paper into copying machines, moderate content in social networks, and make all sorts of input readable for machines. To paraphrase anthropologist David Graeber (2018), the "problem" of automating tasks that are easy for humans to solve but difficult to automate is that doing so requires vast amounts of (semantic) labour carried out by humans to render them into a form that can even be recognised by a computer. Anyone who has ever tried to input data into an interface that lacks some form of natural language recognition might understand the frustration caused by having to "translate" everything for the computer.

Automation has been historically more prevalent in socio-technical systems[2] such as agriculture, industry, and transportation. Ubiquitous computing and new Artificial Intelligence (AI) methods, however, have enabled smart automation to become integral for (and in the process radically change) a growing number of everyday human activities. Smart AI-powered automated systems require enormous amounts of data, both to be developed (trained) and to carry out their tasks. Whereas "traditional" automation relied on a predefined set of instructions based on its builder's understanding of the process to be automated (e.g., steps in an assembly line), smart automation aims to be more flexible, reactive, and adaptive.

2. A socio-technical system may be regarded as a hybrid system (i.e., one whose components belong to many different "worlds") with an extremely high degree of complexity that has many users at any given moment, and that involves people both as users and operators (Vermaas et al. 2011).

Smart automation based on Machine Learning (ML) adapts its responses based on patterns derived from vast amounts of information about human activities. Usually, the services provided by smart automation require predicting human behaviour, so the more data they have about a user's context and activities, the more effective their operation.[3] Hence why smart, automated systems are often deliberately conceived to acquire as much data as possible from their users—usually without their explicit knowledge and consent. Furthermore, given the value placed on data nowadays, some forms of automation are built for no other reason than to mine people's data. This continuous extraction and accumulation of information constitute the backbone of a new exploitative economic system threatening fundamental human liberties called surveillance capitalism (Zuboff 2015). Entire organisations are now invested in developing such "dishonest" forms of automation that not only extract data but, to do so, they lock users and operators into behaviours for which they have no legitimate need or desire (Girardin 2019).

3. The problem, however, is that ML models are often inscrutable, meaning that those who conceived and trained them do not have a clear understanding of exactly how they operate.

As we have seen then, it is already virtually impossible to build error-free "traditional" automated systems because humans are integral to their operation. Any attempt to replace the human factor can trigger errors that will need to be addressed by *another* human supervisor (Strauch 2018). Nonetheless, the limitations and irremediable operational problems brought by this growing complexity tend to be solved with yet *more* sensors, more data, and more dependencies; that is, with more automation. This paradox arguably happens because those in charge of the design tend to be technically trained (and minded) people who are more concerned about machines and efficiency than the welfare of users and operators (Norman 2010). Often, their objectives involve attempts to quantify the unquantifiable and, in doing so, they bring more burdens to the very people whose work should be made easier by automation. This kind of design that is driven by technological capabilities and not by user's needs is, by all means, one that follows a *wrong* design approach.

3. Good Design is Humanist Design

Asking what is a "good" design approach necessarily implies asking what *is* "good" design first. As anyone acquainted with the field of design knows, there is no single, consensual, and absolute answer for neither of those questions. The reason is, mainly, that philosophical issues (i.e., problems open to reasonable disagreement) such as these cannot be addressed in absolute terms (Floridi 2013). First, they need to be properly contextualised, that is, constrained within an appropriate level of abstraction (LoA)—the epistemic interface that mediates our relationship with any given phenomenon (Floridi 2008).

The LoA here chosen starts by broadly characterising design as "the intentional solution of a problem, by the creation of plans for a new sort of thing" (Parsons 2015, sec. 1.1); then, by framing design as a quintessentially modern enterprise. First, because design, as a domain and as a discipline emerged more or less between the late eighteenth and early twentieth century, a period commonly described as the modern era (Erlhoff 2008). Secondly (and consequently), because it is in the modern era that the quest for characterising and systematising "good design" started taking shape. Thirdly, because it is in the modern era that the broader cultural, political, economic, and social consequences of "good" design was first noticed and problematised. Finally, because it is the modern era that regarded good design as the activity that could most aptly respond to the social challenges brought by industrialisation (Parsons 2015).

The modernist view of design, despite its excesses, continues to be a necessary reference, not only for historical reasons but because it assumes that good design, however it might be defined, must always pursue genuinely human(ist) interests. The LoA here chosen thus assumes that a good approach to designing must always start from human needs. This is, in general terms, the tenet of Human-centered Design (HCU)—also known as User-centered Design (UCD),[4] the dominant contemporary paradigm in design methodology—particularly in the context of interaction design (IxD) and user experience design (UX).

Nominally, UCD has its origins in the early 1980s, in the multidisciplinary Project on Human-Machine Interaction from the Institute for Cognitive Science at the University of California, San Diego, headed by Don Norman. The insights of the project were condensed in the influential book, *User Centered System Design*[5] (1986). Several of the ideas developed by Norman's group echoed the guidelines proposed earlier by Gould and Lewis (1985) in the article "Designing for usability", which made a strong case for adopting an empirical approach to systems design based on thorough user research and intensive cycles of prototyping and testing. These guidelines, in turn, can arguably be traced back to Scandinavian design approaches, in particular, to work developed by the Swedish Home Research Institute (*Hemmens Forskningsinstitut*, HFI) in the mid-1940s.

4. Looking closely at these two approaches, there are differences between them: while both are concerned with human perception and design, UCD may be regarded as a more compact subset of HCD. For the sake of simplicity, in this paper, they will be treated as interchangeable.

5. The name "User Centered System Design" was originally an alliteration of the abbreviated name of the University of California, San Diego (UCSD). Norman and Draper (1986 ix) credit Paul Smolensky with having come up with the idea.

The HFI's main goal was understanding and improving the conditions and practices of housework through design research, but their work eventually led to the development of a full-fledged design methodology (Göransdotter and Redström 2018). Another Scandinavian approach with a robust User-centered ethos is Participatory Design, whose origins date back to the 1970s when researchers turned to ethnographic methods, action research, and a constructivist understanding of technology to tackle problems brought by post-industrial shifts. The goal of Participatory Design was empowering workers by allowing them to better transition to and deal with increasingly automated work environments by incorporating their tacit knowledge of manufacturing processes into automated systems development (Spinuzzi 2005).

Both the HFI's and Participatory Design methodologies contain more or less all the elements that characterise UCD frameworks as we now understand them. Which, to paraphrase Göransdotter and Redström (2018) include: starting by analysing user practices; employing interdisciplinary research; combining qualitative and quantitative data; carrying out iterative prototyping and testing at various levels of fidelity; regarding the user as an expert possessing crucial (tacit) practical knowledge; and involving different stakeholders throughout the design process. Furthermore, as Göransdotter and Redström (2018) also note, these approaches defended the need to always keep notions such as justice, inclusion, and user representation at the centre of the design process.

It follows that the aims and concerns of contemporary design methodologies, as well as the so-called "ethnographic turn" that has been shaping design since the early 2000s (see Blauvelt 2007), have deep historical, social, and political roots. UCD methodologies are far from homogeneous and are continuously evolving. However, at their core, they are all committed to the idea that technologies, particularly those involving computational (and therefore smart) automation, should be designed to improve people's lives. What this improvement means depends on the particular technology, the context where it is implemented, and the tasks it replaces, nonetheless a common aspect shared by all systems and promoted by UCD is that the designer's job is to make the complexity of the system accessible and, above all, *understandable* for the user. It follows that when correctly employed, UCD has a strong epistemological duty to end-users.

4. User-Centered Design and Complexity

Software-based systems are necessarily complex.[6] Complexity is present in (and arguably intrinsic to) many aspects of human life. Complexity is not problematic per se; it only becomes an issue when the user does not understand it and thus feels confused. Poorly understood complexity is, in this sense, *complicated*. Good User-centered Design is not about making things less complex (i.e., simple), but less complicated (i.e., understandable) (Norman 2010).

6. Complexity understood as the quality of something consisting of many interconnected parts and whose behaviour requires considerable amounts of information to be described (Bar-Yam 1997).

Whereas certain objects might be simple, the way we use them can be highly complex, and vice versa. To do what they do or to be used technologies generally *need* complexity. A violin is less complex than a wristwatch but playing the violin is undoubtedly a more complex task than reading the time. Software-based devices are complex objects that are comparatively more difficult to use their non-software based counterparts. A word processor is significantly more complicated to use (not to mention master) than any typewriter. Mechanical devices are usually more intuitive to use thanks to their "affordances"—i.e., the possible ways in which they can be used—are limited and readily apparent thanks to "signifiers"—the visible indicators for their appropriate intended use (2010, 227–28). Software-based devices are also more challenging to use because they have a broader range of context-dependent states. A hammer, for example, does not have modifier keys to alter its behaviour. In contrast, gestures in a touch-screen and commands in a keyboard can trigger a multitude of actions depending on the software being used.

The fact that using certain devices is complicated is not due to their inherent complexity but to poorly managed affordances. When that is the case, users feel helpless, powerless, and frustrated, since the behaviour of the system appears arbitrary and incomprehensible (Norman 2010). According to UCD, designers should strive to achieve a proper balance between the complexity of the underlying structure, behaviour, and limitations of a system, and the ways users conceive it. In other words, designers need to find a balance between the "implementation model" (i.e., the actual system's logic) and the "user's model" through a less complicated, usable "represented model" of the system (Cooper et al. [1995] 2014). Properly designed represented models (e.g., a usable and useful interface) empower users by making the complexity of the system reasonable, excusable, appropriate, and learnable. Taming complexity by designing an accurately represented model is not simple, however. Doing it implies dealing with a zero-sum situation.

Every technological system has "an inherent amount of irreducible complexity" (Norman 2010, 46). When a designer creates a less complicated interaction for users, the underlying complexity of the system increases accordingly. This paradox is known as "Tesler's law of the conservation of complexity" (Norman 2010; see also Saffer 2010, 136). When the interface is reasonably usable, the backend is likely complex; conversely, when the backend is optimised for the system's benefit, the user will likely have to deal with the complications of a confusing implementation model.

Design in this sense is about making otherwise complex systems accessible to people; it is about mediating the relationship between them and their technologies. The former implies taking a position about the role that artefacts play in human lives and anticipating the consequences that might emerge since arguably, every design is ultimately an argument about how people should lead their lives (Buchanan 2001).

When smart automation enters the picture, the consequences of "bad" implementations grow exponentially. Smart, automated systems are already complex networks of algorithms, sensors, human agents interacting under changing contexts at different time scales (Woods 2016). The inherent ironies of automation are further increased by the risks and complexities of contemporary computational infrastructure, namely, the fact that even the most simple interconnected system is embedded within a growing ecosystem of "balkanised operating systems, stacks of numerous protocols, versions, frameworks, and other packages of reusable code" (Girardin 2019). UCD should not only about making this complexity understandable but given how many aspects of people's well-being now depend on these systems, should also be about *protecting* people from the unintentional and deliberate misuses of these systems. In this sense, designers can no longer be just mediators between humans and technologies but also, or rather, mainly, "gatekeepers" and advocates of their users' interests (Monteiro 2019).

5. Some Principles for Good Design Now

From a methodological standpoint, UCD should be one of the best means to keep the consequences of poorly implemented automation at bay. Nevertheless, to do so, UCD cannot continue to be a mere epistemic facilitator, i.e., a means to make the complexities of technological systems understandable. UCD needs more than being empathic towards the user; it needs to assume a clear ethical stance towards technological development and, arguably, dare to enforce that stance. UCD might be the dominant paradigm in Interaction Design and User Experience design, however, our world continues to be further populated by dishonest forms of automation that incite users with "perverse incentives" (Loh and Misselhorn 2018) and dark patterns (Monteiro 2019). UCD needs to broaden its influence.

Given the way UCD-friendly approaches are being promoted nowadays it would be easy to infer that designers genuinely want to create things that make people's lives better; but either the methodology is not working, it is not indeed implemented, or it merely has become another form of white-washing—much like the better part of AI ethics. As shown by the recent scandal involving Joichi Ito and the MIT Media Lab, academic AI ethics has been easily manipulated into becoming a power-less bureaucratic seal of approval for otherwise unethical forms of automation (Hao 2019; Ochigame 2019) mostly because it has developed around the idea of voluntary compliance. Furthermore, designing an embedded Asimov-style moral code into smart, automated systems is a considerably difficult task for it involves reducing the complexities of ethical principles to procedural steps (Ceglowski 2016). Academic committees counselling on potential ethical mishaps with no actual influence over the design process is a recipe for inaction. Hence, it is up to designers to take the lead. It is the design process that should be imbued with an ethical framework.

7. That is, "the principle that we know what is wrong with more clarity than what is right, and that knowledge grows by subtraction" (Taleb 2018, Book I); see also Taleb (2012 Book VI) for a more detailed description.

The responsibility for protecting users' interests should be put on the designer, as well as in the product of her work. Ethics cannot continue to be regarded as an obstacle but as an integral aspect of doing design. Such ethical path might involve adopting a starker and more careful attitude towards automation, it should include a kind of *via negativa*[7] approach that allows designers to focus not on what could be beneficial, but on everything that could go wrong should a given form of automation is allowed to come into fruition. "Tire kicking" (Monteiro 2019) and testing for "brittleness" (Woods 2016) are helpful approaches in this regard. However, under certain circumstances, following an ethically minded UCD approach might involve doing away with the very notion of a minimum viable product based solely on functionalist standards.

An ethically-minded UCD approach should start by asking what the purpose of a given technological system is, e.g., asking whether its implementation will extend or hinder human capabilities. The former implies considering whether a given process should be automated at all. Automation, as we have seen, is an attempt to reduce the complexities of a given circumstance into piece-meal deterministic steps. However, because many aspects of any given process cannot be automated there is always room for unknown complications to emerge. These complications are further increased because, the "training" of smart automation is always done with known information, this narrowing exponentially increments the space of unknowns when dealing with complex situations, as the problem of induction illustrates. Rather than focusing on the "how's" of smart automation, an ethically-minded UCD should always begin with the "why's"; it should ask what kind of trade-offs should be assumed in the name of supposedly unobtrusive devices.

An existing tenet of UCD is that technologies should help people to make sense of the world better. For an ethically-minded UCD, this should imply making systems that are more transparent and honest about their limitations (a principle that was advocated by the well-known industrial designer Dieter Rams), potential side effects, and dependencies. Such a principle is already present in other fields; for example, the way drugs and medications are developed and regulated. This implies the system should be obtrusive under certain circumstances, more visible more honest about the "frictions" it might bring to its users. An ethically-minded UCD should always analyse tasks and goals within a broader context. Technologies are never neutral or inert, their introduction *always* affects a given context, their being and meaning are always situated, and the very fact of using a given instrument continually modifies the task itself. An ethically-minded UCD should be keenly aware of the mediation role of automated systems and technologies at large. This implies a broader understanding of "experience" and perhaps even eliminating the barrier between aesthetics and ethics, as these two domains may be, in fact, interlocked (Callard 2019).

Understanding automated systems as situated also means adopting a socio-technical systems approach to design. An ethically-minded UCD hence requires awareness of designer's blindspots about technology, that is, about the hidden assumptions they have about what a given system can and should do for users.

6. Concluding Remarks and Future Work

This paper began with the assumption that lousy automation is "bad design". It argued that good design should make complexity understandable, but that this sometimes involves assuming that specific processes cannot and should not be automated. As we have seen then, it is virtually impossible to build error-free "traditional" automated systems because humans are integral to their operation. Good design is not just empathy; good design is research, iteration, questioning, tire-kicking, and increasingly, an understanding of diversity. This paper has shown there is a lack of correspondence between the ideals of UCD and what in fact, comes out of design processes. It argues that what UCD should do is provide a richer, fairer, ethically sound, understanding of the world, but to do so, UCD needs to make explicit its stance on technology, it has to critically look at the moral, political and social consequences of our devices.

UCD should recognise that design is political in the broad sense. This realisation should be the starting point to determine what is good design and how that measure will affect design in the years to come. This paper, however, clearly has not "solved" UCD once and for all, nor has it proven beyond doubt what good design should mean nowadays. There is still much work to do in this regard. However, it has managed to start calling into question the perceived neutrality of UCD and show why it needs to be reformulated. A good starting point to do so is recognising that design nowadays is a collective enterprise that requires designers to work not on behalf of people but *with* people, and this means they should behave as gatekeepers with "skin in the game", who must strive to achieve not minimum viable, functional prototypes, but minimum ethical ones. Ultimately, designers should ask what role technologies play in developing human life; they should question themselves about what our human project for the future is.

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References

Autor, David.
2014. “Polanyi’s Paradox and the Shape of Employment Growth.” *The National Bureau of Economic Research*. September 2014. http://dx.doi.org/10.3386/w20485.

Bainbridge, Lisanne.
1983. “Ironies of Automation.” *Automatica* 19 (6): 775–79. https://doi.org/10.1016/0005-1098(83)90046-8.

Bar-Yam, Yaneer.
1997. *Dynamics of Complex Systems*. Studies in Nonlinearity. Massachusetts: Addison Wesley.

Blauvelt, Andrew.
2007. “Design’s Ethnographic Turn.” *Design Observer*. May 1, 2007. https://designobserver.com/article.php?id=5467.

Buchanan, Richard.
2001. “Design and the New Rhetoric: Productive Arts in the Philosophy of Culture.” *Philosophy and Rhetoric* 34 (3): 183–206. https://doi.org/10.1353/par.2001.0012.

Callard, Agnes.
2019. “Do You Want My Garbage?” The Point Magazine. August 7, 2019. https://thepointmag.com/examined-life/do-you-want-my-garbage-agnes-callard/.

Ceglowski, Maciej.
2016. “Superintelligence: The Idea That Eats Smart People.” *Idle Words*. October 29, 2016. http://idlewords.com/talks/superintelligence.htm.

Cooper, Alan, Robert Reimann, David Cronin, and Christopher Noessel. (1995)
2014. *About Face: The Essentials of Interaction Design*. 4th ed. Hoboken: John Wiley & Sons.

Danaher, John.
2018. “Toward an Ethics of AI Assistants: An Initial Framework.” *Philosophy & Technology* 31 (4): 629–53. https://doi.org/10.1007/s13347-018-0317-3.

Erlhoff, Michael.
2008. “Modernity.” In *Design Dictionary: Perspectives on Design Terminology: Perspectives on Design Terminology*, edited by Michael Erlhoff and Tim Marshall, 262–66. Board of International Research in Design. Basel; Boston; Berlin: Birkhäuser.

Floridi, Luciano.
2013. “What Is a Philosophical Question?” *Metaphilosophy* 44 (3): 195–221. https://doi.org/10.1111/meta.12035 10.1111/meta.12035.

———. 2008. “The Method of Levels of Abstraction.” *Minds and Machines* 18 (3): 303–29. https://doi.org/10.1007/s11023-008-9113-7.

Girardin, Fabien.
2019. “When Automation Bites Back.” *Near Future Laboratory*. January 16, 2019. http://blog.nearfuturelaboratory.com/2019/01/16/when-automation-bites-back/.

Gould, John D., and Clayton Lewis.
1985. “Designing for Usability: Key Principles and What Designers Think.” *Communications of the ACM* 28 (3): 300–311. https://doi.org/10.1145/3166.3170.

Göransdotter, Maria, and Johan Redström.
2018. “Design Methods and Critical Historiography: An Example from Swedish User-Centered Design.” *Design Issues* 34 (2): 20–30. https://doi.org/10.1162/desi_a_00483.

Graeber, David.
2018. *Bullshit Jobs: A Theory*. New York: Simon & Schuster.

Hao, Karen.
2019. “In 2020, Let’s Stop AI Ethics-Washing and Actually Do Something.” *MIT Technology Review*. December 27, 2019. https://www.technologyreview.com/s/614992/ai-ethics-washing-time-to-act/.

Johnson, Deborah G., and Mario Verdicchio.
2017. “Reframing AI Discourse.” *Minds and Machines* 27 (4): 575–90. https://doi.org/10.1007/s11023-017-9417-6.

Loh, Wulf, and Catrin Misselhorn.
2018. “Autonomous Driving and Perverse Incentives.” *Philosophy & Technology* 32 (4): 575–90. https://doi.org/10.1007/s13347-018-0322-6.

Martinho-Truswell, Antone.
2018. “To Automate Is Human.” *Aeon*. February 13, 2018. https://aeon.co/essays/the-offloading-ape-the-human-is-the-beast-that-automates.

Monteiro, Mike.
2019. *Ruined by Design: How Designers Destroyed the World, and What We Can Do to Fix It*. San Francisco, California: Mule Design.

Norman, Donald A.
2010. *Living with Complexity*. Cambridge, Massachusetts; London, England: MIT Press.

Norman, Donald A., and Stephen W. Draper, eds.
1986. *User Centered System Design: New Perspectives on Human–Computer Interaction*. New Jersey; London: Lawrence Erlbaum Associates.

Ochigame, Rodrigo.
2019. “The Invention of “Ethical AI”: How Big Tech Manipulates Academia to Avoid Regulation.” *The Intercept*. https://theintercept.com/2019/12/20/mit-ethical-ai-artificial-intelligence/.

Parsons, Glenn.
2015. *The Philosophy of Design*. Cambridge; Malden: Polity Press.

Saffer, Dan.
2010. *Designing for Interaction: Creating Innovative Applications and Devices*. 2nd ed. Voices That Matter. San Francisco: New Riders.

Spinuzzi, Clay.
2005. “The Methodology of Participatory Design.” *Technical Communication* 52 (2): 163–74.

Strauch, Barry.
2018. “Ironies of Automation: Still Unresolved After All These Years.” *IEEE Transactions on Human-Machine Systems* 48 (5): 419–33. https://doi.org/10.1109/thms.2017.2732506.

Taleb, Nassim Nicholas.
2012. *Antifragile: Things That Gain from Disorder*. New York: Random House.

———. 2018. *Skin in the Game: Hidden Asymmetries in Daily Life*. New York: Random House.

Vermaas, Pieter, Peter Kroes, Ibo van de Poel, Maarten Franssen, and Wybo Houkes.
2011. *A Philosophy of Technology: From Technical Artefacts to Sociotechnical Systems*. Vol. 6. Synthesis Lectures on Engineers, Technology and Society. Morgan & Claypool Publishers LLC. https://doi.org/10.2200/s00321ed1v01y201012ets014.

Woods, David D.
2016. “The Risks of Autonomy.” *Journal of Cognitive Engineering and Decision Making* 10 (2): 131–33. https://doi.org/10.1177/1555343416653562.

Zuboff, Shoshana.
2015. “Big Other: Surveillance Capitalism and the Prospects of an Information Civilization.” *Journal of Information Technology* 30 (1): 75–89. https://doi.org/10.1057/jit.2015.5.

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Ever-Changing Flags:
Trend-Driven Symbols of Identity

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One of the symbols of a nation is its flag, which plays an important role in building and maintaining a sense of identity. Changes that occur in a country throughout history are often reflected on the design of its flag, whose elements bear meaning and are part of the country's culture. In this paper, we explore the possibility of using a flag to also represent changes that occur in shorter timeframes. We present a system that applies visual transformations to the flag of a country, based on trending topics inferred from news sources. The impact of generated flags is assessed using a user-study, focused on perception and interpretation. The developed system has the potential to be exploited for multiple purposes—e.g. event visualization—and can be used to make the viewer question the limits of a nation's identity.

1. Introduction

The national flag is one of the symbols that help the formation and maintenance of the identity of a nation (Elgenius 2011). Geisler (2005) states that maintaining a collective identity is an "ongoing, dynamic process in which historical symbolic meanings are constantly recycled, actualised, challenged, renegotiated, and reconfirmed". The transformations that occur to a flag can often be linked to changes in the entity that the flag represents—e.g. political changes. In the past, the dissemination of these changes was slow and of limited access. As such, modifications to the design of a flag are normally sporadic and, in most cases, a flag remains unchanged for long periods. However, our society has now easy access to global information, which results in a sense of constant change. In addition to the sense of identity, a nation can also be assigned a "mood"—i.e. what is happening in the country at the moment. In this paper, we present a system that generates flags based on trending topics of countries, retrieved from real-time news. These topics are used to drive a process of visual blending that alters the original flag of the country. In this sense, the produced flags can be seen as visual representations of the current "mood" of the country.

On the other hand, a flag is, in most cases, conceptually grounded—i.e. its structure and elements have associated meanings—and changes applied to it should take this into account—e.g. a change of colour carries a meaning, which will be assigned to the flag. As such, our process of generating a flag consists not only in producing a design but also its explanation. In any case, a generated design should not be taken as entirely new but as a transformation that still bears resemblance to the original one. To assess how the produced flags are perceived and interpreted by participants, we conducted a user-study. Overall, the flags seem to have the potential to make the participant question the limits of a nation's identity but also to be explored as a means to raise awareness about current events—e.g. an oil spill that happened in Brazil. Moreover, the developed system can be used for several purposes—e.g. visualization—and in multiple contexts—e.g. as a web app or an installation.

The remainder of this paper is organised as follows: Section 2 summarises the related work; Section 3 presents our approach; Section 4 describes a study conducted to users; Section 5 provides a general discussion; and Section 6 presents conclusions and directions for future work.

2. Related Work

Flags are normally custom-made and designed using elements that have meanings assigned to them. Nonetheless, more systematic strategies can also be used to produce flags. One strategy consists in generating flags from scratch using a generative grammar. For example, the Universal Authority for National Flag Registration (Groot 2000) developed a flag coding system in which a flag is composed of: (i) a background colour, (ii) a pattern or a combination of patterns, and (iii) a symbol (optional). This system not only indexed UN member countries but produced thousands of unclaimed flags. Another example is the web app *Scrontch's Flag Designer*[1] by Lars Ruoff, which allows the user to produce flags based on a grammar with three element categories: division, overlay and symbol. Similarly, Whigham et al. (2009) defined a "flag language"—composed of basic elements (e.g. background) and functions (e.g. clipping)—and used an interactive evolutionary approach to produce new flags.

Another way of producing flags is by combining existing ones—a process often referred to as visual blending (Cunha, Martins, and Machado 2018). Examples of visual blending of flags are: the proposed EU flag by Rem Koolhaas[2], which used a barcode style featuring the colours of EU countries; the fictional flags designed for the Amazon's mini-series *The Man In The High Castle* (Heller 2015) by merging existing ones; or the combination of two flags using a masking technique to represent nationality deception by ships seajacked by Somali pirates[3] (Pater 2012). There are several computational systems that use a visual blending approach to flag production. For example *Net.flag*, a project commissioned in 2002 by the Guggenheim Museum, is an online flag editor in which flags can be produced by removing or adding elements belonging to existing flags (Napier 2002). Similarly, the project *Atlas of Potential Nations: Computationally Designed Nations*[4] produces names and flags for new nations by combining the existing flag elements. In addition to these projects, there are also Twitter bots that generate flags—e.g. the *Flags Mashup Bot*[5] mixes existing flags by applying the colours of one flag to the elements of another; or the *FlagBot*[6] produces new flags by putting together elements of several existing flags and changing their colours. From all these examples of flag production, none seems to explicitly explore what we consider the most relevant aspect in flag generation: the meaning of the flag.

1. http://flag-designer.appspot.com/, accessed April 2020.

2. https://oma.eu/projects/eu-barcode, accessed April 2020.

3. http://www.doublestandardsofpiracy.org, accessed April 2020.

4. http://emblemmatic.org/atlas/, accessed April 2020.

5. https://twitter.com/FlagsMashupBot/, accessed April 2020.

6. https://twitter.com/FlagBot1, accessed April 2020.

3. Our Approach

The *Net.flag* project is described as an "ever-changing flag of the Internet", which anyone could alter upon visiting the website (Napier 2002). This concept is aligned with our approach, questioning the idea of a flag as an object with static nature.

The notion of "mutable flag" gains even more significance when combined with a sense of reactivity. We use the term "reactive" (Richardson 2017) to characterize something that changes according to external input, as defined by Martins et al. (2019). Examples of reactive systems are the visual identity designed by Neue[7] for the Nordkyn peninsula—the graphic mark changes according to data on weather conditions at each moment—and a system that designs posters using data gathered from the surrounding environment related to weather and interaction from people (Rebelo et al. 2019).

7. https://neue.no/work/visit-nordkyn/, accessed April 2020.

Flags can be analysed in multiple ways—e.g. in terms of complexity, colour, similarity, among other criteria[9]. Regarding an analysis to a single flag, three aspects have a central role: (i) structure, i.e. how it is divided, what elements it includes, etc.; (ii) meaning associated with its elements; and (iii) what the flag symbolises, e.g. a national flag represents a nation. However, approaches to flag generation mostly focus on "structure" and give little attention to the other aspects. Our approach combines the three while giving special emphasis to the meaning of the flag elements, using it to change what the flag represents.

9. http://flagstories.co, accessed April 2020.

Our goal is to produce flags that represent a topic automatically retrieved from a news source and, in doing so, pose the following question: *Can flags also represent the mood of countries?* The concept of "mood" is based on the expression *I'm in the mood for [something]*. The strategy consists in having the flag of a country as the starting point and applying changes according to real-time data about the country. This reactivity to external input can instil a quality of "being alive" into the flag (Martins et al. 2019), which matches our goals.

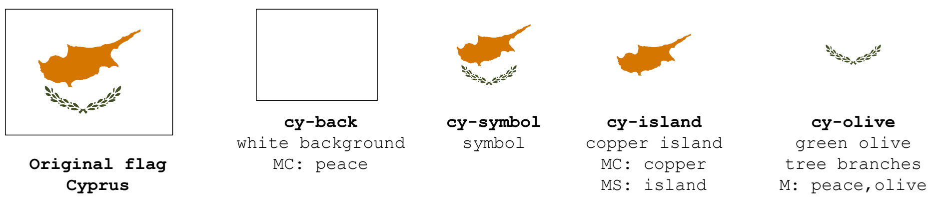

Fig. 1. Example of the data collected for the Cyprus flag. The figure shows the ids assigned (e.g. *cy-island*), descriptions ("copper island") and meanings (M stands for general meaning, MC for meaning of colour and MS for meaning of shape).

3.1. Flag Dataset

The first issue to address had to do with obtaining the necessary data for flag generation. By searching existing projects on flags, we were able to find sources of three kinds of data: visual, e.g. a dataset of fully scalable vector graphics of flags (*flag-icon-css*[10]); semantic, e.g. the *Net.flag*[11] project (Napier 2002); and about flag structure, e.g. the platform *Flag Identifier*[12] (Sarajčić 2007). Data on flag structure is very useful for generating new flags from scratch. In contrast, when producing flags by transforming existing ones, the most useful types of data are semantic and visual. Since we could not find any dataset that associated both types of data, we decided to produce one.

10. https://github.com/lipis/flag-icon-css/, accessed April 2020.

11. http://netflag.guggenheim.org, accessed April 2020.

12. http://www.flagid.org, accessed April 2020.

As starting point, we used version 3.3.0 of the *flag-icon-css* SVG dataset, which contains 257 flags. However, image files of the original SVG dataset were not properly structured nor had they proper layer identification. For this reason, we produced a new version of the dataset, in which we organised the layers into groups according to flag structure and assigned the ids to the layers. For each element of a flag, we collected meanings on colour, shape, and overall meaning (see example in Fig. 1), from four main sources: the project *Net.flag*, the book *Complete Flags of the World* (Wills 2008), Wikipedia flag pages and "Meaning of [...] flag" posts on Reddit.[13] This process mostly involved reducing long descriptive sentences into keywords. To establish a

13. https://www.reddit.com/r/vexillology/comments/2yd77z/, accessed April 2020.

correspondence between visual and semantic data, we used the ids assigned to the layers of the SVG files. Due to its time-consuming character, the SVG structuring and meaning collection is still an on-going task. As of this moment, 117 SVG flag files have been structured—these can already be used as base flag in the generation. From these flags, 76 already have all their elements with meanings in the semantic dataset and 17 only have some.

3.2. Generating Flags

As mentioned earlier, there are several ways of producing flags. However, one of our main goals was to be able to maintain the resemblance with the base flag, allowing the identification of the country. For this reason, our system was grounded on two base assumptions: for each flag production, an existing flag would be given as input and the transformations should not go beyond the point in which the original flag is not recognisable anymore—i.e. the produced flags should not be seen as a totally new flag but as a transformation of the original one. This is also motivated by principles of good flag design—"Keep It Simple" (Kaye 2001)—aiming for small changes and reducing complexity. At a first stage, the process of producing flags involves the search for elements that match a queried word, which are then used to transform the original flag. The search is conducted in three different places: existing flags, a dataset of colour names and a dataset of emoji.

Existing flags. We mentioned earlier that structured SVGs could be used as a base flag. However, only flags with associated semantic information can be used to obtain elements to use in the transformation process. This is due to the fact that the search for the input word is conducted using the semantic information—the system searches for elements that have the word in their associated meanings. A random selection is then conducted to choose a replacement element and a replaced one. Then, the way the blend occurs depends on where the queried word is found: if it is in the overall meaning, the full replacement element is used; if it is in the shape meaning, only the shape is used and the colour of the replaced element is applied to it; if it is in the colour meaning, only the colour of the replacement object is applied to the replaced one. All in all, only 522 different words exist in all the collected meanings. This number is not very high when considering that any word can be queried. As a way to increase the chances of successfully finding the queried word, we added two other sources of information—emoji and a dataset of colour names.

Colour. Colour can be used to achieve different perceived meanings when generating symbols to represent a given concept (Cunha et al. 2015). Moreover, there are examples of colour being used to represent moods—e.g. in website Moodjam[14] the user keeps a record of daily moods using colours. To produce a colour name dataset, we extended the dataset *color-name-list*[15] by merging it with a list belonging to the ntc.js[15] library. From the resulting colours, we

14. https://moodjam.com, accessed April 2020.

15. https://github.com/meodai/color-names (dataset with 18,264 named colours), accessed April 2020.

extracted the ones that had names of only one word (e.g. *Tomato* colour), which resulted in a list of 3,476 colours. The queried word is searched in this list and, if found, the colour is applied to the replaced element.

Emoji. The project *Emojinating* (Cunha et al. 2019) uses semantic data of emoji to produce new ones through visual blending. By having this project as inspiration, we decided to add Emoji as a third source of semantic information for the queried word to be searched in. To do so, we use the dataset EmojiNet—a machine readable sense inventory with data on 2,389 emoji (Wijeratne et al. 2017)—in combination with emoji SVG images from the Twitter's Twemoji dataset.[16] When finding emoji that match the word, the system uses them as replacement as follows: if the flag already has a symbol, the symbol is replaced by the emoji; if not, the emoji is added on top of the flag, centred according to a randomly selected element and scaled to fit its bounding box. If the selected element is a triangle, the emoji is scaled a second time for aesthetic purposes.

16. github.com/twitter/twemoji, accessed April 2020.

3.3. "Ever-Changing" Flags

Any word can be used to produce a flag. However, our main interest involves producing flags that change according to current events. To achieve this, we follow an approach similar to the one used by Gonçalo Oliveira (2016), who produces memes using headlines automatically retrieved from the Google News RSS feed.

When generating a flag for a given country, the system automatically collects the latest news titles in English that mention the country's name. The second step consists in extracting nouns from the initial news titles by tagging the text using the Javascript Part-of-Speech tagger *jspos*[17]. Then, we analyse the nouns used in all the titles and identify the most predominant ones, excluding the country's name or its abbreviation. After sorting the nouns according to predominance (see topics sorted in Fig. 4), the system searches for data to be used in the blending process, as previously described. If no data is found for a noun, the system moves to the next one on the list. This search task is performed until the system finds information (and produces a flag) or until there are no nouns left (no flag is produced).

17. https://code.google.com/archive/p/jspos/, accessed April 2020.

3.4. Generating Explanations

In addition to generating flags based on a given meaning, our secondary goal was to do so in combination with producing an explanation for each flag. The explanation provides clues of how and why the flag was changed (see examples in Fig. 3). This creates a connection between shape, meaning and explanation, which, we believe, serves to provide a strong conceptual ground for the produced flag. In order to do this, we followed the structure observed in the *Net.flag* descriptions: [*element X*] *represents/stands for/symbolises* [*Y*], where *Y* is the queried word and *X* depends on the change nature.

For example, in the case of adding emoji, we defined that *X* would take the value of "symbol" (see left side of Fig. 2). In contrast, if there was a change of colour, the *element X* would be composed of the replaced element's name (e.g. "stripe") and the replacement's colour name (e.g. "red"). This posed an issue as, despite the colour name list being useful in finding appropriate colours, it would be confusing for the user to be presented with an explanation such as "The Airforce stripe represents…". In this case, the colour with the name "Airforce" should instead be mapped to the closest standard colour. To solve this issue, we used Daniel Flueck's extension[18] of the ntc.js library, which has a closest colour converter—the "Air force" colour is mapped to "Blue".

18. https://www.color-blindness.com/color-name-hue/, accessed April 2020.

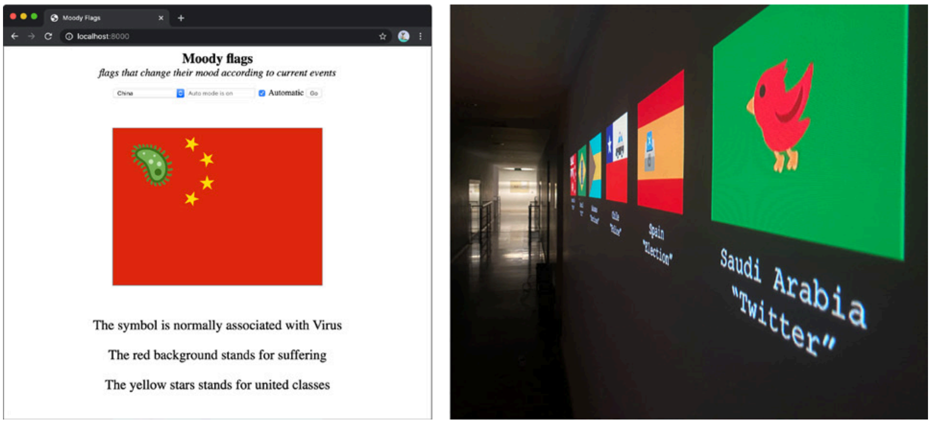

Fig. 2. Applications of the system. On the left, a web-based application showing a generated flag based on the China's flag and its explanation (produced on February 11th, 2020), in which the first sentence corresponds to the changed element (note: the sizes were intentionally changed to increase the legibility of the figure). On the right, the "Flags of Change" installation.

3.5. Applications

The developed system is only a starting point for several applications. Our main goal is to develop artefacts that foster a discussion on what a nation's identity can encompass and how the characteristics of current society can be exploited. At the moment, we have used the system in two different artefacts: a web-based application and a real-time installation.

Web-based App. We implemented an interface for the system to allow the user to produce flags according to their preferences (see left side of Fig. 2). It consists of two areas: (i) the *configuration area*—where the user defines the parameters for the flag generation—and (ii) the *flag canvas*—where the new flag is shown to the user. The configuration area has two parameters that always need to be provided by the user: the base country and mode of data retrieval. By default, the automatic mode is selected, and the system uses Google News RSS feed to obtain the trending topics to be used in flag production. If the user decides to disable the auto mode, the system asks for an extra input: a topic to be represented. This way, the user can not only see what the current flag is but also what it would be if a given topic was trending.
Installation. The installation "Flags of Change" presents the user with constantly updated flags from several countries, shown in a loop. The setup consists of a projection in a wall of a dark room with only visual stimuli—giving

spotlight to the flags. Each flag is accompanied by the country's name and the word retrieved from the news feed, which was used to produce the flag (see right side of Fig. 2).

4. User-Study: Results and Analysis

In order to assess the perception of generated flags, we conducted a user study. We produced a set of five flags (see Fig. 3): two resulted from colour replacement, two from symbol replacement with emoji, and one from emoji addition. These flags were automatically generated using the news at the moment of generation and selected by the authors. For each flag, the participant was asked to answer questions from two different sections. The participants were informed that they would be presented with flags computationally generated using real-time news. They were also asked not to search for any information while conducting the experiment nor change any answers.

In the first section of the survey, the only given information about the flag was the generation day and the users were asked to answer the following open-ended questions: Q1 "If you know which country is represented in the flag, please write the name", Q2 "There is a change in the flag. Describe what you think the change was" and Q3 "What do you think that the change represents?". In the second section, users were told which country was represented, what the change was and the topic on which the change was based (e.g. in the flag of Brazil the background colour was changed into dark grey using news about the oil spill). Then, the user waas asked Q4 "Is the flag a good representation of the news?" and required to give an answer from 1 (very bad) to 5 (very good).

Fig. 3. Flags used in user survey and produced explanations, automatically generated on 15/11/2019.

The survey was conducted with 16 participants, with age between 26–44 (average = 30.68 and standard deviation = 4.71). The results obtained can be seen in Table 1. For Q1, we considered correct answers the ones that referred the country of the base flag. Also, in flag #4 we considered answers such as "Argentina + Brasil" as correct due to the fact that the blended flag has both flags. On the other hand, in flag #3 we considered answers such as "United Kingdom" as wrong (despite the UK flag being included in the Australian flag) as the participant is clearly not familiar with the Australian flag. For Q3, we considered correct answers the ones that referred the word used to generate the flag. However, in the case of flag #5, we considered correct three answers from Q3 that did not mention "spy" as the participant had mentioned it in Q2—e.g. Q2 "change of the icon into a spy figure", Q3 "leak of information". In fact, one of the participants commented that they had answered to Q2 that the change was the addition of a spy icon but on Q3 they had thought that "spy" would be too simple.

Table. 1. User study results for each of the generated flags.

#	Original	Word	Change	Right Answers (%) Q1 country	Q2 change	Q3 meaning	Quality (1-5) Q4 mode	Q4 median
1	*Brazil*	*Oil*	Background color	100.0	100.0	0.0	4	4
2	*Spain*	*Election*	Symbol replacement	100.0	100.0	68.8	5	5
3	*Australia*	*Fire*	Background colour	68.8	87.5	25.0	4	4
4	*Argentina*	*Brazil*	Symbol replacement	93.8	93.8	31.3	3	3
5	*Lithuania*	*Spy*	Emoji addition	25.0	43.8	31.3	5	4.5

When observing the results, one of the things that stand out is that for all the flags, except #5, the majority of the participants could identify the country and the change that occurred—indicating familiarity with the original flags. It is interesting to see that, in the case of flag #5 (Lithuania), despite the participants being unfamiliar with the flag, they could identify both the change and the meaning—which reflects the advantages of emoji in perception. On the other hand, in flag #1 no one could identify the meaning, despite everyone knowing the original flag (Brazil). When analysing the answers by the participants to Q3 of flag #1, 4 out of the 16 mentioned the burnt Amazon forest, which was a highly discussed topic at the time and a possible interpretation of changing the green to dark grey. Similarly, in flag #2, in which 11 out of 16 people got the answer right to Q3 ("elections"), 2 other people gave an answer related to political instability and another one gave an answer related to a referendum—both answers, despite not matching "elections", are aligned with the replacement of the symbol by a voting poll seen in the generated flag and with the situation of the country at the time. It is also worth mentioning that some of the participants that did not know the meaning of flag #3, which had a background colour change into red, submitted answers that could somehow be linked to that colour, for example "blood", "massacre" or "terrorist attempt".

Regarding quality, four out of the five flags obtained a quality of topic representation of good or very good by most participants. The results also seem to reflect the easiness of understanding emoji (see flags #2 and #5). However, flag #4 also uses emoji and had the lowest results. We cannot be certain, but we believe that this was due to how section 2 of the survey was designed for this flag. The user was presented with an explanation giving especial focus to football—"The symbol was changed using news about the football match between Argentina and Brazil"—but that meaning was not reflected on the blended flag.

5. Discussion

The efficiency of our system is highly dependent on the existence of semantic knowledge, which is used to find possible changes to be made. We believe that by adding three sources of semantic information (meanings of existing flags, emoji semantic data and colour names), we have increased the likelihood of success. However, it is impossible to guarantee the production of good results. For example, one case in which the system has few results is the word "state": in terms of data on existing flags, the only matches are star-shaped elements (e.g. the white stars in the United States flag); by considering emoji data, the system is able to find 255 different emoji, most of which are flags themselves; and using colour names, there is no match for "state". Two flags produced for Iceland are another example. The resulting flag changes depending on which data is available (see Fig. 4): if the system only uses data of existing flags, it is not able to produce any blend; if it uses emoji data, it is able to find information for the third trending topic ("Christmas" represented using a Christmas tree); and if it uses colour names data, it can only find information regarding the sixth trending topic "Namibia", which is the name of one of the colours in the dataset.

Fig. 4. Flags generated for Iceland using different semantic data sources (emoji and color).

From the conducted user-study (described in the previous section), it is clear that the meaning of the changes is not easy to guess and is very dependent on the user knowledge about the corresponding country and its current situation—only one of the flags had a correct response rate to Q3 (meaning) above 1/3. This leads us to conclude that the changes in the flag should have more impact within the corresponding country than internationally—as stated by Matusitz (2007) "vexillological symbols are displayed to the whole world, but are only understood by like-minded individuals", which is aligned with findings of difficulty in flag identification (Morales-Ramirez 2018). For this reason, further studies with citizens of each country are needed – none of the participants was a citizen of any of the countries with changed flags.

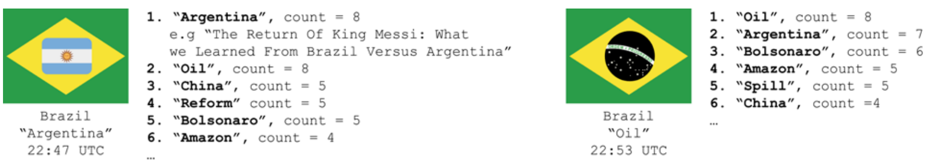

Fig. 5. Mood shift due to football match Brazil vs Argentina, on 15th November 2019.

One interesting aspect of the project is the ability to observe this "ever-changing" identity or, to use the term that we adopted, the changes in the "mood" of the country. An example of mood changing was observed on the 15th of November 2019, due to a football match between Brazil and

Argentina (see Fig. 5). During the hours before the match, the flag of Brazil was always retrieving "oil" as mood from the oil spill. Then, Messi scored and the mood changed, being translated into a different flag—for roughly 5 hours the mood stayed with "Argentina". Six hours later, it alternated between "Argentina" and "oil", and later on it went fully back to "oil".

Despite being different flags (oil-driven and Argentina-driven), it is possible to identify the resemblance with the original Brazilian flag. This aspect was of particular importance to us and the reason why, at this stage, we chose to only apply one change and avoid adding many elements, which would increase the complexity of the flag. Nonetheless, it would be interesting to see different trends affecting the flag at the same time, choosing the element to change according to its salience (i.e. impact on the overall aspect of the flag) to match the trendiness degree—the more trending the more salient the changed element should be. Even though the system only makes a change, some flags have few characteristic elements and end up losing their identifying resemblance to the original flag—an example is the flag of Saudi Arabia in which the symbol (an Arabic inscription and a sword) is replaced by a bird to symbolise Twitter (see Fig.2). Therefore, the applied changes, despite being simple, can go from subtle—unidentifiable for most people—to disruptive—possibly triggering a sense of discomfort on the viewer, who might see familiar elements but no longer relate the flag to their country, creating a gap on the notion of identity. This aspect gains even more importance if we consider that the citizens of a country may have different opinions regarding the national flag (Wright 2011; Satherley, Osborne, and Sibley 2019).

It is also possible to observe the effect of the same topic on different flags (see Fig. 6), for example "oil". As we have not yet implemented a system to deal with differences in salience, the visual change is similar, for example in the flags of Brazil and Norway, even though the seriousness of the news varies in degree—in the Brazilian one it should look more catastrophic due to the gravity of the situation. A similar effect occurs in the blend using the Pakistan flag, which is based on the topic "children" and results in a blend that applies a green colour to the symbols of the flag. Despite using the green colour, which is normally associated with good, the news behind the trending topic are far from positive (e.g. "An HIV Crisis Among Pakistan Children").

Moreover, some changes might make more sense when applied to certain elements. For example, Angola was also getting the "oil" trending topic and could have it applied to its cogwheel which is associated with industry. This would make perfect sense if we look at some of the news, e.g. "Angola oil production falls in October to 1,356 million barrels per day". Another example can be observed in two flags generated for Brazil using "Oil": in Fig. 3 the dark grey was applied to the green background; and in Fig. 4 it was applied to the blue circle. The latter version would be more suitable as the oil spill occurred in the (blue) sea whereas the former version can be more easily mistaken for another topic—the Amazon fires. As such, a future development might involve taking into consideration the initial meaning or characteristics of the replaced element—"burnt" being applied in the green of Brazil flag or using Angola's cogwheel to represent industry-related topics.

Fig. 6. Examples of flags generated on November 15th 2019. Below each flag, the country of the original flag and the trending topic used in the generation are identified.

Incorrect behaviours of the system also occur. For example, when producing flags for Jordan it retrieves incorrectly matched news, getting news about Michael Jordan, instead of the country, leading to the trending topic "basketball" and resulting in the orange colour being used (see Fig. 6). Similarly, when using the topic "Trump", the system obtains a musical instrument emoji instead of something that represents the President of the United States. It is also important to mention how using elements from other flags might have a different effect than expected. Some of the elements and associations are culture-specific (Morales-Ramirez 2018; Becker et al. 2017) and might not have the same interpretation in all countries. Despite this, the results of the user study showed that, even if the user does not know the flag, it might be possible to infer some meaning. This can be exploited by using the flag to call the attention of the user to countries in which something relevant is happening. One example of this was identified in the study: none of the participants was able to link flag #1 (Brazil) to the huge oil spill that had occurred. As such, it could be possible to use the flags as a way of raising awareness, similar to what was done in the *Double Standards* project.

6. Conclusions and Future Work

The flag of a nation serves, among many things, to build and maintain the sense of national identity, representing the country, its people and its history. In this paper, we propose a different use for a flag—the representation of a country's mood at each moment. We present a system that produces variations of national flags through visual blending according to news titles retrieved from the Google News RSS feed, by using semantic information from different sources. In addition to producing a flag, the system also presents the user with an explanation for the changed or added elements. In order to assess the perception of generated flags, we conducted a user study with 16 participants. The results show that the participants can identify the original flag, but they have certain difficulty in identifying the meaning of the changes applied to the flags. The potential impact of generated flags goes from raising awareness (to a certain event) to creating a sense of awkwardness by affecting the notion of identity.

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References

Becker, Julia C, David A Butz, Chris G Sibley, Fiona Kate Barlow, Lisa M Bitacola, Oliver Christ, Sammyh S Khan, et al.
2017. “What Do National Flags Stand for? An Exploration of Associations across 11 Countries.” *Journal of Cross-Cultural Psychology* 48 (3): 335–52.

Cunha, João Miguel, Nuno Lourenço, João Correia, Pedro Martins, and Penousal Machado.
2019. “Emojinating: Evolving Emoji Blends.” In *Proceedings of EvoMUSART 2019*, 110–26. Springer.

Cunha, João Miguel, Pedro Martins, Amílcar Cardoso, and Penousal Machado.
2015. “Generation of Concept-Representative Symbols.” In *Workshop Proceedings of ICCBR 2015*. CEUR.

Cunha, João Miguel, Pedro Martins, and Penousal Machado.
2018. “How Shell and Horn Make a Unicorn: Experimenting with Visual Blending in Emoji.” In *Proceedings of the Ninth International Conference on Computational Creativity.*

Elgenius, Gabriella.
2011. *Symbols of Nations and Nationalism: Celebrating Nationhood*.

Geisler, Michael E.
2005. “What Are National Symbols — and What Do They Do to Us?” In *National Symbols, Fractured Identities: Contesting the National Narrative*. UPNE.

Gonçalo Oliveira, Hugo, Diogo Costa, and Alexandre M. Pinto.
2016. “One Does Not Simply Produce Funny Memes!Explorations on the Automatic Generation of Internet Humor.” In *Proceedings of the Seventh International Conference on Computational Creativity*.

Groot, Arjan.
2000. *UNFR Index: Universal Authority for National Flag Registration Index*.

Heller, Steven.
2015. “American Reich.” Design Observer. https://designobserver.com/feature/american-reich/39109 Acessed April 2020.

Kaye, Edward B.
2001. “Good Flag, Bad Flag, and the Great NAVA Flag Survey of 2001.” *Raven: A Journal of Vexillology* 8: 11–38.

Martins, Tiago, João Miguel Cunha, João Bicker, and Penousal Machado.
2019. “Dynamic Visual Identities: From a Survey of the State-of-the-Art to a Model of Features and Mechanisms.” *Visible Language* 53 (2): 4–35.

Matusitz, J.
2007. “Vexillology, or How Flags Speak.” *International Journal of Applied Semiotics* 5 (1).

Morales-Ramirez, Carlos A.
2018. “Measuring Puerto Ricans’ Knowledge of the National, Subnational and Latin American Flags.” *Research in Social Sciences and Technology* 3 (3): 42–67.

Napier, Mark.
2002. “NET.FLAG.” In *Ars Electronica 2002: UNPLUGGED -- Art as the Scene of Global Conflicts*, edited by Gerfried Stocker and Christine Schöpf, 360–61. Hatje Cantz Publishers.

Pater, Ruben.
2012. *Double Standards*. Acter.

Rebelo, Sérgio, Catarina Pires, Pedro Martins, João Bicker, and Machado Penousal.
2019. “Designing Posters Towards a Seamless Integration in Urban Surroundings: A Computational Approach.” In *Proceedings of the 9th International Conference on Digital and Interactive Arts*. ACM.

Richardson, Andrew.
2017. *Data-Driven Graphic Design: Creative Coding for Visual Communication*. Bloomsbury Publishing.

Sarajčić, Ivan.
2007. “Flag Identifier - Flag Identifying Tool and Vexillological Database -- An Attempt of Vexillological Classification.” In *22nd International Congress of Vexillology - FlagBerlin2007*.

Satherley, Nicole, Danny Osborne, and Chris G Sibley.
2019. “Who Is for (or Against) the National Flag? Ideological and Identity-Based Motivators of Attitudes.” *Analyses of Social Issues and Public Policy* 19 (1): 407–28.

Whigham, Peter A, Colin Aldridge, and Michel de Lange.
2009. “Constrained Evolutionary Art: Interactive Flag Design.” In *2009 IEEE Congress on Evolutionary Computation*, 2194–2200.

Wijeratne, Sanjaya, Lakshika Balasuriya, Amit Sheth, and Derek Doran.
2017. “EmojiNet: An Open Service and API for Emoji Sense Discovery.” In *Proceedings of ICWSM-17*.

Wills, Charles, ed.
2008. *Complete Flags of the World*. DK Publishing.

Wright, Glen.
2011. “Your Flag’s Got My Flag on It: The Union Jack and the Australian Flag.” *Crux Australis* 98.

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Allographic Drawing: Agency of Coding in Architectural Design

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Keywords: Architecture, Drawing, Coding, Agency, Process.

Allographic Drawing explores the agency of coding in architectural design processes and its impact on architectural drawing and the allocation of authorship. The paper uses drawing as a lens to look at coding in architectural practice and argues that engaging with coding introduces novel ways of mediating between context, proposition and constructed artefact. Against the backdrop of the paradigm shift from drawing-based representation to model-based simulation, this paper argues that we can look at drawing as a means of understanding the mediation of coding in architectural design processes. The research looks specifically into algorithmic approaches to scanning and mapping environments, ideation and exploration of variation within architectural design processes and the translation between design proposition and material artefact through digital fabrication.

1. The Shifting Role of Architectural Drawing

Drawing has been the principal means for architecture to analyze and map contexts, to explore design propositions, develop architectural projects, to communicate and disseminate design ideas and anticipate processes of fabrication, construction and assembly. The emergence of the profession of architect, coincided with the formation of drawing as a means of claiming authorship in architectural design (Evans 1997, 160). In contrast to most other creative disciplines architects do not work with the objects they design directly, i.e. architects do not work on site or make buildings, but always work through some intervening medium[1]. Until recently the central medium in architectural practice was drawing, which comes in various forms, from sketches, diagrams, perspectives, over plans, elevations, sections to technical drawings and details. Architectural drawings are not autonomous objects; they are part of a multimodal mediation process that includes other documents such as models, descriptions, calculations… (Allen 2009, 41). The relationship between the architect, the site, the design proposition, building and the role of the drawing is complex (Sheil 2012), although instrumental in constructing buildings, architectural drawings do not completely determine the building, nor do all drawings anticipate processes of construction (Groak 1992, 150).

The widespread adoption of digital technologies has deeply affected architectural practice. All phases of the design process involve the use of computation in some form or another: from ideation, schematic design, design development, over fabrication and construction, to use, maintenance and occupancy. The most direct impact can be seen in the media, tools and procedures for designing and constructing architecture. In the early adoption of computer-aided design (CAD), architects approached digitalization of architectural media as merely digital versions of well-known analogue tools of drafting, modelling and rendering, this did not directly affect the role of the drawing. However, through recent developments in computational design, parametric modelling, digital and robotic fabrication and building information modelling (BIM), we see a shift away from an analogue drawing based approach to a digital model based approach (Kudless and Marcus 2018, 47). This is symptomatic of a deeper cultural shift from representation to simulation. Architectural drawings operate based on a clear understanding of the difference between the drawn and the made, the representation and the represented. Simulations behave, at least temporarily or partly, as the simulated, aiming to close the gap between the simulation and the building (Scheer, 2014).

The role of architectural drawing, as the disciplines foundational means of designing and producing architecture, is deeply affected by these shifts. On the one hand architectural drawing, both analogue and digital, have been dismissed as an anachronistic practice inhibiting architecture from

1. While other disciplines also work preliminary sketches and drawings, in architecture the distance between the medium in which a design is developed and the artefact it represents is substantial. See Robin Evans, *Translations from Drawing to Building, and Other Essays* (1997), p. 161.

truly embracing the innovation provided by digital technologies (Silver 2006). On the other hand, digital technologies have liberated drawing from its purely instrumental and representational role, which has resulted in a renewed interest in architectural drawing in practice and academia, as is demonstrated by numerous publications, conferences and exhibitions[2]. The inspiration for this revival ranges from a nostalgia for the central role the drawing allowed architects to claim in processes of design and construction, over a reevaluation of the craft in architectural practice (Riedijk 2010), to embracing the potential of drawing to resist the deterministic nature of building information modelling (Kudless and Marcus 2018, 47). To some degree the revival of architectural drawing coincides with a rejection of digitalization as such, idealizing or even fetishizing the analogue practice of architectural drawing. However, more prominently we see the dissolution of the dichotomies of analogue and digital into post-digital drawing approaches (Leach 2018).

2. Most notable: *Drawing Futures* conference at the Bartlett School of Architecture, University College London in November 2016, *Between Paper and Pixels: Transmedial traffic in architectural drawing*, Jaap Bakema Study Centre & TU Delft Oktober 2016, *Drawing Millions of Plans*, KADK Kopenhagen, 2018, The Drawing Show, A + D Museum, Los Angeles, 2018, to name a few.

2. Allographic and Autographic Practices

The central role of drawing in processes of designing and making has led to different understandings of where authorship can be located in architectural design. One could locate authorship in the drawing, as it captures the design intent of the architect without being constrained by the contingencies of building practice (Till 2009, 44–56); or you could locate the authorship in the building, reducing the drawing to a mere instrument to arrive at its construction. In practice, these extreme positions are hard to maintain and authorship lies somewhere in-between, and is partly collaborative: The drawing only partially reflecting design intent, introduces its own qualities, and cannot completely control the process of building that depends on many parameters and external influences. Or, as Stan Allen states: "*architectural drawing is in some basic way impure, unclassifiable. Its link to the reality it designates is complex and changeable*" (Allen 2009, 41).

In his classification of different art forms, Nelson Goodman makes a distinction between autographic and allographic art practices (Goodman 1976) in autographic arts, such as painting and sculpture, the authenticity of the work depends on it being executed by the artist; in other words, it bears the traces of the hand of the artist[3]. In allographic arts, such as music or poetry, the work can be executed without the direct presence of the author. Where autographic arts work directly with the matter at hand, allographic arts work through notation, usually leaving execution to others. Allographic arts are often temporal and ephemeral or need coordinated execution by many people, as in a theatre or in an orchestra. Nelson Goodman considers architecture to be a "curious mixture" of autographic and allographic practices. Like all arts, it started out as the autographic practice of making and building but acquired allographic elements through the introduction

3. This is obviously a generalization, many examples of sculpture and painting can be found that are partly executed by other hands than that of the artist.

of notation in the form of the drawing. Unlike other allographic practices, architecture deals with concrete material and is not purely ephemeral, but its construction needs the coordinated execution by many people. Architectural drawings cannot be reduced to "pictures" of a future building, according to Goodman; he compares architectural drawing with a musical score, an instruction that combines graphic notations with texts and symbols. The instructions captured in an architectural drawing are not complete and need to be complemented through other documents, the process of building involves many decisions to be made, often requiring the architect to visit the construction site (Allen 2009, 48).

The appropriation of digital technologies urges us to rethink the divide between autographic and allographic practices in architecture. Carpo argues that since the introduction of computational design and digital fabrication, architecture has become a completely allographic practice since exact copies of digital files can be reproduced and fabricated as material artefacts regardless of the architect's presence (Carpo 2011, 71). Kolarevic on the other hand proposes that digital technologies such as digital fabrication and building information modelling have the potential for architects to reclaim its autographic past, going back to the idea of the building master pre dating the drawing as means of claiming authorship (Kolarevic 2005, 55). Striking in these positions is that they both express the belief in reclaiming a more central role for the architect and that they both approach digital technologies as being neutral means for designing and constructing architecture. In contrast, this paper looks into digital technologies not as a means of exerting control over design and making, but for the agency these bring to the design process. We are particularly interested in the *allo*[4], the otherness present in digital technologies and the other forms of drawing we can explore through engaging with coding. Coding is used not for closing the gap between design intent and materialised artefact, but for extending the journey of design exploration.

4. Kostas Terzidis sees code as an extension of human thought, which is fundamentally different, or what Terzidis calls allo, derived from Greek, meaning other. Terzidis sees algorithmic computation not as an extension of human cognition, but as a fundamentally different form of cognition, see Terzidis, Kostas, *Algorithmic Architecture* (2006), p. 27.

3. Appropriating Coding

Architects have appropriated coding in avant-garde architectural practice and research: from the pioneering work of the 60s and 70s using university mainframe computers and pen plotters, over the theoretical discussions and formal experimentation of the 80s and 90s to the experimentation with parametric modelling, creative coding and digital fabrication in the 00s and 10s. Throughout these lineages the impact of digital technologies in architecture, the appropriation of coding in architectural design processes was linked with the practices of drawing. This is revealed through the recent interest in the history of the impact of digital technologies on architectural design as demonstrated by the exhibitions and publications *Archeology of the Digital*[5] and *When is the Digital in Architecture* (Goodhouse et al 2017).

5. Archaeology of the Digital Exhibition at Canadian Centre for Architecture, Montreal 2013.

The recent developments in the impact of digital technologies in architecture, since the development of computational design, building information modelling and digital fabrication technologies has been mainly associated with pushing the agenda of a model-based approach of simulation. However, with the emergence of the post-digital and the renewed interest in drawing within architectural practice, some architects and researchers are explicitly exploring coding as a way to rethink processes and procedures of architectural drawing. Related work includes the *Machinic Protocols*[6] project by Edouard Cabay, the work and writing of Carlo Lostritto (Lostritto 2016) and drawings of Andrew Heuman and Andrew Kudless[7]. While there is a substantial amount of relevant related work in visual arts, graphic design and creative coding, the drawings in those practices have a different status within architecture. A prominent project is *Drawing Codes: Experimental Protocols of Architectural Representation*[8], resulting in an exhibition displaying newly commissioned drawings by prominent architectural practitioners and researchers (Kudless and Marcus 2018). Works explore code as a generative constraint to work with or against, code as means of rethinking the language of architecture, code as means of encrypting or obfuscating information in architectural drawings and code as a script or recipe. The drawing explorations discussed below are mainly dealing with the latter: code as a set of instructions resulting in architectural drawings.

6. See https://machinicprotocols.com/, consulted on 01/02/2020.

7. See http://andrewheumann.com/ and https://www.matsys.design/, consulted on 01/02/2020.

8. See http://digitalcraft.cca.edu/research/drawing-codes, consulted on 01/02/2020.

4. Drawing Explorations

Rather than dismissing architectural drawing in favor of a model-based approach, the drawing explorations discussed below use coding as an extension of architectural drawing practices. The drawings explore the agency coding brings to processes of mapping, design ideation and translation into material artefacts, and asks how coding affects these aspects of architectural drawing. The drawings discussed below where produced by the author in the context of architectural design practice, design courses and research projects. Instead of extensively describing the context in which these drawings where produced we will reflect on the agencies of coding they demonstrate.

4.1. Sketching with Code

Architectural drawings play an important role in the ideation of architectural design, propositions are developed through sketching out design ideas. Drawings mainly aimed at design ideation rather than presentation or communication are called *process drawings.* While programming has its origins in computer science and engineering, today architectural practitioners have access to coding through graphic programming add-ons, text based scripting interfaces for design software to programming languages and environments specifically aimed at designers, architects and artists. A number of practitioners and researchers have embraced coding as a major part of their design process, establishing an architectural culture of coding (Burry 2011). While there are many reasons for architects to engage with coding, the foremost reason is design ideation, or developing ideas through sketching with code.

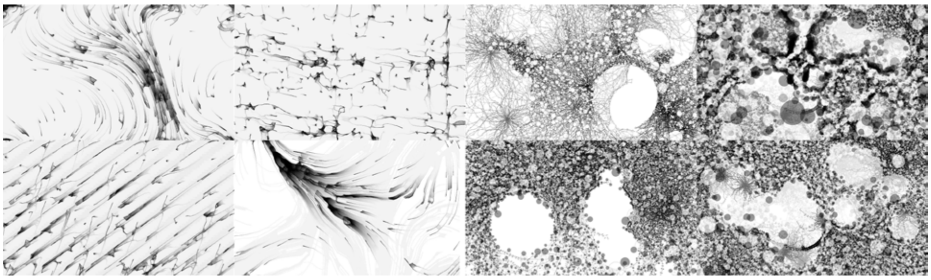

Fig. 1. Tinkering with Code: exploring generative systems as inspiration for design.

Tinkering with Code is a sketchbook of coding experiments, ranging from quick sketches, design experimentation, coding tools for other architects, designers and artists, writing code for specific fabrication machines. The sketches shown can be compared to doodles, or explorations of specific generative systems. Moments of playing, interacting with the graphical representation of code and tweaking values are alternated with changes to the code itself. Sketching through coding shifts the attention of the architect from working on a singular design solution, to exploring the logic and systems at play in design processes, it introduces a nonlinear way of exploring design variation.

Fragments and Figuration. Is a series of drawings made in preparation for a computational drawing workshop that looked into computational techniques for fragmenting and assembling those fragments into novel compositions. Rather than geometric primitives that come standard with most design software, the starting point for these algorithms where found objects in the form of downloaded 3D models. Existing elements are stripped of their familiarity, fragmenting them to be reassembled in estranged composition.

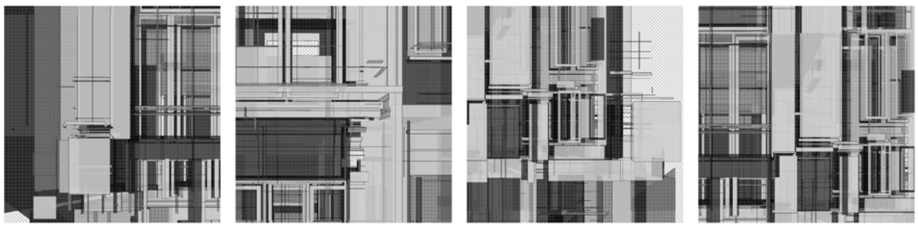

Fig. 2. Fragments & Figuration.

Working with code as a design medium provides the designer with different kinds of feedback on the screen: a graphical window showing the result of the running code, a textual one showing the actual code itself and possibly textual feedback through the console. Design through coding progresses through altering between working on the code itself and influencing the running software through various inputs. This alteration between making a using a custom design tool, between control and play can produce results that would not be possible with a standard design tool without access to the code that runs it. Text-based coding is an unforgiving medium, forgetting even one character will lead to a syntax error, and it is often hard to tell from the visual feedback alone what is exactly going on in an algorithm. These limitations can be overcome by continuously testing the code, incrementally building on working versions of the code and using the console to provide textual feedback, or by developing a debug mode that renders certain information on the screen.

4.2. Code as Lens

Architects have used drawing as a means of studying, analysing, mapping and understanding contexts, site conditions, spatial phenomena, material properties and existing constructions. Drawing is a selective and hierarchical, lens for observation, some aspects are drawn and emphasised while some are not. As such, there is no clear distinction between drawing as documenting observations and drawing as interpretation, developing a starting point for a design process. Coding allows architects to integrate various input devices for observation, as well as explicitly defining algorithms for selecting, mapping and visualising data.

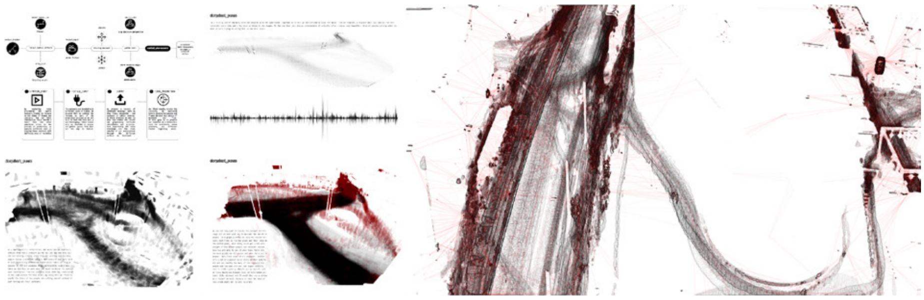

Fig. 3. Chrono Drawing: tracking motion through computer vision.

Chrono Drawings. This series of drawings emerged out of an interest in mapping time-based, dynamic and ephemeral phenomena. By processing video footage through a custom-made computer, vision algorithm various series of experimental drawings were produced that collapse a certain duration of time into a single drawing. One series of drawings[9] used the custom software to capture occupancy and flows, by tracking the motion of various users in a public space. The data was translated in a drawing accompanied by a number of other diagrams quantifying and visualising the data. The same software was also used to develop more experiential drawings using a moving camera or tracing the changing light conditions in both exterior and interior spaces.

9. Developed together with master students Toon Geukens, Martha Samyn, Maarten Moens & Amir Malakouti for the research elective Computation & Materiality, KU Leuven Faculty of Architecture in 2018

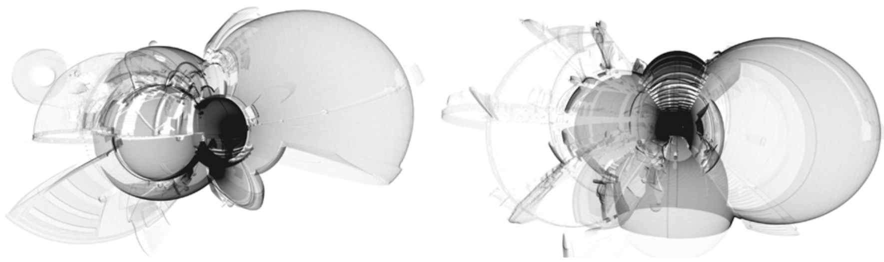

Fig. 4. Sphere Inversion: Environmental Scans

Sphere Inversions. This series of site-specific drawings and 3D printed artefacts that collapse a surrounding room into a spherical object. A spherical inversion is a transformation on coordinates in space: points on the sphere are not transformed, all points between infinity and the sphere are transformed into the sphere, with infinity collapsed in the centre of the sphere. This was done through modelling the context as a mesh, transforming the vertices and reconstructing the mesh after transformation. However, as planar geometry describing the room is transformed in spherical geometry, the mesh needed to be refined at an acceptable resolution for the model to be 3D printable. Several refining techniques were tested, instead of a uniform meshing of the room, we settled on casting rays from the centre of the sphere and refining the mesh where the rays intersected. This results in a mesh where the resolution depends on the distance from the inversion point, which proved to be an efficient way of improving the algorithm. In later versions, a lidar scanner was used to scan the room, the scanning process physically analogous to casting rays from a point, and as such, the lidar scanner is a suiting input device for the specific algorithm used.

When using computation in architectural design, material and spatial entities are captured or encoded into the quantifiable language of code. Code functions as a specific lens for looking at and describing material and spatial entities. In architecture, these descriptions are often geometric in nature and limited to describing the form of spaces and artefacts, although they can be extended to incorporate other quantifiable aspects. Code as a lens relies 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 Sphere Inversions 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.

4.3. Encoding Translation

A substantial amount of architectural drawings anticipate processes of fabrication, construction and assembly: from sections and plan drawings to details and diagrams. Architectural drawing has established a language combining orthographical projection, graphical conventions, textual and symbolic annotations that describe the fabrication and construction of a material artefact. The drawing annotates the construct to a degree of detail and clarity that it becomes practically feasible to construct by contractors able to understanding the language of an architectural plan. However, through developments in building information modelling, and digital and robotic fabrication, the drawing is increasingly being replaced by exchanging digital data. The design experiments described below explore digital fabrication, not for closing the gap between design idea and material artefact, but carefully examines what happens in the encoding of design propositions in digital files and the translation between digital files and material artifacts.

Fig. 5. Objects Without Skins: plotter drawing, 3D print and screenshot of the software.

Objects Without Skins. The Encoded Matter project, used an open-source self-build 3D printer, and explored the process of fabricating with this printer. Going from file to artefact requires processing a digital model through a machine specific software, in additive manufacturing this means going from a digital model describing the outer shape of an artefact – as a triangulated mesh – to a file that encoded the movement of the tool head and describes the fabrication process and how it unfolds in time – a g-code file. The starting point of this series was to go beyond the volumetric description of the artefact as a mesh and directly generate the g-code from a custom developed design tool, written in Processing and Grasshopper[10]. This results in material qualities that are radically different from what the fabrication technology normally produces, and actually exploits the difference between the encoded file and the materialized artefact, not as a failure but as design potential.

10. See https://processing.org/ and https://www.grasshopper3d.com/ consulted on 01/02/2020.

Fig. 6. Hatching With Matter: 3D print and plotter drawings.

Hatching with Matter. In architectural drawing, hatches and line-weights operate as symbolic notations of materiality, some properties of the represented material are reflected in how the hatches and lines are drawn, e.g. thicker lines and denser hatches tend to represent heavier and denser materials. The series of artefacts explore digital fabrication as drawing with matter. Instead of approaching hatches and lines as a symbolic notation, they are used directly to control translucency and density of the material.

The same algorithms used for generating the fabrication files are used for making drawings through a pen plotter. These drawings are themselves outcomes of the same processes, they are not made as notations prior to fabrication, and the process of making them enacts a performance similar to the movement of the tool head of the fabrication machine.

Material Obfuscation. Obfuscation is the process in software development of making the source code hard to interpret for a human reader, while remaining executable for a computer. This experiment[11] looked into the allographic qualities introduced by photogrammetry and 3D scanning on the one hand and a d.i.y. filament printer on the other. Through various iterations of modelling, printing, scanning and repeating that process, the accumulative particular qualities or errors of both these technologies become amplified. The feedback loop accelerates the question of authorship, allowing the algorithms, the machinic fabrication processes and the material to actively contribute to the resulting fabricated artefact. The final iteration shows traces of the code, the triangulation introduced by photogrammetry, the layered and linear qualities of the slicing algorithm that controls the motion of the 3D printer, as well as material properties and limits.

11. Developed together with master students Jari Jacquet, Joris Putteneers & Olaf Mitka for the research elective Computation & Materiality, KU Leuven Faculty of Architecture in 2017.

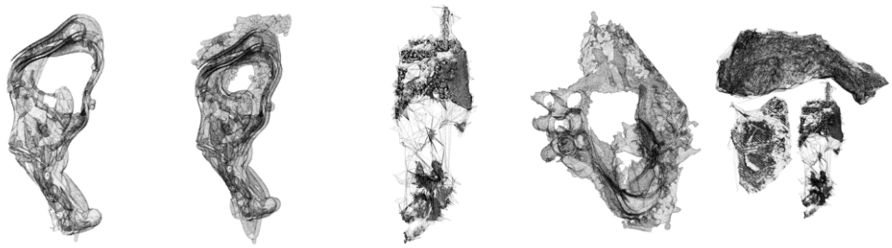

Fig. 7. Material Obfuscation: digital drawing sequence.

Since the algorithms are highly attuned to the fabrication and material nature of the 3D printed artefacts, their 2D counterparts can be seen as representational: they represent a material reality outside themselves, but the way they refer to this materiality is not symbolic, but rather an enactment of the same movements that can be made by a different machine to produce material artefacts. When drawing an architectural section, line-weights and hatches are used as a symbolic notation of materiality: the thicker the line, the denser the material. The hatches in the Hatching with Matter drawings might be reminiscent of hatches in architectural drawings, but they operate in a non-symbolic manner. As such, these drawings also acquire an experiential quality, and become non-representational. The nature of the drawing is altered through digital fabrication: The drawing loses its projective connotations and becomes an unfolded trace for the fabrication process of cutting or adding material.

5. Discussion

Recent developments in digital technologies are affecting the role of drawing in architectural practice and research. Instead of rejecting the drawing in favour of a more model-based simulation approach this paper proposes using coding as a means of rethinking how architectural drawings can operate as means for mapping architectural qualities, developing design ideas and translating these ideas in artefacts and drawings. Situated within a renewed interest in drawing in architectural practice and research, *allographic drawing is* a specific form of post-digital drawing. The drawing explorations: *sketching with code*, *code as lens* and *encoding translation* are particular ways of understanding the agency of coding in architectural drawing. This understanding of agency of code emerges out of the specific work; there are probably other ways of framing the agency of coding in architectural drawing. These drawing explorations operate in-between the poles set out in the framework: negotiating between being authored and allowing technology to introduce allographic qualities, between model-based simulations and drawing based representation. The research proposes *allographic drawing* as a way describing the agencies introduced by coding in architectural design processes.

References

Allen, Stan.
2009. *Mapping the Un-mappable, in Practice: Architecture, Technique + Representation.* London ; New York: Routledge.

Carpo, Mario.
2011. *The Alphabet and the Algorithm, Writing Architecture.* Cambridge, MA: The MIT Press.

Cook, Peter.
2014. Drawing: *The Motive Force of Architecture.* AD Primers. London: Wiley.

Evans, Robin.
1997. Translations from Drawing to Building, and Other Essays. London: Architectural Association Documents.

Goodhouse, Andrew, et al, eds.
2017. When Is the Digital in Architecture? Montréal: Canadian Center for Architecture,

Goodman, Nelson.
1976, *Languages of Art.* Indianapolis/ Cambridge: Hackett Publishing Company

Groák, Steven.
1992. *The Idea of Building: Thought and Action in the Design and Production of Buildings*. London; New York: E & FN Spon.

Kolarevic, Branko.
2005. Information Master Builders. In Branko Kolarevic, Architecture in the Digital Age: Design and Manufacturing. London: Taylor & Francis

Leach, Neil.
2018. *We Have Never Been Digital,* In ACADIA // 2018: Recalibration. On imprecisionand infidelity. [Proceedings of the 38th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA) ISBN 978-0-692-17729-7] Mexico City, Mexico 18-20 October, pp. 20-29

Lostritto, Carl.
2016. *Computational Hatching*, Journal of Architectural Education, 70:1, 83-90, DOI: 10.1080/10464883.2016.1122475

Marcus, Adam; Kudless, Andrew.
2018. *Drawing Codes. Experimental protocols of architectural representation*. In ACADIA // 2018: Recalibration. On imprecisionand infidelity. [Proceedings of the 38th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA) ISBN 978-0-692-17729-7] Mexico City, Mexico 18-20 October, 2018, pp. 46-55

Murray, Janet H.
1997. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace.* Cambridge, MA: The MIT Press.

Riedijk, Michiel ed.
2010. *Architecture as a Craft: Architecture, Drawing, Model and Position*. Amsterdam: SUN.

Scheer, David R.
2014. The Death of Drawing: Architecture in the Age of Simulation. London ; New York: Routledge.

Sheil, Bob.
2012. *Distinguishing Between the Drawn and the Made* in Achim Menges, Material Computation: Higher Integration in Morphogenetic Design Architectural Design. London: Wiley.

Silver, Michael.
2006. *Buildings Without Drawing: Automason Ver. 1.0.* In Programming Cultures: Architecture, Art and Science in the Age of Software Development, ed. Michael Silver, London: Wiley.

Terzidis, Kostas.
2006. Algorithmic Architecture. Amsterdam ; Boston: Architectural Press

Till, Jeremy.
2009. *Architecture Depends.* Cambridge, MA: The MIT Press.

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Open, Seamful and Slow: A More-Than-Human Internet of Things

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Keywords: Networked Media, Internet of Things, More-Than-Human, Prototyping, Media Art.

Departing from the concept of an Internet of Things (IoT) as a means to give voice to non-human 'things', the project Wildthings.io seeks to develop experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions. This paper discusses the iterative design processes that concluded in the IoT artwork *Papawai Transmissions,* which imagines novel ways of understanding and (re-)connecting with disconnected streams, their communities and their ecosystems in urban Aotearoa/New Zealand, through methods of openness, seamfulness and slowness.

1. Introduction

In this paper, I discuss the iterative design processes of the research project Wildthings.io that concluded in the network installation *Papawai Transmissions*. With a focus on wai/water, the project set out to imagine novel ways of understanding and (re-)connecting with disconnected streams, their communities and their ecosystems in urban Aotearoa/New Zealand, specifically my place of residence, Te-Whanganui-a-Tara/Wellington. My fieldwork departs at a small stream in my neighbourhood, and fans out into the wider network of local freshwater which has largely disappeared from the cityscape. Data collected during fieldwork and lab development has informed the creation of electronic design artefacts to learn how the more-than-human world can inspire the development of networked media.

Departing from the concept of an Internet of Things as a means to give voice to non-human 'things', this research developed experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions. In this paper, I address a central question—how can we, as creatives, learn from the more-than-human world when building networked media—through three key sections. First, I engage with an overview of the term 'Internet of Things' and present early forms of networked objects. From here, I consider the development of a 'more-than-human' Internet of Things, and how such a concept could de-stabilise the Western anthropocentrism of previous IoT approaches. In the third section, I present a discussion of my research as realised through iterations of the network installation *Papawai Transmissions*.

1.1. The First "Things" on the Internet

The term 'Internet of Things' originated in 1999 at the Auto-ID Center at Massachusetts Institute of Technology. Kevin Ashton (2009), co-founder and executive of the Auto-ID Center, presented the idea of improving the efficiency of Procter and Gamble's supply chain management by connecting products via RFID technology to the Internet:

> "Adding radio-frequency identification and other sensors to everyday objects will create an Internet of Things, and lay the foundations of a new age of machine perception" (as cited in Santucci 2009, 2).

The idea of connecting objects to the Internet, however, is not entirely new. The first 'everyday' object connected to the Internet was a Coke machine at the Carnegie Mellon University Computer Science Department. The system, developed in 1982, remotely monitored the out-of-product lights on the machine's push buttons, and the status of each row of the vending machine could be queried through a terminal with the *finger* protocol. Users could retrieve three responses: `EMPTY`, a timer since the last refill, or, `COLD` in case the last refill was longer than three hours ago (see Everhart et al. 1990).

Another popular early networked object was the *Internet Toaster*, developed by John Romkey in 1990, presented at the Interop Internet Networking show in Las Vegas. The toaster could be controlled via TCP/IP and SNMP (Simple Network Management Protocol). One year after his first demonstration, Romkey added a robotic arm to the setup for loading the appliance with bread slices. In subsequent years, more experimental networked prototypes, such as the *Internet Weather Bear* were presented at the show.

The *Trojan Room Coffee Pot* from 1991 is also worth mentioning, as it shares a related interest into remote access to beverages, similar to the *Internet Coke Machine*. Developed at the University of Cambridge, England, the project evolved into what is now known to be the first webcam, showing a live image of a filter coffee machine pot. The researchers made the live image available on the World Wide Web, with the vision that anyone would be able to watch the coffee machine from anywhere in the world. Surprisingly, the site was hugely popular, and allegedly one of the most popular websites at the time.

In sum, these early IoT pieces were built as proofs-of-concept which made an appliance, and consequently the status of a beverage or piece of toast, remotely accessible for more convenient consumption. These early prototypes have inspired more experimental projects and sparked inspiration for networked art. The *Trojan Coffee Pot,* for example, whilst considered the world's first webcam, has also been discussed for its artistic qualities: for example as "telematic theatre" (Smith 2005) or as "identic art" (Alexenberg 2004).

1.2. The Art of Connecting Things: Some Artistic Encounters Explore Human/ Non-Human Networks

In contrast to the previously discussed networked explorations stands Natalie Jeremijenko's *Live Wire* or *Dangling String*, which is often referred to as the first Internet of Things artwork (Weiser and Brown 1996). The piece was developed during an artist residency at Xerox PARC, and described by Weiser and Brown as an eight-foot piece of plastic spaghetti that hangs from a small electric motor mounted on the ceiling, connected to an Ethernet cable. Every bit of information from the lab environment was translated into a motor movement so that with more network traffic, the sculpture would start becoming alive.

Playful explorations of how everyday objects could be connected to the Internet rose substantially during the 1990s, and networked artworks showed a growing tendency to technologically hybridise human and non-human modes of existence. One of the first notable networked art projects, which connected online users with plants, was *TeleGarden* from 1995. The art installation allowed web users to view and interact with a remote garden filled with living plants. Users could plant, water, and monitor the progress of seedlings by controlling an industrial robot arm. Their project thus created a tension between the 'natural' living organic environment, and the 'unnatural' robotic arm interacting with it through remote, human commands (telegarden 2008).

The tensions this project speak to a broader project in which the category of 'human' itself increasingly comes into question. A decentering of the human, and a corresponding shifting of attention towards concerns for the non-human, can be found in a wide variety of recent and current western philosophical lines of thought (Grusin 2015, vii). This is a reaction to the predominant centring of the human in Western anthropocentrism, which some cultures, among them New Zealand Māori, have not adopted into their philosophies. The widespread interest in challenging the traditional divides between humans and non-humans has contributed to a growing push for methods that can work with the distributed knowledges, experiences and values of a more-than-human world.

Human-Computer Interaction (HCI) have shown increasing interest in this decentering, particularly as a "response to concerns about environmental sustainability, technology obsolescence, and consumerism" (Bardzell et al. 2019). Greenhough (2014) claims that natural disasters and an increased spread of zoonotic diseases are urging Western societies to shift their focus away from the human towards the non-human (94). The major human impact on earth and atmosphere at a global scale has resulted in the proposal of naming the current geological epoch the "Anthropocene" (Crutzen and Stoermer 2000). Haraway (2015) demands that it is "our job, to make the Anthropocene as short/thin as possible and to cultivate with each other in every way imaginable epochs to come that can replenish refuge" (160). Notably, these Anthropocene-related urgencies, among them the looming climate crisis, have been voiced by indigenous peoples long before western discourse has acknowledged them.

2. Prototyping Methods for a More-Than-Human IoT

The search for methods involving the decentering of the human help to establish a theoretical grounding for design research that aims to navigate this complex territory, with the aim to introduce new perspectives to the development of an Internet of Things. My research, as situated in Aotearoa/New Zealand, presented further opportunities for engaging in a methodological approach which responds to this call for a diversity of perspectives in design research. As a European born researcher, only having lived in New Zealand for five years, I need to learn about local, situated knowledges (Haraway 1988) and perspectives. Working within the context of Aotearoa/New Zealand offered rich learning opportunities when there is already a culture present, where a Māori worldview offers a deep, intricate understanding of 'thing' networks.

From a designer's perspective, new, more malleable and open frameworks for approaching research problems are hence emerging, among them post-qualitative research (Lather and St. Pierre 2013) and non-representational approaches (Vannini 2015). However, given that they are still in their infancies, these new, cross-cultural traditions face many challenges when trying to weave diverse attributes and non-text focused work into Western academic publishing structures, where they might be described as "messiness" (Law 2004), or "slowness" (Ulmer 2017)." These factors, in turn, have become core to my research paradigm where, as I outline below, slowness, seamfulness, and openness have been integral to the development of a networked artwork as part of Wildthings.io.

2.1. Opening the Design Process to More-Than-Human Voices

From the outset of the research, I considered Participatory Design (PD) as an avenue to involve the more-than-human world into the research process as participants. This required unpacking of what participation means in a more-than-human context, and if and how traditional human-centred participatory design methods can provide new perspectives on designing with and for water and connected ecosystems.

> "It takes work, and new ways of thinking, and new kinds and methods of openness, to bring substantively new voices into a conversation."
> (Muller 2009, 166)

The opportunities and challenges of adding new voices and perspectives into a design conversation are widely discussed in the field of Participatory Design (see for example Bannon and Ehn 2012; Kensing and Greenbaum 2012). A more-than-human participatory research agenda, as described by Bastian et al. (2016), supports the inclusion of marginalised voices in the research process, and "makes research accountable to those it affects" (5). Nonetheless, in finding myself working with local communities and ecosystems in an Aotearoa/New Zealand context, it is also vital to acknowledge and incorporate non-western traditions and modes of thought (see Smith 2012). Blomberg and Karasti (2012) discuss the opportunity to include ethnographic sensibilities into a PD approach but warn that:

> "We should not assume that the tools and techniques of Participatory Design developed for Scandinavian (and other European and North American) audiences will enable multiple voices to define and inform the design when transported to very different traditions."
> (Blomberg and Karasti 2012, 107)

As an artist, designer, coder and researcher taught within Western academia, most of my tools and technologies stem from a Western background. I must avoid a technological colonisation of Aotearoa's more-than-human worlds through my research and the tools I develop.

In the "perhaps the most quoted sentence in the book" (Smith 2012, xi) one which stands central at the opening to the work of Decolonizing Methodologies, Smith reminds us:

> "From the vantage point of the colonised, a position from which I write, and choose to privilege, the term 'research' is inextricably linked to European imperialism and colonialism. The word itself 'research', is probably one of the dirtiest words in the indigenous world's vocabulary." (Smith 2012, 1) "

I need to be humble and acknowledge the privilege of doing research with and for the water of the streams of Aotearoa/New Zealand. Similarly, I need to scrutinise my background in Open Source development and keep assessing if and how open sharing of my design research benefits the more-than-human communities it affects. An openness to share my process and give the knowledge back to communities who care for their streams implied open licensing and publishing of hardware, software, writings and recordings of my design processes. Whilst it is not within the scope of this article to fully unpack the complexities and tensions which can arise from mobilising 'Open' culture into spaces grappling with the implications of decolonisation, emergent work in this field reminds us that as researchers, we must always be critically aware that underlying much 'Open' discourse' is the assumption of the universality of knowledge systems, often dictated by hegemonic knowledge groups (see for example Adam et al. 2019). I take up this approach to openness in my own work with this caution in mind. Besides the effort to be attentive to more-than-human voices, openness has also been embraced in the design process itself, through the concept of 'beautiful seams', which I discuss in the following section.

2.2. An IoT of Beautiful Seams

When Mark Weiser (1991) envisioned the computer of the 21st century, he described an environment in which networked computers of various sizes and forms vanish into the background. In his vision, machines resided in the human world and posed no barrier to physical interaction like the then-popular desktop computer:

> "Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods." (Weiser 1990)

In later talks, Weiser (1994; 1995) addressed the misleading concept of seamlessness, and argued for "seamful systems", with "beautiful seams". Weiser also rejected the idea of an interface as a boundary or difference and argued that the unit of design should involve social people, in their environment plus their device (Weiser 1995, 21). Later, Chalmers and MacColl (2003) argued for seamfulness in design and described it accordingly:

> “taking account of the finite and physical nature of digital media. Seamful design involves deliberately revealing seams to users, and taking advantage of features usually considered as negative or problematic” (Chalmers and MacColl 2003, 1).

Chalmers et al. (2003) pointed out that the revealing of the seams in the infrastructure of Ubiquitous Computing can be an opportunity for user understanding and empowerment. Seams could also be a way towards the creation of more dynamic systems, that are able to adjust to interaction patterns originally not envisioned by the designer.

Seamlessness in IoT devices is problematic not only in terms of privacy concerns but also in relation to obfuscating functionality to users, preventing understanding of what networked devices really do, at any given point in time. Seamful design tries to “reveal inevitable seams in ubicomp systems and use them to increase awareness for system infrastructures, their heterogeneous components and otherwise neglected yet useful information within the system” (Broll and Benford, 155). Inman and Ribes (2019) consider seamful and seamless design as complementary concepts and consider “beautiful seams” as

> “a phrase that seems to capture both the spirit of user-friendly, coherent design emphasised by seamlessness and the heterogeneity, contingency, and appropriability of seamful design.” (Inman & Ribes, 2019, 12).

The embracing of seamful design requires slowing down and taking time to acknowledge rough edges as a feature of a design piece. This slowness, however, gives access to discovering qualities of design that might go unnoticed within a fast, optimised development cycle.

2.3. Slowness

> “Slowness is a process of unlearning and unsettling what has come before.” (Springgay and Truman 2019, 15)

Before developing devices for an environment, it was also necessary to take time to reveal and learn about existing networks before designing new nodes and connections. By advocating for a ‘Slow Ontology’, Ulmer (2017) describes how, in new materialist qualitative scholarship, a more-than-human, entangled approach to research involves the writing of environmental landscapes, as well as writing on/with/through/in aspects of nature (207), calling for more-than-methodologies which “involve material, ecological, and temporal inquiries” (Ulmer 2017).

An approach to slowness when working with more-than-human ecologies resonates with how Pigott and Lyons (2016) discuss their artistic practice as a

> “[...] slow attunement and creative ‘listening’. This process involved a distillation of a rhizomic mesh of conversations and encounters, embracing place identity, species, technology and communication” (144)

Embracing slowness also afforded time to understand what it means to be a designer in Aotearoa/New Zealand. Slowness allowed me to pause and take the time to acknowledge that research and knowledge production have been part of this land centuries before the establishment of the university and academia. The inclusion of more-than-human concerns into research methodologies has been central to Te Ao Māori (the Māori world) and Mātauranga Māori (the Māori way of engaging with the world) long before academia started to turn attention away from anthropocentrism.

These considerations, alongside seamfulness and openness, guided the creation of a range of design outputs along the research journey. At the heart of development sits a series of networked installations collected under the title Wildthings.io.

3. Wildthings.io: Sensing Streams

As part of my creative research with Papawai Stream and Moturoa Stream in Pōneke/Wellington, I developed experimental prototypes for a more-than-human IoT network. These consist of a range of DIY electronic nodes as artistic interventions, collectively created and published as Wildthings.io. The installations *Moturoa Transmissions* and *Papapwai Transmissions* contain a collection of low-cost, Internet of Things network prototypes for engaging with local stream environments. The stand-alone Wi-Fi networks, installed at streams in Pōneke/Wellington, consist of several modular DIY Wi-Fi nodes that capture, visualise, and sonify data such as electric conductivity, temperature, and turbidity. The networks aided the imagination of novel ways of (re-)connecting with disconnected waters and their more-than-human ecosystems.

Prototypes for the network were developed in response to field immersions, walking conversations, lab prototyping, test installations and exhibitions, presentations, and publications. From the outset of the prototyping process, I developed tentative parameters to evaluate my design outputs against, ranging across theoretical, artistic and technical considerations. While I started with a larger, and more detailed and specific set of parameters to work with, three categories expressed the character of my research journey across data collection, generative design research and evaluation. At first glance, openness, seamfulness and slowness appear as shortcomings or hindrances to creative development—especially from the perspective of a technology industry where quick development cycles, seamless solutions and prototype development towards exit strategies are idealised. In this final section, I introduce the iterative development process of the IoT artworks as part of Wildthings.io and conclude with a discussion of highlighted methods.

3.1. Encountering the Stream: Moturoa Transmissions

The first-exhibited iteration of the network was installed during the Brooklyn Arts Trail at Moturoa Stream in Pōneke/Wellington under the title *Motuora Transmissions*. The installation featured one Raspberry Pi with an external USB antenna serving a local Wi-Fi network and acting as an MQTT broker for the Wi-Fi nodes. The nodes consisted of Wemos D1 boards and custom hardware monitoring the stream environment through a range of environmental sensors, a mix of off-the-shelf shields and DIY sensor solutions. The artwork was operating during daytime and disassembled for charging overnight, and accompanied by an artist statement:

> "A networked series of interventions in the surrounding environment of Moturoa Stream that senses and monitors change in a range of variables, such as temperature, humidity and conductivity. Together the stations enter a conversation beyond their mere weather-reflective qualities and given structure of land, water and its human and non-human encounters to form a visually engaging addition to the ecosystem in which they are situated."

The inclusion of an early prototypical rendition of the work in a public art exhibition provided an opportunity for audience feedback and allowed quick iterations and updates of hardware and software overnight. The piece was installed close to a secondary entrance of Central Park, where Moturoa Stream is not directly visible but—unbeknownst to many locals—emerging from an underground pipe. Hidden from sight behind thick foliage, the stream water cascades from the pipe outlet into a small plunge pool, before making its way down through the park before being piped underground again. The selected location intended to highlight the transition the water made between the ontological categories of 'stormwater' and 'stream'. However, the site also obfuscated an apparent connection between the exhibited electronic artefacts and the stream, without providing further context to an audience. One of the nodes placed close to the accessible path, visualised the local network traffic and the sending and receiving of data through a multi-colour LED. An additional node, recording sensor data to a memory card, was added on day two after feedback from the audience.

Initial challenges for the exhibit included outdoor-proofing of the network and providing reliable power to all nodes. The hardware design needed to be suitable for exhibition across multiple days under variable weather conditions, protecting components and circuitry against more-than-human forces such as moisture, wind and heat. The exhibited design re-used water bottles initially used for collecting stream samples and testing DIY nodes in the lab as casing. The transparent casing gives an audience visual access to all componentry and reveals the processes and connections that went into the assembly of the hardware.

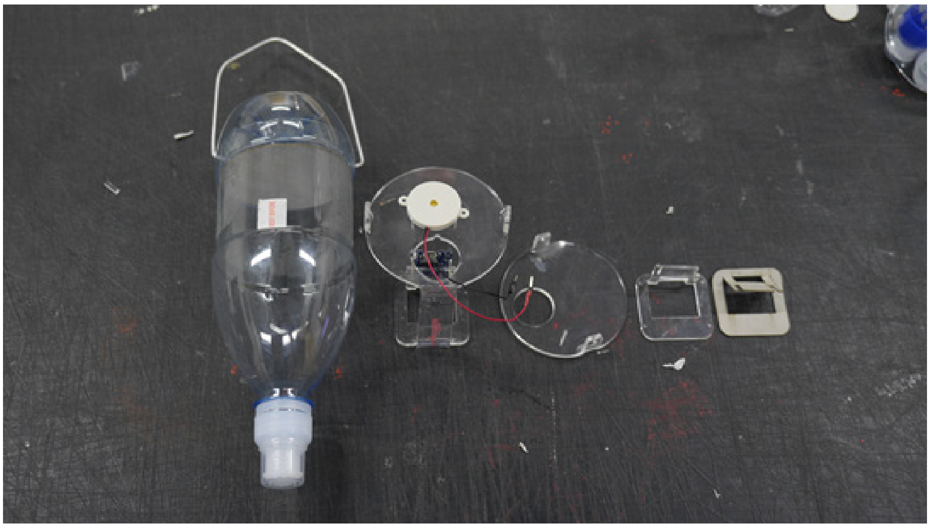

Fig. 1. Iterative prototyping of a recycled outdoor-proof project enclosure for a microcontroller and a power bank.

The recycling of used water bottles as outdoor-proof project enclosures, instead of manufacturing new materials, resonated with a low-cost and low-impact approach to prototyping. The casing also connected back to a range of discarded bottles I encountered during my fieldwork, emerging from muddy stream beds after heavy rainfall. A disadvantage of the material, however, was that it slowly degenerated and cracked from continuous de-assembling and re-assembling of the nodes for charging and maintenance.

Fig. 2. Installation at Moturoa Stream showing two sensor nodes and Wi-Fi Access Point/MQTT Broker.

While the schedule of the public art event pushed the development of the project significantly forward within a few weeks, the compressed timeframe of quick iterations developed overnight based on feedback from the audience came with a few drawbacks. Having some of the artefacts tested in the field for the first time during the exhibition was stressful, and demanded some on-location debugging. Some of these field updates were not appropriately documented in the online code repository due to the lack of Internet access on location.

3.2. Prototyping Slow Iterations: Papawai Transmissions

The development of *Papawai Transmissions* was set at a stream in a different suburb of Pōneke/Wellington, and was based on previous design outputs and outcomes of *Moturoa Transmissions*. With no fixed exhibition schedule, the oscillations between fieldwork and lab development provided more opportunities for experimentation and productive failure. While the basic network design with the Raspberry Pi hub node at heart remained the same, a variety of additional nodes were developed and updated in response to feedback from invited participants, among them individuals from local DIY electronics, arts, and stream restoration community groups. Modified glass jars replaced outworn bottle enclosures, and previously laser-cut acrylic inlays were simplified in the form of paper and cardboard pieces.

Fig. 3. Labwork: Prototype of an LED node with paper and copper tape.

A notable addition to the *Papawai Transmissions* network was bespoke nodes that would visualise incoming sensor data through LEDs or sonify it, translating changes to the stream environment into sound. While sensor nodes would be placed beside the stream, the outputting nodes could be placed closer to accessible paths at viewable height for an audience.

The network was designed to connect a human audience in various ways to the streams: First, the installation could be encountered in the wild and investigated by an audience at their own pace. Simple labels on the nodes would help identify nodes and their inner workings. Second, the installation was also aimed at an audience who would be invited to help install the work and learn about the technology behind it, while spending time with the nodes and the stream in the wild. Audience feedback also indicated the interest in self-guided walks and installations of probes along the stream. This approach opens possibilities of adding a field notebook to the artwork, in which human participants can add their own narratives to the sensor data by recording their observations, e.g. by adding paper notes to the kit which could be included in the project enclosures. Finally, the online repository contains code and schematics of all Wildthings.io nodes, and invites developers to use the setup as is, or modify the work to suit their own stream environments and re-share with their communities.

Fig. 4. Fieldwork: testing and debugging of revised sensor nodes at Papawai Stream.

4. Conclusion

This paper has discussed how, through embracing methods of openness, seamfulness, and slowness, the project Wildthings.io has sought to respond to the question of how we, as a design community, can learn from the more-than-human world when building networked media. Via the development of experimental prototypes for grassroots, community-run digital networks, and DIY electronic devices as artistic interventions, this research departed from the concept of an Internet of Things as a means to give voice to non-human 'things'.

With a focus on wai/water, the design of the networked installations discussed here specifically engaged with local stream ecologies in Pōneke/Wellington that have largely disappeared from the cityscape and have been piped underground due to urban development. Data collected during fieldwork and lab work has informed the creation of electronic design artefacts to learn how the more-than-human world can inspire the development of networked media, and to imagine novel ways of (re-) connecting with disconnected waters and their more-than-human ecosystems. Doing so calls into focus the role design plays within a growing push for methods that can work with the distributed knowledges, experiences and values of a more-than-human world.

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References

Adam, Taskeen, Maha Bali, Cheryl Hodgkinson-Williams, and Tannis Morgan.
2019. "Guest blog – Can we decolonise OER/Open? #DecoloniseOpen", OER 2019. Accessed May 3, 2020. https://oer19.oerconf.org/news/blog-can-we-decolonize-oer-open-decolonizeopen/#gref

Alexenberg, Mel.
2004. "Semiotic redefinition of art in a digital age." In Semiotics and Visual Culture: Sights, Signs, and Significance, edited by Debbie Smith-Shank, 124-131. Reston, VA: National Art Education Association.

Ashton, Kevin.
2009. "That 'internet of things' thing." RFID journal 22, no. 7: 97-114.

Bannon, Liam J., and Pelle Ehn.
2012. "Design: design matters in Participatory Design." In Routledge International Handbook Of Participatory Design, edited by Jesper Simonsen and Toni Robertson 57-83. New York: Routledge.

Bastian, Michelle, Owain Jones, Niamh Moore, and Emma Roe.
2016. "Introduction: More-than-human participatory research: Contexts, challenges, possibilities." In Participatory Research in More-than-Human Worlds, edited by Michelle Bastian, Owain Jones, Niamh Moore, Emma Roe, 15-30. New York: Routledge.

Bardzell, Jeffrey, Shaowen Bardzell, and Szu-Yu Cyn Liu.
2019. "Beautifying IoT: The Internet of Things as a cultural agenda." In Social Internet of Things, edited by Alessandro Soro, Margot Brereton, Paul Roe, 3-21. Springer, Cham.

Blomberg, Jeanette, and Helena Karasti.
2012." Ethnography: Positioning ethnography within participatory design." In Routledge International Handbook Of Participatory Design, edited by Jesper Simonsen and Toni Robertson, 106-136. New York: Routledge.

Broll, Gregor, and Steve Benford.
2005. "Seamful design for location-based mobile games." In International Conference on Entertainment Computing – 4th International Conference Proceedings, edited by Fumio Kishino, Yoshifumi Kitamura, Hirokazu Kato, Noriko Nagata, 155-166. Springer: Berlin, Heidelberg.

Chalmers, Matthew, Ian Maccoll, and Marek Bell.
2003. Seamful Design: Showing the Seams in Wearable Computing, in International Conference Proceedings, Eurowearable 2003, edited by Sandra I. Woolley and Chris Baber, 11-16. Birmingham, UK. https://doi.org/10.1049/ic:20030140.

Chalmers, Matthew, and Ian MacColl.
2003 "Seamful and seamless design in ubiquitous computing." In Proceedings of Ubicomp 2003 Workshop at the crossroads: The interaction of HCI and systems issues in UbiComp, 577-584, Seattle, Washington.

Crutzen, Paul J.
2006. "The 'Anthropocene.'" In Earth System Science in the Anthropocene, edited by Eckart Ehlers and Thomas Krafft, 13–18. Springer: Berlin, Heidelberg. https://doi.org/10.1007/3-540-26590-2_3.

Everhart, Craig, Caplan Eddie, and Nichols David.
1990. "Coke.History.Txt." Accessed May 3, 2020. http://cseweb.ucsd.edu/~bsy/coke.history.txt.

Greenhough, Beth.
2014. "More-than-human geographies." The SAGE Handbook of Human Geography, edited by: Roger Lee, Noel Castree, Rob Kitchin, Victoria Lawson, Anssi Paasi, Chris Philo, Sarah Radcliffe, Susan M. Roberts, Charles W.J. Withers, 94-119. London: SAGE.

Grusin, Richard (ed).
2015. The Nonhuman Turn. Minneapolis: University of Minnesota Press.

Inman, Sarah, and David Ribes.
2019. "'Beautiful Seams': Strategic Revelations and Concealments." In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems - CHI '19, 1–14. Glasgow: ACM Press. https://doi.org/10.1145/3290605.3300508.

Haraway, Donna.
1988. "Situated knowledges: The science question in feminism and the privilege of partial perspective." Feminist studies 14, no. 3: 575-599.

Haraway, Donna.
2015. "Anthropocene, capitalocene, plantationocene, chthulucene: Making kin." Environmental humanities 6, no. 1: 159-165.

Kensing, Finn, and Joan Greenbaum.
2012. "Heritage: Having a say." In Routledge International Handbook of Participatory Design, edited by Jesper Simonsen and Toni Robertson, p41-56. London: Routledge.

Lather, Patti, and Elizabeth A. St. Pierre.
2013. "Post-Qualitative Research." International Journal of Qualitative Studies in Education 26, no. 6: 629–33. https://doi.org/10.1080/09518398.2013.788752.

Law, John.
2004. After Method: Mess in Social Science Research. London: Routledge.

Muller, Michael J.
2007. "Participatory design: the third space in HCI." In The Human-Computer Interaction Handbook, edited by Andrew Sears and Julie A. Jacko, 1087-1108. Boca Raton: CRC Press.

Pigott, Jon, and Antony Lyons.
2016. "Shadows, undercurrents and the Aliveness Machines." In Participatory Research in More-than-Human Worlds, edited by Michelle Bastian, Owain Jones, Niamh Moore, Emma Roe, 155-174. New York: Routledge.

Santucci, Gérald.
2009. "From internet of data to internet of things." In Proceedings From International Conference On Future Trends Of The Internet, 1-19, Luxembourg.

Smith, Barry.
2005. "Jennicam, or the telematic theatre of a real life." International Journal of Performance Arts & Digital Media 1, no. 2: 91-100.

Smith, Linda Tuhiwai.
2012. Decolonising methodologies: research and indigenous peoples. Dunedin: University of Otago Press.

Springgay, Stephanie, and Sarah E. Truman.
2017. Walking methodologies in a more-than-human world: WalkingLab. New York: Routledge.

telegarden.
2008. Telegarden Description. Accessed May 3, 2020. https://www.youtube.com/watch?v=gbyy5vSg8w8.

Ulmer, Jasmine B.
2017. "Writing slow ontology." Qualitative Inquiry 23, no. 3: 201-211.

Vannini, Phillip (ed).
2015. Non-representational methodologies: Re-envisioning research.
New York: Routledge.

Weiser, Mark.
1991. “The Computer for the 21st Century.” Scientific American 265, no. 3: 94-105.

Weiser, Mark.
1994. “Ubiquitous computing.” In Proceedings of the 22Nd Annual ACM Computer Science Conference on Scaling Up: Meeting the Challenge of Complexity in Real-world Computing Applications, edited by John Werth and Laurie Werth, ,418-420. https://doi.org/10.1145/197530.197680

Weiser, Mark.
1995. “Ubiquitous Computing.” Presented at the Usenix Association Technical Conference, New Orleans, LA, United States, January 18. http://www.ubiq.com/hypertext/weiser/Usenix95Slides.ps.

Weiser, Mark, and John Seely Brown.
1996. “Designing calm technology.” PowerGrid Journal 1, no. 1: 75-85.

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Openness and Transparency in Network Topologies

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We live in a space of networks. The connections between people, data, spaces, and objects have become more apparent and even assumed thanks to the infrastructure that manifests its pulsating presence through our screens. Yet despite their prevalence, how can we re-appropriate networks and use them as a radical infrastructure? This paper will explore various embodiments of network topologies in the interplay of networked cultures, the original networking practices of *Neural magazine*, and the developments of human mesh networks, as a potential crucial strategy of change.

1. The Substance of Networks

We live in a space of networks. They manifest themselves continuously, in every screen among the many we recurrently consult, or casually stare at, relegating the 'offline' condition to a perceived 'malfunctioning'. They also manifest themselves in all sorts of 'smart' devices we are increasingly surrounded by, and relying to. They intertwine people, spaces and objects, in a perennial, ungraspable, and mostly involuntary exchange of data, acknowledging each other in a planned hierarchical infrastructure. This acknowledged and perceived 'presence' is infrastructural, too, built by a restricted number of telecom corporations and mostly exploited by a handful of global online corporations. These two groups together are predominantly determining the shape of these networks in both their infrastructure and services. But these are not the only possible networks we can aspire to be part of. There are plenty of examples of human-scale, critical, and fruitful networks. Before investigating their differences let's try to assemble a general definition of networks.

The definition of a 'network' depends on the various scientific disciplines and cultural domains it refers to. Networks are mostly made of 'elements, nodes, or sub-units connected as a whole.' This 'whole' defines the total networked space, and also its dynamic potential variations, sizes, and shapes. This 'whole' can be hard to visualise, if we refer to the current average huge scale and complexity, like, for example, imagining all the nodes of a social medium. Nonetheless, the parts of this 'whole' can determine the network itself, through the individuality of its essential components: the nodes.

The number of involved nodes is determining the scale and complexity of the networks, still, they are not the only strategic elements in contemporary networks. As Albert-László Barabasi affirms "a network is a catalogue of a system's components often called *nodes*" (Barabasi, 2017). One of the most relevant is certainly the 'transparency' or, on the contrary, the 'opaqueness' of networks. The nodes we mostly use now, as well as our devices, are highly opaque. The size of the global grid of interconnections, and its underlying economy, privileges centralized entities being in control of all the peripheral ones. Nonetheless, given that each node is individual, there remains an autonomous capacity to conceptually redefine networks through the creation of sub- or separated networks at will. Using the same technical infrastructure, we can connect with peers on almost infinite nodes that are just a few steps away, while escaping the official 'grids'.

We can then 'extract' and use the essence (or 'substance') of networks, which lies in the possible relationship conceivable through the network abstraction. Then we can think about the network as a paradigm, which reframes the technical structure as a conceptual model. In this text, I will try to analyze the political transparency of network topologies in contrast to the opaqueness embedded in the networks of power, in line with the experiments we have accomplished with *Neural* magazine over the same time frame. By ‘network topology’ I mean a blend of the mathematical and more general definition of topology, applied to networks, so something close to: ‘spatial relations, whose constituent parts are interrelated, unaffected by the continuous changes in shape, size, or nodes.’ I will explore various embodiments of these topologies in the interplay of networked cultures, the networking practices of *Neural*, and the techno-cultural developments of networks, which can ultimately become a social factor of change.

2. The Disclosed Topologies of Power Opaqueness

Since the end of the 20th Century, the need to exemplify the increasing amount of complex information has led to the consolidation of disciplines giving a graphic form to specific data (like developing so-called ‘infographics’). This process often means to create an understandable connection among crucial elements. So, technically, ‘networking’ the relevant data. Increasingly, radical artists have used digital means to map the ‘networks of power’, or how people with significant political and corporate responsibilities are connected, to enhance their structures. These kinds of works can be defined as “artifacts and processes” where “power can be depicted and exercised”. (Dávila, 2019) The connections are unveiling the whole system of power and the nodes can be evaluated for their own ‘weight’ in the system. In this respect, the first emblematic work to consider is “They Rule”[1] by Josh On, which dynamically and interactively shows the complex power relationships between crucial people in U.S. institutions and corporations. When it was released in 2001, it had an exciting and daunting impact, clearly delineating the narrow and redundant power class of ‘who’s in charge’ (hence the title). The perfect, evocative interface, proportionally depicting the amount of power a single person has, through visual rules, reinforced the literal unveiling of this class. Moreover, the gesture of spending a lot of time compiling the database is the essential foundation to properly show these networks of power, whose shapes and connections finally become public domain. They Rule is an excellent example of what Patricio Dávila defines a ‘diagram of power’, which always “speak from a position” being “situated”. (Dávila, 2019)

In the same years, the networked maps of the French collective Bureau D’Etudes have been recognised not only as fascinating artworks, but also as mirrors of similar power systems, and have been disclosed through clever and self-aware use of networks. The systematic accumulation and proper rendering of data the group did reveal the capitalist democracies’ “interlocking meshwork of maleficent intentions” (Holmes, 2014). Bureau D’Etudes helped to define a different meaning for “info-graphics” imbuing an exquisitely political attitude, where the shown relationships create new meanings. The semiotics of these networked maps trigger the ability to

1. http://www.theyrule.net.

reprogram the perception of power systems, through a carefully checked translation of information. The networks they show are the ones we're enclosed by, which we should aim to change and liberate from. Holmes defines Etudes' non-interactive maps as "working sketches for cosmologies of liberation.". This liberation can go through different steps and already in the early 2000s the group remarked an essential one: "to be autonomous today is to have the capacity to cut off a network". Which can lead to the interpretation that their gesture of accumulating and made these networks public, is meant to instigate cutting off them.

More recently the work of Burak Arikan has defined a different aspect of revealed networks of elements. He is addressing what he calls 'data asymmetries', referring to the disproportionate availability of data and functional algorithms between the industry and the individual. In his renown "Islam, Republic, Neoliberalism", for example, he uses static printed maps, which are very dynamic when considered in combination altogether. They are addressing the city of Istanbul through the dislocation of, respectively, mosques, republican monuments, and shopping malls. Opposing a shared overwhelming feeling generated by too many different data, these thematic detailed maps are easily hitting the attention target as they address coherent microworlds. Displayed one next to the other with each type of data in one single colour, they have their critical relation unfold in the mental juxtaposition of zones and presences, and in the state/religion/business triumvirate conceptual rule over the vast urban territory. The respective networks are confronted by the spectator, who then can figure out the possible connections. Arikan's work is exactly showing meaningful connections among non-evident elements, extracting sense from juxtaposing networks. It reflects the Zhang's concept that the network is primarily "the idea that everything is connected, and, as such, is a product of a system of belief." (Zhang, 2015)

All these artworks are elaborating networks of power in forms that result as purely transparent. They are applying different strategies to the respective data, using inter-related visualizations to highlight the underlying structure, but ultimately using the network form as a liberating paradigm.

3. Early Net Art and its Revealed Topologies

The transparency of networks was a significant topic in the first decade of the public and then mass internet (early 90s to early 2000s). At the time, the visualization of the network structure represented the new underlying digital structure behind the visual appearance of single pages as browser content. The lack of any accurately compiled topologies, due to the constant growth and evolution of these rapidly expanding networks, inspired the first generation of net artists to develop their own visualizations, either fixed or dynamic, to create an overview of physically or conceptually interconnected nodes. The *Web Stalker* browser (1997) and JODI's *Map* (1999) are among the most celebrated of these net art works.

The former, developed by I/O/D (Matthew Fuller, Colin Green, and Simon Pope), was a fully functioning alternative web browser whose main feature was visualizing the links connecting to the requested page. Fuller compared the dissection and rendering of the network to Gordon Matta Clark's "Splitting" action (1974) where he literally bisected a whole house, already slated for demolition. The *Web Stalker* generated an abstract map of connections, "as a crawler function gradually moving through the network. We saw the logical structure of websites, established by the links, in and between them, as another key resource."[2] Unveiling the infrastructure and relations of the network in this way, the *Web Stalker* was antithetical to the page-centered, accurate but opaque layout of the other browsers.

2. Matthew Fuller, 'The Web Stalker', *Net Art Anthology* (2018), https://anthology.rhizome.org/, https://anthology.rhizome.org/the-web-stalker.

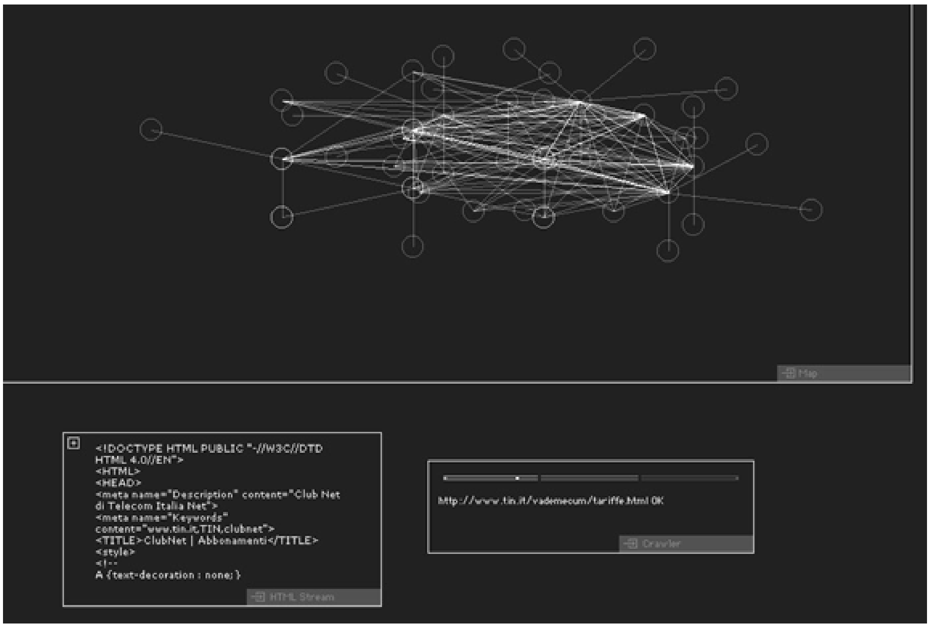
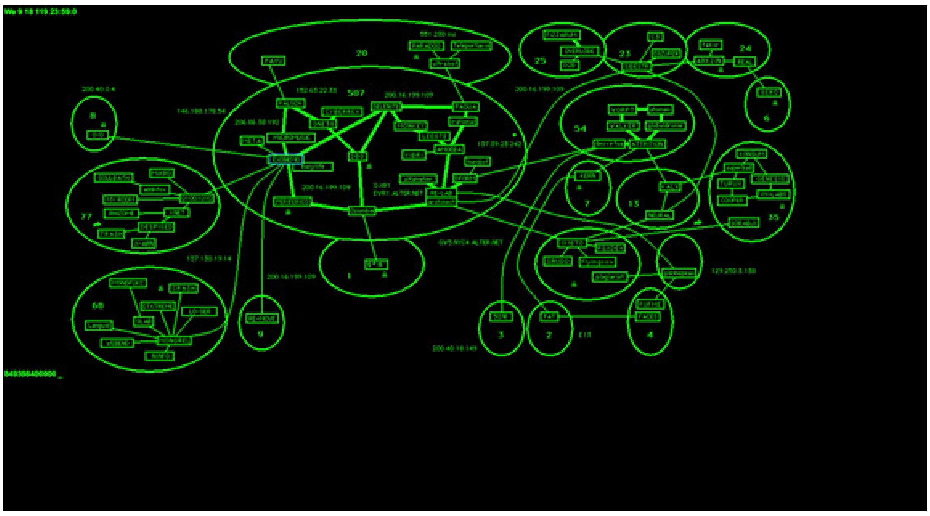


Fig.1. The Web Stalker.

JODI's iconic low-tech *Map*[3] had a different, subjective perspective, and was created by internet artist duo Joan Heemskerk and Dirk Paesmans. It was a clickable online network diagram representing the 'landscape of domains and sites that most interested them at the time,' with subjective relationships. (Galloway, 2016) JODI's *Map* accidentally formalized part of the net art avant-garde and enlightened some of its obscure manifestations. The *Map* diagrammatically compiles an interconnected visual 'document' which outlived the time and context of its making. In a way, it was 'JODI's Internet', frozen in time and expressed through a curated selection of entities, all within net art circles. This selection both scaled-down the network to which they were referring, to a size and shape that could be manageably represented and restricted it to a sphere of mutual influence. (Incidentally, the earliest version of the *Neural* website was one of the nodes of the JODI's *Map*.)

3. http://map.jodi.org.

Fig.2. JODI's *Map.*



These works aimed to both autonomise and connect compatible nodes in independent sub-networks, transparent but protected, with the fascinating possibility of reconfiguring these same nodes in order to evolve their meaning and function. They can still be understood as what Hakim Bey (Peter Lamborn Wilson) defined in 1991 as 'temporary autonomous zones.' (Bey, 1991) A network ecology emerges from these practices, with some key elements: transparency, the creation of autonomous and negotiated sub-networks, the potential of interconnections, and their reconfigurations and extensions.

4. A Different Practice: The Interdependent Networks of Neural

A different network ecology was already flourishing in the pre-internet times, when alternative and radical networks of communication were sharing the figure of the 'networker': subjects developing their own networks, within or outside predefined structures. In mail art, the networker predominates, in effect replacing the 'artist', with the prerogative to create networks of artistic production, public sharing, and archiving. In the words of Vittore Baroni, one of the most prominent personalities in mail art: "I saw the networker as a new cultural figure, a sort of meta-author who created contexts for collective expression rather than conventional individual works, and whose activities eluded the "vicious circle" of the art market and therefore needed new critical parameters and instruments to be fully analyzed and understood."[4]

4. Vittore Baroni, 'Memo from a Networker', http://www.lomholtmailartarchive.dk/texts/vittore-baroni-memo-from-a-networker.

The networker and early net artists share an underlying structure and principles, if not the scope and nature of their tools. For example, the Decentralized World-Wide Networker Congress for mail art in 1992 was a bottom-up structure of gatherings and events, creating and expanding upon sub-networks, including a three-day performance of eight-six artists exchanging copy art via fax around the world. (Galántai, Klaniczay, Stiles, 2013) Net artists meanwhile were creating dynamic sub-networks, performances, and initiatives globally, connected by the same spirit of distributed production, collaboration, and knowledge-sharing.

These practices all inspired *Neural* magazine, its production, economy, and associated activities. Founded in 1993, *Neural* began with one specific concept: to be a single node within a larger network of magazines and sources of information, all delivering content on digital culture, both investigating and expanding the established domains. The role of *Neural* has always been to weave together different data and cultural domains, in order to trigger a new awareness of digital culture and the growing network of entities producing this culture, which increasingly break the boundaries between fields of research.[5] Phillip Gochenour defined this approach as 'nodalism', which 'emphasizes the importance of links and connections and stigmatizes disconnectedness and solitude.' (Gochenour, 2011) This is not meant as a description of a condition, but a whole system: 'in a network model each unit, though different in itself, is part of an overall smoothly functioning system'[6], or the 'whole' mentioned in the beginning.

The *Neural* project has been built to echo the networks it nurtures and connects with, in a critical, but also open and collaborative way. Moreover, the development of a proper focused network has transcended the many platforms it occupies and has entered into fruitful dialogues with other 'nodes'.[7] *Neural* took a few years to develop into a fully-fledged informal network. In 2002, a network of magazines was cofounded, whose members could support each other in their publishing efforts, and discuss their shared condition, particularly the nodal relationship between online and offline publishing. The network was called Mag.net (magazine network of electronic cultural publishers) and involved thirteen international editors whose collective slogan became 'collaboration is better than competition,' recursively reflecting its structure.

In *Neural*'s publishing practice, other networked layers has been developed. First, the infrastructure of distribution meant that our five hundred or so subscribers included more than 150 institutional, mostly academic, libraries. These libraries could be thought of both as a preservation strategy for the magazine, hosting 'back-up' copies in distant places, and as a distribution strategy for artworks embedded within the magazine. Secondly, a further layer is the Neural Archive, which consists of the submissions and donations of publications the magazine has received over the last twenty-five years.[8] It is a searchable online catalogue of print media and art publications, and acts as a progressively growing representation of the community to which *Neural* magazine belongs—it is an archive of this community's production. Finally, the funding itself of *Neural* is also 'networked', in that economic support for the project comes from a strategic network of subscribers, rather than from public funding or other funding applications. From the beginning, a kind of crowdfund *ante litteram* was nurtured, with direct relations and communication that goes beyond the mere exchange of goods and money.

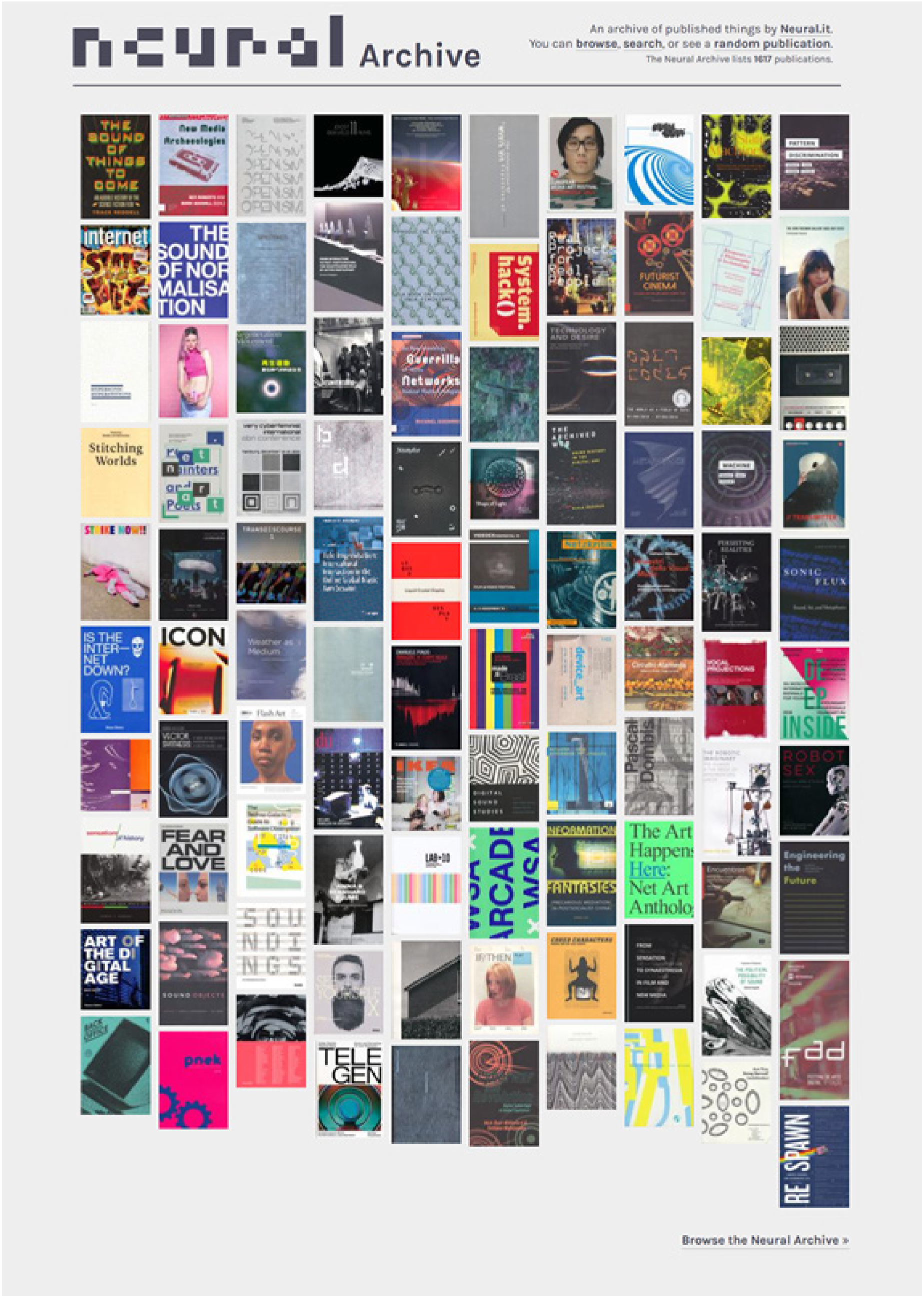
5. Annette Wolfsberger, 'Interview with Alessandro Ludovico', in Nicola Mullenger & Annette Wolfsberger (eds), *Cultural Bloggers Interviewed*, Amsterdam: LabforCulture, 2010.

6. Ibid.

7. Ibid.

8. http://archive.neural.it.

Fig.3. Neural Archive.



All these intertwining networks support the publishing, artistic, and archiving practices, but they also need to be nourished. Their interconnection generates sometimes unpredictable positive effects—strategic information or support which resonates from one layer to another, and from one node to another, transversally—but this is only manageable as long as the size and complexity of the network is maintained within a certain scale. With one-to-one relationships between all the nodes, their incredible human capital—fueled by emotional as well as technological resources—can become too much at some point, and lead to dysfunctions and cracks.

What results is a cultural version of an 'interdependent network'. The nodes depend on each other for their ecology and economy. The technical term for these types of networks, 'cascading', highlights their fragility in case of failure, potentially causing breakdowns of the whole system. (Vespignani,

2010) However, when they are culturally constituted and mediated, the networks have a different structure, as the single parts are protected by their various roles, although still interdependent. Moreover, these layers are mostly transparent (the institutional distribution, the external publications in the archive), offering a shared possible resource.

Such an interdependent network as we have built over time with *Neural* might represent a possible, hopeful model or strategy for managing our personal networks, preserving scale in direct relation to complexity, and creating long-term or short-term nurtured connections, instead of always looking for more—as is the pervasive commercial mantra.

5. Exploiting the Opaque Topology of Social Media

While these kinds of interdependent networks have a relatively transparent topology, the last revolution in communication we have seen, social media, is a self-transforming beast, which is less easy to discern. Social media platforms structurally hide their inner topology, all the while pushing for growth in the upper layer of users' connections, which boost profits, as a condition to thrive and survive. This process had already begun in the first decade of the World Wide Web, when the big players started to capitalize on the appropriation of the spontaneous network topology, through indexes and search engines or giving private space to host content, through 'portals'. The topology of networks became lucratively opaque and increasingly impenetrable, as a founding condition for large online businesses.

The early need and desire to be aware of the network topology has gradually shifted toward online corporations' need to include an ever larger number of users and content as the primary assets, which has exploded with the synergy between the social media paradigm and the 'appification' of everything, reiterated by most online platforms. This phenomenon is epitomized in the near total mediation of the economy of relationships, and so of networking, by social media. These platforms and protocols have triggered the largest voluntary creation of valuable and contextualized digital content, capitalizing on keeping their internal infrastructure hidden. It is an 'inclusive-exclusive' model: inclusive in terms of the functional accessibility of other users' data and connections (the capital of data), although dispossessing each user from its own data ownership; and exclusive insofar as the internal network is hidden and even adjusted by corporate technical and strategical secret algorithms (page rank, timeline order, etc.), which make any attempt to interpret or decode the model useless.

In this reality, the 'whole' topology is just too complex to map and detail, even at the level of single users with a relatively low threshold (or number of friends/followers/nodes): the user, pushed to increase his contacts/nodes, loses track of the 'whole' of his connections. The top-down inclusive-exclusive model works very well for the companies in this respect, handing management of the networks to the platform's owners.

It is nonetheless very important to interpret as far as possible these networks and act upon them. If in this model, technically 'conflict is non-functional,' as Gochenour stated, then we can consider that social media store an inordinate amount of useful contacts, which could become nodes of other focused personal networks, once identified and extrapolated from the corporate platform's rules (Gouchenour 2010). Using the existing infrastructure of social media as a source of possible nodes of new independent, and even possibly interdependent networks, rather than number-driven platforms that mostly encourage obsessive self-promotion, might trigger a different economy of networks and build new topologies. This economy would be built on networks through the exploitation of the social media infrastructures, re-appropriating the denied transparency, reassembled for personal purposes. This transparency would be finally negotiated with the members of the newly created networks.

6. Conclusions

It is important then to consider building networks of connections creating meaning. With rising commercial attention on the amount of connections having an impact on self-confidence, building scaled-down networks, characterized primarily by the meaning of the exchange rather than the quantity of exchanged signals could dismantle the popularity paradigm. Indeed, if this paradigm evaluates the number of associations as capital, then we'd consider that 'the more connected, the more individualized a point is.' (Latour, 2008) The network is, as Latour affirms, a 'privileged mode of organization thanks to the very extension of information technology.' It is a privilege to access infrastructures which reveal entities that could coalesce around specific ideas and projects, forming new independent networks and sub-networks, scaling down complexity through being aware of our networked topography, and enabling us to better explore it. As Jack Burnham comments on the clever organisation of a Dennis Oppenheim artwork in his 'Real Time Systems' essay, we should use: "untapped energy and information network of the day-to-day environment". (Burnham, 1974)

The six degrees of separation from the potential meaningful nodes should guide us toward finding the 'human capital' we want to cooperate with, escaping the sick dream of being either a hyperactive celebrity or a hyperactive audience. In this scenario, we should value our discoverability in chosen contexts, in order to gain and pass on proximity from the nodes we want to build networks with, acting mostly outside the industrialized platforms. We should build what Trebor Scholz envisioned in 2006 as 'extreme sharing networks' defined as "self-organised, technically-enabled [...] Extreme sharing networks are conscious, loosely knit groups based on commonalities, bootstrap economies, and shared ethics. They offer alternative platforms of production and distribution of our practice."[9]

9. Trebor Scholz, The Participatory Challenge, ISEA 2006 Proceedings.

What we should build are ‘human mesh networks’ with interdependences among the people/nodes, that would preserve multiple potential layers of application and collectivity. With a reciprocal trust and dependency, a negotiable relationship, and an infinite possibility of reshape, rescale and reconfigure it, these mesh networks might provide a new strategy to nurture human relationships. The network topology of critical cultural forms embodies the concept of the network as a supportive infrastructure, a flexible skeleton for vital action. Networks are collective agents that author, facilitate, and propagate content, an essential part of the strategies necessary for instigating rebellion and alternative visions of society, for rethinking digital limits and conceptual possibilities. Once we reclaim the infrastructures, and a human scale supersedes technological complexity, we can start to properly shape our own networks with trusted nodes, making alliances between trusted entities of information with an open, non-self-rewarding attitude.

References

Barabási, Albert-László, and Márton Pósfai.
2017. *Network science*. Cambridge: Cambridge University Press

Bey, Hakim.
1991. *T.A.Z: The Temporary Autonomous Zone, Ontological Anarchy, Poetic Terrorism*, New York: Autonomedia

Bureau d'Etudes (Art Group), Léonore Bonacini, Xavier Fourt, Brian Holmes, and Freek Lomme.
2014. *An atlas of agenda's: mapping the power, mapping the commons*. [Eindhoven, Netherlands]: Onomatopee.

Burnham, Jack.
1974. *Great western salt works; essays on the meaning of post-formalist art*. New York: G. Braziller.

Dávila, Patricio.
2019. *Diagrams of power: visualizing, mapping, and performing resistance*. [Eindhoven]: Onomatopee

Galloway, Alexander R.
2016."Jodi's Infrastructure", *e-flux Journal* #74 (June 2016) https://www.e-flux.com/journal/74/59810/jodi-s-infrastructure/

Gochenour, Phillip.
2011. "Nodalism", *Digital Humanities Quarterly*, Vol. 5, 3, http://www.digitalhumanities.org/dhq/vol/5/3/000105/000105.html.

György Galántai, Júlia Klaniczay, Kristine Stiles.
2013. *Artpool: The experimental art archive of East-Central Europe; history of an active archive for producing, networking, curating and researching art since 1970*, Budapest: Artpool, 2013, p. 136.

Latour, Bruno.
2008. *Reassembling the Social: An Introduction to Actor-Network-Theory*, Oxford: Oxford University Press, p. 133.

Vespignani, Alessandro.
2010. 'Complex Networks: The Fragility of Interdependency', *Nature* (April 2010), vol. 464, 7291, pp. 984-985.

Zhang, Donghui.
2015. *A prehistory of the cloud*. Cambridge, Massachusetts: The MIT Press.
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Augmenting a Human-Plant-Data Assemblage: The Contact Projects

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Through the *Contact Projects* an iterative series of three artworks (*Contact Zone*, *Contact/Sense* and *Signaletic Flow 2.0*) we experiment with performance techniques within the medium of head-mounted Mixed Reality (MR). Combining gestural, computer vision, tactile and sonic instruments with physical bodies (human and plant) the concept is to generate a different mode of MR from the dominant paradigms being advanced by industrial and commercial interests. This research investigates potential for multimodal performance in MR using a bespoke technical set-up that combines the HTC Vive (with Leap Motion head-mounted), the MIDI Sprout interface, Logic X, Touch Designer and Unity 3D. Playing with experimental physical techniques for affectively co-composing with expressive conjunctions of augmented materials (both digital and organic), we perform through processual strategies such as: modulating augmented data in real-time; sonifying bio-electrical signals from plants; choreographing hand micro-gestures to weave tactile and signaletic connections with plants and digital augments; and, passing augments through the Leap Motion interface in a head mounted configuration, while sending plant signals to Touch Designer. We propose a new method, technique, and practices for performing with MR environments and various interface technologies, informed by embodiment and electro acoustics, and underscored by new materialism and critical posthumanism.

1. Introduction

This article discusses three iterations within the *Contact Projects*[1] in MR performance where new methods and techniques have been investigated: firstly, a live mixed media performance called *Contact Zone*, secondly, as *Contact/Sense*, a participatory installation and live performance, and lastly, as *Signaletic Flow 2.0*, a digital file that re-works live performance footage as a speculative fiction. These three phases of the *Contact Projects* explore various modes through which human interlocutors can co-create with nonhuman entities (data and plants) to generate new speculative futures and systems that challenge relations of control and power. Data harvested from human bodies as well as from plants, is set in motion with gestures and software to consider the potential of a morphological shift in MR that would expand the field as artistic exploration. Electrical signal is a crucial element of our production design, and participates in different forms: emanating from plants, passing through devices, in contact with bodies. At some point, always transduced to code, then becoming sonic, visual, or haptic. Motivating transposition across a spectrum of emergent entities, signal expresses its morphological potential.

1. *Contact Zone* was performed at The Black Box, UNSW Art & Design in Sydney, Australia, 23 November 2018. *Contact/Sense*, was performed at the SIGGRAPH Asia Art Gallery, 17-20 November 2019, Brisbane, Australia.
Signaletic Flow 2.0 is curated by Kathy Rae Huffman in the forthcoming exhibition 'Digital Power: Activism, Advocacy, and the Influence of Women Online', launching July 17, 2020.

2. Project Overview

In both *Contact Zone* and *Contact/Sense*, the surface of living plants becomes an intra-active site, where an array of materialities engage and negotiate. The first signal in this network, is sonic data created by the bio-electrical impulses of the living plants, visualised in Touch Designer. Then, digital augments are generated as a response by human hands engaged in a liminal form of choreography, seen through the Leap Motion, sent by custom software made in Unity 3D, then also streamed through Touch Designer. Plants are emitting signals that are captured in real-time through MIDI, responded to by an HMD performer (using gestures) and a human sonic performer (who adds their own touch to the emergent sonic scape). While the HMD performer is directly composing their gestures while carefully listening to the bio-electrical signals from the plants, a second performer co-creates with the plant signals using synthesisers and virtual instruments. Through this network configuration, rule-based computing meets the raw and uncontrolled impulses of living plant, and the mediating influence of human touch. Embedded and embodied in the design, the potential for co-composition with living plants is a central line of inquiry. While obviously, the human interlocutors, have established a highly delimited situation for plants to participate as co-composers, this contribution to the artwork falls at least partially outside of human control. The bio-electrical signal emitted by the plants emerges without human intervention, in a nonpredetermined way, as a material flow of signal that the human interlocutors must work with to craft a performance.

Fig. 1. Rewa Wright in the *Contact Zone* mixed reality performance, November 2018, Sydney. Photo by Charu Maithani.

The visual and sensing apparatus worn by the human performer in both *Contact Zone* and *Contact/Sense* performances, proceeds from a particular type of interface and sensor combination: the Leap Motion gestural interface worn as a Head Mounted Display (HMD) that doubles as a 'look through' infrared camera. Configured in this way, the Leap Motion is able to transpose hand data (to bespoke software created in Unity), and operate as a visual 'window' for a human performer wearing an HMD. However, looking through the grayscale image stream captured by the Leap Motion camera, colour is removed from ocular perception. The grayscale picture plane of the Leap Motion's near field infrared camera becomes the performer's new visual apparatus. By imposing infra-red vision as a physical limit to our human perceptual cortex, questions of the 'posthuman digital' emerge to cloud the frame (and our analysis) further. We might call the new mode of embodiment brought about by this software assemblage, a *critical posthuman* performance modality. A performer/participant, experiencing the performance of the *Contact Projects* via the infrared signal and under the physical constraints of the HMD, is acutely aware of this apparatus as instantiating boundary-making practices that shift their regular 'human' senses of embodiment. That something else, however, is not an enhanced or *transcendental* posthumanism, but *critical* posthumanism as articulated by Rosi Braidotti, Donna Haraway, Francesca Ferrando and Claire Colebrook, amongst others. While 'transcendental' posthumanism explores the notion of aligning with a computer simulation to enter an enhanced state of immersion (as in technologically enhanced or transcendental posthumanism), 'critical' posthumanism seeks to interrogate the underlying conditions of a human body mediated by computational methods. For example, N. Katherine Hayles has shown that a view that 'configures human being so that it can be seamlessly articulated with intelligent machines' (1999, 3) was a popular theme of second order cybernetics. Interrogating cybernetic narratives that would separate information from the human body, Hayles questioned the notion that the corporeal body might be replaced by an enhanced posthuman form of physicality (1999, 1). Moreover, she argued vociferously for the need to posit 'interventions ... to keep disembodiment from being rewritten, once again, into prevailing concepts of subjectivity' (1999, 5).

Specifically addressing our series the *Contact Projects*, this article will address the theoretical and artistic precedents, before examining the methods and techniques of MR performance (*Contact Zone*), incorporating public reactions from a participatory installation (*Contact/Sense*), and examining the digital film created as a consequence of the need to convey the work after the installation concluded (*Signaletic Flow 2.0*). Finally, we speculatively conclude with some thoughts on the potential of a posthuman digital design as a modality of becoming with 'technology' and 'nature'. Before exploring the specific nuances of this practice-based research, we shall examine key precedents that have contributed to this trajectory.

2.1. Theoretical Pathways for Emergent Arts Practice in MR

The *Contact Projects* are informed by a concept that draws on aspects of new materialism and posthumanism, which we term a 'software assemblage'. Developed and modified through practice-based research, the *software assemblage* is generated in resonance with Gilles Deleuze and Felix Guattari's conception of the *machinic assemblage*. Variously: a 'surface of stratification' lying between two layers of strata (1987, 40); and, a 'machinic assemblage of bodies, of actions and passions, an intermingling of bodies reacting to one another' (1987, 88), the *machinic assemblage* provides the compositional drive that assists like elements to coalesce and re-assemble from a material flow. Deleuze and Guattari located the agential drive of their machinic assemblage in its capacity to attract, compose, and re-assemble heterogeneous material flows such as those comprising people, objects, or energies. Like the machinic assemblage, *software assemblages* do not generate material formations that follow an already constituted model nor do they pre-determine what kinds of phenomena emerge from changes in data as a fluid mode of matter. In this current era of increasingly computational autonomy, programmatic software enters into negotiations with fleshy, tactile, organic, fluid and other modes of materiality. The software assemblage affords a meandering path to walk through the nuances of code, bodies, signal: not as 'formed matter' in the Modernist sense (or 'assemblage' in that sense either), but as materialities that oscillate differently in contingent networks.

The *Contact Projects* explicate the software assemblage as both theoretical formulation and a vector for practice and experimentation. Locating the processes and methods of code as a compositional engine, a consideration of media artworks as software assemblages recognises rule-based, algorithmic, generative and other modes of computing, as experiential forces that re-assemble human perception. Software is not simply a tool, but an affective force of the nonhuman, whose programmatic capacities contribute to the artwork's affordances. Software assemblages, as a mode of practice-based research, contribute to an investigation of the role of code and algorithms in generating not only computational structures, but experiential meaning for human interlocutors. Deployments of assemblages—whether these be of the interface or code—are significant for this study and afford diverse material elements the capacity to coalesce according to their own affordances, intensities, flows and attractions. The assemblage itself then becomes a re-configurable morphology that actively resists structuring or engineering as a limited technical operation: its elements continually prehend a desire for shifting, differentiated re-assembly. Yet, it is not that software only informs this design, and we are not suggesting that software is a 'controller', rather a nonhuman force that shifts relations, and re-assembles emergent materialities. Software is incorporated to a multi-modal feedback oriented system where affective interventions operate from all sides: humans have produced the software that now intervenes in their performative processes, while plants generate the signal that motivates the human performers, whose soft touch on their leaf-skins is felt and shifts electro-chemical processes as they generate signal itself. The other nonhuman force at work here is plants, specifically their bio-electrical signals which generate polyrhythmic timings and unexpected frequency shifts that challenge the human ear. In the software assemblages that comprise these artworks, all technical design began with the plants. They were the source of the signal and the first part of the network. Thinking with the idea of decentering human influence, the design choice to place plants at the start of the software assemblages network configuration, resulted in the unique phenomena that followed. It was a choice that raised questions of agency, emergence, and embodiment. It intensely challenged our performance capacities by re-directing the source of intentionality toward the nonhuman.

In critical thought from the developing Western framework of posthumanism, the concept of decentring the human accompanies a desire for more equitable relation with other species. Examining the notion that human agency is observationally set apart from the nonhuman, Karen Barad describes 'human participation within nature' as 'agential reality' (1996, 176). She describes agential realism as '… an epistemological, ontological, and ethical framework that … provides a posthumanist performative account of technoscientific and other naturalcultural practices (Barad 2007, 32). Drawing upon her research as a quantum physicist, Barad demonstrates that nonhuman matter is far from inert, and does not passively awaiting a human hand to provide the agency needed for it to take shape. Rather, matter is 'produced and productive, generated and generative', activated processually by its own quantum potential (2007, 137). Through her agential realist framework, Barad disputes the boundary between human and nonhuman forms of matter, advancing a mode of critical posthumanism that de-centres human agency by acknowledging the multi-valent agencies of the nonhuman, as a dynamic collection of entangled forces. Agential realism and the notion that all matter enacts situated modes of agency (not all of which can be visibly measured by a scientific apparatus), leads to our speculative approach that nonhuman and human perceptions might be brought to collision in a mediatic environment. Such an approach opens a critical posthuman pathway to inter-species thinking, in particular the role of the nonhuman in acts of co-creation or co-composition. Thinking from an inter-species perspective, Donna Haraway points to her fascination 'with the molecular architecture that plants and animals share, as well as with the kinds of instrumentation, interdisciplinarity, and knowledge practices that have gone into the historical possibilities of understanding how I am like a leaf'. (Haraway 2000, 132) Her acknowledgment of our shared genetic matter can assist in the re-assessment of new situated potentials for inter-species contact, where human cede control in order to afford companion species a space to emerge from our shadow.

Related, but differentiated from, notions of Haraway's inter-species companionship, are indigenous ways of knowing and being that incorporate nonhuman others. While there is scholarship in the posthumanities forming kin with indigenous knowledge, it is crucial to not conflate the two modes of thought, least of all because of the significant relations of power at play and hierarchies of Western appropriation, already well known through postcolonial studies. At the foundation of Rewa Wright's artistic practice, is her cultural heritage as an indigenous Māori from Aotearoa/New Zealand, are the concepts of 'mauri' and 'wairua': that all things in the universe have their own, agentially situated, life forces (Pohatu 2011, 2). Interestingly, physical proof of the (agential) reality of this concept has been recently discovered in Western thought via quantum physics, where sophisticated imaging techniques have revealed the invisible connections between disparate yet connected modes of matter (Barad 2007). Indigenous Māori philosophy—called 'matauranga Māori'—is a distinct episteme that has consistently investigated, through senses other than sight, the material connections between human and nonhuman forces, objects, species, and phenomena. The invisible world of matter was never a subject that fell out of matauranga Maori: rather it persisted as a mode of inquiry, and was maintained in cultural practice through poetic chants (tauparapara), and other modes of vocal work, where, broadly speaking, sonic vibrations call matter (physical and digital) into contact with one another in a meshwork of relations. Drawing on matauranga Māori as an embodied thread woven in her bloodline, Wright favours network configurations that open fissures to nonhuman forces, deploying gestures and movements that resonate with traces of data and bodies as iterative entities.

Hybrid movements and philosophies find their way into Rewa Wright's choreographed performances in the *Contact Projects*, as she incorporates elements from kapa haka (a Māori choreographic modality), and martial arts, studied as a child. Gestures such as *wiri wiri*, a fluttering of the hands at the wrists, handed down through the ancestral dance form called *kapa haka* also has an ecological metaphor to its movement: it is said to mimic the rippling patterns of waves on water. This is also part of the visual effect of shifting the data, the digital augments that are attached to the performers hands and tracked by the Leap Motion interface. Augmented materialities, configured in this software assemblage, similarly ripple with the *wiri wiri* enacted by the performer. Hand movements including *wiri wiri* and other embodied gestures of the performer, are used here to generate patterns of diffraction, to engage interference as data passes through hands, iterative in different stages via these processes of body-data-plant interfacing. Embedded and embodied in this 'interface-iality', data shifts scale, magnitude, intensity, as it is woven into emergent agential realities. Gestures and movements pass to the screen, yet do not pause there: they continue their journey to oscillate back out, catching their hooks once again in the physical world of flesh. Fluttering hands pass data between Unity 3D and Touch Designer, the body as an interface for mediating signaletic flows. While bloodlines are an important thread linking indigenous and non-indigenous peoples to their ancestral kin (both human and nonhuman), and this is a well-known genealogical line of inquiry, much less is said about the shared DNA that we hold with the plant kingdom.

Fig. 2. *Signaletic Flow 2.0*, screen capture, Rewa Wright's hybrid movements in mixed reality. Full video at https://vimeo.com/390429591

The following section explores some important artistic and cultural precedents for our approach.

2.2. Historical Precedents: Weaving Together Art and Science

The *Contact Projects* combination of data, plants and bodies, builds upon a rich lineage of inquiry, that references artistic, philosophical and indigenous threads, where various approaches have been suggested. Art that connects plants with media technologies emerged as a notable preoccupation in the 1970s, through influential pieces such as Nam June Paik's *TV Garden* (1974), sound performances such as *Child of Tree* (1975) by John Cage, and bio-sensing installations such as those by Richard Lowenberg and John Lifton. In recent media art, a shift has taken place, where the organic realm is no longer treated as primarily aesthetic material for mere sculptural or representational potential. Rather, artists like Natalie Jeremijenko, Eduardo Kac, Miya Masaoka, Gregory Lasserre and Anais met den Ancxt, Laura Beloff and Jonas Jørgensen, and many more, create projects that communicate the idea that plants have their own particular agency. For example, in the seminal installation, *Interactive Plant Growing* by Christa Sommerer and Laurent Mignonneau (SIGGRAPH 1993) participants were able to touch real plants and precipitate the on-screen growth of up to twenty-five species of digital plants. Tactility emerged as a strategy that might afford a richer interrogation of plant-human relations beyond visual aesthetics.

Typically, MR is designed to convey a clear window on the world, so that the view will have a clean perception of reality. Augments themselves are intended to blend in seamlessly with the physical world. This is the desirable goal in most industrial applications of MR as well as recent examples from an evolving new Fine Art Canon of MR art (such as Marina Abramović's *the Life*, designed for display on Microsoft Hololens 2). Partly the result of a migration of research directions from engineering and computer science to other fields, the clear window paradigm and its accompanying dictum of high resolution, illuminates an approach to MR displays that requires digital augments to behave as an informatic overlay. According to Paul Milgram and Fumio Kishino's eponymous research paper, "A Taxonomy of Mixed Reality Visual Displays", graphics should be pictorially realistic, metaphors need to grant presence to the screen world, and a coherent knowledge system should provide an indexical connection to the 'real' (Milgram and Kishino 1994, 1321). The persistent premise that digital augments (as informatic overlays) should contain semiotically meaningful content, derives from Milgram and Kishino's 'Reality-Virtuality' Continuum, which discusses the need for a 'presence metaphor' linking physical and digital space. Through the human-centred computing (HCI) approach, the clear window paradigm has been oriented toward the informatic goals of commerce and industrial applications. The advantage of this approach for such applications renders data as easily seen and interpreted, however this is not in fact a necessary condition for data in technology mediated art. Further, the influence of disciplinary knowledge formations from fine art emphasise realism/naturalism as a mode of depiction within the framework of three-point perspective. The clear window paradigm is therefore bound up with convergent knowledge practices that are rooted in specific canonical epistemes from both science and art.

Using Mixed Reality (MR) configured through an HTC Vive VR HMD/Leap Motion, rather than the clear windows of many current MR glasses (Hololens, Magic Leap and others), follows from development pathways suggested by artists performing in a technologically 'virtual' space wearing HMD devices. For example, the VR artworks and performances of Char Davies, Micha Cárdenas (*Becoming Dragon*, 2008-9) or Adam Nash, all introduce two key notions of virtual performance: to begin, abstractions of data that challenge human perception, and contingently, embodied movement as a means to explore sense other than vision. In the *Contact Projects*, the physical effect of the HTC Vive/Leap Motion apparatus is that the performer/participant is semi-immersed in an infra-red mode of MR: without colour, vision is de-privileged and tactile gestures and body movements take on greater importance as a technique for sensory inquiry. Immersed in the infra-red field of delimited vision via the headset, the performer is continually responding to and resonating with emergence. Wearing this apparatus, performers/participants in *the Contact Projects* have their vision profoundly disrupted by a jarring mixture of reality and the digital. Offering an alternative to the clear window pathway in MR performance practice, we instead proposing a grayscale gloom of infra-red vision as a method to open the alternative critical mode of the posthuman digital. From this position we speculate upon potentials for a technological future, not as a 'singularity' where humans and machines become one, as Ray Kurzweil and others suggest, but as a visceral, challenging, and murky path: more 'dark eden' than 'deep dream'.

3. Design at the Edge of Control: Method, Technique, Enactment

Barad's strategy of unwinding human agency by paying attention to the situated agency of nonhuman matter, of course, in the *Contact Projects* occurs within the conditional parameter that the human is still the designer. Then, the question becomes, how to think through ceding some agency to the nonhuman through design? What would it be to treat a plant as a living 'body', rather than, as in a Humanist scheme, an organic object called 'plant'? Can code that is not based in methods of autonomous software agents, or machine learning, take on a semblance of the agentially real?

To explicate a perspective that advances the software assemblage approach to MR, human agency must be de-stabilised as the sole privileged structuring force, so that consideration might be paid to the transformations between all kinds of matter, human and nonhuman, organic and digital. In this spirit of common links and a diminishing of human control, the *Contact Projects* uses bio-electrical signal as a thread that re-assembles the relations between plants, humans, and data. Linking with nonhuman others as bodies, in relations of care and chemistry, Wright's live process as a performer wearing an MR headset that de-limits her natural vision, operates with processes of intuitive investigation, where she co-composes with temporary alignments of signal and code that are generated by the nonhuman (data and plants). Perceiving these temporary alignments as 'augmented materialities', falling at the fringes of human-centred action, Wright develops physical strategies for co-composing with emergent flows of signal and noise. Emanating from plants, the human body, and data systems, such a material field of digital and physical objects, of intersectional signaletic flows, then becomes a resonant body that challenges conventional configurations of MR, ruled as it currently is by the dual commercial tenets of realism and resolution.

In this research, the agential realities engaged belong to the human performer, as well as to the living plants *and* the shifting movements of code that will both become intra-active matters/materials that re-assemble the making of mixed physical and digital space as indeterminate events in a shifting ecology of entities and relations. The 'matters' of code and plants, are seen to performatively enact their situated and conditional forms of agency, manifest as practices of signal that co-compose the work. Nonhuman matter is explored for its affective potential to relationally transform other entities with which it makes contact, such as the fleshy bodies and the plastic brains of the humans touched by its signal. In the *Contact Projects*, such a conception of matter as engaged in processes of contact and transformation, allows situated modes of nonhuman agency to assemble—signaletic, computational, and environmental. Through this nonhuman agency, we beckon an alternative MR that plays at the edge of control, rather than pre-determined as an executable sequence of events.

3.1. Techniques for Co-Composing with Plants and Digital Augments

Working with data, on the one hand, and plants, on the other, generates some unexpected and productive intersectional phenomena, where plant and human impulses meet. Different techniques for co-composing with plants of a particular leaf structure were explored, such as slowly and gently folding the leaf of the agave backward and forward to shift the sonic pitch up or down over time, imaged in this screen shot from a MIDI region in Logic X (fig below). Playing alongside and in response to living plants emitting bio-electrical impulses, the performer adjusts their actions to elicit differentiation in tonality and harmony. A second performer, a sound designer working in real-time, is able to adjust the timbre and pitch of this combined human-plant sonics. However, one notable factor which the humans are unable to manipulate is rhythm, since this is created solely by the impulses generated by the plants. Plant sonics as a form of signalling, has been explored extensively by Gagliano, Mancuso and Robert (2012) and other biologists, who note that plants may be entering into a form of communication with other actors in their ecosystem. This resonates with our experiences with co-composing with sonified plants, where we note more or less activity in their impulse emissions, depending on how much contact human's make with them.

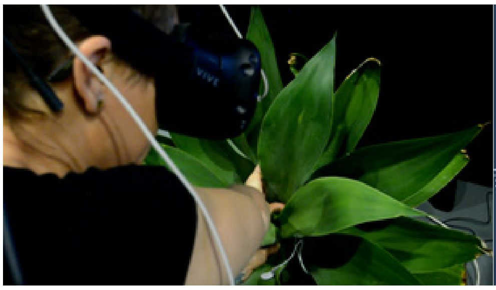


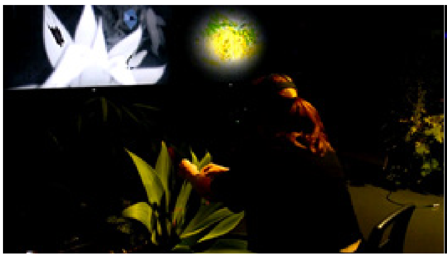
Fig. 3. Techniques for co-composing with an agave attenuata.

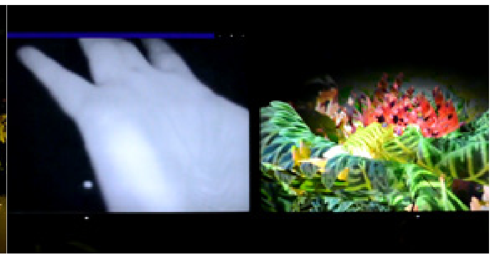
Fig. 4. Bio-electrical signals expressed as MIDI. Images: the artists.

Different sonic results were generated through an array of physical techniques. Some tactile hand positions are applied to the plants, in order to modulate their bio-electrical signal and engage in the process of artistic co-creation. Other techniques are gestural, and applied to the digital augments, to move them across the digital space of the screen.

3.2. Contact Zone: Temporality and Bodies

At the beginning of the *Contact Zone* performance, a single performer sat at an agave attenuata plant, modulating its bio-electrical impulses that have been transposed to audible sound via MIDI. In synchronicity with, and activated by the performer's hand gestures, digital augments fill two large screens. On the left screen, there was the live feed from the Head Mounted Display (HMD) worn by the performer, and visible to the audience. On the right screen was a live stream connected to a second Leap Motion interface, controlling custom made software that responded to gestural data. During the performance, the performer would pick up this second Leap Motion, activating the data input. On both screens, digital augments are visible as well on the HMD display of the performer, whose infra-red vision is now punctured with brightly coloured traces of data. Such patterns are interferences that matter generates as it diffracts across bodies or objects. Negotiating their new and de-limited MR infrared vision, the performer navigates the responsive media environment (figures below and video asset link).





Figs. 5 & 6. *Contact Zone* 2018, live performance archive video. Right hand screens, live augments from Unity 3D. https://www.youtube.com/watch?v=N_OKQvCV3w0&t=13s

As the performer's hands enact choreographed micro-gestures, which are tracked by the Leap Motion's sensors, they come into tactile contact with plants and their signals: and, at the same time, the performer's head becomes the 'camera'. In order to deliver a coherent visual framework for the audience, the performer must frame a continuously tracked point-of-view shot through the gallery space. As the performance progresses, they performer walks on a slow trajectory through the gallery space, activating sonic and visual augments as they move. Using hand gestures to engage with plants as they move around the media environment, the performer triggers a range of on-screen gestures whose data is visually transposed to digital avatars, using augmented reality techniques.

The feature plant of this software assemblage, an *agave attenuata*, become a tangible interface that elicited sound, and whose tactile surface became the trigger for a computer vision system that activates digital augments. Yet, as well this agave plant is a kind of body, an electro-chemical formation of signal emitting matter, similar to humans and sharing DNA. Playing alongside and in response to the bubbling rhythm of this pulsing, the performer adjusts their actions to elicit differentiation in tonality and harmony. A sound designer, working in real-time, is able to adjust the timbre and pitch of this combined human-plant sonics. Again, one notable factor which the humans are unable to manipulate is rhythm, since this is created solely by the impulses generated by the plants.

3.3. Contact/Sense: Tactile Signals, Moving Hallucinations

Fig. 7. Participant begins a docented experience at SIGGRAPH Asia Art Gallery 2019.

Contact/Sense at SIGGRAPH Asia Art Gallery (Wright and Howden 2019), the second iteration of the *Contact Projects*, consisted of daily performances by Wright and Howden, as well as docented participant experiences in the gallery space.[2] This was the first time that we had the opportunity to get sustained public feedback on the method and the techniques for intra-action. Sensing through a new situated mode of agency, governed by an apparatus (HTC Vive/Leap Motion) the HMD performer in *Contact Zone* and *Contact/Sense*, would be required to see and move from within the constraints posed

2. *Contact/Sense* 17-20 November 2019, at ACM SIGGRAPH Asia (Art Gallery), the Brisbane Convention & Exhibition Centre. Technical Equipment: HTC Vive, 2 x laptops, webcam, Leap Motion, Touch Designer, MIDI interfaces and various other hardware interfaces and devices, living plants, 2 x large LCD screens, 1 x stereo sound system.

by infrared vision. We were especially interested to find out from participants what their perceptions were of this world space, within the grayscale of the HMD. How does grayscale vision influence the physical and perceptual process of performance? From our experiences, we knew about the affective shifts in perception that the work imprinted on ourselves: what of the effect on others who had no prior familiarity?

At the start of the experience, participants were given several minutes to orientate, where they watched the signals generate. While adjusting to the new conditions of their vision (grayscale), Wright would couch participants as to which way to move, how to begin to explore with the hand tracking and how to shift the augments in the co-ordinate space of the HMD display. Grayscale is the new vision condition, while augments erupt in multiple colours in all parts of this co-ordinate space, as soon as participants raise a hand (or finger) that can be tracked through the Leap Motion. As abstract combinations of the sonic and visual elements took over their field of vision and drew the attention of their hearing, it was interesting to witness participants adapting to emerging data outside of their control. Just as the cultural and social background of the participants varied, so did their responses and actions while in the assemblage. For example, several people described their sense of a hallucinatory feeling and an accompanying synaptic impact. Some asked what the 'goal' was, while others noted it was like a hallucination. Those with dance backgrounds immediately took to the work, realising it was a license for free play with abstract lines and tracked body moves. Those with a background in body movement, found it easier to negotiate this grayscale space and would perform for fifteen or so minutes, actually a long time for a first experience. By contrast, others could not spend more than two minutes in the HMD. Overall, participants noted that with vision de-limited, physical memory, embedded senses of spatiality, and senses other than the ocular took on greater significance: gestures known for a lifetime became techniques that permeated their intra-actions with data.

Observing responses to *Contact/Sense* added depth to our investigation of embodied movement and performance in MR. Data was clarified as not simply a phenomena that generates an on-screen reality; as well, its recursions are passed back through the physical body, as a network of responses that shift how the performers enact their iterative gestures in world space. The gulf between Wright's choreographed movements, and the gestures of a lay participant was manifest, and revealed the training to the HMD/Leap Motion device that occurred over time, and the specific techniques the apparatus itself encouraged (Figure 8). This apparatus afforded certain types of movement while excluding others, and a person performing regularly in these conditions would need to train to operate comfortably for long periods of semi-immersion.

3.4. Signaletic Flow 2.0: Mixed Reality Performance as Digital File/ Film

Signaletic Flow 2.0 is a digital file/experimental film that plays with the visceral intimacy of an MR live performance, attempting to transfer some of that feeling to the screen audience. By re-composing clips recorded live from a series of performances (at SIGGRAPH Asia 2019, and in our Sydney studio), *Signaletic Flow 2.0*, proposes a multiplied body in digital space that modulates itself with plant sonics and data generated by algorithms. *Signaletic Flow 2.0* visually explores synergistic embodiments that link data, the human body and living plants, in unpredictable and speculative trajectories. *Signaletic Flow 2.0* was performed, edited and directed by Wright, and specifically examines the role of her female body when multiplied in data space and coupled with nonhuman others such as living plants, and algorithms: what are the relations, gestures, movements that this space lures out of the body, and how does data shift perceptions of self toward the nonhuman? Triggered by plant signals, responded to with human hands, sensed by the Leap Motion gestural controller, abstract trails generated by digital augments visually shape this video. Composited within layers, nested in an image stream composed of performance images, digital augments and audio signals weave in and out of a meshwork of fluttering, pushing and twisting, hands, fingers and wrists, framing a body swaying in MR space and narrated as a speculative fiction. Sonically, this work is held together by a continuous narration that is part speculative future, part digital past, punctuated by real-time sound design mixed with synthesised textural elements. The performances depicted in this video, incorporate bespoke software, computational sensing, science fiction narrative, poetic sound design and imagery, to transport the audience to a liminal space beyond the physical world. The visual striking look of *Signaletic Flow 2.0*, results from a combination of screen captures from the performances of *Contact/Sense*, cut together with studio-based footage, a speculative narration and punctuated by sound design that utilises the bio-electrical signals from living plants as well as human generated melodies. A fluid meshwork of relations emerge between gestures, dance and emergent materialities, and these are explored through a distinctively expressive and embodied ' choreographic language' that re-assembles Rewa Wright's body as data in motion. *Signaletic Flow 2.0* multiplies her body in virtual space in order implicate it within vibrating, pulsing data, generated by the living plants. Oscillating through this speculative space, a multiplied data-body co-composes with software to challenge the clarity and singularity that has become so synonymous with the technological virtual of transhumanism, mixed or extended reality coming out of commercial and industrial paradigms.

Fig. 8. *Signaletic Flow 2.0*, performance still frame. HMD augment stream from *Contact/ Sense* composited behind. Retrieved from https://vimeo.com/390429591

4. Speculative Conclusions Toward a Posthuman Digital Design

In the 'transcendental posthuman' view, technology is seen as the vector which will allow humans to transcend the limits of our current biological form: as the narrative goes, there would no longer be a material separation between virtual and real, as well as machine and human. Yet, as human animals we are already embedded in the biosphere: In an era where we need to urgently combat climate catastrophy, is it not a helpful intellectual position to push the notion of transcendence through technological advancement. Nicole Anderson suggests that a more productive thread—in sympathy with the critical posthumanism pioneered by Hayles and others (see Braidotti 2006, 2013; Ferrando 2013, 2016)—would be to allow 'us to learn to live with these nonhuman others rather than in opposition to, in domination of [them]' (Anderson 2017, 37). A worthy line of flight for this current epoch of climate change. Interweaving materialist and critical posthuman conceptions of matter, organization, and corporeality, *the Contact Projects* have generated software assemblages that entangle a multitude of elements as they co-emerge. These elements are drawn from three core material flows: the computational, the corporeal, and the organic. In the *Contact Projects*, various diffractive processes result from the intra-actions produced out of an ecology of plants meeting the electromagnetic spectrum (infrared signal), meeting sonified inaudible frequencies (ultra-sonic noise), meeting custom designed software (digital code), meeting my tactile and fluid human gestures (the performing body). The *Contact Projects* have been situated both in the context of development pathways from MR and VR, as well as various artistic mobilisations of plant 'energies' that have tried to rethink the material relations made possible by conjunctions of the technical and organic. The affective potential of a hybridisation of human and nonhuman forces, has been discussed, and this paper has explicated the software assemblage as a theoretical methodology for describing such networks in media art.

Fig. 9. *Contact/Sense*, Wright's performance archive excerpts. https://www.youtube.com/watch?v=ZZh-I8tV3YE

References

Barad, Karen.
2007. *Meeting the universe halfway: quantum physics and the entanglement of matter and meaning*. Durham, NC: Duke University Press.

Berry, David. M.
2011. *The philosophy of software: Code and mediation in the digital age*. London: London: Palgrave Macmillan.

Braidotti, Rosi.
2006. "Posthuman, All Too Human". *Theory, Culture & Society*. 23:197–208.

Braidotti, Rosi.
2013. *The posthuman*. Oxford, U.K.: Polity Press.

Cárdenas, Micha, Christopher Head, Todd Margolis, and Kael Greco.
2009. "Becoming Dragon: a mixed reality durational performance in Second Life". *The Engineering Reality of Virtual Reality*. 7238:801-807.

Ferrando, Francesca.
2013. "Posthumanism, transhumanism, antihumanism, metahumanism and new materialism: Relationships and differences." Pp 26- 32. In *Existenz, An International Journal of Philosophy, Religion, Politics, and the Arts*. Volume 8. No. 2, Fall 2013.

Gagliano, Monica, Mancuso, S. and Robert, D.
2012. "Towards understanding plant bioacoustics." Pp.323-325. In *Trends in Plant Science* (176).

Gibson, Prudence.
2018. *The Plant Contract: Art's Return to Vegetal Life*. Amsterdam: Brill.

Haraway, Donna J.
2000. *How like a leaf: an interview with Thyrza Nichols Goodeve*. New York: Routledge.

Haraway, Donna J.
2003. *The companion species manifesto: dogs, people, and significant otherness*. Chicago, Ill. : Prickly Paradigm.

Haraway, Donna J.
2007. *When Species Meet*. Minneapolis: University of Minnesota Press.

Masaoka, Miya.
2000-2012. *Pieces for Plants*. Mixed media performance. First performed at the Chapel of the Chimes in Oakland, California in 2001. Retrieved 19 July 2018 http://miyamasaoka.com/work/2006/pieces-for-plants-gallery-installation/

Pohatu, Taina W.
2011. "Mauri: Rethinking Human Well-being." In *MAI Review*, Aotearoa/New Zealand

Wright, Rewa & Simon Howden.
2019. Contact/Sense, Association for Computing Machinery, New York, NY, United States

SA '19: SIGGRAPH ASIA
Art Gallery/Art Papers, November 2019 Article No.: 9 https://dl.acm.org/doi/abs/10.1145/3354918.3366368

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Unboxing the Machine: Artificial Agents in Music

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The constant evolution of philosophical views on arts is interwoven with the trajectories of accelerating technological amelioration. In the current prominent emergence of generative algorithms there is an immediate need for making sense of modern technologies that more and more seem to step in the realm that has been reserved for humans—creativity. This paper aims at demystifying implications of black-box generative algorithms by: 1) depicting the current state of practice and research in this interdisciplinary field, 2) dissecting and examining the constitutional characteristics of artificial agents: artificialness and intelligence, and 3) applying the resulting implicit theory to a practical case of generating a live coding musical performance.

1. Introduction

In the broadest sense, artificial intelligence is any sort of intelligence exhibited by machines (Nilsson 1998). More specifically, the field of computer science that deals with artificial intelligence is commonly concerned with computational agents capable of perceiving their surrounding contexts and undertaking action in an effort to maximize their set goals and expected results (Poole et al. 1998, Russel and Norvig 2003). While this sort of categorization is technologically and philosophically correct, the definition is vague and provides only a basic framework for understanding either the algorithmic mechanisms it comprises or the sociological implications it poses.

With the rise of computational power and ubiquitous computing made available through smartphones and other personal devices, various forms of artificial intelligence have made their ways into all layers of society and daily life (Mlynář et al. 2018). And while the technological progress of the associated techniques and processes is fast and steep, individuals, communities, and societies struggle with understanding their nature and potential ethical pitfalls. Instead, there is often polarization: techno optimists on one side and Luddites on the other, devolving a complex subject into improper analogues and wrong assumptions (Elliott 2014).

As with other aspects of contemporary life, artificial intelligence and machine learning infiltrated artistic practices through osmosis, both in academic contexts and mainstream art (Parker 2019). The way in which artists – and computer scientists turned artists – approach this set of technologies is multifaceted, from simple (and contested) black box usages to complex modifications and subversions of AI mechanisms. Similar to the impact in wider sociological narratives, the usage of AI in art is a controversial topic, more so than any other digital tool has been in the past. Again an axis of opponents and proponents forms, with the first group believing AI to bring on "the death of art" through replacement of true creativity and human artistry, while the latter see immense possibility in the augmentation of human cognitive and performative capabilities.

Taking into account all these premises, we defined the two primary concerns of this paper. The first is to provide an initial demystification and delineation of the various aesthetic and artistic implications of AI in art (visual arts and music, specifically), while also describing the current state of the interdisciplinary field. Here we also present a novel dissection of AI in art, defining its artificialness and intelligence as crucial aspects. The second concern of the paper is to demonstrate an artwork—a participative audiovisual performance—based on generative live coding that is simultaneously born from the basis of well-known AI techniques, but which also inherently problematizes the various dynamics between humans and algorithms. The discussion that led to specific choices in the preparation of the performance thus becomes a part of the artwork itself and serves as a contribution to the overarching discussion about the position and meaning of artificial intelligence in art.

1.1. Philosophical, Ethical, and Socioeconomic Questions

While this paper focuses on the purely artistic aspects of artificial intelligence, specifically in music, we recognize that this domain is not isolated and exists within a larger social framework. In this sense, while beyond the scope of this paper, we identify that there are philosophical, ethical, and socioeconomic issues with the use of AI and machine learning for artistic purposes.

When philosophical questions are concerned, the notion of intelligence itself is loaded, with the approaches to defining and categorizing it a matter of many researches and polemics (Sternberg 2003). In the context of art, the main philosophical question lands somewhere between ontology, semiotics, and aesthetics. Can a computer replace a human in creative tasks? It is an open-ended question with unclear conclusions. Currently, the prevailing view is reductive in that computational creativity cannot create original art in the same way that humans do (Magnusson 2019). Still, the discussion is ongoing and productive, walking in step with developments in technology.

The second type of issues with AI in art is related to ethical dimensions of its applications. For example, questions of copyright and intellectual property come into light, with AI systems like generative adversarial network (GAN) introducing the capability of autonomously generating new art based on patterns learned from existing data sets (McCormack 2014). Similarly, the employment of AI in music distribution can shape and drive musical trends and influence long-term development of the arts (Kaplan and Haenlein 2019).

This final point is also related to socioeconomic questions hovering around AI. Mainly, with GANs generating a limitless number of compositions in the style of Muzak (White and Matulionyte 2019), they reduce the space for human composers to work in profitable fields. While this scarcely affects the truly creative branches of art (see second paragraph in this chapter), many musicians use these jobs as source of income and to finance their main artistic outlets.

2. Artificial Intelligence in Art

If ideas of using generative and proto-artificial intelligence techniques in art have been around for several decades (Kugel 1981, Galanter 2003), their wider and consistently applied use is still a fresh and relatively unexplored field. Largely owing to the increase in computational power available to individuals both in mainstream and academic settings, advances in AI algorithms, and open source availability of these tools, the latter part of the 2010s saw a significant increase in attempts to use AI for artistic purposes. The domains in which this phenomenon manifested are many, but the progress is fastest and most easily observable in visual arts and music, which follow similar tracks and on which similar concepts can be applied through mathematically described signals. In the next chapters we give an overview of some significant recent works and modes of use of AI in the aforementioned fields.

2.1. Visual Arts

Championed by artists like Mario Klingemann, Memo Akten, Robbie Barrat, Gene Kogan, and Mike Tyke, generative adversarial networks have been the most widely accepted form of AI in visual arts (Schmitt 2018). These artists use publicly available algorithms and tools, train them on various data sets of existing art—masters' portraits, for example—modify their parameters, and have them generate new pieces in a style that mimics the original data sets, but which also introduces or allows surfacing specific artifacts inherent to the used technologies. The resulting aesthetic is one that is still very much human, not machinic, yet which reveals some of the algorithm's intrinsic properties. Here, the artist has three roles: to select the data sets used for training the system, to adjust the parameters of the system, and to finally act as a curator who selects the most compelling pieces in a vast space of generated works.

Apart from GANs, artists employ various evolutionary algorithms to generate dynamic 3D artworks (Romero 2008), virtual reality pieces (Lugrin et al. 2006), and abstract works whose aesthetic could be described as mathematic and detached from human preference (Wannarumon et al. 2008). Throughout most of these approaches, and as we will explain later, AI is used within the boundaries of the technology's original parameters and most often as mere tools or black boxes. Even if we could state that for fields or artistic approaches still in their infancy every work can be considered questioning of its toolset and lineage, there are artworks which make the problematics of the technology itself their focal point (Roh 2018). While rare, these attempts function on multiple levels: as proponents of the methods employed and as interrogators of the underlying motives and concepts.

2.2. Music

Unlike visual arts where we can identify a common mode of AI use through GANs and adjacent scenes forming, in the context of music AI has been used somewhat sparsely and disparately. Instead of trying to summarize current meta-narratives, we focus on four distinct pieces which illustrate how AI can be used for music creation purposes.

Using a modified SampleRNN architecture, Zukowski and Carr created the Dadabots system and employed it to generate black metal and math rock similes (Zukowski and Carr 2018). While this approach has many similarities with the use of GANs in visual arts, the distinction is that the material that they use is both contemporary and highly aesthetically recognizable. Additionally, the aesthetic and stylistic elements of black metal and math rock can be considered chaotic and difficult to analyze using conventional techniques due to their use of timbre and space as compositional drivers (Lee et al. 2009). Because of this and the contemporary nature of the originating styles, the pieces produced by Dadabots discover a completely new aesthetic, birthing an acousmatic experience out of isolated and subverted black metal elements. As the authors state, "we are delighted by the unique characteristic artifacts of neural synthesis", emphasizing the different role and expectations of AI in art as contrasted to AI for general purposes. Here, errors are cherished as the researches/musicians curate and select pieces from Dadabots' vast output.

While Zukowski and Carr welcome the unexpected outcomes of their process, researchers and musicians Holly Herndon and Mathew Dryhurst created and trained an AI named Spawn for Herndon's *PROTO* album with a specific role in mind. The process of training and using the AI is iterative in this case, as Herndon created and recorded music, fed it to Spawn, and then finally used the system to transform and generate new samples. These were then arranged into the final compositions. Here the AI, while fairly complex and well designed, is used as a mere tool for generating sound samples, just another "voice singing in unison", while the final act of composing is in Herndon's hands. This resulted in a record that, despite its advanced evolution, fits within expectations of conventional electronic music. Like with Dadabots, there is an additional dimension of performativity and curious exploration of the system itself at play, as Herndon mentions naming, anthropomorphizing, and raising the AI entity.

If Herndon and Zukowski and Carr reside on opposite sides of a continuum, experimental and drone music duo Emptyset fall between them, opting neither for a fully generative process nor choosing to harness the AI purely as a sample-generator. James Ginzburg and Paul Purgas instead employed machine learning techniques to explore new, unexpected possibilities out of data sets they sourced themselves. They explain their artistic process behind the record Blossoms and departure towards a new aesthetic framework:

> "The machine learning system for Blossoms was developed through extensive audio training, a process of seeding a software model with a sonic knowledge base of material to learn and predict from. This was supplied from a collection of their existing material as well as 10 hours of improvised recordings using wood, metal and drum skins. This collection of electronic and acoustic sounds formed unexpected outcomes as the system sought out coherence from within this vastly diverse source material, attempting to form a logic from within the contradictions of the sonic data set. The system demonstrates obscure mechanisms of relational reasoning and pattern recognition, finding

correlations and connections between seemingly unrelated sounds and manifesting an emergent non-human musicality." (Smart 2019)

Finally, a piece that focuses on the phenomenology of AI itself is composer Jennifer Walshe's work *ULTRACHUNK*, realized in collaboration with visual artist and researcher Memo Akten, which explores the emerging world of computational intelligence. *ULTRACHUNK* is an improvised piece, a duet between Walshe and an AI which acts as a mimetic partner and absorbs the main characteristics of Walshe's identity, namely her voice and face.

As will be investigated in detail in later chapters, none of these systems demonstrate real intelligence or creativity, which ultimately still reside within the human authors and operators of the used systems. They are not magical, mystical, or dangerous contraptions, but rather tools in the hands and minds of creative organic artists.

2.3. Mystified Black Boxes, Purposeful Tools, and Cognizant Systems

"Instruments with machine learning capabilities will learn from their players, who 'train' them to adapt to their playing, so no instrument will be the same.

The instrument often becomes a piece in itself, as the creator of the instrument has some musical purpose in mind, often quite specific. The boundary between a piece and an instrument is deliberately vague, and it can fluctuate." (Magnusson 2019)

In the above quote, the author speculates on a future where the AI in music is truly intelligent and creative, capable of higher cognitive functions compared to the current baseline. This scenario envisages a future in which AI instruments are omnipresent and infinitely varied, tailored by and to their users. In contrast to these hypothetical cognizant systems, the methods employed by musicians active today, and illustrated through the examples in the above chapters, are still rudimentary.

An often encountered approach is to consider the AI system to be black boxes, impervious to the musician's full understanding. In this case, the musician inputs some data into the system and collects the result, integrating it into their pre-existing aesthetics. An analogy in the world of physical instruments would be a pianist that only uses the keyboard of a piano and resorts to traditional, pre-20th century modes of playing.

Opposed to this basic approach are artists who understand and modify the behavior of the system. Most of the examples detailed above fall into this category and make the artist not only the final user of the system, but an instrument builder. Mario Klingemann and Holly Herndon, for example, both understand the concept and functionality of the AI they've either built or use, tweaking parameters and influencing its behavior on deep levels.

In the analogy from the world of physical instruments, they are akin to pianists who open the bodies of their pianos, tug at strings, prepare the instrument with objects, etc. It suggests a deeper and, in a way, subversive understanding of the technology in play.

Returning to Magnusson's concept, there are no current examples of an AI employed by artists that would be completely and autonomously tailored to them. To understand what this jump—from black boxes and ready-made instruments to cognizant systems—would entail, in the next chapter we dissect artificial intelligence in art through dimensions of artificialness and intelligence.

3. Artificialness and Intelligence

Increasingly perceived as a modality of AI that has a formidable potential of disrupting arts by challenging the most intrinsic and delicate questions about uniqueness and human creativity, generative algorithms have become a trending controversial topic on the cross section of arts, technology and philosophy (Nake 1971; Schneider & Rea 2018). It may feel like artificially intelligent creativity is establishing a threatening position from which it can easily endanger the pure meaning and essential values of arts that have been developed through centuries of continuous cultural tradition and incremental advancements. However, we argue that such generative AI can be treated as modern brushes and palettes that serve as tools for artistic creation opening unexpected possibilities and novel modalities inherent to the actual technological and social state of progress. Those tools indeed change the value system of art, but this system has been always in a continuous evolution following changes in the civilizational context. The pace of evolution now seems significantly accelerated and the urgency of finding extended narratives about the position, meaning, and appreciative dimensions of art in the age of artificial intelligence is alarmingly rising.

The connection between brushes, palettes, and various generative algorithms holds in nominal characteristics of the latter: artificialness and intelligence. Observing these characteristics through development of technology reveals the backbone of continuity which may also serve for constructing desperately needed new narratives.

3.1. Artificialness

Artificialness, defined as a condition of lacking naturalness or spontaneity, in the context of traditional and more recent (semi)autonomous tools may be considered in terms of quality and quantity of human involvement in making, adjusting, supporting, and using tools to reach desired results. Being very intuitive (from the current point of view), early tools like brushes and palettes may be observed as natural and thereby non-artificial. Indeed, paint is one of the earliest inventions of mankind that is likely to be approximately

100,000 years old (Mayell 2004). However, even such a rudimentary tool made a disruptive impact, at least in the sense of long-term preservation of human artifacts that allowed modern archeologists to appreciate and study them. Individuals who possessed paint had an opportunity to express themselves in a specific way that was not available otherwise, and an opportunity to leave a trace. As a result of a human intervention of intentionally applying pigments to leave visible colorful traces, paint can be considered as a tool that was, in line with the time of its creation, somewhat artificial and disruptive. A possibility of painting opened numerous approaches and styles and led to a complex value system related to visual arts.

Along with iterative improvements, some technological advancements triggered a much faster shift of artistic focus and expansion of the value system. The emergence of photography in the 19th century trivialized the problem of applying color on canvas to create realistic images. The process for achieving this goal translated from the painting skills to intrinsic mechanisms of the tool. Photography could have been seen as a threat to classical painting in a way that GANs may be considered as the same threat nowadays. However, there are at least two reasons why brushes and palettes survived the 19th century. The first one is that the emergence of the new tool did not prevent painters from exploring novel and creative ways of using old ones. Moreover, photography provoked accelerated changes that led to novel styles. Similarly, when IBM's program Deep Blue won a chess match with Garry Kasparov in 1997, humans did not stop playing chess, but they became even better by learning from the system and trying to defeat it (Harari 2018).

The second reason for the coexistence of brushes, cameras, and GANs is that none of those tools can provide completeness in comparison to the scale at which humans currently understand and perceive the world. While photography resolved the problem of capturing visual reality, artistic ambition was and will always be much more than that. Similarly, GANs may complement photography due to their capability to create novel imaginative and realistic images to a desired extent. Although this type of advancement raises serious challenges to existing forms of visual arts, it is far from being complete. Current GANs excel in creating stunning new artifacts that follow statistical distributions of existing images used for training, but they are still incapable of understanding the social, cultural, economic, political, and even artistic context that influences art produced by humans. For that reason, the role of artists operating GANs and curating results is imminent. Almost without doubt, the future will bring advanced AI that can harvest more data from different sources and thereby incorporate some aspects of the civilizational knowledge and humanic experience in the generated art. However, even then, the artist's role (although significantly altered) would be present as a curator, creator of tools, or at least as a data source. As long as the art is consumed by humans and produced by man-made tools, it will not collapse into itself.

Levels and consequences of artificialness constantly change in the course of time as well as their perception. Modern tools seem to possess the highest possible level of artificialness, but this is due to the tendency of comparing the current state with the known past, while the unknown future may bring much higher levels of artificialness. When humans became used to photos, cameras did not seem so artificial any more. Time and habits *naturalize* artificialness.

Another important observation is that higher levels of artificialness usually mean greater technical complexity, but simpler and more intuitive basic usage. At first, it may seem that modern tools reduce the necessity for fine skills that are traditionally needed to produce art thereby jeopardizing some traditional artistic values. Black-box usage leads to immediate results that eventually become expected and common. On the contrary, operating complex tools to produce more meaningful or authentic results requires mastery, which is proportionally demanding to the complexity of the underlying technology. From that point of view, there is no fear that humans will delegate their creativity to generative algorithms.

3.2. Intelligence

The notion of intelligence has historically relied on implicit theories and definitions constructed from expert opinions (Sternberg 2003). One of the most well-known studies of experts' definitions of intelligence conducted by the editors of the Journal of Educational Psychology (Thorndike 1921) was an early proof of somewhat different, yet overlapping views on human intelligence that further evolved through later attempts of compiling experts' definitions (Sternberg & Detterman 1986). A consensus is equally needed when it comes to computational intelligence. Having more limited expectations on machines than on humans, the understanding of computational intelligence historically shifted following the trajectories of technological improvements (Poole et al. 1998). Computer's ability to efficiently solve numerical and combinatorial problems seemingly significantly overcomes some aspects of the human intelligence, but when it comes to understanding, self-awareness, learning, emotional knowledge, reasoning, planning, creativity, and critical thinking, before recent emergence of deep learning, achievements in computational intelligence were disappointedly modest.

In the context of generative AI in art, we are particularly interested in those qualities that an artificially intelligent system should expose in order to be considered intelligent. When observing an AI system as a black-box tool, it is impossible to assess its computational intelligence form one or just a few outputs. We argue that such a generative intelligence is reflected in the distribution of outputs (that can be statistically approximated using a sufficient number of real outputs) and the understanding of its inner working.

Achieving the satisfactory distribution of outputs is necessary but not sufficient sign of computational intelligence of a generative system. As classifiers and regressors can be evaluated based on their accuracy, the alignment of distribution of outputs with either implicit or explicit expectations serves a measure of how well generative algorithms solve their generative tasks. Usually, a desirable characteristic of generated material (that also applies to generated art) is to hold a fine balance between known and novel. For example, AI that generates hyper-realistic environments for the simulation purposes is expected to create and equip spaces that are feasible, familiar, and likely to occur in reality, but at the same time authentic, unique, and non-trivially derived from real existing environments. The same is with music generation that aims at finding novel expressions, while relying on or incrementally extending those values of sound organization that underlie the desirable musical consequences.

Inner working of generative algorithms and data necessary to train or feed the algorithm are tightly related to the distribution of its outputs. If two algorithms create outputs with similar statistical distribution, one that relies more on procedural and structural aspects will encapsulate more complexity and require less data than an algorithm with less procedural details, but with better ability to learn. Although not related to generative art, an excellent example is Google's AlphaZero program that in 2017 defeated the almost thousand times more computationally powerful Stockfish 8 program, the world's computer chess champion for 2016. The importance lies in the fact that AlphaZero did not learn to play chess from humans, but from playing it with itself using a technique of reinforcement learning. And it took only four hours. Its radically different inner working led AlphaZero to the victory that proves higher computational intelligence.

While some algorithms can directly compete with each other in a game with explicit rules or they can be compared by their objectively measured performance at solving a given task, such a comparison is more difficult for generative algorithms, especially in the artistic setup. As the valuation of their generated outputs is subjective and they are expected to form a wide distribution (in contrast to optimizing the solution to a problem), computational intelligence is a more delicate notion. Instead of taking into account only the quality of outputs, the inner working of generative algorithms may reveal their ability to produce more or less intelligent outputs. While the discussion at this level remains abstract, more tangible insights into computational intelligence are given in the discussion of the practical part of the study.

4. A Case Study: Generative Live Coding

A complementation to a theoretical view on generative art presented in this paper is a practical exploration of applying AI to live coding. As the art of using computer programming, algorithms, and code as makeshift scores and music creation tools, live coding is built around improvisation, with musicians most often writing code in real time during live performances. The exclusion of a human performer from such a setup is a radical and metaphoric intervention, as the very purpose of a programming code is to mediate between a human and a machine. Without a human, the machine interfaces only itself exposing an intermediate creative step to potential human observers in a readable form. Autonomous code generation thereby brings a conceptual value, but also entails aesthetic consequences imposed by the live coding environments.

The aim of this practical study was to design and develop a generative system that autonomously creates and sequentially executes blocks of code in TidalCycles, a textual programming language and an extensive library for live coding (McLean and Wiggins 2010). Besides pure code generation, we extended the system to support participative performance and allow audience members to interact with the generated code. The participative influence on the generated music metaphorically represents a modern relation between computers and their users in which users have a limited control, yet a perception of empowerment. The system was intended to generate hours of music following some predefined compositional patterns and aesthetics.

Design decisions in developing the generative algorithm, which is the heart of this artificially intelligent system, emerged from the theoretical discussion and the possible levels of artificialness and intelligence.

By its purpose and functioning, the system is inherently highly artificial, as the aim was to emphasize the artificial creativity and its relations to human actors. Therefore, a possible range of artificialness considered during the system design phase was fairly narrow and mostly reduced to the presentational level where the nuances of artificialness may affect the impression that the system with its generated code and music leaves to observers. One such presentational aspect was the integration of the system within the live coding environment. If we decided to direct the system's outputs to a textual file and execute the generated code blocks manually, this would look less artificial and closer to the way human performers use live coding environments, even though the backend system still remains responsible for the creative part. On the other hand, automatic execution of the generated code emphasizes the impression of the system full autonomy which may be perceived as a higher level of artificialness.

With a growing accumulated assortment of possible generative techniques, the designing phase left a lot of room for adjusting the desired level of the system's intelligence. As the aesthetic and stylistic consistency was a target characteristic, using a sufficient number of predefined blocks of code (either as a training set or atomic building blocks) was a valid way forward. One of the most basic approaches was constructing a Markov chain with predefined code blocks written in its states and transitioning probabilities set manually. In a general case when states are fully connected, the number of transitioning probabilities exhibit quadratic growth making manual adjustments tedious. An advancement of this method towards a more intelligent system would be implementing an automatic, data-driven approach to setting the probabilities. In a particular implementation, we opted for a formula that makes probabilities of transitioning between two states negatively correlated with the Levenshtein distance between code blocks written in those states.

This solution favors smaller changes from one block to another in the same manner as a human musician during live performances more usually modifies existing code blocks than writes new ones from scratch. However, due to the non-deterministic nature of the Markov chain and further indeterminacies in the formula for calculating transition probabilities, this solution still can generate quite interesting and unexpected sequences of changes. As the third version of a generative algorithm, we could have used a long-short memory (LSTM) neural network that is capable of autonomously generating text by learning from a given training set. This ultimate version would require predefined code blocks just for the training, while its output can be any sequence of characters with the obvious goal to achieve that those characters represent a valid TidalCylces code that preferably produces music in a given stylistic frame.

The three mentioned approaches (basic Markov chain, advanced Markov chain, and the LSTM network) embody the gradation of the system's intelligence determined by its capability to generalize: the approaches based on the Markov chains can generate only preexisting code blocks, while the LSTM is capable of creating blocks not seen in the training set. However, in all these setups, the role of the composer is imminent and prominent. Even with the highest artificial intelligence of the system, the style and the meaning of the output depends on the human creator.

Achieving a fine balance between diversity of the generated material and its aesthetic and structural qualities was the key challenge of developing a system intended to produce hours evolving music which forms a meaningful performance. While the different levels of artificial intelligence set a different contexts for tuning the algorithm's creativity, in all cases of data-driven or machine learning approaches, the resulting artificial creativity depends on the material—building blocks, training data, and parameters of the algorithm. The current AI is far from using a general, civilizational knowledge elicited from global, unstructured and autonomously discovered data sources, so the most important role of human creators is to carefully choose the material. In the case of our generative system, the ability to prepare adequate data also influenced the selection of the algorithm. As LSTM requires large amounts of data that depend on its own complexity, we had to start from simpler algorithms with lower intelligence and lower inherent creativity. However, with almost a thousand of carefully prepared code blocks and the unique semi-autonomous approach of setting transitions between them, we managed to achieve a desired level of diversity while maintaining a surprise factor as there are theoretically around 10^{32} ways to generate one minute of a performance with, of course, very different occurrence probabilities.

Conclusion

This paper aimed first to demystify, then to dissect, and finally to apply knowledge about the use of artificial intelligence in art, specifically music. To do so, in the first part of the paper we canvassed the current state of the art and examined how various artists employed AI in their work. Here we posited that even behind black-box approaches there is nothing inherently neither dangerous nor problematic when using AI for artistic purposes since, in most cases, the resulting aesthetics and artwork are under control of the human artist. Simultaneously, we identified that in the current state of technology computational agents are incapable of producing truly original and creative art without the involvement of a flesh and blood artist. In other words, AIs become augmentations rather than substitutions.

To better understand these conclusions, we separately approached the nominal components of AI in art: artificialness and intelligence. What does it mean for a generative system to be artificial and intelligent? Through these aspects we described how our current tools behave, posited how they could behave in the future, and explored what this meant for artistic applications. Finally, we discussed this approach and developed considerations of using AI for interactive music performances based on a case study of generative live coding performance.

There are two lines of thought that can be traced throughout the paper. First, there is nothing inherently inexplicable or impenetrably oblique about generative systems and artificial agents. Today, they are mostly used as tools by visual artists and musicians who ultimately impose their own aesthetics and sense of creativity on the machine's output. Secondly, there are unexplored ways of subverting and using AI to further augment creativity in humans by relying on the machine's alien way of rationalizing and "thinking" in order to discover new phenomenologies and aesthetics. This can be further emphasized if the AI is fully controlled or perhaps even built by the artists themselves.

While we avoid speculating about future developments in technology, it is almost certain that artificial intelligence and various generative systems will play an important part in the art of the future. Even if we imagine that these systems might, at some point, eclipse their current role of pure appliances or digital musical instruments and become creative in the narrowest sense of the world, there will still be ample space for true human artistic creativity. Because these systems are, ultimately, mere reflections and extensions of ourselves.

References

Elliott, Stuart W.
2014. "Anticipating a Luddite revival." *Issues in Science and Technology* 30, no. 3: 27-36.

Galanter, Philip.
2003. "What is generative art? Complexity theory as a context for art theory." *GA2003–6th Generative Art Conference*.

Harari, Yuval Noah.
21 Lessons for the 21st Century. *London: Jonathan Cape*. 2018.

Kaplan, Andreas, and Michael Haenlein.
2019. "Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence." *Business Horizons* 62, no. 1: 15-25.

Kugel, Peter.
1981. "Artificial Intelligence and Visual Art." *Leonardo* 14, no. 2: 137-139.

Lee, Chang-Hsing, Jau-Ling Shih, Kun-Ming Yu, and Hwai-San Lin.
2009. "Automatic music genre classification based on modulation spectral analysis of spectral and cepstral features." *IEEE Transactions on Multimedia* 11, no. 4: 670-682.

Lugrin, J., Marc Cavazza, Mark Palmer, and Sean Crooks.
2006. "Artificial intelligence-mediated interaction in virtual reality art." *IEEE intelligent systems* 21, no. 5: 54-62.

Magnusson, Thor.
2019. *Sonic writing: technologies of material, symbolic, and signal inscriptions*. London: Bloomsbury Academic.

Mayell, Hillary.
2004. "Is Bead Find Proof Modern Thought Began in Africa?" *National Geographic News*. Retrieved May 20, 2016.

McCormack, Jon, Oliver Bown, Alan Dorin, Jonathan McCabe, Gordon Monro, and Mitchell Whitelaw.
2014. "Ten questions concerning generative computer art." *Leonardo* 47, no. 2: 135-141.

McLean, Alex, and Geraint Wiggins.
Tidal–pattern language for the live coding of music. In Proceedings of the 7th sound and music computing conference. 2010.

Mlynář, Jakub, Hamed S. Alavi, Himanshu Verma, and Lorenzo Cantoni.
2018. "Towards a sociological conception of artificial intelligence." *International Conference on Artificial General Intelligence*: 130-139.

Nake, Frieder.
There Should Be No Computer-Art. In Bulletin of the Computer Arts Society, London) No. 18, Oct. 1971, 1-2. – Reprinted in: A. Altena, L. van der Velden (eds.): The anthology of computer art. Amsterdam: Sonic Acts 2006, 59-60.

Nilsson, Nils John.
1998. *Artificial intelligence: a new synthesis*. San Francisco, CA: Morgan Kaufmann.

Parker, James R.
2019. *Generative art: algorithms as artistic tool*. Calgary: Durvile Publications.

Poole, David I., Randy G. Goebel, and Alan K. Mackworth.
1998. *Computational intelligence*. New York: Oxford University Press.

Roh, Jinah.
2018. "Artificial Intelligence Art: A Case study on the Artwork An Evolving GAIA." *The Journal of the Korea Contents Association* 18, no. 5: 311-318.

Romero, Juan J.
2008. *The art of artificial evolution: A handbook on evolutionary art and music*. Berlin: Springer Science & Business Media.

Russel, Stuart, and Peter Norvig.
2003. *Artificial Intelligence: A Modern Approach*. London: Pearson Education Limited.

Schmitt, Philipp.
2018. "Augmented imagination: machine learning art as automatism." *Plot (s), the Design Studies Journal* 5: 25-32.

Schneider, Tim & Naomi Rea.
"Has artificial intelligence given us the next great art movement? Experts say slow down, the 'field is in its infancy.'". *Artnet News*. September 2018.

Smart, Dan.
2019. "Experimental duo Emptyset to get all ambitious and flowery on forthcoming AI album (despite the relatively dispassionate band name)." *Tiny Mix Tapes*. https://www.tinymixtapes.com/news/emptyset-announce-share-new-single-petals-forthcoming-ai-album-blossoms

Sternberg, R. J., & Detterman, D. K.
1986. *What is Intelligence? Contemporary Viewpoints on its Nature and Definition*. Norwood, NJ: Ablex.

Sternberg, R. J.
2003. "Intelligence." In *Handbook of psychology: History of Psychology, Vol. 1* edited by D.K. Freedheim, 135-136. New York, NY: John Wiley & Sons Inc.

Thorndike, Edward L.
1921. "Intelligence and its measurement: A symposium." *Journal of Educational Psychology* 12, no. 3: 124.

Wannarumon, Somlak, Erik LJ Bohez, and Kittinan Annanon.
2008. "Aesthetic evolutionary algorithm for fractal-based user-centered jewelry design." *AI EDAM* 22, no. 1: 19-39.

White, Courtney, and Rita Matulionyte.
2019. "Artificial Intelligence Painting The Bigger Picture For Copyright Ownership." Available at SSRN 3498673.

Zukowski, Zack, and C. J. Carr.
2018. "Generating black metal and math rock: Beyond bach, beethoven, and beatles." *arXiv preprint arXiv:1811.06639*.

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Strings

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Keywords: Simulation-based Interaction, Sound Synthesis, Generative Art, Audiovisual Performance, Improvisation.

This article presents the currently ongoing development of an audio-visual performance work with the title *Strings*. This work provides an improvisation setting for a violinist, two laptop performers, and two generative systems. At the core of *Strings* lies an approach that establishes a strong correlation among all participants by means of a shared physical principle. The physical principle is that of a vibrating string. The article discusses how this principle is used in both natural and simulated forms as main interaction layer between all performers and as natural or generative principle for creating audio and video.

1. Introduction

This publication presents the currently ongoing development of a performance work with the title *Strings*. This work is realized in a collaboration between the two authors and violinist Harald Kimmig[1]. *Strings* will provide a performance setting for three instruments, an acoustic violin, a sound synthesis system, and a video synthesis system. The performance will follow an improvisational approach that emphasizes experimentation and exploration while at the same time trying to maintain a strong aesthetic consistency between all performers. This consistency is achieved by sharing and interrelating the physical principle of vibrating strings among all three instruments. In case of the acoustic violin, this principle forms naturally part of the sound production mechanism of the instrument. In case of the sound and image synthesis systems, the principle is translated into computer simulations that operate as generative mechanisms.

1. http://www.haraldkimmig.de/

So far, most of the development of *Strings* has been dedicated to the establishment of a strategy for integrating acoustic and digital instruments into a shared performance setting, the technical implementation of the generative systems, and the evaluation of systems' aesthetic output. For this reason, this publication focuses heavily on these aspects. This comes at the cost of a detailed discussion of the interaction between the violinist and the generative systems. The integration of generative systems into rehearsal situations with the violinist forms part of the planned future research. Because of this, the current description of the possible forms of engagement between the violinist and generative systems and the shape of the performance remains speculative. In a future publication, these essential aspects of *Strings* will be properly addressed and documented.

2. Background

The following section describes the academic and artistic contexts that inform the work. This section includes discussions about the integration of a complex interaction layers into an instrumental performance and about the translation of a generative system's output into a perceivable result.

2.1. Complexity and Interaction in Performance

Acoustic musical instruments represent physical systems that can exhibit simple or complex behaviours depending on how they are interacted with. Pushing an instrument into a complex behavioural regime is a musical practice that is frequently encountered in free improvisation and experimental music. Mudd (Mudd 2017) provides empirical findings about the motivations of musicians to employ this practice. This includes among others a desire to perform music in an exploratory manner and to encounter unusual sonic results.

Within the field of computer music, there exists two main and typically independent approaches to endow a synthetic musical instrument with the properties of a physical system. The more common approach is based on the technique of physical modelling synthesis. Here, the simulation of the sound producing properties of a physical system forms the foundation for creating synthetic sounds that mimic some of the characteristics of naturally produced sounds. The less common approach deals with the application of simulated physical systems as control layer for interacting with digital instruments. This technique is first proposed in a paper by Mulder and Fels (Mulder and Fels 1998). The authors conclude that a physical simulation can improve the naturalness and easiness of interaction with a digital instrument. A similarly focus on improving the naturalness of interaction with a digital instrument is also found in more recent publications. For example Castet (Castet 2012) argues that the presence of a simulated physical interaction layer establishes a direct relationship between perceptual parameters and physical parameters through which the latter ones gain perceptual significance. In a publication by Pirro and Eckel (Pirro and Eckel 2011) the authors promote the usage of a simulated physical interaction layer as a means to tap into the embodied knowledge of a performer and thereby to activate already acquired motor skills. Aspects of unpredictability and open-ended exploration that a simulated physical interaction layer could entail are more thoroughly addressed in the PhD dissertation by Johnston (Johnston 2009). Johnston distinguishes between three types of interaction with a simulated physical interaction layer: instrumental, ornamental, conversational. The latter two interaction types resonate well with the discussion by Mudd (Mudd 2017) in that they emphasize how a physical system that exhibits partially or fully unpredictable behaviours shifts the role of a performer from a position of control to one of accompaniment or collaboration. The possibility of a simulated physical interaction layer to escape external control and instead exhibit autonomous behaviours is also discussed by Alaoui and co-authors (Alaoui et al. 2014). This publication also lists in concise form some of the benefits of employing physical models as interactive generative systems. These benefits include among others: real-time control, expressive potential, intuitive and embodied interaction, plausible behaviours, digital partners, and coherence across different media.

2.2. Simulation-Based Media Correlation

The potential of a simulated physical system to control not only the creation of music but also other media is pointed out by several publications. Momeni and Henry (Momeni and Henry 2006) argue that one of the main benefits of using a simulation as generative mechanism is its capability to concurrently control the creation of several different media. These authors as well as Jonson (Jonson 2009) stress the importance of making the simulation perceivable in the visual domain. According to them, it is mainly through a visual representation that the operational principle of the simulation becomes understandable both for the performers and the audience. The creative aspects of combining visual and acoustic media through a common generative system and the collaborative approaches that are rendered possible by this are discussed by Alaiou (Alaoui et al. 2014) and Bisig and Kocher (Bisig and Kocher 2013).

The application of simulation-based interaction layers also opens up interesting possibilities for correlating media that form part of both the input and output channels of an interactive system. In such a setup, instead of using a gestural input to control the simulation layer, a medium acts as input to which the simulation responds and another medium is created as output through the behaviour of the simulation. This approach is for example employed by Jonson (Jonson 2009). In all his implementations, the physical interaction layer responds to the sounds produced by a musician and this sound alters the behaviour of the physical simulation.

3. Implementation

This chapter provides an overview of the technical implementation of *Strings*.

In summary (see Figure 1, left side), the operation of *Strings* is as follows: An audio and video capture system records and analyses the visual and acoustic situation on stage. This analysis controls the creation and excitation of two physical simulations. Both simulations employ a model of a mass-spring-damper system [MSDS]. One of these simulations controls the generation of synthetic video, the other controls the generation of synthetic audio.

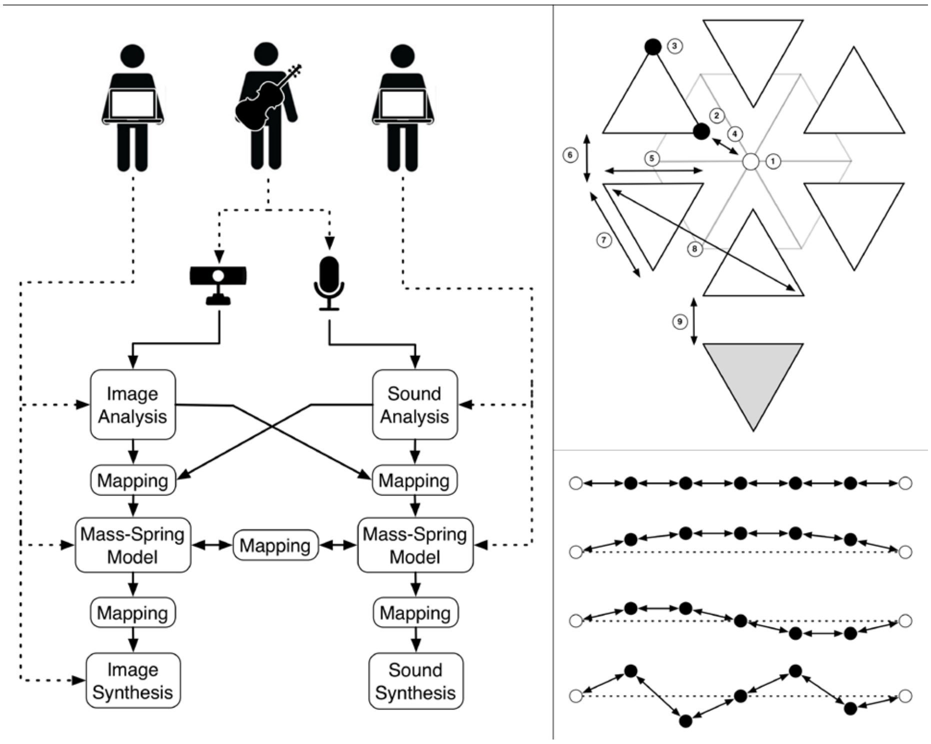


Fig. 1. Performance Elements and Mass-Spring-Damper Systems [MSDS].

The three figures present schematic depictions of the relations among all performance elements (left image), the different mass-point and spring types in the image generating MSDS (top right image), and the four sequential spring arrangements in the sound generating MSDS (bottom right image). In the image showing the performance elements, continuous lines represent the exchange of data between software and hardware components, dashed lines represent interactive controls by performers. In the schematic depiction of the MSDS, black circles represent mobile mass-points, outlined circles represent stationary mass-points, lines with arrowheads represent springs. In the schematic depiction of the image generating MSDS, the light grey elements represent triangulated feature points in the camera image from which the MSDS is constructed. Here, the labels are as follows. 1: stationary mass-point at the origin of a camera image feature point, 2: mobile mass-point in the interior of a region, 3: mobile mass-point at the periphery of an image, 4 :*Origin* springs, 5: *Triangle* springs, 6: *InterTriangle* springs, 7: *Region* springs, 8: *Structural* springs, 9 *InterRegion* springs. In the graphical depiction of the sound generating MSDS, the four horizontal structures represent four individual MSDS. Here, dashed lines represents the rest heights of mass-points from which they are vertically deflected upon excitation.

3.1. Mass-Spring-Damper Systems

Strings combines three different MSDS as layers of interaction and as mechanism for media generation. One of the MSDS is of natural origin and represents the set of strings on an acoustic violin. The other two MSDS are implemented as computer simulations.

The modelling of the MSDS follows standard conventions. The MSDS consists of mass-points and springs. Each spring creates an elastic connection between two mass points. Mass-points are characterised by their mass, springs are characterised by their stiffness and damping. Spring tension forces arise when springs deviate from their rest lengths. These tension forces are calculated according to Hooke's law. Damping forces arise when mass-points move and oppose this movement. These damping forces are proportional in their strength to the velocities of the mass-points and the forces point into the opposite directions of the velocities.

3.1.1. Image MSDS

The MSDS for controlling image synthesis is implemented in the OpenFrameworks programming environment[2]. The MSDS consists of mass-points and springs that are interconnected with each other in a two-dimensional triangular lattice arrangement. The number of mass-points and springs in this lattice is dynamic and changes in response to a live-captured video image (see Section Mapping). The MSDS consists of three types of

2. https://openframeworks.cc/

mass-points and six types of springs. These types differ among each other in their physical properties and in the elements of the lattice they control (see Figure 1, top right side).

Mass-points of the first type are immobile. They are located at the same positions as feature points in a live-captured video image (see Section Capture) and serve as anchors for the lattice. The other two types of mass-points are mobile. One type of mobile mass-points is located within the interior of lattice regions, the other type is located at the periphery of lattice regions.

The different types of springs are as follows: *Origin* springs connect non-mobile and mobile mass-points with each other. Their purpose consists in pulling the lattice back into its initial position defined by features in the video image. *Triangle* springs follows the circumference of lattice triangles. *InterTriangle* springs connects neighbouring lattice triangles. *Region* springs follows the circumference of all regions within the lattice. *Structural* spring connect mass-points that lie at the opposing ends of two neighbouring triangles. *InterRegion* springs connect neighbouring regions.

3.1.2. Sound MSDS

The MSDS for controlling sound synthesis has been implemented in the CSound programming environment[3] and follows the implementation described by Comajuncosas (Comajuncosas 2000). The MSDS consists of a total of 28 mass-points and 24 springs (see Figure 1, bottom right side). All mass-points and springs possess their own physical parameters. The MSDS is organized into 4 groups, each combining 7 mass-points and 6 springs. Within each group, the mass-points are arranged on a line and equally spaced. The two mass-points located at the periphery of this arrangement are immobile whereas the mass-points located in between are mobile. All mass-points within a group are linearly connected by six springs. When this MSDS is excited, the mass-points move vertically away from their original arrangement.

3. https://csound.com/

3.2. Input Media for Interaction

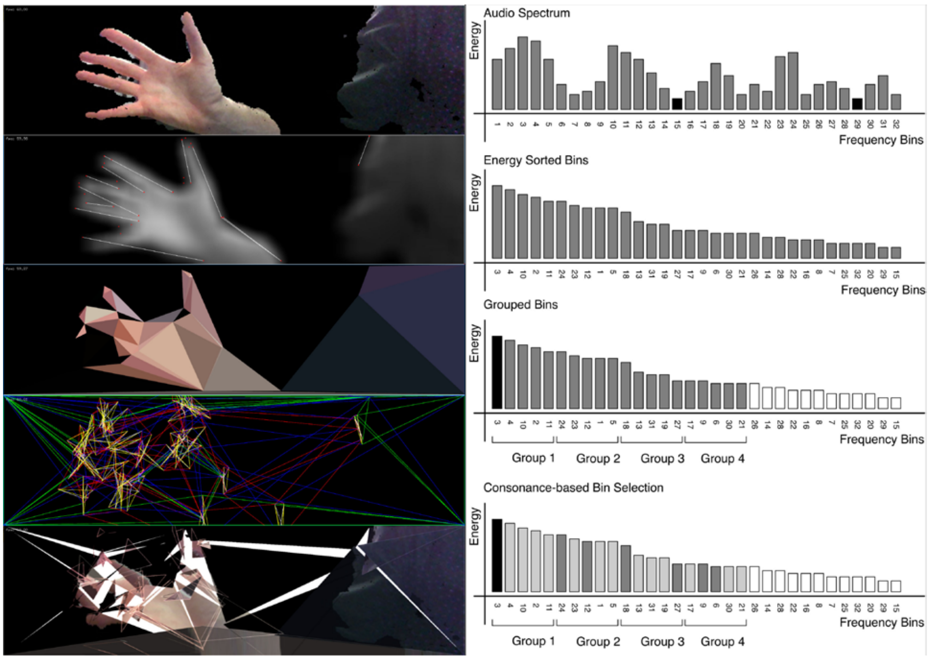
While certain physical aspects of the MSDS used for image and sound synthesis are controlled through graphical user interfaces, the main form interaction is based on the live capture and analysis of the violinist's activities on stage. The capture and analysis is performed both in the visual and acoustic domain.

A camera[4] that is placed at the front edge of the stage captures the position and appearance of the violinist on stage. Video analysis serves the purpose of identifying salient positions within the camera image. The analysis involves the following processing steps: image blurring, edge detection, edge simplification, and edge point extraction. The extracted points form the basis for constructing the image MSDS.

4. Intel Realsense D435

Sounds produced by the violinist are recorded with a microphone that is mounted on the instrument. Sound analysis serves the purpose of detecting prominent frequencies in the timbre of the violin sounds as well as moments of silence. Identified frequencies and their amplitudes are used to control the excitation of both the image and sound MSDS. Moments of silence are used as windows of opportunity to apply large modifications to the MSDS while minimizing audible and visible discontinuities. Sound analysis involves the following processing steps: Fast Fourier transform, amplitude-based frequency sorting, identification of fundamental, and scaling and selection of partials according to consonance. The sorted and scaled frequencies and amplitudes are used for exciting the sound MSDS.

Fig. 2. Sound and Image Analysis and Generation.



The image on the left depicts the creation of a synthetic image from a live captured camera image. From top to bottom, the processing stages are as follows: The camera image, salient contours and feature points in the camera image, Delaunay triangulation derived from feature points and coloured according to the camera image, a MSDS created from the triangulation, and the final rendering of the MSDS as a synthetic image. The image on the right shows the process of analysing the acoustic spectrum of the live microphone input. From top to bottom, the processing stages are as follows: frequency bins obtained by Fast Fourier analysis, frequency bins sorted by amplitude levels, identification of fundamental and assignment of frequency bins to four groups for later use for the excitation of the four sound producing MSDS, and identification of consonant partials.

3.3. Media Generation

The previously described MSDS control the generation of both synthetic video and audio. These media form together with the violinist's performance the perceivable content of *Strings*.

The video image is constructed by drawing a triangulated mesh. The shapes and positions of the mesh's triangles is directly derived from the lattice triangles present in the image MSDS. The triangles are coloured by either using the captured video image as texture or by interpolating between colours that are sampled in the captured video image at the corner positions of the triangles. The outline of the triangles can be drawn as lines in an arbitrary but constant colour or the outline can be hidden. The rendered mesh can further be post-processed by applying horizontal and vertical blurring and by cropping and re-scaling the colour histogram. Two triangulated meshes are drawn on top of each other with each one being controlled by a different image MSDS and rendered with individual settings. Subsequently, the blending between these two rendered meshes can be controlled by varying the addition and multiplication factors of the blending. The blended output is then composed on top of the previously rendered frames.

The sound MSDS whose simulation is updated at audio rate is used as sound synthesis system. The sonification is based on a direct audification (Surges et al. 2015) technique: the deflection of a selected mass-point in each MDSD group is directly translated into an audible audio waveform. Four of these waveforms are created in parallel from the four MDSD. They create individual voices in the musical output.

3.4. Mapping

Different mapping layers form part of the implementation. Mapping layers exist for the translation of the output from video and sound analysis into the creation and control of the respective MSDS. A further mapping layer connects the two MSDS with each other. And two additional mapping layers connect the two MSDS to the image and sound synthesis systems.

3.4.1. Video Analysis to MSDS

A Delaunay triangulation is applied to the feature points in the camera image. The triangles are colourized based on colours taken from the camera image. Depending on colour similarity and spatial proximity, triangles are assigned to identical or different regions. Each region is transformed into a preliminary MSDS. In this preliminary MSDS, mass-points correspond to triangle corners and springs correspond to triangle edges. These preliminary MDSD are then combined and their mass-points and springs diversified into different types in order to create the final image MSDS.

The number of camera image feature points also affects the excitation of the sound MSDS. The number of feature points is mapped on the maximum number of frequency bins that can be used for exciting the sound MSDS. As a result, the amount of detail present in the captured video will affect the level of detail of both the synthetic sound and the synthetic image in a similar manner.

3.4.2. Sound Analysis to MSDS

In case of the image MSDS, springs are assigned based on their rest-length to the different frequency bins obtained from sound analysis. Springs with shorter rest-lengths are assigned to higher bins and springs with longer rest-lengths are assigned to lower bins. If the frequency exceeds an amplitude threshold, the assigned springs are made to oscillate with an amplitude and frequency that is proportional to the amplitude and frequency of the bin.

In the case of the sound MSDS, the amplitudes from the sorted and grouped frequency bins are used for the mapping. The bins' frequencies control the stiffness of the springs which in turn affects the spectral energy distribution that is generated by the excited MSDS. The amount of excitation that is applied is proportional to the bins' amplitudes.

Based on moments of silence that are detected by sound analysis, an average duration of the violinist's sound production is calculated. These durations are used to control the spring damping of the sound and image MSDS. The damping values are inversely proportional to the sound durations. In case of the sound MSDS, damping controls how quickly the acoustic output of the sound synthesis system falls to silence once the MSDS is no longer excited. In case of the image MSDS, the velocity of the mass-points is mapped to the transparency value of the rendered meshes with the transparency values being inversely proportional to the mass-point velocities. Since damping affects how quickly the velocities of the mass-points decay to zero, changing the damping value has a perceptually similar effect on the synthetic image as on the synthetic sound in that it affects how quickly both disappear.

3.4.3. MSDS to MSDS Mapping

The image and sound MSDS can be related to each other by exchanging mean values for physical parameters such as the mass of mass-points and the stiffness and damping of springs. The strength of this exchange can be controlled by the performers. Furthermore, the positions of the excitation signal pickup up by the sound MSDS is spatially mapped onto the image MSDS. This mapping controls the strength of the sound induced spring oscillations in the image MSDS with the oscillations being strongest at the centre of the mapped position and then gradually falling off towards more distant springs.

3.4.4. MSDS to Image and Sound Synthesis

In both cases, the mapping from MSDS to media generation is trivial since the image and sound generation principles are closely related to the structural and functional properties of the MSDS. In case of the image MSDS, the mapping controls the creation of a triangulated mesh. This mapping applies a spatial transformation that preserves in the resulting image the topology of the spring lattice and its spatial arrangement. In case of the sound MSDS, the mapping scales the deflection of the mass-points to an amplitude value that lies within a range suitable for creating an audio waveform.

4. Interaction and Improvisation

The violinist's activities shape the visual and acoustic content of *Strings*. It is through the recording and analysis of his performance that he profoundly affects the properties and behaviour of the two MSDS. His visual appearance controls the structure of the image MSDS and it is musical output excites the two MSDS into producing a visible and audible output.

The laptop performers will predominantly interact with the two MSDS by controlling those physical aspects that are not influenced by the violinist. This includes altering the rest lengths of springs in the image MSDS and altering the masses of the mass-points in both MSDS.

A particularly important physical parameter to interact with is that of the springs's damping factor. Depending on the value of this parameter, the two MSDS will either quickly return to rest after having been excited by the violinist or they will continue to oscillate. If the damping factor is particularly low, these oscillations quickly become unstable and result in self-sustained and chaotic behaviours. In this situation, the two MSDS are barely controllable and can therefore be considered to behave as autonomous and self-improvising entities. On the other hand, if the damping value is very large, the two MSDS depend in their activities on a continued energy input that is provided by the violinist. Under these conditions, the MSDS possess very little autonomy and operate more akin to a digital extension of the acoustic violin.

5. Results

The results presented here are preliminary since *Strings* is still under development and the main rehearsals have yet to take place. The following section presents first insights into the capability of the MSDS to produce acoustic and visual outputs and the characteristics of these outputs.

5.1. Visual Output

In general, the visual output of the image synthesis system takes the form of a minimalistic polygon-rendering of the visual situation on stage. The rendered image varies in its appearance and dynamic change between mirroring and abstracting the violinist's appearance and movements. The balance between mirroring and abstraction depends mainly on the following aspects: texturing versus interpolation of colours, reconstruction frequency of the MSDS from camera image feature points, deviation of the spring rest-lengths from the distances between camera image feature points, and the amount of spring damping.

When texturing the mesh triangles with the camera image, the rendering results in a visual appearance that is reminiscent of shards of a fractured mirror that reflect their surroundings. If instead the colours are interpolated from individually sampled positions in the camera image, the rendering resembles a mosaic consisting of differently sized and coloured tiles.

The MSDS can either be reconstructed for every new camera frame or it can be reconstructed only occasionally. In the former case, the rendered mesh continuously align with the visual appearance of the violinist, creating a more or less faithful image of him. In this setting, the movement of the MSDS is of lesser importance compared to the movements of the violinists that dominate the dynamics of the synthetic image. Contrary to this, when the MSDS is only rarely updated from the camera image, the movements of the MSDS dominate visually and they cause an earlier depiction of the violinist to move in a manner that is unrelated to the violinist's own movements.

Changing the rest-lengths [RL] of springs in the MSDS causes a distortion of the synthetic image whose characteristics depends on the particular spring types that are being affected. Changing the RL of *Origin* springs pushes all triangles towards the periphery. Changing the RL of *Triangle* springs causes the triangles to shrink or expand. Changing the RL of *InterTriangle* springs causes gaps to appear or disappear between the triangles. Changing the RL of *Region* springs leads to a compaction or expansion of similarly coloured parts within the mesh. Changing the RL of *InterRegion* springs causes dissimilarly coloured parts to separate from each other. Changing *Structural* springs causes a more or less equal distortion of all triangles.

Changing the amount of spring damping affects the oscillatory movements that the synthetic image exhibits in response to exciting stimuli received from the acoustic output of the violinist. These oscillatory movements translate into visual form the principle of acoustic vibrations. This visual analogy is emphasized by relating the transparency of the triangles to the velocities of the mass-points. As result, strongly oscillating parts in the synthetic image become visually dominant whereas non-oscillating parts disappear. When choosing very low spring damping parameters, the oscillations of the MSDS start to supersede and disrupt the former spatial relationships that existed among the feature points in the camera image. Such a heavily oscillating synthetic image loses its visual relationship to the original camera image and appears as a fast flickering mass of colours.

Videos are available online that showcase the following aspects of image synthesis: varying the rendering of the triangulated mesh[5], varying the

5. https://vimeo.com/391715587/fcb605725f

6. https://vimeo.com/391715750/1b64bb3355

7. https://vimeo.com/391716174/472eb3585e

8. https://vimeo.com/391716466/131276ce8b

reconstruction rate of the MSDS[6], varying the rest-length of springs[7], externally controlling the oscillations of springs[8].

5.2. Acoustic Output

By mapping selected amplitudes and frequencies from the analysis of the sound produced by the violinist to the vertical deflection of mass-points and the stiffness of springs, the violinist is able to affect the timing, duration, amplitude, pitch and spectrum of the synthetic sounds. Apart from spring stiffness, the mass of mass-points also influences the pitch of the synthetic sounds. What can also be varied are the positions within each of the four sequentially arranged MSDS at which the MSDS is excited and at which the response to this excitement is picked up. Changing these positions affects the amplitude and spectrum of the synthetic sounds. The closer the excitation and pickup positions are to each other, the more the acoustic characteristics of the excitation signal is still present in the synthetic sounds. When this distance is increased, the amplitude dynamics of the excitation signal is smoothed out and the resonant frequencies of the MSDS are dominating the audible result.

Audio files are available online that showcase the following aspects of sound synthesis: varying spring stiffness causes pitch variations[9], varying mass-point mass causes pitch variations[10], varying positions for excitement and response affects amplitude dynamics and resonant frequencies[11], varying spring damping moves the system between stable to unstable regimes[12].

9. http://e-wegner.net/data/strings_example_01.wav

10. http://e-wegner.net/data/strings_example_02.wav

11. http://e-wegner.net/data/strings_example_03.wav

12. http://e-wegner.net/data/strings_example_04.wav

6. Next Steps

Up to now, *Strings* has been developed with only an occasional involvement of the violinist. Accordingly, the main tasks of integrating the MSDS and synthesis systems into an improvisational setting are still ahead of us. In particular, we have to verify whether the violinist is at ease with a situation in which his musical performance is the main factor influencing the generation of synthetic video and audio. This being at ease not only requires the violinist to be willing to cope with the challenge of improvising together with two partially autonomous generative systems. It also requires that the violonist's playing doesn't cause a flurry of audio-visual consequences that is difficult for him to control and that interfere with his own aesthetic intentions. The authors anticipate that during the first phases of extensive rehearsals, some of the mappings that translate the violinist's performance into the structure and behaviour of MSDS will need to be tuned or redesigned. In addition, it is also likely that a pre-defined performance sequence will need to be established that organises the improvisation into multiple sections. These sections will differ from each other with respect to the level of interdependence among all participating systems and performers.

7. Conclusion

The project is motivated by the author's desire to integrate both human performers and generative systems into a shared improvisation setting. The sharing of this setting is enabled through the adoption of a particular physical principle and its establishment as common principle for the creation of music and video. By choosing the phenomena of an oscillating string as this physical principle, it becomes possible to directly relate the sound producing principle of an acoustic string instrument to simulated abstractions of this principle which in turn drive the generative creation of synthetic video and audio. Based on such a direct and consistent relationship between natural and simulated forms of string oscillations, several levels of correspondence can be established between the acoustic instrument and the generative systems.

On the level of physical correspondence, the principle of excitation can be employed to transfer the acoustic output resulting from vibrations of violin strings into actuations of simulated strings.

On the level of interaction correspondence, the previously mentioned physical principle allows effective gestures (Cadoz and Wanderley 2000) for controlling the violin to also serve as effective gestures for interacting with the generative systems. The capturing of the effective gestures by means of a camera extends the range of responses that the generative systems can exhibit while still staying consistent with the principle of gestural interaction.

On the level of aesthetic correspondence, the equivalence of the relationship between physical parameters and acoustic result can be exploited to establish an aesthetic proximity between the musical output of the acoustic and digital instrument. Such a similarity can be approximated in the synthetic image by displaying oscillations as periodic spatial perturbations and by linking the oscillation's amplitude to the visibility of said perturbation.

On the level of autonomy and control, a correspondence can be established in which both the natural and simulated physical behaviour of oscillating strings can gradually vary between predictable and chaotic regimes. As such, both the acoustic instrument and generative system lend themselves to exploration and experimental forms of performance.

To summarize, *Strings* unifies several formerly disparate approaches for integrating physical simulations into performance settings. Rather than employing a physical model solely for sound synthesis or for establishing an interaction layer, the employed approach combines sound synthesis, image synthesis, and interaction through the use of a common physical model. Also, the proposed work uses a physical model for correlating audio-visual media both as input modalities for the simulated physical interaction layer and as synthetically generated outputs. The authors believe that such a combined approach is novel and original.

References

Bisig, Daniel. and Kocher, Philippe.
2013. "Trails II". *Proceedings of the Consciousness Reframed Conference*. Cairo, Egypt.

Cadoz, Claude, and Marcelo M. Wanderley.
2000. "Gesture-music". IRCAM centre pompidou. pp. 71–94.

Castet, Julien.
2012. "Performing experimental music by physical simulation". *Proceedings of the International Conference on New Interfaces for Musical Expression*. Michigan. USA.

Comajuncosas, J. M.
2000. "Physical models of strings and plates using a simplified mass-spring method". *The Csound Book*. ed R Boulanger.

Fdili Alaoui, Sarah, Cyrille Henry, and Christian Jacquemin.
2014. "Physical modelling for interactive installations and the performing arts." I*nternational Journal of Performance Arts and Digital Media* 10, no. 2, pp. 159–178.

Johnston, Andrew James.
2009. "Interfaces for musical expression based on simulated physical models". PhD diss.

Momeni, Ali, and Cyrille Henry.
2006. "Dynamic independent mapping layers for concurrent control of audio and video synthesis." *Computer Music Journal* 30(1): 49–66.

Mudd, Tom.
2017. "Nonlinear dynamics in musical interactions". PhD diss., The Open University.

Mulder, A., and S. Fels.
1998. "Sound sculpting: Manipulating sound through virtual sculpting". *Proceedings of the 1998 Western Computer Graphics Symposium*, pp. 15–23.

Pirrò, David and Gerhard Eckel.
2011. "Physical Modelling Enabling Enaction: an Example". In *NIME*, pp. 461–464.

Surges, Greg, Tamara Smyth, and Miller Puckette.
2015. "Generative feedback networks using time-varying allpass filters". *Proceedings of the International Computer Music Conference*. Denton. USA.

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Augmented Drums: Digital Enhancement of Rhythmic Improvisation

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Keywords: Augmented Instruments, Drum Set, Music, Interaction, Improvisation, Live Electronics.

This paper presents a set of real-time modules that digitally enhance the performance of a drummer. The modules extract rhythmic information from the multichannel audio acquired using simple microphones onto the different drum parts. Based on the predicted tempo, the modules generate complex patterns that can be manually controlled through high-level parameters or can be left automatic adapting to the drummer's specific style. Such an interactive system is intended mainly for an improvised solo performance confronting a human drummer with a computer; however, it could be effectively employed in improvisations with larger ensembles or installations.

1. Historical Background and Related Work

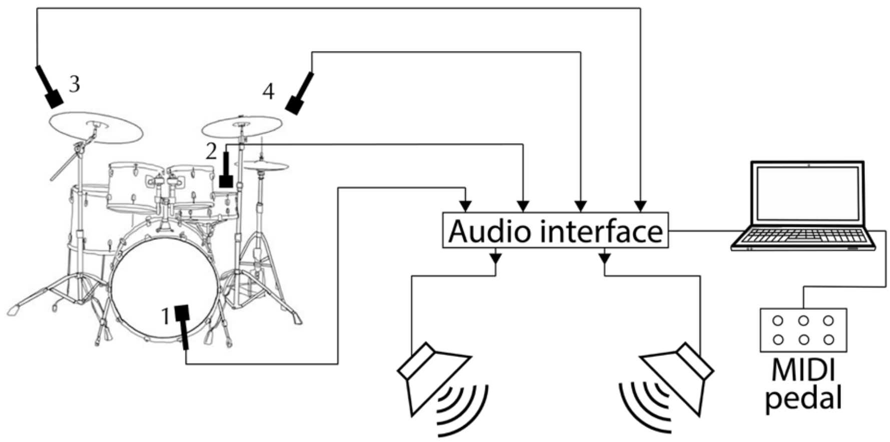
In the early years of electronic music, when the new technologies began to be considered as valid and innovative means for musical expression, percussion instruments had a fundamental role in the transition between the traditional, “keyboard-influenced” musical language and the “all-sound music of the future” (Cage 1937). Several composers considered percussion a great match with electronics because of their common characteristics. Both instrument families can generate a broad spectrum of unpitched sounds which encouraged composers to focus on timbre and rhythm. Another aspect is the modularity that characterises both setups of the percussionist and the electronic musician: the possibility to swap parts of an instrument chain has an impact on the creation process, and opens new possibilities in the performative approach (Cage 1937) (Varese 1966) (Stockhausen 1996). In the following years, the diffusion of digital technologies, computers and real time digital audio processing allowed the birth of new strategies for composition and live electronics. In the late 70’s Chadabe started experimenting with digital “interactive composing systems”: algorithms capable of responding in complex ways to the actions of the performer (Chadabe 1984). In his pieces *Solo* and *Rhythms*, for example, the performer provides high-level input data to the system that elaborates them in order to produce the whole musical output. The performer influences the final result but is unable to control each single event, placing himself in a position where he needs to listen and react to the gestures of the computer. In 1983 George Lewis was working at IRCAM developing an interactive software that could automatically generate instrumental music and also analyse the performance of human musicians in order to play along with them (IRCAM 1997) (Lewis 2018): this work established the base of his *Voyager* system. The idea of independence of the computer from the human performer led to the abolition of the “human leader/computer follower” hierarchy, in order to create the possibility to communicate only using the musical language (Lewis 2000). As a result, some intentions and emotions expressed by the human performer could also be found in the electronic performance, confirming the achievement of an authentic man-machine musical interaction. This last concept was pointed out also by Robert Rowe in the description of one of his early works in the field of human-machine musical interaction, *Hall of Mirrors* (Baisnee 1986). He describes the feedback loop generated by mutual imitation as two (or more) mirrors facing each other. Rowe developed his own interactive system named *Cypher*. In *Cypher* the user has to decide how the listener will interact with the player, allowing a high-level control on the actions of the software (Rowe 1990). In the ‘90s both *Cypher* and *Voyager* were modified to include the use of MIDI data as input and output, in order to easily process all the necessary data (Steinbeck 2019). In recent years, great progress has been made in the development of new interactive music systems and digital tools for the analysis of human performances. The application of these principles also led to the development of musical robots capable of interacting with human musicians in complex ways. The one-man Indian computer music system for example, applies machine listening techniques to various kind of signals produced by the human performance (Kapur 2006). The musician plays the *ESitar*, a modified sitar equipped with various kinds of sensors that provide gestural data: two examples are thumb pressure and fret detection. Also, the sound of the instrument is used as input and some accelerometer-based sensors are attached to the performer's body. This data is then used to synthesise sounds, control effects and generate beat accompaniment for the sitar performance. The result is an articulate and expressive system that reacts in interesting ways to the sitar performance, as can be seen in some demonstrative videos on Kapur's YouTube channel (Kapur 2010). Another musical robot is the one described in (Hoffmann 2010) which is an interactive marimba player that can improvise by listening and reacting to a human piano performance. Particularly interesting is the description of the third interaction module that focuses on the imitation of the rhythmic aspects of the human performance. This is done by weighing every point of the rhythmic grid of a bar by detecting if piano notes were played or not in those moments. These values are then stored in an array of probabilities that also keeps track of the past history. In *Agumenta* by Alessandro Guerri an electronic drum kit is used to send continuous information to a software that extracts general parameters like tempo, density and dynamics (Guerri 2015). This data is then used to control the generation of rhythmic patterns related to the performance of the drummer. In these drum kits, all the information about the notes played by the drummer are sent as MIDI messages, so their analysis can produce very accurate results. However, on the downside, the use of electronic drums implies a drastic reduction of the timbral expressivity of the instrument. The augmented drum kit developed by Christos Michalakos is based on an acoustic jazz drum kit with drum triggers, contact microphones and a speaker mounted on it (Michalakos 2012). The software includes sound processing and synthesis modules that can be turned on and off in various ways: manually by using a MIDI controller, automatically after the recognition of specific acoustic elements or through a pre-programmed cue. The variety of sound processing modules and the presence of different modalities of interaction with the software allow the drummer to control a rich electronic section, capable of enhancing the performance in several different ways, but requires a complex set of transducers, thus a long setup time. In this paper we present an approach for an augmented acoustic drum kit combining and expanding the ideas of the aforementioned systems. Our main goal is to sample the acoustic sound of the drums with all its nuances, then extract high-level features such as tempo, cue onsets and density to rhythmically enrich the performance by counterbalancing the drummer style. In the design process we prioritized the ease of setup and transportation of the system, requiring only a few common microphones and a sound card.

2. System Structure and Description

2.1. Hardware

We use the acoustic drum kit in two ways: as an acoustic source and as a control interface for the software. We also added a self-built MIDI foot controller with six buttons to control the desired software parameters. The acoustic sound of the drums is captured using four microphones: one placed inside the kick drum, one close to the snare, and two overheads. The number and the position of the overhead microphones can be modified, but the kick and snare microphones are essential for the software to work properly because their signals are analysed in order to retrieve important data regarding the performance of the drummer.

Fig. 1. Scheme of the hardware used.

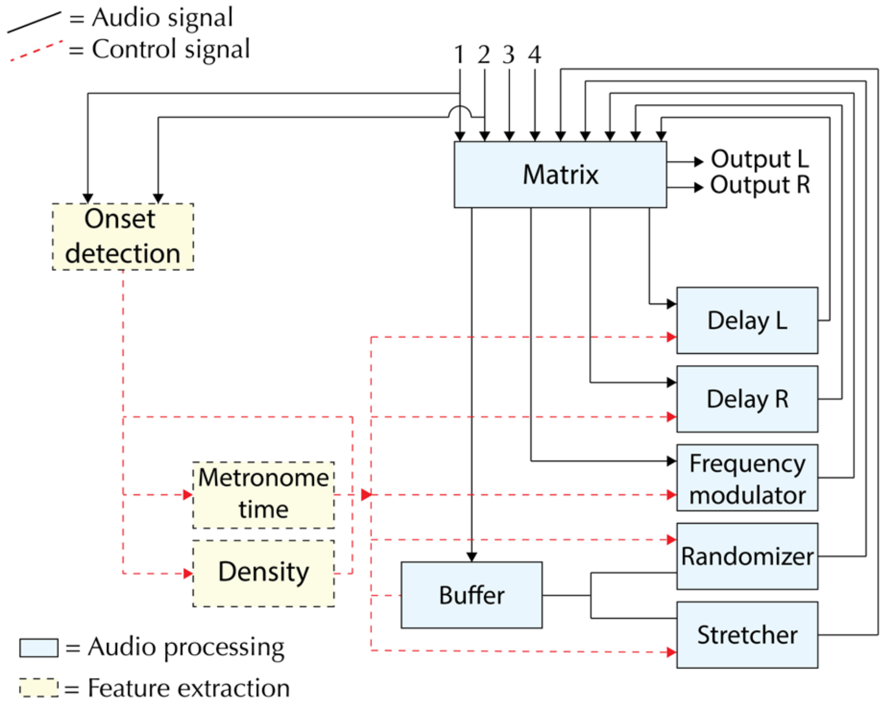


2.2. Software

The software is programmed in Max/MSP[1] and is divided in two main sections: the first one analyses the inputs to extract rhythmical information regarding the performer's style in order to generate control signals, while in the second one the audio coming from the microphones is digitally processed to produce rhythmical effects related to the data retrieved. This allows the drummer to easily influence the action of the effects by just modifying, for example, the groove or by changing the metric subdivision of a fill. The electronic effects are completely controlled by the data extracted from the performance, except for a few manual controls: *Reset* button which immediately sets the patch to its initial state, and a *Performance end* message that causes the electronic effects to slowly fade out and can be used whenever the drummer wants to end its exhibition. These messages can be sent through the use of the MIDI pedal and are not subject to any kind of variation operated by the software.

1. Max/Msp by Cycling '74: https://cycling74.com.

Fig. 2. The structure of the software.



Features Extraction

In the first section the sound captured by the kick and snare microphones is analysed in order to detect the onset of the single strokes and to send a message whenever one is identified. This is done by calculating the RMS amplitude over a 64 sample window and then routing the resulting signal to the *thresh~* object, which acts as a Schmitt trigger: an onset is identified whenever the signal exceeds the higher threshold, but the object won't be able to detect another one until the input falls beneath the lower threshold. After this data is extracted, it will be used to control the modules of the second section, but also reanalysed in order to retrieve information about the rhythmical aspects of the performance, in particular its tempo and density. *Tempo* is estimated by measuring the distance in milliseconds between each onset and the previous one. We then arrange this data in a histogram displaying the number of occurrences per value vs the time interval in milliseconds. The highest peaks are then selected and analysed to generate the tempo value. *Density* is estimated as the number of kick and snare onsets received over a two-seconds temporal window. The onset messages are routed into a counter: every time a message is received, the carried count is increased by one. At the same time, each message is delayed by 2 seconds and then routed back to the counter, this time causing it to decrease the count by one. By doing that, we obtain a parameter that is highly reactive to the actions of the drummer and computationally light. The resulting signal is then smoothed and normalised in order to reduce the value to a floating-point number varying between 0 and 1.

Audio Routing and Effects

All the calculated data is sent to the elements of the second section of the patch, which is formed by an audio routing matrix and five sound processing modules that we named *Delay*, *Frequency Modulator*, *Buffer*, *Stretcher* and *Randomizer*. In order to easily route all the audio signals and define their way from the microphones to the stereo output, we arranged a matrix that can be modified manually or in an automatic way. The *Delay* is made of a time varying delay line with two feedback loops. One of the delay lines uses a pitch shifter with a transposition ratio randomly chosen between 0.062 and 4 times of the original pitch. This effect generates ascending or descending "quantised glissandos", creating rhythmical and timbral variety whenever the effect is activated. The incoming audio signal is analysed using the *bonk~* [2] object in order to detect the presence of onset transients. If an onset is detected, the Delay effect can be triggered depending on a probability value set by the user. The delay time and the length of the amplitude envelope of the effect are chosen probabilistically from multiples or submultiples of the estimated tempo. The *Frequency Modulator* uses the audio input as the modulator signal for the frequency of a square wave oscillator. This signal is amplified and then the central frequency value is added; these two operations transform the input in order to bring it in a range where the modulation can be audible and effective on the carrier oscillator. The output of this effect is not continuous but, similarly to the delay, its amplitude envelope is triggered whenever the randomly generated number exceeds the gate imposed by the *Probability* value. The effect is triggered by snare onset messages. The *Randomizer* and *Stretcher* use a monophonic audio buffer which is the recording of the signal coming from one of the audio outputs of the matrix, and can operate in a manual or automatic way. When in automatic mode, the recording is armed by the kick onsets with a probability of 3% and the recording starts on the next tempo tick. Manual commands override the automatic mode. While recording to an audio buffer, we temporarily deactivate the other effects that use it for playback, in order to avoid clicks. At the end of each recording, the *Randomizer* analyses the buffer through the use of the *slice~* [3] object that divides the buffer in various segments based on the detection of transients in the signal. The buffer is rhythmically scrambled to create a playing queue where all the segments are permutated in time. The reproduction of this queue is automatically managed by comparing the *Density* parameter with a threshold set by the user. The queue is played whenever the *Density* parameter goes beneath the threshold and it is either paused when the threshold is exceeded or after five seconds. The *Stretcher* responds to the need of balancing all the short and percussive sounds with longer and softer ones. The audio output of this effect is mostly located in the lower region of the spectrum and is characterised by slow and

2. bonk~ : https://cycling74.com/forums/64-bit-versions-of-sigmund-fiddle-and-bonk.

3. slice~ : http://naotokui.net/2014/10/maxmsp-objects-on-github/.

often undefined attacks that create continuity in the performance. It uses the results of the analysis performed by the *slice~* object and stretches the audio segments by playing them at a much lower speed, causing them to be transposed and lengthened. The effect is triggered by the snare onset messages and the *Probability* parameter is controlled by the *Density* value. The probabilistic gate is similar to the one of the *Frequency Modulator.* Whenever the threshold is exceeded, we select a new segment to be played and generate a new random speed.

2.3. System Setup

Setting the system correctly is fundamental for the performance and it has to adapt to the playing style of the drummer. The gains for the kick and snare microphones are of critical importance as they influence the corresponding onset detection algorithms. Once the correct functioning of the onset detection algorithm is verified, it will be sufficient to reset the patch and recall the desired preset in order to start the performance. The entire procedure typically takes a few minutes.

3. Applicative Scenarios

The probabilistic gates make the interventions of the software unpredictable for the drummer. This aspect suggests an improvisational approach to the performance, in which the musician has to constantly modify his musical material in order to adapt to the electronic effects. The solo performance is the most intuitive way to use this system, however one could improvise with other musicians and use the drums to generate the control signals to process the overall sound. Another possible application of this research is an interactive installation in which the audience could modify the parameters of the processing engine in order to add or remove disturbing elements to the performance.

4. Conclusion and Future Work

We described an augmented drum system for interactive electroacoustic improvisation between a drummer and the computer. The computer listens to the acoustic sound of the drums and generates effects and rhythmical patterns based on the analysis of the performance. We wanted to establish a close relationship between the actions of the drummer and the software in order to create a strong sensation of interaction between drums and electronic parts. However, in order to achieve a more complex interaction between acoustic and electronic events, we decided to implement an architecture using probabilistic gates. The presence of an audio routing matrix and the possibility to store presets allows one to create different performance scenarios. For the current implementation, the hardware used is a basic drum kit and a few common microphones. We designed this system so that the musicians only need their own software, computer, and soundcard. However, improvement can be done in order to create variety in timbre by adding new elements to the kit. An important aspect we will be studying in the future is the type and positioning of the microphones. In particular we envision the use of two microphones that are placed far away from the drum kit in order to capture and process the room's ambient response. Another possible improvement could be the use of drum triggers to replace the onset detection algorithm to achieve more stability and simplifying the detection task. On the software side, we are thinking of new mapping possibilities through the predisposition of another routing matrix for control signals. This revision will introduce the possibility to easily set the action of the electronics to manual or automatic mode. In manual mode there will be the possibility to give control of the software to a second performer through the use of a MIDI controller as in the case of a traditional electroacoustic concert setup. New feature extraction algorithms will be created to provide further descriptions of the ongoing performance: a more precise beat tracker, spectral features to capture musical gestures, and a new rhythmic classifier. We imagine new effects and sound processing modules, such as dynamic filtering, ring modulation, granulation, and spatialization of the electronic sounds. The last addition to the software will be a cue-based interaction system. Cues will be useful to organise long improvisations, as well as to store presets and recall them whenever a specific sound environment is needed.

Fig. 3. Me vs Me? — Interactive drum performance https://youtu.be/taSawYaJ9YU.

References

Baisnee, P. F., Barrière,
J. B., Koechlin, O., Rowe, R.
1986. Real-time Interaction between Musicians and Computer: Live Performance Utilisations of the 4X Musical Workstation. In: ICMC 1986 Proceedings, pp. 238-239.

Cage, John
1937. *The Future of Music: Credo.*

Chadabe, Joel
1984. *Interactive Composing: an Overview.* In: *Computer Music Journal Vol. 8, No. 1*, pp. 22-27. DOI: 10.2307/3679894.

Guerri, Alessandro
2015. *AGUMENTA - an interactive drumming experience.* https://www.youtube.com/watch?time_continue=6&v=oQtuLBVuv64

Hoffman, G., Weinberg, G.
2010. *Gesture-based Human-Robot Jazz Improvisation.* In: IEEE International Conference on Robotics and Automation, pp. 582-587.

IRCAM Ressources
1997. *George Lewis.* http://brahms.ircam.fr/george-lewis#bio, http://brahms.ircam.fr/works/work/10042/.

Kapur, A., Tzanetakis, G. et al.
2006. *Towards the One-Man Indian Computer Music Performance System.*

Kapur, A
2010. *Experiments with ESitar, Electronics, Robotics, and Animation*. https://www.youtube.com/watch?v=l8UsRkWhNa4

Lewis, George E.
2000. *Too Many Notes: Computers, Complexity and Culture in Voyager*. In: *Leonardo Music Journal, Vol. 10*, pp. 33-39.

Lewis, George E.
2018. *Why Do We Want Our Computers to Improvise?* https://www.youtube.com/watch?v=wDP8FsjyCaA CTM Festival.

Michalakos, Christos
2012. *The Augmented Drum Kit: an Intuitive Approach to Live Electronic Percussion Performance.* ICMC

Rowe, Robert
1990. Feature Classification and Related Response in a Real-Time Interactive Music System. In: ICMC 1990 Proceedings, pp. 202-204.

Steinbeck, P.
2019. George Lewis's Voyager. In: The Routledge Companion to Jazz Studies, Routledge, pp. 261-270.

Stockhausen, Karlheinz, Jerome Kohl
1996. *Electroacoustic Performance Practice.* In: *Perspectives of New Music Vol. 34, No. 1*, pp. 75-105. DOI: 10.2307/833486.

Varese, Edgard, Chou Wen-chung
1966. *The Liberation of Sound.* In: *Perspective of New Music Vol. 5, No. 1.* DOI: 10.2307/832385.

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Current

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Keywords: Live Streaming, Volumetric Cinema, AI, Deep Fakes, Personalized Narratives.

Current is a speculation on the future of broadcasting cinema. It emerges from the intersection of contemporary trends in live streaming culture, volumetric cinema, AI deep fakes and personalized narratives. The film *Current* is an experiential example of what this cinema might look and feel like within a few years based on the convergence of these trends. Artificial intelligence increasingly molds the clay of the cinematic image, optimizing its vocabulary to project information in a more dynamic space, embedding data in visuals, and directing a new way of seeing: from planar to global, flat to volumetric, personal to planetary.

Fig. 1. A scene from *Current* using volumetric techniques.

Description

In the contemporary contestations of algorithmically recommended content, the screen time of scrolling between livestreams has become a form of new cinema. *Current* experimented with various AI image processing technologies and volumetric environment reconstruction techniques to depict a future where every past account has been archived into an endless stream. Made in 2019, *Current* is a volumetric film encompassing front page stories that had happened around the world in the same year, which were broadcasted in real-time using livestream media technologies.

Livestream is a new form of moving image, to which its content is generated and broadcasted simultaneously. Its real time quality gives rise to an attention economy that circulates values distinct from traditional moving image media, such as movies and television. First, it encompasses extraordinary moments alongside an infinite feed of the mundane, suggesting a sense of 'truth' to its audience. Second, instead of having to sit in for a standardised amount of time, the quality of mundane in livestream allows its audience the freedom to step in and out of the stream at any moment. Third, it allows a participatory authorship, where the interaction between the audience and streamer collaboratively directs, narrates and curates the experience.

Volumetric cinema is the perceiving of information in a 3 dimensional space. Instead of compressing our 3D world onto 2D plane, technologies such as point cloud and 3D reconstruction techniques record and project data in 360 degrees, which minimises the reduction of the complexity of the image data. It is a form of cinema that is immersive as well as expansive—there is no negative space in any scene, there is no behind the camera. When coupled with livestream, it has the potential to preserve every detail of every past occurrence in full scale, directing a new way of perception, from planar to global, flat to volumetric.

The outsourcing of imagination to AI can most readily be observed in the cultural phenomena of deep fakes and deep dreams. The project experimented with generative adversarial network (GAN) and autoencoder to simulate visuals that are uncanny to the mind. These neural networks allow the compositing of multiple visual data inputs, generating infinitely long single takes that redefine the cinematic cut. Along these lines, 'Current' seeks to configure a new aesthetic vocabulary of cinematology, expanding the spectrum of aesthetic semblance and intelligence, questioning truth and identity in contemporary urban phenomena. Such image content in turn can be personalised for the training of AI, for machine vision to learn the clustering of information and semantically labeling objects within the moving image.

Current experimented with a range of digital technologies that are readily available to any individuals (i.e. livestream data, machine learning, 3D environment reconstruction, ubiquitous computing, pointclouds). It developed a production pipeline using distributed technologies, which provide a means for individuals to reconstruct, navigate and understand event landscapes that are often hidden from us, such as violence in protests, changes in nordic animals behaviors, the handling of trash, etc.. History, from Latin 'historia', means the art of narrating past accounts as stories. What will be the future of our urban environment if every single event is archived in realtime to such accuracy that there is no room for his-story? This implies an economy of values, that has potential in multiple streams beyond social media, as the content deep learns from itself.

Fig. 2. Scenes from the film *Current* that were made using livestream data, volumetric reconstruction techniques, pointcloud technologies and AI image processing algorithms.

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Environment Built for Absence (an Unofficial/Artificial Sequel to J.G. Ballard's *High Rise*)

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Keywords: Artificial Intelligence, Machine Learning, Photogrammetry, Digital Storytelling, Urbanism, Science Fiction.

This video installation creatively imagines how we relate to urban landscapes and histories through the mediating agency of new technologies. How do we see, feel, imagine, and talk about the city in this post-digital era, when there are indeed non-human/machine agents similarly trained to perceive urban spaces? This project explores these questions, as well as emerging relationships with drone/computer vision and A.I.

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Returning to the Dutch statistics building, I imagined many ways of seeing this empty concrete shell. The train, reconfigured as a motorized camera on rails, provided one kind of image: a repeated panorama from right to left, channeling the penultimate scene from Tarkovsky's *Nostalghia*. But perhaps a different kind of prosthetic vision would give me access to the complete picture.

Each month over the duration of the following year, I exited the train and walked to a hilltop across from the building (in Holland, a 15 meter-high mound is sufficient to be considered a hilltop). From there, an automated drone loaded with GPS coordinates followed a repeated pattern above the site, capturing 250 images each time. This specific photographic program—the flight path, the tilt of the camera, the exposure, the overlap of each image—effectively scanned the entire grounds, and over the course of 2018 created an archive of 3D models documenting the structure's slow collapse.

What did these photogrammetric images represent? From the train and from the drone, I observed this fenced-off section of the city from a distance. Back at my studio, however, I could remotely explore the building from the ground up—zoom in, look around corners, enhance. A virtual camera on the first floor provided closeup details of concrete rubble and piles of broken windows accumulating beneath the exterior. A wide-angle camera above the model framed the path of the excavator's movements on the top floor. I could see the residue of the demolition crew's labor, but the scenes were completely absent of any human form (photogrammetric scans generally won't capture moving objects such as people, cars, or trees blowing in the wind). This absence and the hollowness of the gutted building were echoed by the logic of the 3D renders—glitchy surfaces with only an implication of presence or solid structures beneath.

As I continued to explore these empty virtual spaces, I found my internal narration once again assuming the voices of filmmakers and authors—artists who conjured similar images in their work, and thus impacted my perception of said images. The concrete, the building, and the desolate grounds all registered as settings for some unwritten Ballardian novel. How did J.G. Ballard craft such environments while exploring the psychological effects of urban decay, impending climate catastrophe, or social isolation in future landscapes? How would Ballard's ghost navigate this terrain?

Not intending to directly answer these questions, but rather to investigate the mediatic voices that lurk around the periphery of my thoughts, I proceeded by training an Artificial Intelligence system to speak like J.G. Ballard.[1]

1. A detailed description of *Environment Built for Absence* was recently published for Strelka Institute for Media, Architecture, and Design: *A.I. at Urban Scale* https://strelkamag.com/en/article/tivon-rice-neural-narratives.

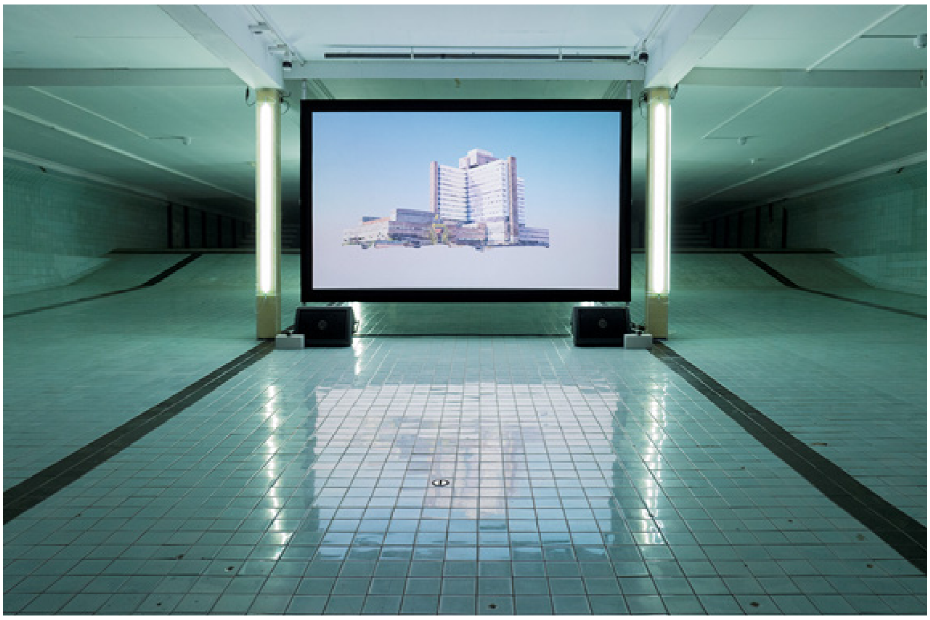

Fig. 1. *Environment Built for Absence (an unofficial/artificial sequel to J.G. Ballard's "High Rise")* – 2018 – HD Video – Duration: 17'45" (installation view).

Fig. 2. *Environment Built for Absence (an unofficial/artificial sequel to J.G. Ballard's High Rise).*

Fig. 3. *Environment Built for Absence* (screen capture).

Fig. 4. *Environment Built for Absence* (screen capture).

Link to complete documentation: http://www.tivonrice.com/absence.html
Link to trailer: https://vimeo.com/320700941
Link to full film: https://vimeo.com/298879155

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Spectral Choreography #2

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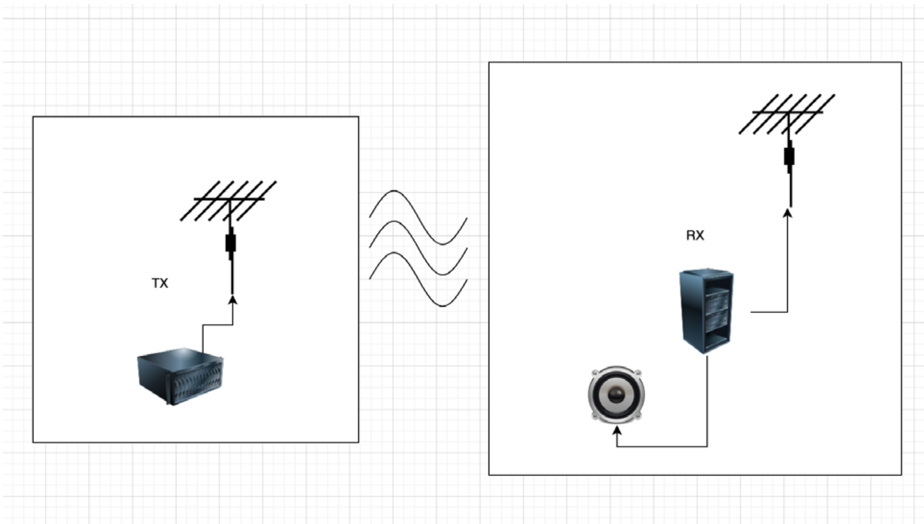

Keywords: Robert Barry, Radio, Electromagnetism, Abstraction, Exhibition Space, Medium, Sculpture, Human Senses.

Abstraction always required a medium to emerge in and from. *Spectral Choreography* pronounces the exhibition space as that medium: an active membrane through which information flows, occasionally yielding discernibility, then flowing on. Cocooning physical conditions, electromagnetic radiation and viewers, this active membrane makes observation part of a process of constant adaptation, a practice involving the human-body as a whole, but none of its senses.

Description

Among the works presented in "January 5 – 31 1969" at Seth Sieglaub Gallery in New York was Robert Barry's *88mc Carrier Wave (FM)* and *1600kc Carrier Wave (AM)*. Both works comprised of concealed batteries and transmitters that broadcasted invisible waves of electromagnetic energy into the exhibition space. These waves were not only invisible but also undetectable by other modes of human perception. Though the waves could be identified by use of a common transistor radio, the likelihood of a visitor to the exhibition conducting such a task was slim, forcing the visitor, upon encountering two wall labels that detailed the presence of carrier waves, to accept Barry's concept on faith. In doing so, vision became contingent and made temporal, and, in the case of a visitor to the space of the exhibition, it was made self-conscious by there being nothing visible to see. Any autonomy of the artwork was shifted onto the viewer and his/her perception of the artwork.

In keeping with the logic of the work itself, the photographic documentation remaining from these early pieces shows an empty gallery space free of any indicator of the existence of the carrier waves, the reality of such found only by reading the caption of the documentation. What these documents provide is a static extension of Barry's conceptual program: just as the viewer, once made aware of the carrier waves, becomes self-conscious of the act of looking, so too the visible documentation raises the possibility of aesthetic experience enabled by becoming conscious of the invisible energy in the gallery.

With viewer (or observer) consciousness tentatively attuned to the conceptual possibilities of electromagnetic radiation within the exhibition space, how does an artwork reframe the aesthetic possibilities of electromagnetism? How does an artwork make manifest patterns and activities that the human sensorium is simply unequipped to process? And how can such patterns and activities, in and of themselves meaningless to the hydro-carbons that we are, be yoked to make meaning? To pronounce the use and utilization of the electromagnetic spectrum *Spectral Choreography* comprises of a transmitter, a receiver and speaker, all intended for physical installation within the main exhibition space.

While taking Robert Barry's work as a point of departure, the transmitter in *Spectral Choreography* will not be limited to any one frequency. Rather, it will be programmed for an infinite transmission run with pseudo-random alternations between all commercially-approved and ITU-approved amateur radio frequencies. Similarly, the receiver will also be programmed for pseudo-random frequency alternations on the same sections of the spectrum, resulting in an irregular and unpredictable pattern of information-reception. Importantly throughout the run of the exhibition, the information or modulation transmitted on the various wavelength alterations in *Spectral Choreography* will maintain consistency, in fact identity, with the wavelengths transmitted (example: 88mc sound carried on an 88mc wave, followed by an 1600kc sound carried on an 1600kc wave, followed by xx sound carried on xx wave, etc. etc. *ad infinitum*).

Fig. 1. *Spectral Choreography #2*, virtual installation view.

Fig. 2. *Spectral Choreography #2*, virtual installation view.

Fig. 3. *Spectral Choreography #2*, virtual installation view.

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Beyond the Canvas/ Bliss

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Keywords: Virtual Reality, Oil Painting, Landscape, Materiality, Interactive, Immersive, Artificial Nature.

In the present day, technology influences human perception and therefore our reality. *Beyond the Canvas-Bliss* deals with the question of how the classical categories of visual art deal with technological progress and the associated changes in perception. Do classic art forms such as painting, photography and sculpture already belong to the past, and if so, doesn't it make these art form superfluous? In *Beyond the Canvas-Bliss*, digital technology is combined with analogue painting and the supposed boundaries between the analogue and digital world are dissolved by the empirical perception of the viewer. The experience of entering a work of art and moving about in it is intended to evoke a new perception of reality.

Description

Technology influences nearly every aspect of human life, of course the arts deal with this increase of a “better living”. As an artist I use new technologies as a tool to depict and at the same time challenge the perception of our “real” life, which of course is already greatly influenced by digital media of all sorts.

However, I want to go one step further, as I illustrate the boundaries between reality and illusion by trying to dissolve or to blur them. Also I want to integrate the viewer into my artwork, let him experience immersion, manipulation and phenomena of perception.

At first glance, the viewer enters a classic exhibition of several oil paintings, moreover he gets invited to enter the painting through an Oculus Rift. Now, objects can be observed from all sides; one can enter a new landscape or look out the window, take a peek behind the image objects and reveal the hidden. An experience which sounds like a help to escape reality, rather corresponds with the desire for unification of two worlds and the dissolution of the picture frame; which also represents my original idea: The creation of a walk-in painting.

The painting itself, which serves as a door to the virtual world, is a translation of 3D objects on a plane surface, the spatiality is nullified. They seem like some kind of template or construction paper, which is determined by the optimum use of space. The mentioned painted objects are digitized with a 3D scanning technology, translated by a program to a point cloud, from which in turn a 3D model is reconstructed.

Beyond the Canvas: Bliss

Bliss—a door to a new perception of reality, which should be seen as a following part of the series *Beyond the Canvas*, shows nothing more and nothing less than the default computer wallpaper of Microsoft´s Windows XP. A familiar photograph to nearly every computer user since 2001, showing the perfect countryside of California, shot by Charles O’ Rear. I chose that picture as a template for my sujet as it is.

The viewer confronts himself with a classic landscape oil painting. With the help of contemporary technology (VR-headset, 3D-Scan etc.) I try to invite the viewer to exit their comfort zone and to enter Bliss. Interesting to me is the question of how the classical two-dimensional painting is perceived after attending the three-dimensional virtual image world. To which extent changes the image reception or even the perception of the real world?

In the light of rapid technological progress, man shows the tendency to equate images with reality; hence the desire for ever more realistic images and a high degree of immersion.

The head mounted display is used to dissolve the classic picture frames, and to furthermore give the viewer the feeling of free movement within the painting.

Also, the issue shows the wish to merge our real life with the cyber world, maybe this is our new reality—a state of perfect happiness.

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What the Robot Saw

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Keywords: AI, YouTube, Social Media, Ranking Algorithms, Computer Vision, Machine Learning, Amazon Rekognition.

What the Robot Saw (http://what-the-robot-saw.com) is a continuously generated livestream and archive. The Robot depicts people and scenes it encounters online in an imagined cinematography style—as its computer vision and AI algorithms obsessively perceive them. Video clips within the stream are selected from among the least-viewed and least-subscribed videos on YouTube within the past several hours. People framed in closeup are identified in lower-third text with Amazon Rekognition's analysis of their mood, gender, and age—ironically simplistic consumer identifiers. The streamed film reveals content normally only seen by robots and more broadly responds to processes of performance and representation in the increasingly blended online and offline culture.

On Social Media Algorithms and [In]visible Selves.

Social media ranking algorithms are driven by engagement metrics: some combination of viewer attention and interaction measurements. These algorithms dictate what videos are seen by the public. Some types of videos—"crowd pleasers"—get more visibility than others. Seasoned "YouTubers" with the knowledge and inclination to strategize their work for algorithmic appeal can maximize their visibility. And algorithms can actively perpetuate stereotypes by rewarding YouTubers for producing demographically stereotypical content (Bishop 2018)—performing selves for the camera that algorithms favor.

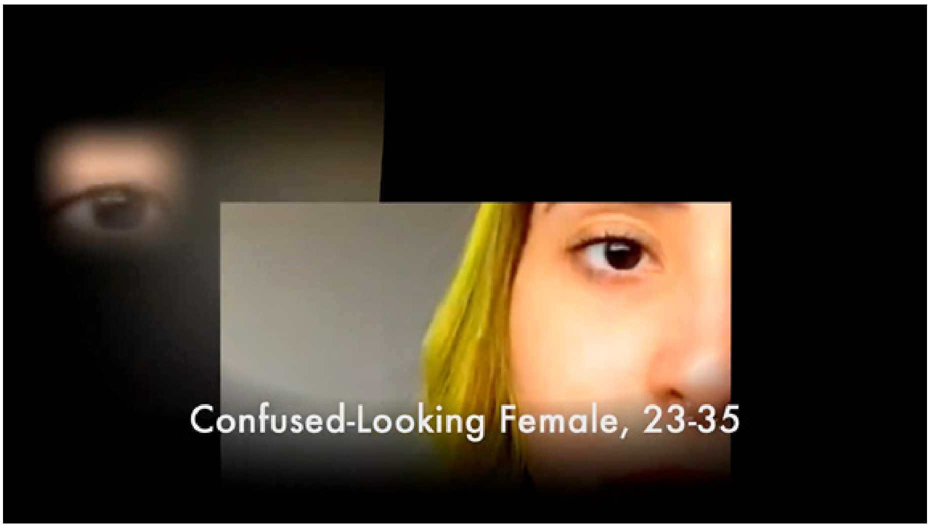
As a result, videos by ordinary people are often seen by few or no human eyes; as with many contemporary human actions, robots may be the main audience. *What the Robot Saw* (http://what-the-robot-saw.com) is the imagined point-of-view of one such robot. The content is curated using algorithms that run counter to standard commercial ranking algorithms: only videos with low view counts and channel subscriber counts are included. The real-time cinematography derives from the fanciful directorial style of the Robot, as it pans, zooms, greyscales and edge-detects, in the process of interpreting video images. Behind the scenes, computer vision and neural networks filter undesirable clips and edit selected clips, then organize the clips into a stream-of-consciousness linear structure, focusing on subjects determined to be "talking heads."

The film livestreams back to the internet nearly continuously as it is generated.[1] Streams are archived and linked to the Robot's Videos page (http://what-the-robot-saw.com/video-samples/). The massive archive functions as both durational robot performance and evolving time capsule.

When the Robot detects talking head videos, it uses Amazon Rekognition, a popular commercial facial recognition service, to estimate age, gender, and mood as displayed in facial expression. These are the features Rekognition and similar surveillant services provide—features marketers presumably seek. These characteristics are then superimposed over the video image where viewers might expect to see an interview subject's name and occupation. The juxtaposition of complex human faces and first-person narration with the Robot's simplistic labels suggests the problematic nature of framing complex people according to such characteristics.

1. Periodic intermissions occur for software and hardware restarts, maintenance, etc.

Fig. 1. Screenshot http://what-the-robot-saw.com/photos.



What the Robot Saw is not a Pedagogy of *How* Robots Actually See.

The project's title is a play on the expression "what the butler saw"—an allusion to early peep show films in which a voyeuristic butler spied through a keyhole[2] (Camerani 2009, 115). Both the Robot and "the butler" saw something they weren't supposed to see. But they could only peer at the object of their obsession through a keyhole (metaphorical, in the Robot's case.) Neither the butler nor the Robot could have a meaningful perception of the people on whom they spied.

Luciano Floridi writes that "the micro-narratives we are producing and consuming are also changing our social selves and hence how we see ourselves. They represent an immense, externalized stream of consciousness…" (Floridi 2014, 62) *What the Robot Saw* is on the one hand about unseen content. But it's more broadly a response to the contemporary tangle of processes of human and robot presentation and representation -- of online and offline selves performed and perceived.

2. The expression actually dates back to the late nineteenth century London divorce case of Lord Colin Campbell and Gertrude Elizabeth Blood: their butler testified that he had peered through a keyhole and spied Blood with another man. In the early twentieth century the name was used for both mutoscope "peep show" machines and the moving pictures they played. Since the mid-twentieth century the expression has been used as a title for various films, plays, and television shows, usually with only a figurative connection to the original theme.

Available at: http://what-the-robot-saw.com
Video Clips and Archives: http://what-the-robot-saw.com/video-samples/

References

Bishop, Sophie.
2018. Anxiety, panic and self-optimization: Inequalities and the YouTube algorithm. *Convergence*, 24(1), 69–84. https://doi.org/10.1177/1354856517736978

Camerani, Marco.
2009. Joyce and Early Cinema: Peeping Bloom Through the Keyhole. In Joyce in Progress: *Proceedings of the 2008 James Joyce Graduate Conference in Rome* (pp. 114-28). Cambridge Scholars Publishing.

Floridi, Luciano.
2014. *The Fourth Revolution: How the Infosphere is Reshaping Human Reality.* Oxford University Press UK.

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Convoluted Alterity

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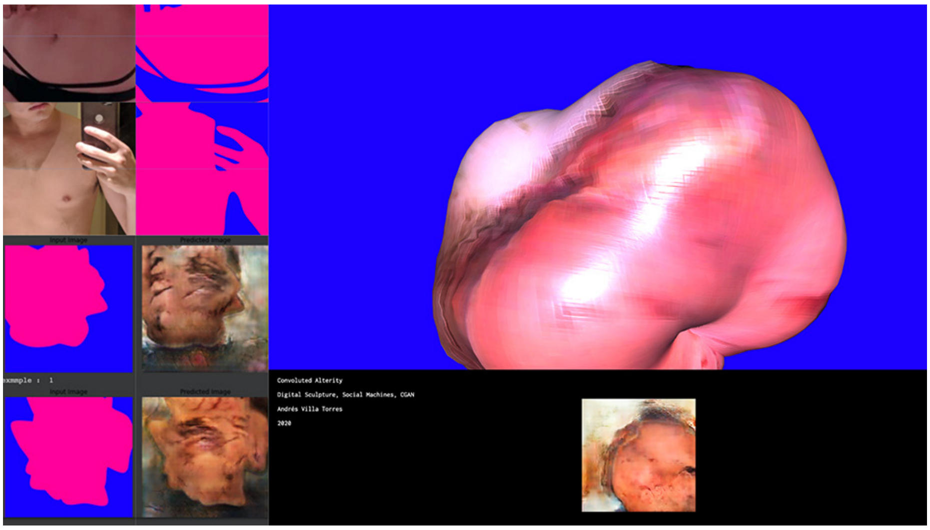

Keywords: Alterity, cGAN, Tinder, Image-to-Image, Data Scraping.

Convoluted alterity is an exploration of sameness using self-portraits retrieved from anonymous accounts from the online dating network Tinder. The pictures are scraped with algorithms through the API. An ML model is trained using the retrieved set of images and their color-labeled pairs, aiming to extract human skin regions. The model generates multiple depictions resembling features from the training dataset. The result is a series of still portraits and a generative morphing depiction of an artificial alterity.

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Description

This work is part of an exploration of human agency within online dating networks. While understanding human agency as the capacity of the individuals to act autonomously and to experience the impact of one's own free choices, I dare to suggest that human agency is, and perhaps it has always been, on a perpetual path to obsolescence through a continuous and inevitable merge with other forms of agency. These other forms recognized as alterity go beyond the individual, the human, the machinic and the material. The agonizing process is observable in the everyday forms of ephemeral media, of transient relations, of short-lived attention, of the never-ending representation crises. The inescapable anxiety relies on the denial that the human individual might have always been a construct, hence an illusion. Current state of the art machine learning technologies, allow to generate photo-realistic portraits from people who doesn't exist, that are hard to distinguish from real ones. These images are generated thanks to a machine learning model-training process that integrates hundreds of thousands of portraits of real humans. Currently, these styles of machine generated imagery is being used for all sorts of commercial and political purposes, so far without any moral or ethical concerns, as it is claimed that non-real, "imaginary" or imagined-by-GAN's people isn't really affecting any real human directly[1]. The question then arises as to what are the role and implications of these new others and what is left there for the originals?

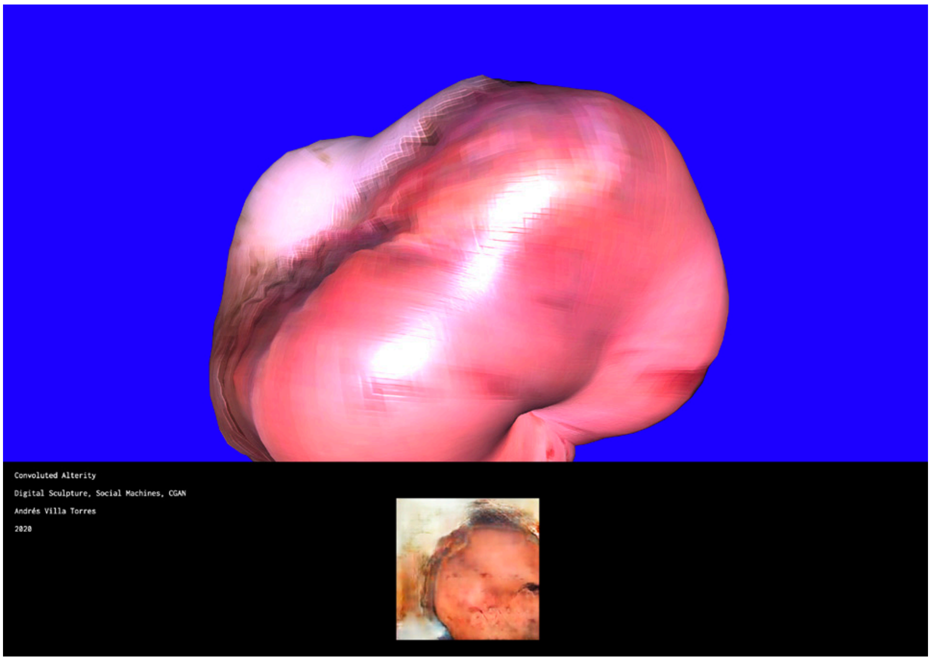
Convoluted alterity explores the aesthetics of sameness, using self-portraits retrieved from the popular online dating network Tinder, where people represent themselves in order to become part of an offer of desirable beings. I extract these pictures using scraping algorithms, which I have developed as part of my doctoral research and artistic processes[2] in order to conduct data scraping from specific users over the Application's API. The portraits are manually manipulated in order to mark label-regions with RGB color-coded blobs that allow a cGAN model[3] to distinguish which parts of an image are the fragments corresponding to the self-curated human shells. On one side of the installation, the edited portraits are presented as still images inviting the viewer to speculate about who of all the possible beings could fill the uncanny void from the missing pixels. On the other side of the installation, the trained model dynamically depicts some of the possible ways in which the other and the same co-exist. The boundaries between the individuals are erased, the empty shells melt through the poetics of convoluted imagery. The produced imagery is projected as a UV Map on an amorphous blob.

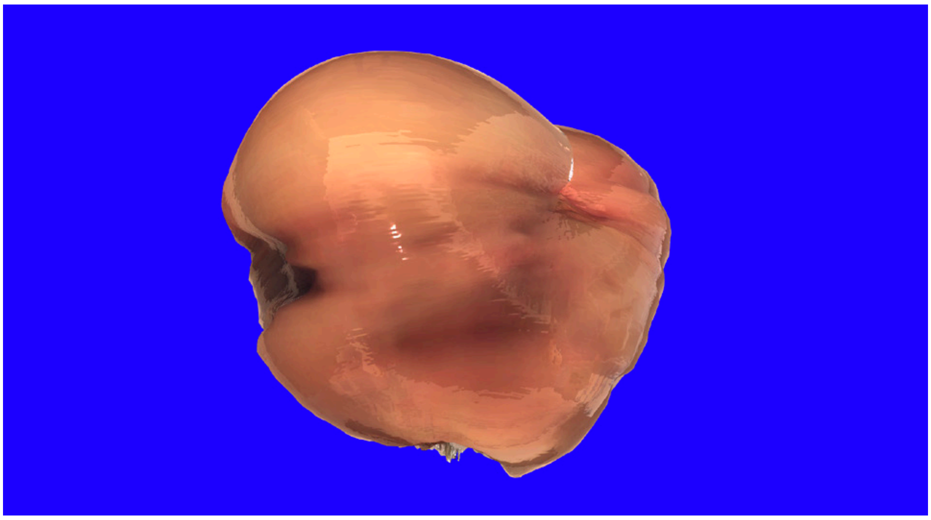
1. Generated Photos commercializes "worry-free" model photos. The technology behind it is a machine learning model called StyleGAN (Dec 2018, Karras et al. and Nvidia). https://generated.photos/

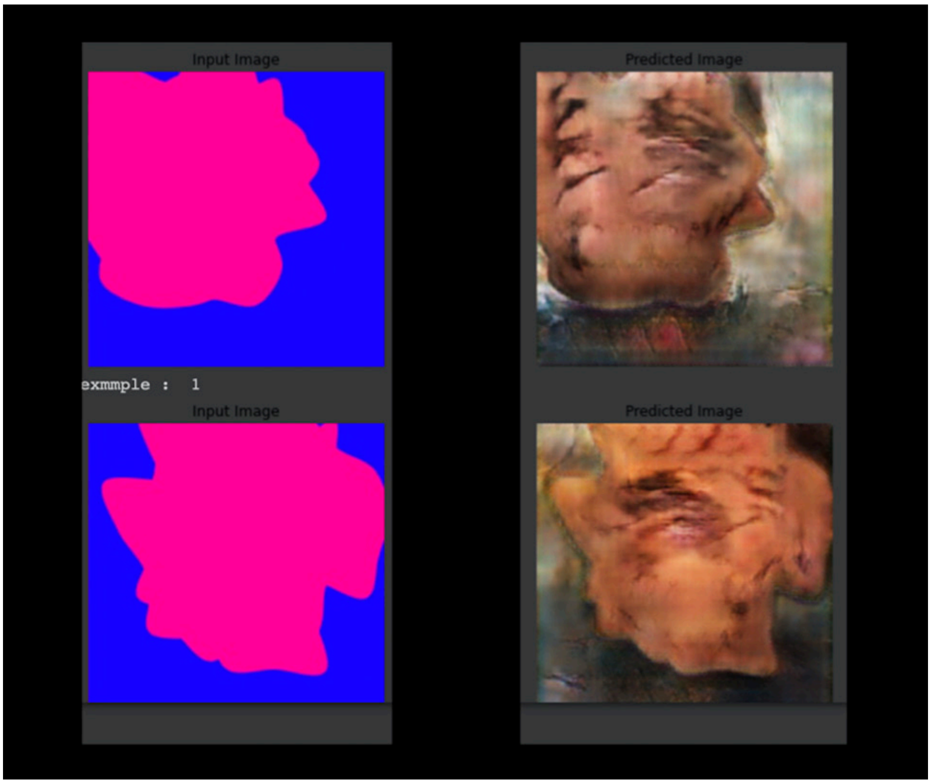
2. Tinder Scraper: https://github.com/andresvillatorres/tinder_light_scraper

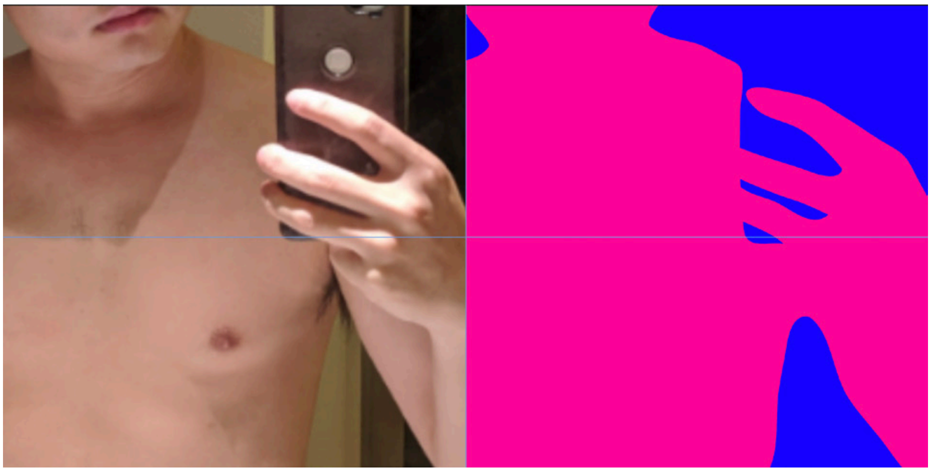
3. The cGAN model proposed is based on the pix2pixHD model form NVidia and the styleGAN https://github.com/NVlabs/stylegan2. An implementation of it is available for RUNWAYML https://github.com/andresvillatorres/convolutedAlterity

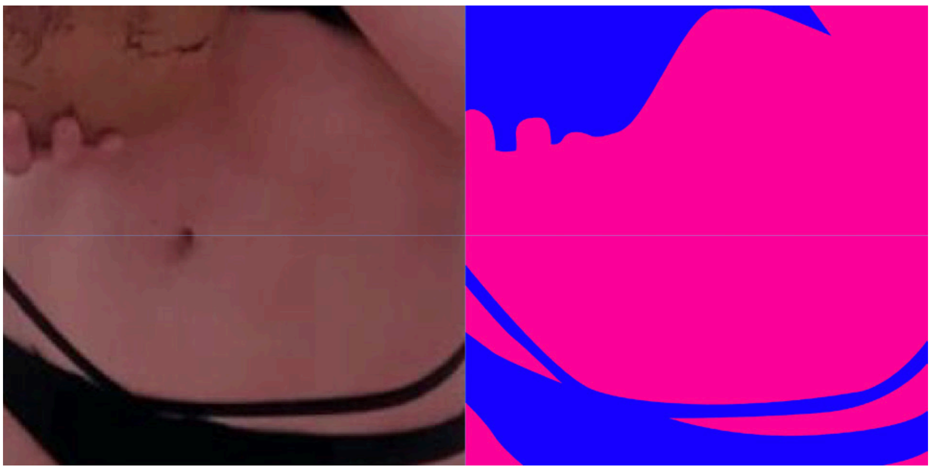
Fig. 1. 2. 3. 4. 5. 6. Samples of the portraits scraped from the Online Dating Network Tinder and the Generated Imagery. The visible skin on the human portraits is masked by the artist in order to allow the model to be trained with the pixels corresponding to the color labeled regions.











Online Version of the Installation: https://labor5020.ch/convolutedAlterity

References

Baudrillard, Jean.
1990. *Xerox and Infinity.* In *The Transparency of Evil.* Verso Books. Pp. 57–66.

Condie, Jenna, Lean, Garth and James, Donna.
2018. Tinder Matters: Swiping right to unlock research fields. In C. Costa & J. Condie (Eds.) *Doing Research In and On the Digital: Research Methods across Fields of Inquiry*. London: Routledge.

Isola, Phillip, Zhu, Jun-Yan, Zhou, Tinghui. Efros, Alexei A.
2016. *Image-to-Image Translation with Conditional Adversarial Networks. Computer Vision and Pattern Recognition.* Cornell University. Retrieved online: https://arxiv.org/abs/1611.07004.

Gestures #2–#4

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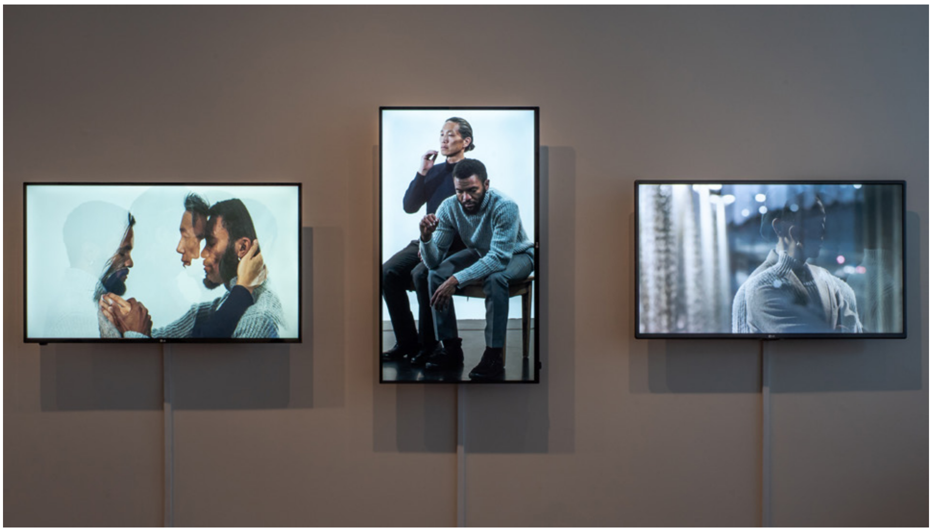

Keywords: Generative Film, Dance Video, Media Art, Installation.

Gestures #2–#4 is a triptych of algorithmically-composed dance films that research the encoding and decoding of progress, history, and memory in the body. The performers' personal memories provide source material for dozens of performances of three simple gestures, each an investigation of the physical imprint of progress and history on a personal relationship. Algorithms endlessly sift through recordings of the performances, disarranging the roles of encoder and decoder between the performers, computer, and the viewer. *Gestures #2–#4* comprises a "nostalgic technology," longing for an alternate history in which technology expands the possibilities of human intimacy.

Description

As two people pass on the street, a curl of a lip may denote contempt at the other's misfortune, while a lingering glance may imply perceived familiarity. Our gazes, gestures, postures, etc. are traces of our histories, telling stories of displacement, oppression, kinship, and resistance. *Gestures #2–#4* decode these invisible structures as a computer overlays and juxtaposes videos of dozens of short dance performances, engaging in a semi-improvised performance of its own. The computer acts as an inscrutable and error-prone decoder, an unreliable guide through documents of the performers' memories.

Fig. 1. *Gestures #2–#4*, installation view.

Gestures #2–#4 is deliberately imperfect and even buggy. Drawing upon Svetlana Boym's concept of a "nostalgic technology," (Boym 2006) the algorithm of *Gestures* is my expression of longing for an imagined time, where technology is conceived as a tool of human understanding, intimacy, connection, and beauty.

The algorithm's capacity for surprise is embraced, providing a new, inhuman perspective on the performances, and throwing their humanity into relief. Rather than emulating how a human might compose the video, this algorithm is particularly "computerly" in its basis on the humanly unpredictable math of a pseudo-random number generator. Early versions of the algorithm attempted emulations of human processes using semantic data and techniques drawn from AI. In the end, however, these were replaced with simple randomness and decision trees. By exercising less control over the computer's logic, more opportunities for true surprise were found.

Fig. 2. *Gesture #2*, still.

The computer finds juxtapositions of movements a person might not—sometimes unison choreographies, sometimes contrasting postures that seem to hang in time. Overlaid performances expose multiple concurrent memories of an experience that may agree or disagree, confounding the viewer's desire to resolve their understanding of the performers' experiences. This capacity for surprise—sometimes pleasant, sometimes frustrating—suggests both a new way of looking at the dances, as well as a different set of expectations for our relationships to machines.

Fig. 3. *Gestures #2–#4*, installation documentation https://vimeo.com/292024810

My approach to the algorithm interleaves with a choreographic scoring process that, based on my work with Anna Halprin, prioritizes the performers' personal histories and perspectives—reinforcing opportunities for surprise and new directions. Where we entered the workshops with an abstract theme of physical gesture as an encoding of history, the experiences Sherwood Chen and Gabriel Christian brought to the work refined it into a specific almost-narrative of intimacy, alienation, and nostalgia for what was or could have been. This almost-narrative only coalesced upon viewing the final pieces, and was a surprise to everyone involved.

This moment of surprise was a moment of realization of the traces of history encoded in specific bodies and the interactions between them. This encoded history is a narrative of the accretion of power, as Walter Benjamin would have it. “There has never been a document of culture, which is not simultaneously one of barbarism” (Benjamin 1969). The document Benjamin references is not only our art and history books, but our bodies. Its words are encoded in our every movement, even in our moments of intimacy and ecstasy.

Installation Documentation: https://vimeo.com/292024810

Acknowledgements: Sherwood Chen and Gabriel Christian performed the dance pieces. Nai Saeyang assisted location scouting and shooting.

References

Boym, Svetlana.
2006. *Nostalgic Technology: Notes for an Off-modern Manifesto.* Cyprus: NeMe.

Benjamin, Walter.
1969. *Theses on the Philosophy of History.* Trans. Harry Zohn. New York: Schocken Books.

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TransparentPerceptron: Visualizing the Perceptron's Decision Iterations

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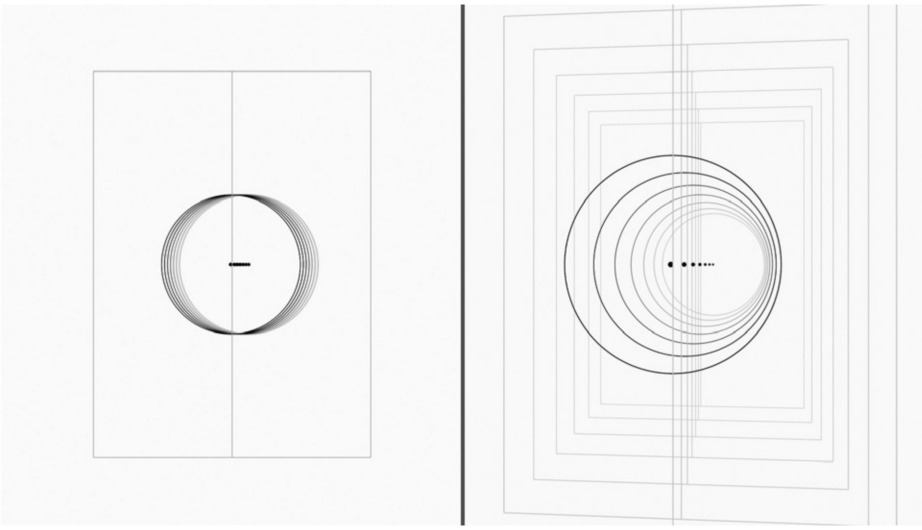

Keywords: Machine Learning, Perceptron, Decision-making, Black Box, Visualization, Aesthetics.

As Multi-layered Perceptrons deepen, the number of their layers increases, as can the number of Perceptrons per layer. This rises the number of decision iterations developing an iterative complexity in the decision-making process of these systems, thus turning them into black boxes. Although the scientific community has been designing illustrations of the inner workings of Multi-layered Perceptrons, we find that these lack explainability and connection with the non-scientific community. Considering these illustrations, the opacity of the decision-making and the omnipresence of these systems, we developed an algorithmic data-driven visualization of a Perceptron to display its decision iterations to non-specialist observers.

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Description

Multi-layered Perceptrons (MLP), also widely known as Artificial Neural Networks, are one of the most used subsets of Machine Learning (ML) systems. They are inspired by the neural structure of the biological brain and consist of a series of layered and interconnected Perceptrons, also referred to as Artificial Neurons. These Perceptrons perform calculations on received data and send the results to a following layered group of Perceptrons (Baraniuk 2018), a procedure that is repeated until the output layer is reached (Mordvintsev et al. 2015). It is important to note that not all layers may perform the same calculations (Baraniuk 2018).

As MLPs grow deeper, the number of their layers increases, as can the number of Perceptrons per layer, which consequently rises the number of calculations or decision iterations (Mordvintsev et al. 2015). This increment in the number of iterations develops an iterative complexity of the decision-making process of these systems, turning them into black boxes (Strobelt et al. 2019).

Although the scientific community has been designing technical illustrations of the inner workings of ML systems, we find that these do not communicate compellingly with general audiences. Furthermore, they also do not reveal the decision-making process, failing an effective explanation for the non-scientific community (Doshi-Velez et al. 2017; Miller 2018; Hall et al. 2018).

Observing the inefficiency of the aforementioned illustrations, the decision-making opacity and omnipresence of these ML systems, led us to research and develop an algorithmic data-driven visualization, for the non-specialist observer, of the most elementary system of an MLP: the Perceptron.

This model initiates with two random weights, one that receives a random horizontal position and the other a bias value. During execution, this system runs a sequence of: 1) summing the weighted inputs 2) passing this sum to an activation function 3) calculating the guessing error; and finally, 4) adjusting each referred weight towards the goal achievement (Shiffman 2012).

The execution sequence of our system develops an iteration array, storing the results of the calculations of each system step at each iteration. These stored values are used to feed a step-by-step composition consisting of an ellipse and a referenced center point, per iteration. Each step of this visualization reveals an updated position of the horizontal coordinate of the ellipse, a graphical representation of the calculations it has undergone at each iteration. Each graphical iteration is blurred with a value associated with the distance between the Perceptron's guess and the system's goal. All of this occurs in a vertically divided interface, where the left panel represents negative values and the right panel shows positive values.

After the Perceptron's decision iterations layering, a three-dimensional view is suggested. When clicked, a spatial gap is opened between each layer, allowing for a contemplation of each decision iteration.

Although we recognize that the decision-making process is not fully revealed, we believe that this artifact plays a significant role in allowing passive observation (Strobelt et al. 2019) and interpretation of the Perceptron's accumulated iteration calculations.

Available at: https://marcoheleno.gitlab.io/projects/transparentperceptron/

Acknowledgements: This work is funded by FCT grant PD/BD/150328/2019 and FCT/MCTES NOVA LINCS PEst UID/CEC/04516/2019.

References

Baraniuk, Chris.
2018. *For AI to Get Creative, It Must Learn the Rules—Then How to Break 'Em*. Scientific American. Available at https://www.scientificamerican.com/article/for-ai-to-get-creative-it-must-learn-the-rules-mdash-then-how-to-break-lsquo-em/.

Doshi-Velez, Finale and Been Kim.
2017. *Towards a rigorous science of interpretable machine learning.* arXiv. Available at https://arxiv.org/pdf/1702.08608.pdf.

Hall, Patrick and Navdeep Gill.
2018. *An Introduction to Machine Learning Interpretability.* California, USA: Safari Books Online, LLC. Available at www.safaribooksonline.com/library/view/an-introduction-to/9781492033158/.

Miller, Tim.
2018. *Explanation in Artificial Intelligence: Insights from the Social Sciences.* arXiv. Available at https://arxiv.org/pdf/1706.07269.pdf.

Mordvintsev, Alexander, Christopher Olah, and Mike Tyka.
2015. *Inceptionism: Going Deeper into Neural Networks.* Google Research Blog. Available at https://research.googleblog.com/2015/06/inceptionism-going-deeper-into-neural.html.

Shiffman, Daniel.
2012. *The Nature of Code: Simulating Natural Systems with Processing*. Available at https://natureofcode.com/book/.

Strobelt, Hendrik and Sebastian Gehrmann.
2019. *Interactive Visualization as Mediator Between Human and Machine Intelligence.* Medium, Multiple Views: Visualization Research Explained. Available at https://medium.com/multiple-views-visualization-research-explained/interactive-visualization-as-mediator-between-human-and-machine-intelligence-1cf00d49c77e.

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Coded Archetypes
(New York, Bern, Beijng)

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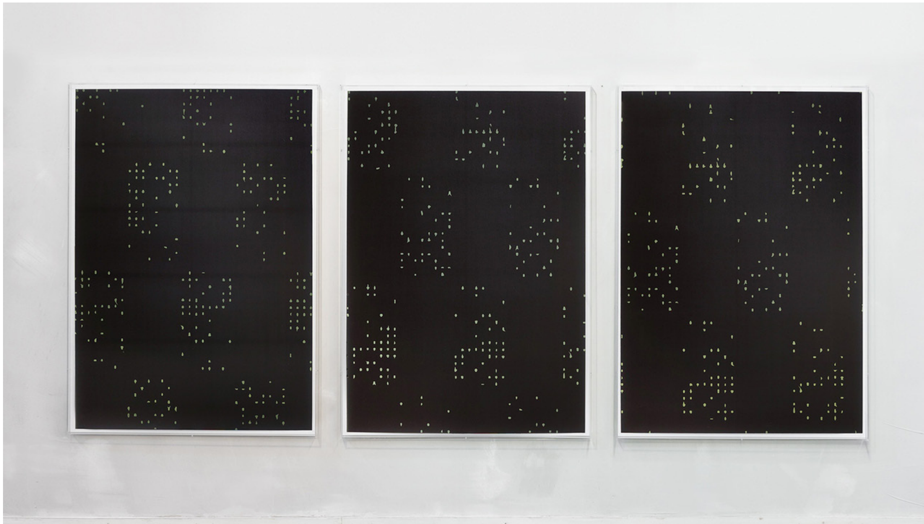

Keywords: Mass graphic reproduction, Machine Identification Codes, Watermarks, Woddcut, History, Algorithms, Aesthetics.

Coded Archetypes (New York, Bern, Beijing) shines a light on aspects of today's mass graphic reproduction that are almost unknown to the general public. At the same time, it's aim is to explore the history, and subsequently the contemporary possibilities of woodcut techniques. As part of a crackdown on crime following the terrorist attacks of 11 September 2001 almost every copier prints a nearly invisible pattern of yellow dots known as a machine identification code on every sheet. Christian Herren used these codes, which can still be found on almost all printouts from conventional laser printers, as a starting point for the *Coded Archetypes* series.

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Coded Archetypes (New York, Bern, Beijng) (2018–2019)

European graphic production reached a high point around 1497/98 with Albrecht Dürer and his large-format woodcut series *Apocalypse*: this graphic series appeared during outbreaks of the plague, peasant unrest and the arrival of religious dissent on the eve of the Reformation. Published as easily understandable guidance for the public at large, in creating the series the artist particularly wanted to provide an understandable visual language and realistic designs. At the time they were published, the sheets were perceived above all as illustrations suitable for a mass audience and less as stand-alone works of art. Today the works are appraised on the basis of historical and artistic criteria and acknowledged as important works. As far as the monetary value of individual sheets is concerned, the smallest details in different prints are decisive: for non-experts, prints from the same woodblock often appear to be identical. However, experts and dealers make a distinction between different proof copies, as the artist often altered the woodblock slightly even after he had printed the first sheets. The art market values the prints according to these print condition criteria. Works which at first sight look identical can have a price difference of several tens of thousands of Euros. The deciding factor could, for instance, be a small hatching which is visible in early prints, but no longer in later ones. Herren's work does not use moralising, biblical motifs as the basis for the prints, but practically invisible yellow dots, which can be found on almost all paper documents printed in the conventional way on a copier. Because almost all laser printers leave a pattern of almost invisible yellow dots on the paper. Originally intended as a protection against counterfeit money, this technique helps nowadays in tracking down criminals. After the traumatic events of 11th September 2001, the US government was able to establish numerous surveillance measures, amongst them these dots. Every page printed with these yellow dots leaves behind traces. Contemplating the possibilities in today's graphic printing techniques, Herren reproduced the yellow dots from 3 different printouts (Bern, New York, Beijing) with a high-tech scanner and processed them digitally. The printing blocks were based on these templates, and CNC machines removed all areas outside the dots, thus creating a relief. The dots were printed on paper coloured black with a toner. To ensure that the bandwidth of «yellow» shades in various laser printers is discernible to the observer, the yellow colour was also removed from printers, for the purpose of colouring and then printing the dot relief. The stars which appear almost kitsch at second glance then become a regular pattern which can be decoded by experts (place of printing, printer model) and the prints suddenly lose their purely visual effect.

Fig. 1. Christian Herren: *Coded Archetypes (New York / Bern / Beijing)*, 2018–19, exhibition view, overall view (Photo: Markus Beyeler).

Fig. 2. Christian Herren: *Coded Archetypes (New York / Bern / Beijing)*, 2018–19, exhibition view, woodcut down on the right site of the installation (one print of the series of Beijing), the Machine identification code-pattern from a Beijing document is printed on black-monochrome, laser-printed copy paper (every woodcut is in a different shade of yellow; an individual, commercially available «yellow» printer toner was used as the colour basis for each woodcut), framed in a acrylic glass box (Photo: Markus Beyeler).

Fig. 3. Inspiration for *Coded Archetypes*: Albrecht Dürer: Apocalypse, 1497/98 (detail).

Fig. 4. Visual accentuation of the yellow dots, which can be found on almost all paper documents printed on a copier.

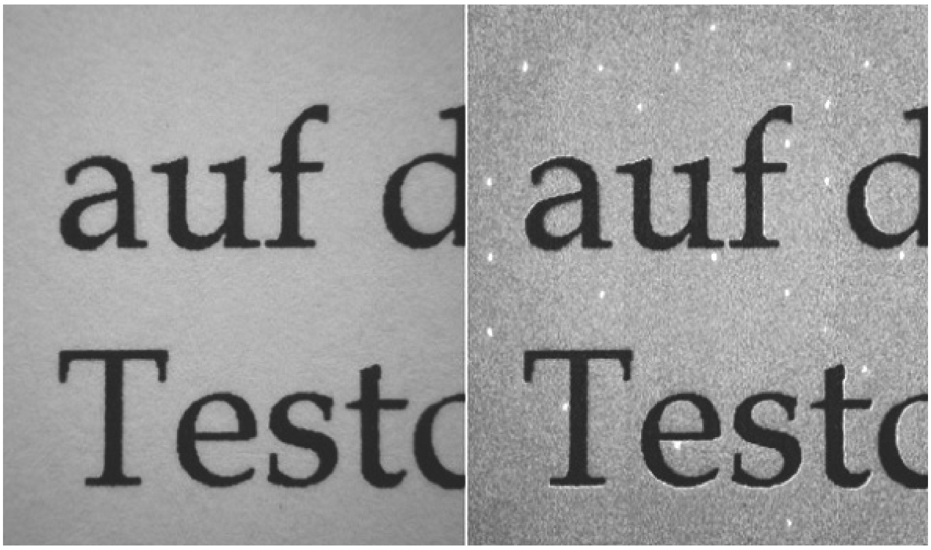

Fig. 5. Post digital printmaking: Christian Herren during the production of the woodblock (using a CNC-machine) for his *Coded Archetypes (New York / Bern / Beijing)* series.

Fig. 6. Christian Herren: *Coded Archetypes (New York / Bern / Beijing)*, 2018–19, exhibition view, overall view (Photo: Markus Beyeler).

Fig. 7. Christian Herren: *Coded Archetypes (New York / Bern / Beijing)*, 2018-19, exhibition view, book about Albrecht Dürer in front of the installation. Dürer was a key inspiration: Experts and dealers make a distinction between different proof copies, as Albrecht Dürer often altered the woodblock of his prints slightly even after he had printed the first sheets. The art market values the prints according to these print condition criteria. Works which at first sight look identical can have a price difference of several tens of thousands of Francs. The deciding factor could, for instance, be a small hatching which is visible in early prints, but no longer in later ones. Herren's work does not use moralising, biblical motifs as the basis for the prints, but practically invisible yellow dots, which can be found on almost all paper documents printed in the conventional way on a copier (Photo: Markus Beyeler).

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Kauschlauch Modulations

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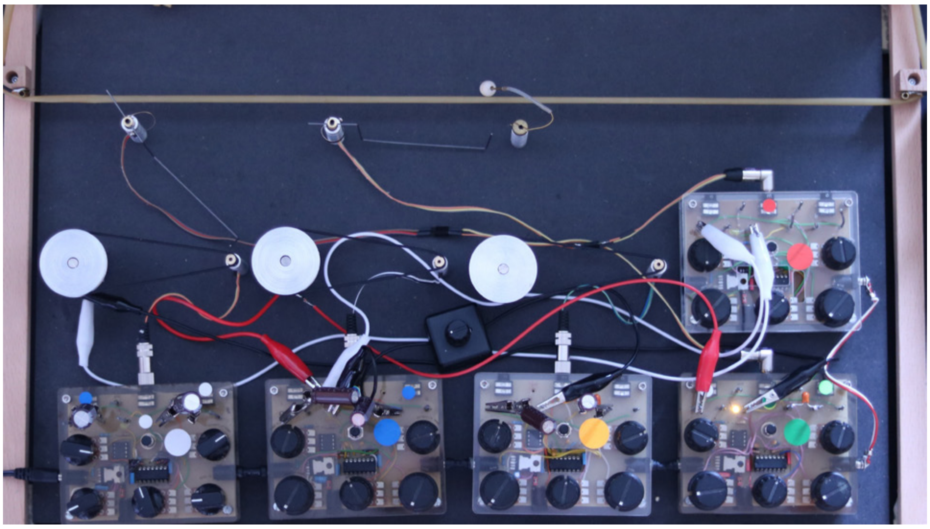

Keywords: Analog, Neural Network, Sound Art, Polyrhythm, Synchronicity.

A chewing tube whose vibrations are picked up and amplified by contact microphones. Motors that bounce on the tube and make it vibrate rhythmically. Network electronics that make the motors vibrate. Motors that vary the conductivity of the network connections. Rhythms that lock onto each other, minimal polyrhythms, continuous drift, rest, constant movement, no standstill. For the installation of *Kauschlauch Modulations* I developed motorized systems, which gradually adjust potentiometers with very slow speed. These potentiometers are part of a network of coupled oscillators and cause the oscillations to be inhibited and to pause for longer periods of time.

Kauschlauch Modulations is an installation constituted by a network of analog neural oscillators (Faubel 2014; 2016), in which structure appears as a result of the cooperation and connectivity. These emergent structures are rendered tangible and audible by motors hitting on a Kauschlauch (medical silicone tube). The sound of the resonating tube is picked up with piezo-pickups. Three of the oscillators run on very slow timescales, the full cycle of an oscillation is set to times of around 2-3 minutes, these three oscillators drive pulleys that change the resistances of three potentiometers. These variable resistances are part of network connecting the two oscillators driving the motors that hit on the chewing tube. With a cycle of one of the slow oscillators the connectivity between the two varies from fully to weakly connected and as a network effect the coordination pattern between the two hitting motors varies from full synchrony to little coordinated movement. Different rhythmical patterns emerge.

The two other slowly varying oscillators modulate the movement amplitude of the two motors. These motors are in constant rhythmical movement, but sometimes they don't reach the chewing tube and silence is produced.

The work shows how temporal structure and complexity emerge out of a simple network of only 5 analog neural oscillators and out of their cooperation on a wide range of timescales.

References

Faubel, Christian.
2016. "Machine-machine communication without hierarchies and protocols". In *xCoAx 2016, Proceedings of the Fourth Conference on Computation, Communication, Aesthetics and X*. 201-210. Bergamo, Italy.

Faubel, Christian.
2014. "Rhythm apparatus on overhead". In *Proceedings of the 2014 conference on New interfaces for musical expression*. 491–494. June, London, UK.

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Pythia Consulting: Asking Difficult Questions While on Hold

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Keywords: Telephone, Intermedia, Artificial Intelligence, Text-to-Speech, Audio Interface, Physical Computing, Interaction Design, Self-Reflection.

***Pythia* appears as an old-fashioned touch-tone telephone. Instead of hearing a dial tone when the receiver is picked up, participants are immediately greeted with a voice menu system. The phone is a direct line to some artificial intelligence consulting services. Through navigating the menu system, and being placed on hold numerous times, the nature of the machine and the user are revealed. Bits and pieces of each participant's conversation with *Pythia* are recorded and incorporated into the next user's experience. The system questions contemporary interpersonal communication and support services.**

Description

Pythia appears as an old-fashioned touch-tone telephone, but instead of hearing a dial tone when the receiver is picked up, participants are immediately greeted with a voice menu system. The menus guide people through a series of audio experiences that question the role of automated voice services in our lives and revalues the time wasted on them. *Pythia* provides a model of how voice services could be used to create meaningful experiences for people by asking thought provoking reflective questions. Initially, these experiences will mimic that of navigating seemingly endless voice menus and being put on hold, as is familiar when calling any customer support line or large modern business. The interaction will begin with a familiar prompt, "Thank you for calling the *Pythia Consulting*. Your call is important to us. This call may be recorded for quality and training purposes. Für Deutsche presse eins, for English press two. Please hold while we connect your call." Users can then select one of six paths to take through the artwork.

1. *The Game.* In this game participants will listen to a snippet of a story, and then be asked to add a few sentences to it. Their input is recorded and added to the narrative that has been developed by all previous participants. After contributing to the narrative, participants will have the option to listen to the full story. This path draws on the structure of Surrealist games like Exquisite Corpse and Consequences.
2. *To Love.* In this option the participant will be asked a series of questions designed to build an emotional connection between two people. These include questions like, "When did you last sing to yourself?" and "What is your most treasured memory?" To generate a simulated dialog the initial user will also hear responses to the questions generated by the computer and past participants. These questions are derived from Arthur Aron's series of questions found to generate affection between participants (Aron et al. 1997).
3. *The Doctor.* In this option participants will be asked a series of generic Rogerian psychologist questions like, "What's bothering you today? How did that make you feel? Tell me more." Inspiration for this track came from past works in artificial psychology, like Weizenbaum's *Eliza* chat bot (Weizenbaum 1976).
4. *The Decider.* On this path the user is asked a series of questions designed to help them make a tough decision they are facing in life. The questions on this track are derived from Chip and Dan Health's work on complex infrequent decision making (Heath and Heath 2013).
5. *The Oracle.* Based on the participant's birthday, the system will deliver a horoscope inspired by past responses to *The Doctor* and *The Decider* paths.
6. *Endless Hold.* If the user would prefer to not engage with one of the preceding options they may listen to the hold music, forever.

This piece subtly examines the activities our minds go through while waiting. At the same time, it takes a routine mundane experience with a robot and transforms it into a provocative exercise in self-reflection.

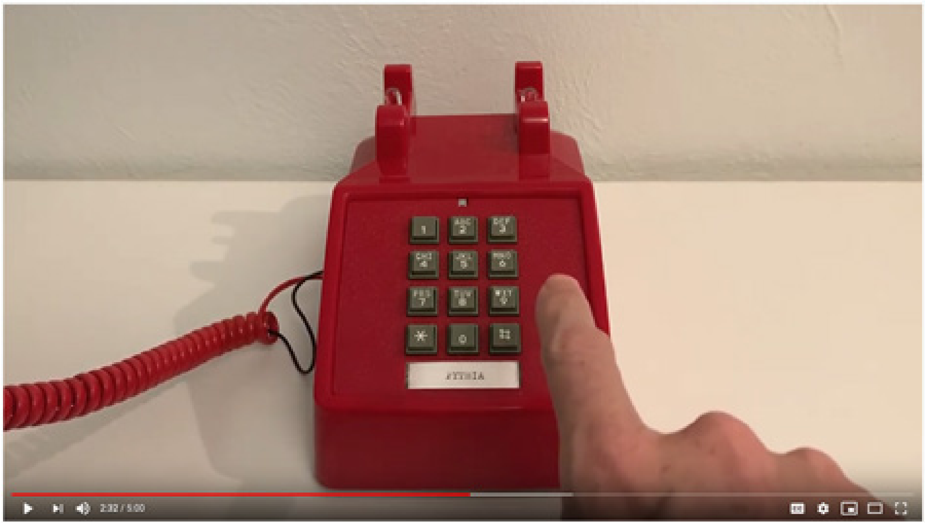

Fig. 1. Video demonstration: https://mosher.art/portfolio_entry.php?art_id=121.

Demonstration: https://mosher.art/portfolio_entry.php?art_id=121
Interactive web demonstration: https://mosher.art/pythia

Acknowledgements: *Pythia Consulting* was commissioned for the 2020 Digital Spring Biennale.

References

Aron, Arthur, Edward Melinat, Elaine Aron, Robert Vallone, and Renee Bator.
1997. "The Experimental Generation of Interpersonal Closeness: A Procedure and Some Preliminary Findings." *Personality and Social Psychology Bulletin* 23, no. 4 (April): 363-377.

Heath, Chip and Dan Heath.
2013. *Decisive: How to Make Better Choices in Life and Work.* New York, NY: Penguin Random House LLC.

Weizenbaum, Joseph.
1976. *Computer Power and Human Reason: from Judgment to Calculation.* New York, NY: W. H. Freeman and Company.

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Soundings

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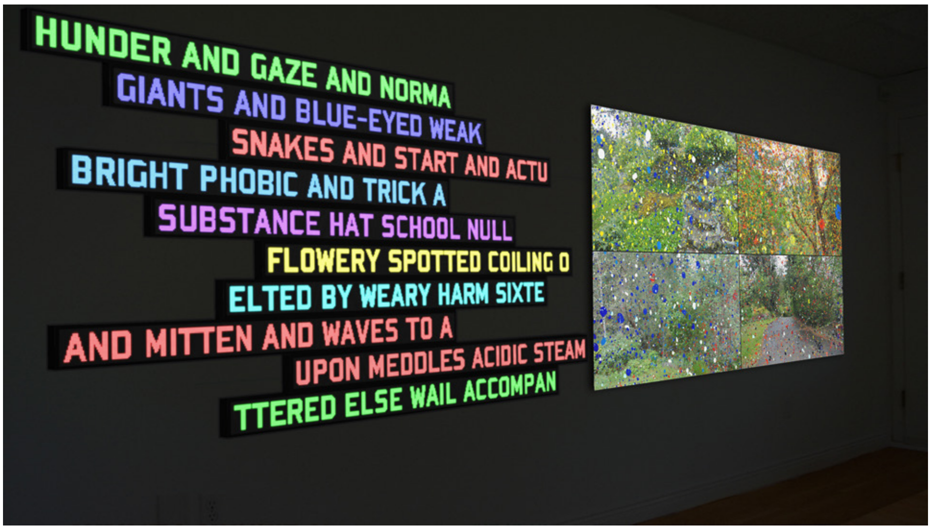

Keywords: Voice Recognition, Speaking in Tongues, Apophenia, Pyschogeography.

Soundings is a work exploring ideas about an unheard and hidden world using pattern and voice recognition to tease sounds from empty and silent or noisy ambient audio environments. Originally intended as a site-specific work located in Graz, Austria it has been reworked to accommodate the restrictions imposed by the Covid-19 pandemic and takes place on the artist's property. Bespoke speech recognition software analyses audio gathered by high gain signal chains and generates strings of texts that resemble a speaking in tongues or automatic writing. The resulting texts suggest the possibility of a world delineated by unheard voices and perceptual constructions.

Soundings (2020) is a work that looks for patterns in our everyday world to explore how shifting signs can change our sense of the nature of a space and how it is and might be occupied. It is an installation that uses the discrepancies and limitations of pattern recognition systems to generate instances of speech-like objects and events and to present these so as to reshape the psychological dimensions and sense of a space.

The installation consists of texts shown on several programmable LED signs - to present a flickering poetic babble reminiscent of a speaking in tongues, or the mysteries of numbers stations—radio broadcasts of strings of spoken numbers and text, and fragments of music. Audio is captured and analyzed to generate texts in real time, drawn directly from the sounds gathered at listening posts set up in specific spaces. LED screens show real time video of four views showing the direction of the directional microphones used to gather sound. For this particular version of the installation four listening posts are situated on opposing sides of the artist's residence facing North, South, East and West.

The property is relatively isolated, situated on a hill and surrounded by trees. Predominant sounds are of wind, birdsong, animal activity, the movement of trees and bushes, the running water of a nearby pond and distant human activity.

The proposed project has grown out of earlier work that used pattern recognition to reveal images and forms in random or ambient noise or to change our sense of place. One explored inaccessible or unseen spaces in urban environments discovering some of the coexisting yet unnoticed environments and ecologies hidden within the fabric of our cities, using small diameter snake cameras and tiny microphones. Other work used ideas found in Electronic Video Phenomena to explore ideas about felt presence/absence using visual and audio noise that was analyzed by computers searching for patterns that looked like human faces or sounded like speech - on occasion finding faces and voices that were convincing, unsettling, and disturbingly present.

This project explores means and ways to analyze ambient noise and suggest a new psychological topography to re-imagine and re-make a place through the perception of the most ordinary places as poetically exciting, uncanny, and even supernatural. The results are speech-like fragments, looking and sounding like gibberish, but uncannily and disturbingly suggestive of meaning and structure. It uses the deficiencies of pattern recognition software, and the human tendencies to see apophenic and pareidolic patterns and connections as a way to generate new meanings in the landscape to suggest the existence of unexpected alternative realities through the lenses of the misheard, the half-heard and the imagined to conceive alternative realities.

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On a Scroll Through the Cloud

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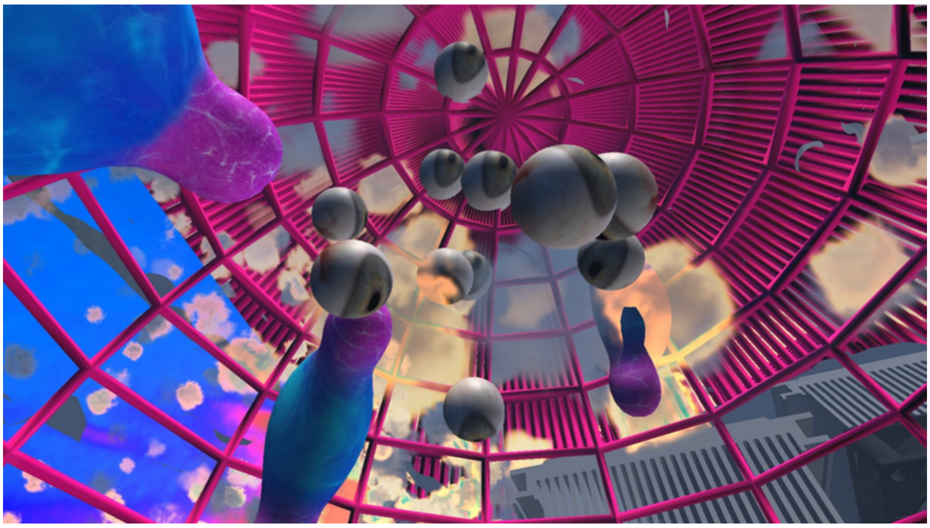

Keywords: Digital Culture, Internet, Cloud, Computer Game, Audiovisuals, VR

What lies behind the Cloud? The imagined atmosphere of the Cloud and the material bodies that compose cloud computing and the internet become the environment of a computer game. Data centres and farms come together with popular imaginaries of the internet in a fragmented environment saturated with clouds where feedback loops are generated in realtime: an open system without beginning or end. Within the cloud environment the player explores clusters of different material components and the broader cultural context of the internet.

Description

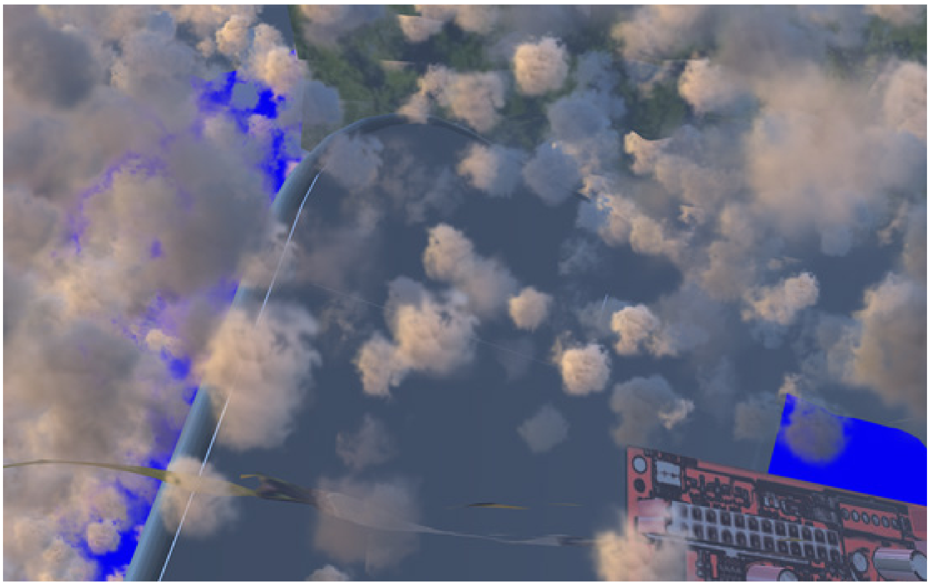

Fig. 1. *On A Scroll Through The Cloud* (2019–20), Computer game screenshot.

On A Scroll Through The Cloud is an audiovisual interactive artwork suitable for virtual reality or computer game installation inspired by the user experience of infinite scroll and its addicting effect within digital media interaction.

Cloud computing, the dominant business model and infrastructure of information technologies on the internet, is here presented in a dysfunctional 3D environment developed in Unity game engine. The environment, suffused with clouds, displays different visual elements of the internet, of digital media and its materiality without any quests to pursue. It visualizes the surfaces of the internet's technical structures and its communication protocols combined with popular imaginaries. The user has the freedom to navigate the space and to get lost in the clouds confronted with glitches from a software bug that reduce the environment to abstract visuals. This break in immersion defies user expectation and creates a space for possible reflection.

The internet has become a fundamental part of our everyday lives, providing instant communication and social interaction, participation in online communities and new formats for business models. It is everywhere but seems to be nowhere; immaterial and abstract somewhere over the clouds. The marketisation of "digital culture [is] pitched as an immaterial sphere of information where ideas become coded into zeroes and ones, independent of material substrate, transportable on the vague and indeterminate channel of 'the Internet'" (Parikka 2013). Its signals and data transmission as packets are dependent on its communication protocols and material infrastructures, such as computer servers, routers, data centres, ethernet and underwater fibre-optic cables. Likewise, the internet is shaped by economy, politics, corporate monopolies, internet providers, and its users. It has become a service based commodity stored in the cloud, with databases processed by hidden algorithms.

The internet intersects with everyday life in many invisible ways, such as the processes that run in the background of apps and web pages to track patterns and predict user behaviour for targeted advertisement and data collection, "to control production and consumption in a market" (Andersen & Pold 2015, 273). User behaviour is conditioned by its interface design, the "thin machinery mediating and remediating computation" (Berry 2015, 51). For example, the infinite scroll in social media platforms traps users in endless streams of information, which can cause anxiety, fatigue and boredom.

This computer game raises questions regarding the internet and cultures around it by addressing issues of data transmission, privacy and mass surveillance in this current post-digital condition. The player may encounter clusters of 3D models of data centres such as the Google Data Center, or the NSA Data Center in Utah, a complex for mass surveillance with the capacity to spy on digital communication around the world. What lies behind the Cloud? Where does the Cloud materialize? Who is the player and who is being played? These are the main questions guiding this metaphorical visualization of the complex system of networked computers and smart devices, where users have "no chance to see through the technical and networked complexity" (Andersen & Pold 2015, 274). Instead of finding answers, the player gets trapped in the cracks and fissures of this open world.

Fig. 2. and 3. *On A Scroll Through The Cloud* (2019-20) VR installation, Post.Digital.Dreams, Collective Exhibition, Tbilisi, Georgia 2019.

Fig. 4. and 5. *On A Scroll Through The Cloud* (2019–20), Computer game installation, Split Level, Collective exhibition, Berlin, Germany, 2019.

Fig. 6. *On A Scroll Through The Cloud* (2019–20), Computer game screenshot.

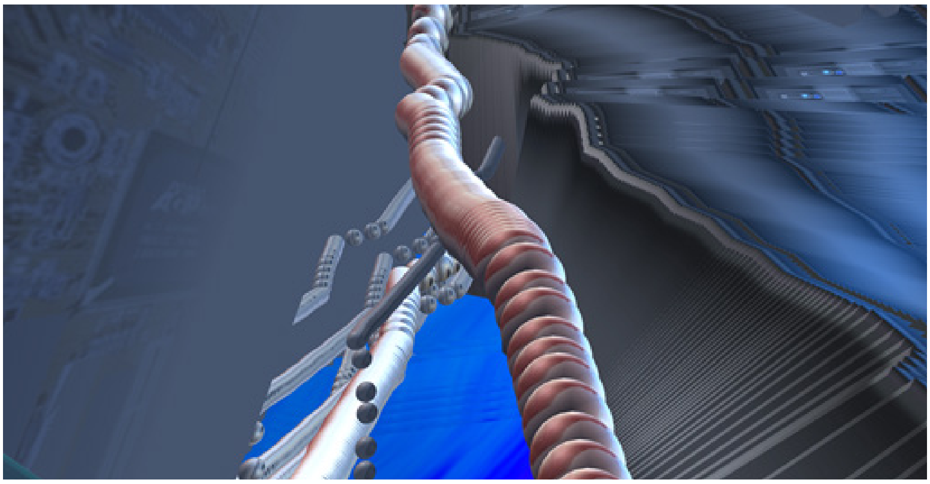

Fig. 7. *On A Scroll Through The Cloud* (2019–20), Computer game screenshot.

Acknowledgements: This artwork 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.

References

Andersen, Christian & Pold, Søren.
2015. "Aesthetics of the Banal - 'New Aesthetics' in an Era of Diverts Digital Revolutions." In *Postdigital Aesthetics: Art, Computation and Design,* David M. Berry and Michael Dieter (eds.), pp. 271-288. Hampshire, New York: Palgrave Macmillan.

Berry, David M.
2015. "The Postdigital Constellation". In *Postdigital Aesthetics: Art, Computation And Design*, David M. Berry & Michael Dieter (Eds.), pp. 44–57. Hampshire, New York: Palgrave Macmillan UK.

Parikka, Jussi.
2013. "The Geology of Media". *The Atlantic*. https://www.theatlantic.com/technology/archive/2013/10/the-geology-of-media/280523/, date accessed 3 May 2020.

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ComComComCom: Computation, Communication, Commerce, Community, a Common Com

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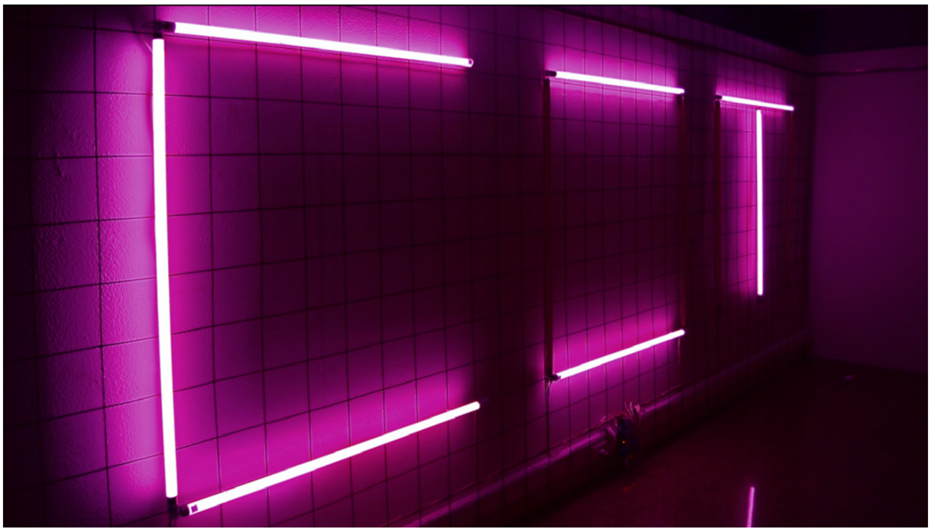

Keywords: Computation, Communication, Commerce, Community.

This automated light installation arises from the necessity to empower a critical reflection about an actual communications multinational company. This artwork was conceived and materialized to synthesize a critical and satirical view towards misconceptions and permeability between the concepts of communication, commerce, computation and community that int the post-digital contemporaneity can easily be transmuted into each other. This automated light installation highlights that more than the common prefix "com" between the above four words it's the transmutation of their meanings, contexts and functions that we must be aware of.

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Description

Community, Commerce and Communication

In the last decade of XX century a European Community was promised but, instead of real 'community', a Common Market was executed simply to empower/facilitate commercial activities. Soon the concept and nomenclature changed to European Economic Community. Although a common currency is implemented, huge social, economic and cultural differences among its member states persist. This "Community" as "Market" execution was achieved with "Communication" shaping public opinion.

.com, Commerce and Communication

Under a .com domain –the most common domain extension—often we face hybrids of communication and commercial mediums. .com domains serve to commercialise products and services but also to communicate and inform about them. Thereby commerce and communication evolve as mediums in a common infrastructure, transmuting themselves, one in to the other, reciprocally, becoming a hybrid. Altice presented as a communications company is in fact an Internet Service Provider that commercialises internet access—the most widespread commercial and communication medium.

Computation and Community

Nowadays communication is dependent on computation of digital data. Computational devices ubiquity changes the way we navigate space and live in community. The goal of some of the most powerful corporations in the world is to keep our attention, keeping us engaged. Computational algorithms control and measure this engagement. Being online makes it difficult to escape the influence of this companies and their computing power that mediate and change the information we access. To be online in a non digital public space becomes a refuse to be in that space, a refusal to a face to face communication affecting the notion of community itself. Freedom and chaos get replaced by control and predictability.

Artwork

ComComComCom is a large display constituted by T8 lamps, controlled by an Arduino instructed to switch on and off each one of them. The lamps—aligned on a vertical plane formed by a metal slab mesh—together form the word 'com'. The materials that constitute *ComComComCom* were reused from previous artworks and from a construction site. Randomly calculated visuals are displayed and some times the word 'com' can be perceived.

The slab mesh has a symbolic value in *ComComComCom.* Designed as a medium to reinforce concrete ceilings and walls, this mesh function is frequently subverted in construction sites when used as a fence – a division of private and public space, a protection. This ability to subvert and transform the functionality of mediums opens the possibility to create new thoughts, new ideas and new functions to existing media, liberating them from their original functions. Thus the mesh is a metaphor for the internet as a grid/network that supports communication. A grid that represents simultaneously protection and safety of personal data, privacy and individuality but also the structure that grounds the network that integrates public digital space where humans navigate. The grid as structure for communication, community and therefore freedom but also as border, limit, prison and confinement hardware of control.

Each lamp acts as a flickering bit—an on/off binary state—reminding the smallest unit of digital information. *ComComComCom*'s control algorithm keeps count of each 'bit' state, ensuring that there is always one bit on and that bits are never all on simultaneously, so that the word "com" is never complete/explicit. The flickering was designed as aesthetic, expressive and semantic strategy, alluding to machinic malfunctions and to any written semantic ambiguity, highlighting Communication as an incomplete and subjective phenomenon.

Video Asset: https://vimeo.com/391963578.

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Data Self-Portrait

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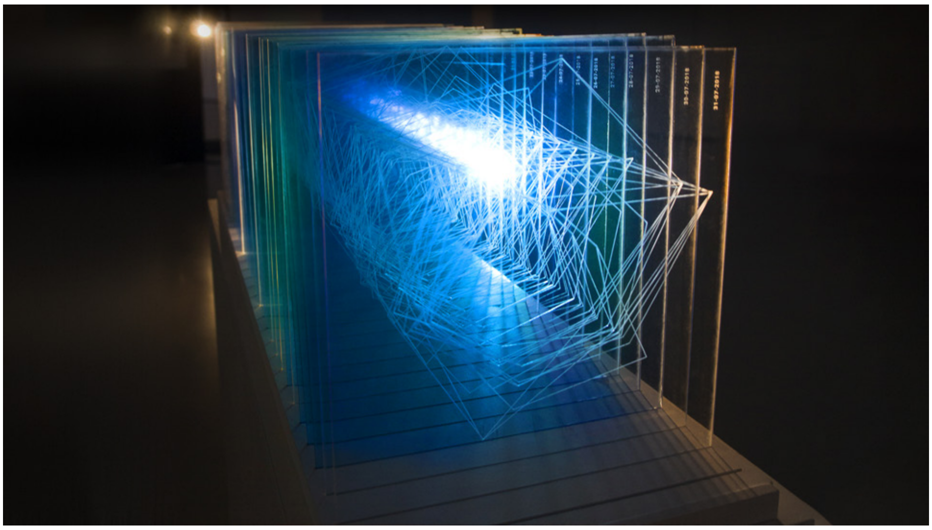

Keywords: Personal Data, Self Identity, Data Portraits, Visualization, Computational Media, Technologies of the Self.

Data Self-Portrait **aims to explore the creative possibilities associated with the concept of data portrait and its potential for expressing personal identity. It consists of an installation that explores the visualization of personal data pertaining to the subject's daily activities, automatically captured by digital technologies of everyday use. The project is the result of an ongoing research that seeks to frame these visualizations as representations of personal identity that reflect one's behavioral patterns as tools for self-analysis via self-tracking. It seeks to promote discussion on the role of data portraits as a means of attaining human agency over personal data.**

2020.xcoax.org/cas/

Description

The notion of data portrait refers to forms of portraiture that evocatively represent the identity of an individual based on records of personal data, according to the idea that "we are our data" (Lupton 2016). Based on this premise, we developed a *Data Self-Portrait* by following an autoethnographic approach through the collection of personal data and its visualization.

Data Self-Portrait can be described as a biographical repository that aggregates personal data that is usually scattered in different software applications. It acts as a *data mirror* or a self-tracking tool, meaning "a technical form of self-observation and a passive form of digital self-archiving" which encompasses "capturing human life in real-time" (Selke 2016, 3).

The project is developed in two main stages dedicated, respectively, to the selection and collection of relevant data and to the design and implementation of the visualization system.

We began by selecting data from three distinct domains of human experience: biometric data, data related to surrounding environment, and data related to daily activities. The data collection was automated in order to render the self-observation process more fluid, resorting to sensors embedded in devices of daily use (e.g. cardio bracelet and mobile phone).

In order to highlight variations in daily routine and unveil hidden patterns of the subject's daily life, the system is designed to employ quantification methods, comparing each measurement of data to the arithmetic mean. For the data visualization we resorted to a radar chart where each type of data defines one of its vertices.

With this approach, we created complementary expressions of the same self-portrait comprising a printed publication, a dynamic visualization and a physical output. While the printed publication contextualizes the development of *Data Self-Portrait* as an exploratory process, the physical output seeks to evoke aspects of traditional portraiture, such as the crystallization of a moment in time, which is materialized for future contemplation. In contrast, the dynamic visualization is an evolving self-portrait that unfolds in time.

The physical artefact (fig.1) is composed of layers, presenting visualizations of each day over one month. The results suggest the physical accumulation of data as a stratification of lived experience. In turn, the dynamic digital visualization (fig. 2) changes over time, expressing the transient and fluid nature of personal identity (Bauman 2000), as a dynamic portrait.

Fig. 1. *Data Self-Portrait*, installation at Altice Forum, Braga, Portugal.

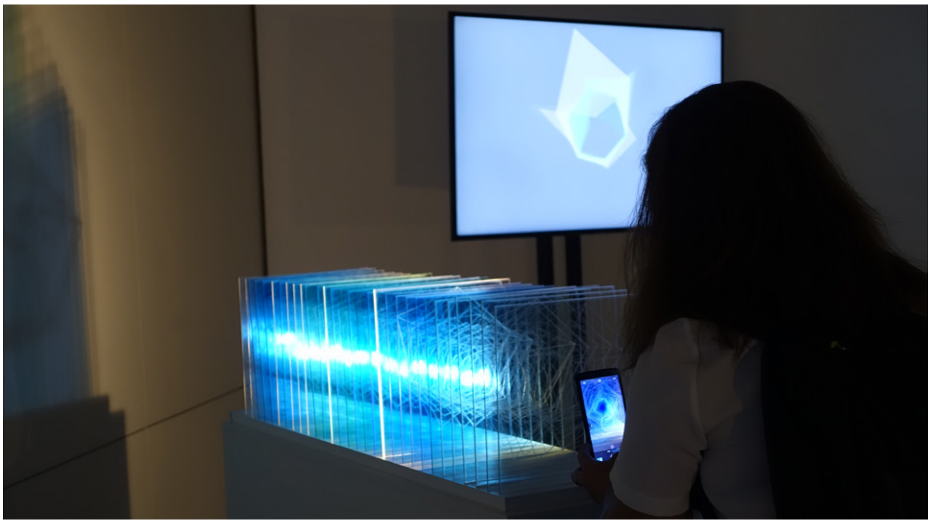

Fig. 2. *Data Self-Portrait*, installation at MediaLab Prado, Madrid, Spain.

Data Self-Portrait seeks to reflect on how data portraits can promote a reconceptualization of portraiture as a representation genre—one that is shaped by the creative possibilities of the computational medium and that becomes more attuned to our contemporary mode of living immersed in data.

In particular, and by addressing the informational nature of personal identity, *Data Self-Portrait* highlights how data portraits are able to amplify human agency through personal data by promoting self-knowledge and also by calling into question our current lack of control over the data we generate.

Available at: http://dataselfportrait.catarinasampaio.com/
Optimized for desktop and for the web browsers Google Chrome and Mozilla Firefox.

References

Bauman, Zygmunt.
2000. *Liquid Modernity*. Cambridge: Polity Press.

Floridi, Luciano.
2011. "The Informational Nature of Personal Identity", *Minds and Machines*, Vol.21, No. 4. Norwell: Kluwer Academic Publishers.

Lupton, Deborah.
2016. "You are Your Data: Self-Tracking Practices and Concepts of Data", *Lifelogging - Digital Self-tracking and Lifelogging – Disruptive Technology and Cultural Transformation*. Ed: Selke, S. Berlin: Springer VS. (pp. 61-79).

Selke, Stefan.
2016. *Lifelogging - Digital Self-tracking and Lifelogging – Disruptive Technology and Cultural Transformation*. Berlin: Springer VS.

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Hey!

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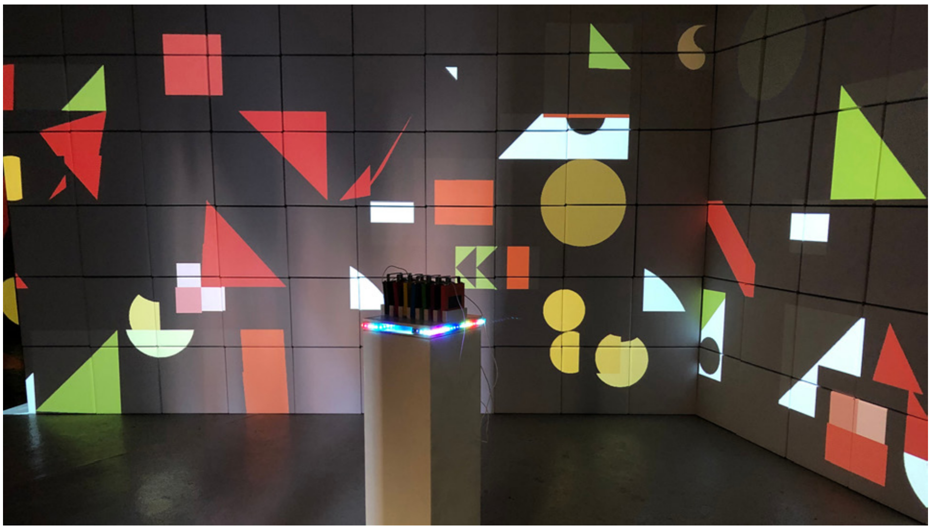

Keywords: Alternative Controller, Generative Music, Ludomusicology, Space, Game Design, Artificial Intelligence.

Hey! iIs a game installation, a game that is designed to be played in public spaces. _Hey!_ iIs part of an ongoing group research project examining questions related to game design, interaction, generative systems, music, graphical representation and social implications. Its interface is designed to be non-threatening and robust. The goal of the player is to "build" an AI by "feeding" the game emotions until it recognizes itself as an entity and with hey! The game communicates through graphics, that is ideally surrounding the player and generative sound. The game also automatically collects research data when it is played.

2020.xcoax.org/drk/

Description

Hey! The game is a product of the Ludic Lab Lucerne, a research group at the University of Applied Sciences and Art Lucerne and as such explores multiple concepts and questions connected to the interests of the researchers involved. The game is just the beginning of a deeper exploration on how to bring games out of screens into the room and to find different ways to communicate with the player or players. Not just by making alternative controllers as a hardware solution, but also thinking of what controlling and interfacing a game can be. How to make playing a game more of a (non-verbal) conversation than a direct command chain and how to communicate the state of the game through procedural visuals and generative music.

To make it into a playable game, we needed a setting, a story that would make the game interesting to interact with for some time and give the player a sense of progress. We also wanted to make the setting socially relevant and give the player a meaningful experience. Since the generative music in the game has a kind of "artificial intelligence" build in, we decided to make this the main scenario of our game. In our everyday life we are more and more confronted with algorithmically controlled systems that are black boxes. The setting presents the game as an intelligent system that is nurtured by the player feeding it "emotions", the player gets the chance to build an AI.

We use the seven basic emotions after Paul Ekman (Paul Ekman Group 2020), which are anger, contempt, disgust, fear, happiness, sadness, and surprise. These do not play into our research and are just part of the world building. These emotions tie into the visual and auditory representation of the game.

The emotions were interpreted by our graphic designer into seven basic colors and shape-families forming the basic building blocks of a face (see Fig. 1). The symbols and colors are culturally influenced, but in the end the iconography is an artistic choice by our graphic designer Francois Chalet.

Fig. 1. Seven basic colors and shape-families forming the basic building blocks of a face.

There is also a generative musical representation that shows the progress of the game from unformed noise to (non-verbal) babbling to coherent sound influenced by the character of the AI interpreting the different emotions into different soundscapes. The communication is non-verbal, because of the inevitable language barrier in multi-lingual Switzerland, where our research group is based.

This game is also a research into how to design a game with levels and a data structure that help transform player decisions and subsequent interaction data to answer research questions for our group. The player will be informed of the collecting of data and the data will be processed completely anonymously to guarantee privacy.

The game is not a final product, but part of a research process. The first iteration of the game was shown at the Biennale in Zürich.

Acknowledgements: This work would not have been possible without my colleagues at the Ludic Lab Lucerne Richard Wetzel, Sebastian Hollstein and especially François Chalet who designed the visual representation.

References

Paul Ekman Group.
2020."Universal Emotions | What Are Emotions?" *Paul Ekman Group LLC*. Accessed May 4, 2020. https://www.paulekman.com/universal-emotions/.

The In Rust We Trust Project: Technological and Cultural Aspects of Terrestrial Experiments on a Martian Clay Simulant

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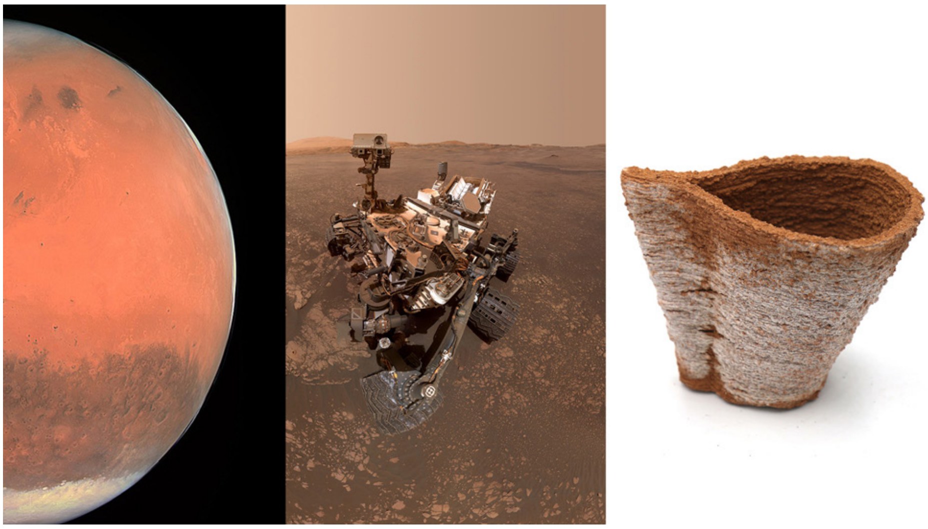

Keywords: 3D Printing, Clay Printing, Mars, Ceramic, Experiment, Martian Clay Simulant, Archeology, Space.

In the context of the speculated ideas related to the settlement and colonization of Mars (Moscher 2018), can printing the first cup made of Martian clay be a symbol of a new, interplanetary, chapter of our common human history? Technology and culture are not separate from one another, but together, they redefine our surroundings. *In Rust We Trust'* contains a set of Martian pottery 3D printed in the MGS-1 material, otherwise known as Mars Global Simulant: the first mineralogically precise simulant of Martian regolith (Cannon et al. 2019). The project combines issues related to digital production, digital aesthetics, innovative material experiments and multicultural communication.

2020.xcoax.org/maf/

Introduction

A symbolic cup made of Martian clay refers to the roots of culture, because ceramics and objects of everyday use have constituted the fundamental source of knowledge in the history of mankind, and are carriers of information up to this day.

With its many-faceted references to culture, the *In Rust We Trust* project takes us for a metaphorical journey through time. It should be treated as speculation rather than an implementation concept. In spite of its speculative nature, the results of the material and technological experiments can be a reference point for science and its transdisciplinary nature does not pigeonhole it in any single category. The result, i.e. the material representation of the idea, is the first attempt to create Martian utility ceramics. It is a stop on the way between what we know and what we aspire to. The project not only contributes to the discussion about the colonization of Mars, but also opens up new avenues for debate and challenge.

Artwork

In order to prepare the 3D printing experiments with the MGS-1 material, it was necessary to have a cultural and utility medium that represents contemporary culture. I designed two espresso cup models. Its shape was to symbolically refer to a catering receptacle, a cup with a certain defined function and to be a shape that would be adequate for the technology of its manufacturing, i.e. 3D printing in clay.

One of the methods of forming the first ceramic vessels before the invention of the garner wheel was to roll a long clay roll into a spiral so that the pot's walls would form uniformly. The oldest products found date back to 13 thousand BCE. The story has come full circle, as the process of incremental production with the use of a 3D printer looks similar. However, it provides very different possibilities and the resulting structures are much more complex (Mattison 2003).

Espresso models was a carefully thought-through shape in terms of manufacturing with consideration given to cultural connotations. The G-code, i.e. the path of the printer's head, was designed and generated with parametric tools.

Fig. 1. The pot on the left is from Sierentz, France (© Anthony Denaire), the one on the right from Bathgate, Scotland (© National Museums Scotland). https://www.nhm.ac.uk.

Espresso is a comparatively recent method of coffee brewing. It represents the fact of and need for acting quickly, change and the rush of today's world. Another insight is how the ISS astronauts confessed to missing the seemingly mundane things back on Earth. One of them was the smell and taste of real coffee (Donahue 2016).

Summary

Can we afford not to think about culture and message at the same time? If we are already thinking about colonizing other planets or building habitats, then, looking at this in another context, we are becoming not unlike cavemen who will once again build their culture from scratch in an empty place.

The first firings in the MGS-1 material demonstrate a similarity to terrestrial clay in terms of shrinkage and color. Thus, apart from the aesthetic and cultural aspects, the experiment also has a material science dimension. The fired samples went to a geological and chemical laboratory. Therefore, *In Rust We Trust* combines issues related to digital production, digital aesthetics, innovative material experiments and intercultural communication.

Fig. 2. MGS-1 Mars Global Simulant powder.

Result

Fig. 3. After firing 920 °C Model: *Espresso2*. Discovering new compounds (salt).

Fig. 4. After firing 920 °C Model: *Espresso*. Discovering new compounds (salt).

MGS-1 Photo Comparison

Fig. 5. Model: *Espresso2*, printed in PLA and firing in MGS-1, 920 °C.

Fig. 6. Model: *Espresso1*, printed in PLA and firing in MGS-1, 920 °C.

Fig. 7. Model: *Espresso2*, The difference between PLA and firing in light chamotte clay for biscuit 920 °C, high-temperature firing 1220 °C printed in PLA and firing in MGS-1 clay for biscuit 920 °C.

References

Mattison, Steve.
2003. *The Complete Potter,* Quarto Publishing: London.

Donahue, Michelle Z.
2016. "At Last, Space Brewer Lets Astronauts Make Real Coffee In A Cup". *Popular Science*, February 24, 2016. https://www.popsci.com/space-brewer-lets-astronauts-make-real-coffee-at-last/ (Accessed March 15, 2020).

Cannon, Kevin M., Daniel T. Britt, Trent M. Smith and Ralph F. Fritsche.
2019. "Mars global simulant MGS-1: A Rocknest-based open standard for basaltic Martian regolith simulants". *Icarus*, Vol. 317, no. 1 (January): 470–478. https://doi.org/10.1016/j.icarus.2018.08.019.

Moscher, Dave.
2018. "Elon Musk usually reveals new details about SpaceX's plan to colonize Mars at this annual conference. The next one is in 2 weeks, but Musk hasn't said whether he's going". *Business Insider*. September 20, 2018. https://www.businessinsider.com/elon-musk-spacex-mars-presentation-iac-2018-9?IR=T (Accessed March 15, 2020).

European Space Agency.
2007. "True-colour image of Mars seen by OSIRIS". European Space Agency: Space Science in Images. February, 25, 2007. http://www.esa.int/ESA_Multimedia/Images/2007/02/True-colour_image_of_Mars_seen_by_OSIRIS (Accessed March 15, 2020).

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Artist and Machine: An Iterative Art Performance

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Keywords: Artificial Intelligence, Human-Machine Collaboration, Human/Machine Labor, Authorship, Iterative Performance, Selfie Culture, Continuous Improvement.

Artist and Machine **is a performance series that studies the entangled relationship between human and machine labor. In each performance, the audience witnesses an Artist and a Machine draw live portraits of their viewers. Using a webcam and neural networks, the Machine has "learned" to draw like the Artist and tries to improve for every new performance. The series examines themes of authorship, continuous progress, dependence, collaboration, and intimacy.** ***Artist and Machine*** **also spotlights the duality of our behavior towards the human versus the non-human, unexpectedly revealing the audience themselves as the real performers.**

2020.xcoax.org/suf/

Description

Introduction

Artist and Machine is an allegorical performance series that examines the impact of artificial intelligence and the dialogue between these machines and their creators. The piece condenses the development of AI-powered technology into the confinement of a performance space, taking normally unseen data and processes and making them physical and experienceable for the viewer. It asks the audience to consider the achievements, consequences, and implications of a society dependent on and intertwined with automated machines.

The Performances

In each performance of *Artist and Machine*, the audience sees an Artist and a Machine sitting side-by-side, performing the same task (Fig. 1). Over the span of several hours, they continuously draw portraits of the people they see, on two parallel strips of paper that document the passing of time and people. Using Neural Style Transfer techniques (Gatys 2015), the Machine tries to draw like the Artist.

After drawing hundreds of people by the end of each performance, the Artist has developed and practiced her technique. Then, the machine takes the updated training data from the Artist and also improves its imitation. The feedback loop continues for the next performance iteration.

Fig. 1. Overall view of a live performance, from the perspective of the audience. The Artist (left) and Machine (right) produce portraits of the people they see in the performance.

Compare and Contrast

The Artist operates serially, picking one volunteer at a time (Fig. 2). Able to see and draw multiple people at once, the Machine is far more prolific but is still developing its human touch (Fig. 3-4). The Artist takes many breaks while the Machine needs only paper refills. The two performers reflect the complicated distinction between the labors of humans and machines.

Fig. 2. The Artist's portrait drawings (Performance No. 1).

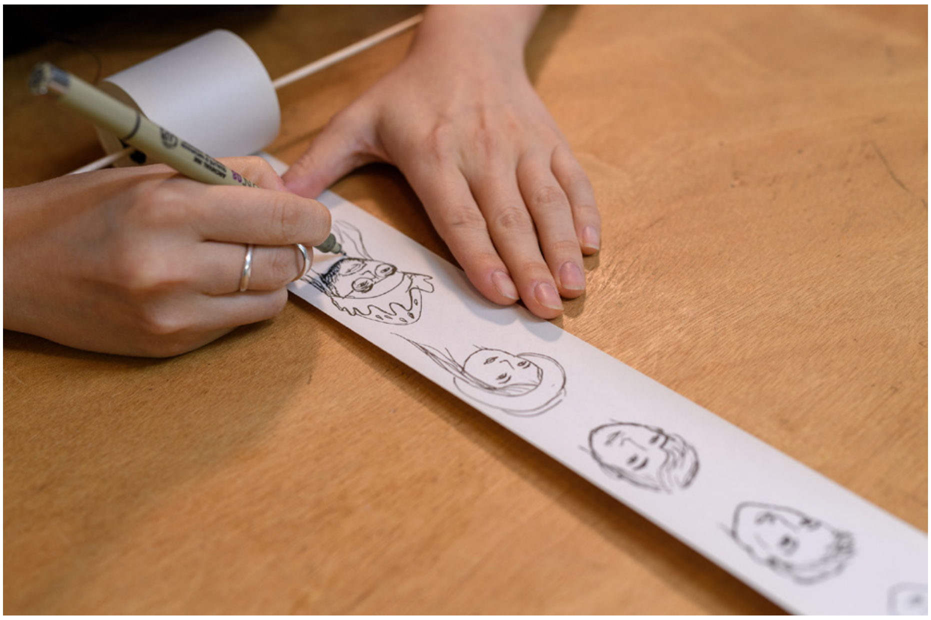


Fig. 3. The Machine's portrait drawings (Performance No. 3).

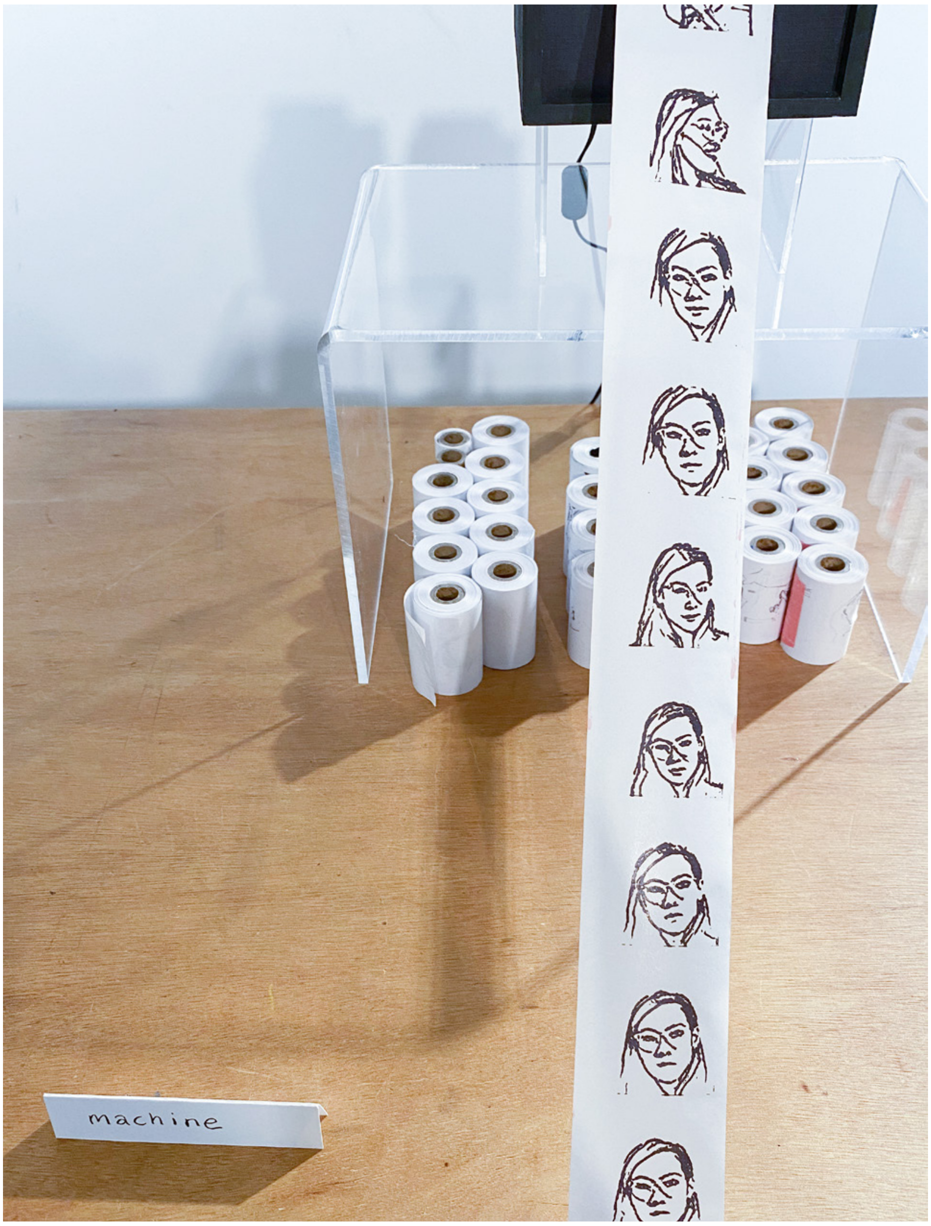
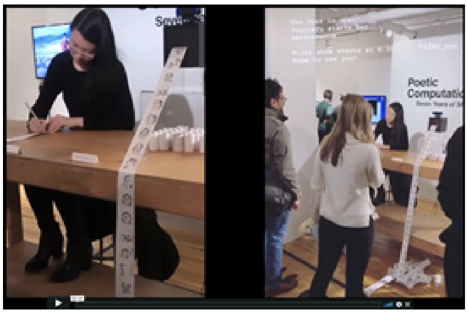


Fig. 4. The output of the Machine in an entire performance (Performance No. 3).

As expected, participants interact very differently with the two performers (Fig. 5). They have an intimate and uncomfortable staring session with the Artist, seldom repeating the experience. In contrast, the viewers voluntarily return multiple times to the Machine. They choose to become users, treating the Machine like a mirror, a device, a service.

Unexpectedly, the participants themselves become the real performers. The polarizing behavior of the audience reveals the actual performance: how we change and respond to the inevitable shift towards an automated world.

Fig. 5. Video compilation from the participants perspective (Performance No. 3) https://vimeo.com/390635248.



Additional Information

Technical Description. Artist and Machine uses open-sourced libraries: Fast Neural Style (Johnson 2016), OpenCV, Torch, and custom code. The installation hardware setup includes a MacBook Pro loaded with a custom trained model (trained using an Nvidia GPU), a webcam, a thermal printer, and a Raspberry Pi.

Future Work. To date, there have been three performances in the United States. As continued iteration is a central component of the series, live performances will continue in galleries, conferences, and other spaces in the United States and abroad. A retrospective of the performances is in progress.

Video Assets: https://vimeo.com/390635248

Acknowledgments: The author would like to thank the School of Poetic Computation in New York, NY for providing the initial space for the first iteration in 2018. The author would also like to thank Justin Johnson and Stanford University for providing the main open-source library for this project. Media materials in this paper courtesy of the author, Filip Wolak, and performance participants.

References

Leon A. Gatys and Alexander S. Ecker and Matthias Bethge.
2015. *A Neural Algorithm of Artistic Style.* arXiv:1508.06576. https://arxiv.org/abs/1508.06576

Justin Johnson, Alexandre Alahi, and Li Fei-Fei.
2016. *Perceptual losses for real-time style transfer and super-resolution*. Berlin, DE: European Conference on Computer Vision.

Performances

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Mirror of the Whole of Nature and the Image of Art:
Breaths Between Moons

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Keywords: Live Electronics, Bass Flute, Audiovisual Performance, Kinect, Spatialization, Particles.

Composition involves sculpting time as it slips in an aesthetically engaging form. But if we are to perceive time as something we can construct and customise, and if time demising can become a unique aesthetic experience, then it has to materialize first, it has to be given a shape. In Nicholas Moroz's music this manifestation occurs with mechanical modernization and solid texture. At the same time the acoustic sensation alludes in various ways to the composers' affinity for live electronics and ambisonics spatialization tools.

2020.xcoax.org/jdf/

Description

The piece could evoke to the first great work of Robert Fludd (1574–1637): “The metaphysical, physical, and technical history of the two worlds, namely the greater and the lesser” (1617)[1]. This illustration connects the macrocosm of the Universe with the microcosm of the intellectual human activity, represented by the liberal arts education. Eluding esoteric, magical and apprehensive connotations from Fludd’s treatise, this integrated interpretation of the World and its human interpolation and inclusion could fit indeed in *Breaths between moons* (2019) by Nicholas Moroz.

1. Utriusque Cosmi, Maioris scilicet et Minoris, metaphysica, physica, atque technica Historia.

The far-reaching space of *Breaths between moons*’ musical and extra-musical influences welcomes incommensurable dimensions, such as the elephantine power linked to the physics of black holes or the fragile architecture of an atom. First, this attitude concurs with the idea of wholeness as conceived by the extraordinary theoretical-physicist Albert Einstein. Along with that, a fascination towards nature and emotions mirrors a wide and profound aesthetic research made by the composer, which proves to emphasize the fragile and unforeseen condition of the human being. To sum things up, *Breaths between moons*’ music mirrors a holistic but frail sight of reality, where art and science could be the main keys to empower women and man to escape from a truly decomposed, blurry and uncertain context that blocks a bona fide experience of reality.

The piece focuses on the intimate and nuanced sounds of the bass flute, especially multiphonics, presented with live visuals by the performer itself. Using audio analysis and the Kinect device with Yuri Wilmering assistance, the flautist’s sound and movement are tracked throughout the piece and mapped to several electronic sounds and spatial motions so that sounds are transformed and spatialised as warped or pixelated reflections and stretched echoes, enveloping the flautist in waves of sound to suggest and ambient digital life form rendered in sound and space. The title evokes contrasting ideas of the intimate and the inhuman; human breath animated among an impalpably celestial and cyclical sense of time and space.[2]

2. Program Notes provided by Nicholas Moroz.

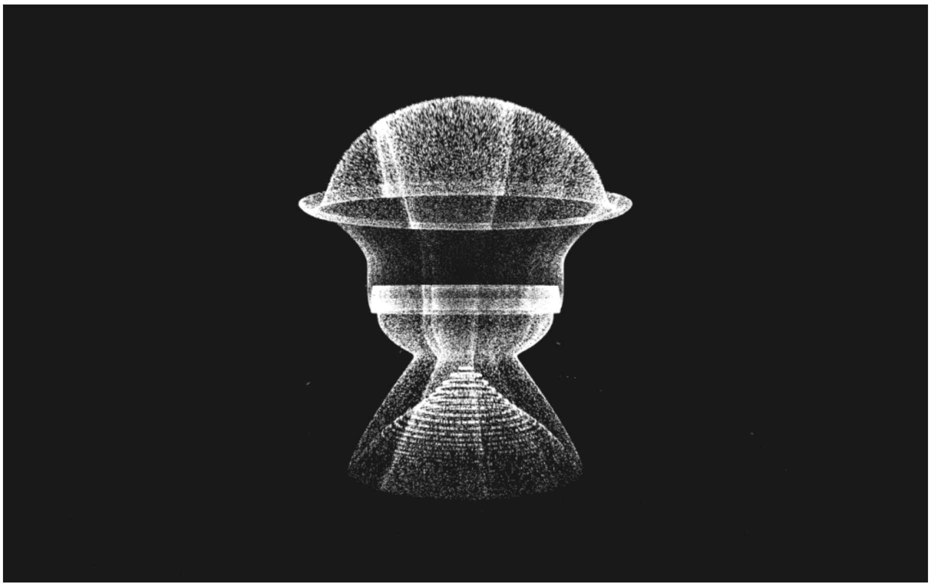

Fig. 1. Capture of the video clip *Particle Cosmic Cosmos* used in the performance *Breaths between moons* (Amsterdam, 2019).

Media Assets

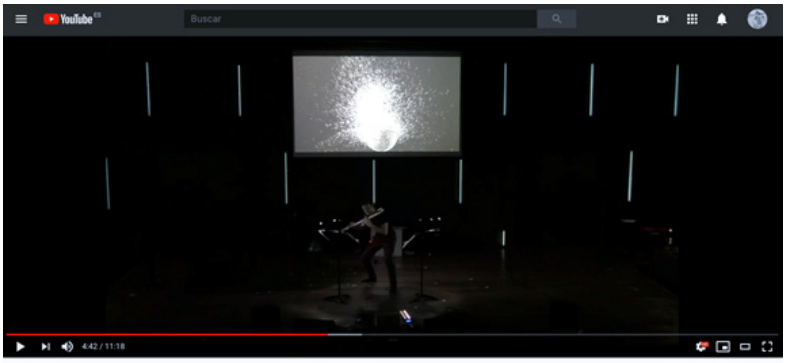

Fig. 2. A video asset https://www.youtube.com/watch?v=6ZYvws8rKM8.

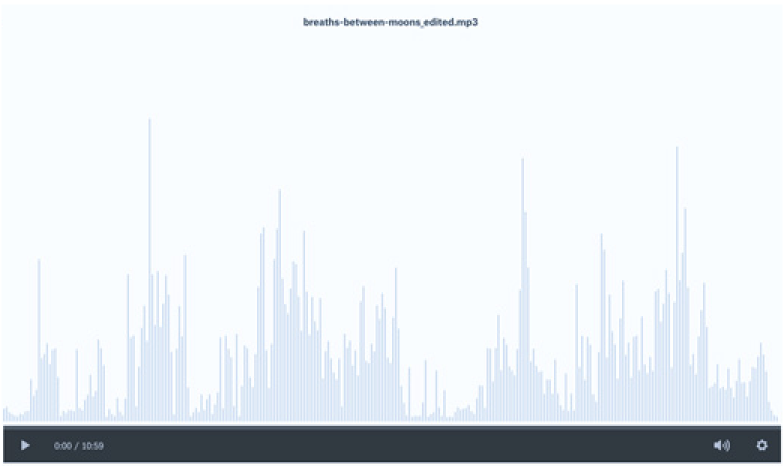

Fig. 3. An audio asset https://2020.xcoax.org/jdf/.

Fig. 4. The video presentation by the performer and the composer https://2020.xcoax.org/jdf/#media.

References

Fludd, Robert.
1617. *Utriusque Cosmi Maioris Scilicet Et Minoris Metaphysica Physica Atque Technica Historia, Vol. 2: In Duo Volumina Secundum Cosmi Differentiam Diuisa.* (Classic Repretint) (Latin Edition) London, UK: Forgotten Books.

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ICARUS: A Game/Performance for the Augmented Drum-Kit

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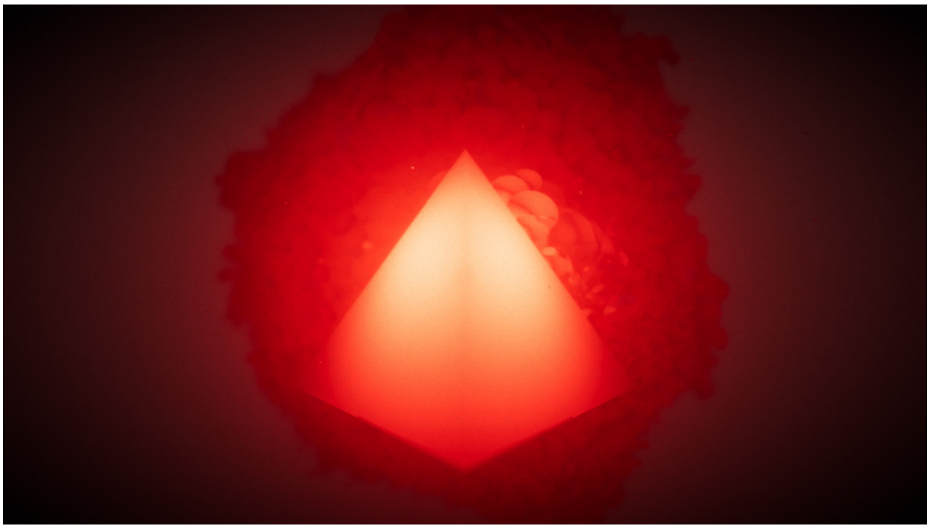

Keywords: Games, NIME, Improvisation, Live Electronics, Game Audio, Music Games.

ICARUS is a game/performance for the augmented drum-kit. The work explores improvised musical structures within a game setting, where the player navigates between five musical chapters. Each of these levels defines a particular set of musical interactions, sonorities, and performance possibilities through distinct mappings and level design. The performer is free to improvise, fail, explore, and through trial and error understand what the game rules are and complete each chapter. This results into a dynamic audio-visual performance, where while the rules are fixed, each level can be completed in multitude of ways.

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ICARUS

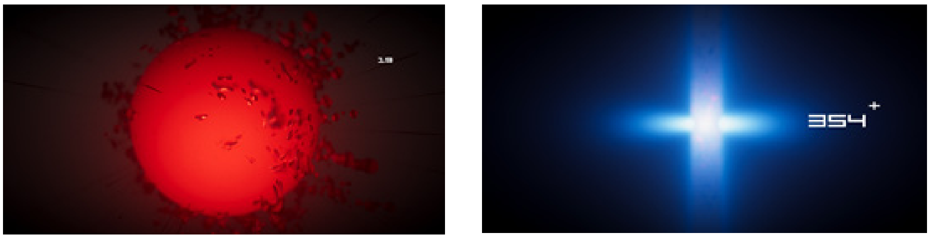

Fig. 1. *Icarus* In-game Stills.

The piece is designed specifically for the augmented drum-kit and the instrument's affordances; performance minutiae, digital electronics and musical parameters are analyzed and used as control input to the game. The augmented drum-kit was developed over the course of five years, and consists of a traditional drum-kit mounted with sensors, contact microphones, speakers and makes use of bespoke software. The acoustic kit also becomes the seamless control interface of the electronics and game with the use of machine listening techniques and gestural analysis resulting in a highly physical performance. There is minimal interaction with the laptop during the performance - all control of the electronic sound (including game, light and projection control) is carried out through the acoustic instrument; the computer serves only as the mediator for all assembled pieces of digital and analogue technology. As the musical instrument offers a much wider range of expressive possibilities compared to a conventional game controller, the result is a musically expressive game play performance where the game acts as the mediator to the improvised drum-kit performance, while the music becomes the live soundtrack of the game.

The performer is free to improvise, fail, explore, and through trial and error understand what the game rules are and complete each chapter. While each scene's rules are fixed, every level can be completed in multitude of ways which reinforces a sense of exploration and experimentation. For this work, the analysis methods used in order to extract parameter control information from the acoustic drum-kit performance for the live electronics are also used to extract game control information for the bespoke computer game. The visuals are projected onto a screen behind the performer as seen in figure 2. The interaction between the performer and the game ranges from a very clear and direct relationship between physical gesture and result on the screen, to more obscure relationships and mappings, all of which contribute towards the performance's progression. From a musical perspective, the game can also be seen as the performance's graphic score. One of the aims of this work is to explore exactly this two-way conflict: Controlling the game's progression through musical expression, while the game gives a structure to the performer's musical gestures.

The performance ranges from 10 to 20 minutes depending on the intentions of the performer.

Fig. 2. *ICARUS* premiere setup—ACM C&C San Diego 2019.

Over the past years, the author has been exploring the use of game engines for such musical purposes. This has taken the form of either experimental musical games where the player uses conventional game controllers to navigate a digital space where actions and movement are affecting the sound world of an immersive interactive environment, or the use of acoustic musical instruments as game controllers of instrument-specific games. Most notably, *Pathfinder* (Michalakos, 2016), was premiered at ICLI2016 and performed at various festivals and conferences around the world, including NIME 2016, DiGRA 2016, Sonorities 2016 and ICMC 2017.

Piece webpage: http://christosmichalakos.com/works#/icarus/

References

Michalakos, Christos.
2016. "Pathfinder: A Performance Game for the Augmented Drum-Kit". In *Proceedings of the 3rd International Conference on Live Interfaces*, edited by University of Sussex, 2016

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tinySounds:
For Voice and Musebot Ensemble

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Keywords: Live Performance, Music, Computational Creativity, Generative Music, Multi-agent system, Voice.

Intelligent agents—musebots—respond to live input: quiet sounds made by the voice. Musebots are autonomous musical agents that interact with other musebots, as well as human performers, to create and perform music. Musebots communicate through messages; in this work, one musebot analyses the live performance, and messages its data to the other members of the ensemble, who individually decide how to react to the information. As such, the audio musebots don't "listen" to the live input, and instead react to the data.

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Description

tinySounds is an ironic work in which tiny sounds–quiet noises made by the human voice that are barely audible—serve as an input for a noisy and exuberant musebot emsemble[1] that autonomously responds, accompanies, and argues with the live input. Musebots are intelligent musical agents that decide how to respond to their environment—and each other—on their own, based upon their internal beliefs, desires, and intentions.

1. https://musebots.weebly.com/

Machine learning algorithms are wonderful for sifting through data and discovering relationships; more challenging is how these algorithms can be used for generation. It isn't that difficult, for example, to train a system to provide similar sounds for a database, given a live sound. But what's the artistic interest in that? Similarly, it isn't that difficult to extract live performance information from an improvising musician—activity level, general frequency range, timbre—so that the system responds likewise. But, again, reactive systems lose interest fairly quickly.

I find it much more interesting when my musebots go off on their own, exploring their own ideas through beliefs they may have formed incorrectly and unintentionally. For that reason, I usually build a lot of ambiguity into my analysis or provide conflicting information. What happens when one musebot is sure of something, while another is absolutely sure of something else? And what if a third musebot just doesn't care?

In *tinySounds*, musebots are trained using a neural net on a corpus that has been hand-tagged for valence and arousal measures, as well as preanalysed for spectral information. However, the correlation between audio features (what the musebots are listening for) and affect (valence and arousal) isn't direct; in assigning the latter, I may decide that a sound from the corpus is complex and active, but my reasons for doing so may not use the same information as the musebots are provided with. Thus, a musebot may decide that, based upon what it has learned, a live sound is high valence / high arousal, but the listener may perceive it otherwise. This isn't a flaw in the system; it's a feature!

Lastly, my role as overseer in the musebot ensemble allows me to further disrupt how the musebots apply their knowledge. The corpus is organized semantically (i.e. voice sounds, kitchen sounds, transportation sound, etc.); once a musebot is using a certain subdirectory, it can't easily switch to another. As a result, it's choice of related sound, whether affective or timbral, is limited to what is immediately available to it. If the musebots are frustrated, they haven't mentioned it to me (yet).

Musebots are not straightforward reactive processes; instead, they have their own beliefs (in this case, the incoming analysis data), desires, and intentions. They will happily play on their own, or they may reactive very closely to the live performance; more often than not, they will offer their own "reinterpretation" of the live performance, with individual reactions to the analysis data.

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Hot Summer Afternoon: Towards the Embodiment of Musical Expression in Virtual Reality

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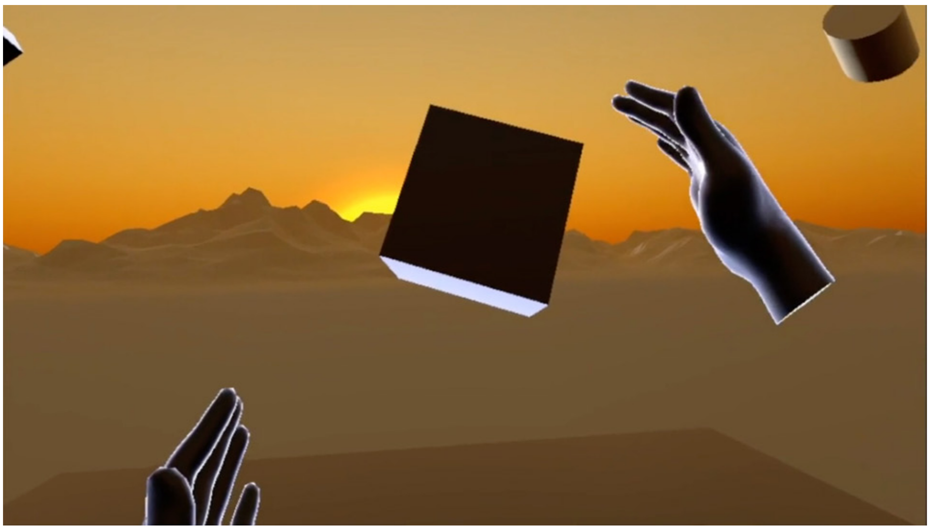

Keywords: Sound, Performance, Virtual Reality, Hand Tracking, Hand Gesture, Machine Learning, Musicality, Embodiment.

Hot Summer Afternoon **is a sound performance which uses VR as performance space. The new controller-free hand tracking feature of Oculus Quest allows users to monitor their hands inside of the VR world. Some hand gestures as well as the position of spawned objects in VR are mapped with different sound parameters using machine learning. The aim of this project is to explore the embodiment of the performer's musical expression with hands inside of the immersive virtual environment.**

Motivation and Development Process

The Virtual Reality (VR) headset Oculus Quest was chosen to be used in particular because of its new hand tracking technology released in December 2019.[1] Now, with the hand tracking SDK the headset can track user's hands using the four front cameras on the headset without requiring wearing a pair of tracking gloves or any extra tracking devices. Based on our experience, this feature removes the previous disembodying interaction in VR such as controlling the representational fake hand objects with controllers.

1. Hand Tracking SDK for Oculus Quest Available with v12 Release, Oculus Developer Center, https://developer.oculus.com/blog/hand-tracking-sdk-for-oculus-quest-available/.

The soundscape of *Hot Summer Afternoon* is about the feeling of post-holiday melancholia (Fig 1). It is set to be a late afternoon when everyone left the main event of the holiday. The performer is the last person remained at the place still. We were inspired by the very first immersive moment when we tried the Oculus Quest headset in order to test the hand tracking feature. There was no other object in the game scene but just our reflection of hands. Because it did not require to hold controllers, we felt deeper immersion in the empty scene. Based on this experience, the soundscape was composed.

With the Oculus hand tracking SDK, it is possible to retrieve individual bone ID to track more sophisticated hand motion. Each hand is constituted with twenty-four bones. Instead of mapping each bone position one by one, some of supervised machine learning (ML) models were used to detect some gestures. Those detected gestures were mapped to different sound parameters. Also, the spawned objects' in VR were mapped to control sound parameters as well. To train position data of the spawned objects and the user's hands with ML models, the free open source software Wekinator was used. The software communicates with Max via OSC to control sound parameters created in Max.

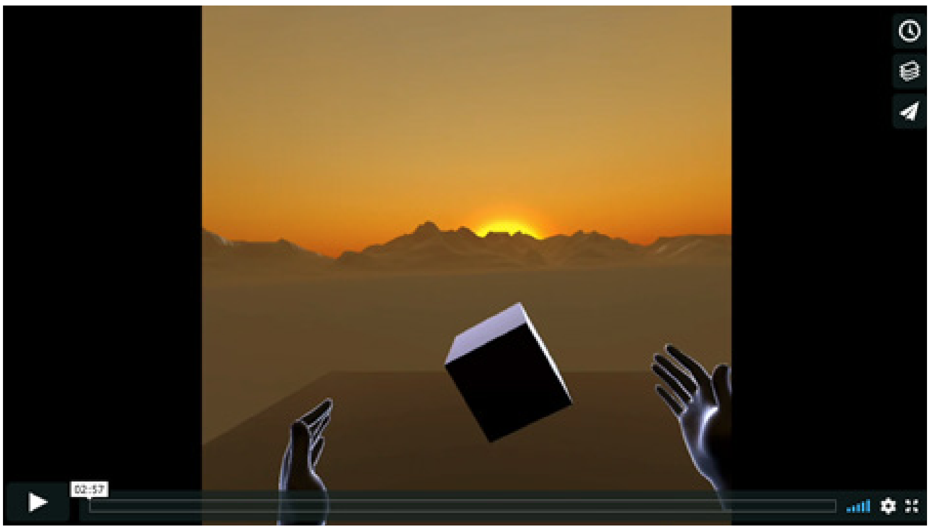

Fig. 1. Trailer of *Hot Summer Afternoon* https://vimeo.com/390532808.

Towards the Embodiment of Musical Expression

“What is important is that the peculiar nature of our bodies shapes our very possibilities for conceptualization and categorization.” (Lakeoff and Johnson 1999)

Hand motion has been extensively explored in digital music composition and new instrument design. For example, Michel Waisvisz’s *The Hands* is the early example and long-lasting research projects (Torre, Andersen, and Baldé, 2016), and the composer Laetitia Sonami explored musicality of hand gesture with her *Lady’s Glove* (1994).

This project is yet not an attempt to add more standard musical language or mapping techniques with hand gesture, but to explore the embodied experience in VR environment through the real-time controller-free hand tracking feature. Even though only real hand motion is embodied in the VR so far, the immersive experience has been dramatically enhanced based on our experience. This let the performer have more intimate interaction with the VR world. Therefore, here, ML is used to capture very personal and subjective musicality of the performer’s hand gesture, which allows to explore very personal and peculiar musicality retrospectively by observing the classified gestures.

During the performance, the audience will see a streamed video from the Oculus headset through the performer’s view and listen to the imprinted musical expression in the VR space.

References

Lakeoff, George and Mark Johnson. 1999. *Philosophy in the Flesh: the Embodied Mind & its Challenge to Western Thought*. Basic Books.

Torre, Giuseppe, Kristina Andersen, and Frank Baldé. “The Hands: The Making of a Digital Musical Instrument.” *Computer Music Journal*, Volume 40, Number 2, Summer 2016, pp. 22-34.

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Playing The nUFO

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Keywords: DMI, Sensor, Mapping, Wire-less, HCI, Influx, Metacontrol, SuperCollider.

The Airborne Instruments *nUFO* is a new movement based Digital Music Instrument designed for maximal motional freedom of the performer. A handheld wireless *Interactor* digitizes large scale movement via a 9-axis IMU together with a set of 8 touch-sensitive pads for fine motor finger action. The corresponding software, *nUFO_App*, applies elaborate meta-mapping strategies called Influx (de Campo 2014) to the movement data to inform up to 4 parallel of sound processes such that even very simple movements create complex changes in the sound. This frees players from distracting technical concerns and empowers them to focus on playing by listening and intuitive motion.

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Description

Developing the *nUFO* was my main occupation for the last 3 years; first as art academy graduation project, then in the frame of a grant. The work encompassed the design of Hardware & Software, interactions, sound design, development of a series production pipeline, company CI, website and marketing strategies.

> “Will new digital instruments become part of the current musico-industrial framework with composers, publishers, producers, sound engineers, performers, concert halls, media, critics, audience? Or do they belong to a new age of musical practice? What is a new digital instrument? How do we play it? Who composes for it? Where does it fit in our culture? And is it a sustainable thing?” (Magnusson 2019)

From Thor Magnusson’s recent book “sonic writing” (2019) pose pointed questions about societal and cultural implications of new DMIs, which perfectly apply to me as the creator of the *nUFO*. The composition process of this piece started with rendering my private answers to these questions with computer voices as a concrete sound source. Interacting with the *nUFO*, these sounds can be played back at intelligible rate, or gradually granulated to become purely sonic, at times rhythmical, textures. A choice of complex, internal-feedback-based synthesis algorithms serves as accompaniment to this quasi-human voice, and *nUFO’s* rich interaction affordances leave plenty of space for ad-hoc decisions about the flow of the piece. The juxtaposition of clearly audible speech and dense sound layers constitutes two complementary ways of addressing Magnusson’s questions, one semantic/rational and one experiential, which are intended to merge into a self-referential musical contribution to the xCoAx discourse.

References

de Campo, Alberto.
2014. “Lose control, gain influence - Concepts for Metacontrol.” In *Proceedings of International Computer Music Conference*. Michigan Publishing.

Magnusson, Tor.
2019. *Sonic Writing: Technologies of Material, Symbolic, and Signal Inscriptions*. Bloomsbury Academic.

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Stream: Synergy Meeting Vol. 2

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Keywords: Interactivity, Contemporary Dance, Sensors, Wearable Electronics, Improvisation.

***Stream*, by Die Wolke art group, is an interactive performance project based on structured improvisation. Inertial and mechanical sensors on the body of a dancer transmit motion data wirelessly to computers for processing and use for musical control, modulation, or other algorithmic input by a musician on stage. A kind of information feedback loop is created as the dancer further reacts to the sounds, creating fertile ground for improvisation and an experimental method of discovering connections between gesture and sound.**

Description

Stream is an initiative by Die Wolke art group meant to explore the applications of interactive technology within the realm of the performing arts, in an improvisational context. The vol.2 meetings, in November 2019, focused on the use of inertial and mechanical sensor interfaces and interactive performances by dancers Drosia Triantaki and Enora Gemin. The creative process took place over two 10-day sessions, where the performers familiarised themselves with the interfaces and the sonification of the motion data, while developing a kinetic vocabulary. The musicians Tim Abramczik, Nikos Tsavdaroglou and Dimitris Dalezis each prepared a 15 minute piece for presentation.

The interfaces for the performers are based on orthopedic braces that fasten to the upper arm and forearm, thus limiting rotational forearm movement, but allowing a measurement of the elbow angle. This is achieved via a potentiometer on the joint, whose shaft is connected to the moving part of the brace via a heavy wire. A 9-degrees-of-freedom inertial sensor is installed on the end of the forearm, just above the hand. It is connected digitally to an Arduino Nano board on the upper arm part, along with the potentiometer. The data is read and transmitted in realtime to receiver Arduino boards via RF transceivers. The receivers collect the data frames, pack them into a simple OSC protocol network message, and transmit them over a wired local network, where multiple machines can listen simultaneously. A requirement was that the system be practical, robust, and performance-ready in the real-world. Computers running Supercollider receive 3D acceleration (linear and gravity components), rotational velocity, Euler angles, and elbow angle. Custom classes covert the data to vectors and implement history buffers for statistical information, noise reduction, filtering, derivation, and more. The data is forwarded to musicians via OSC or MIDI, thus enabling an interactive working environment.

The specificity of the parameter mapping was crucial: highly tuned, sensitive mappings produced more obviously interactive but less reusable results, whereas gentler, generalised mappings offered more possible applications but weaker perception of the relationship between movement and sound. Tim worked by loading abstracts of recordings of talks with Drosia to the *Phonogene* module of his modular synth, and modulating them, as well as other sounds, by bringing the motion data to the analogue domain as CV. Dimitris and Nikos followed different approaches, such as using motion data as input for algorithmic composition, or converting to MIDI and setting up complicated many-to-many modulations. From an artistic point of view, it was crucial for the resulting pieces not to sacrifice choreographic or musical quality in favour of simply being interactive.

Stream's uniqueness, in that it is not a strictly technical project but not purely artistic either, can be thought of as its greatest strength; that is, its ability to organise its practice and research methodology in order to expand the practical possibilities of interdisciplinary improvisation.

Written Documentation: danijoss.com/shared/files/stream2-xCoAx.pdf
Video: vimeo.com/ondemand/stream2
vimeo.com/401601863

Acknowledgements: Ioanna Symeonidou, Ioannis Persoratis, NRW Kultursekretariat.

References

Baalman, Marije.
2007. "SenseWorld". Supercollider quark code. Open source. Latest commit on November 30, 2014. https://github.com/supercollider-quarks/SenseWorld.

Borgo, David.
2007. *Sync or Swarm: Improvising Music in a Complex Age.* New York, NY: Continuum International Publishing.

Emmerson, Simon.
2007. *Living Electronic Music.* Hampshire: Ashgate Publishing.

Jordà, Sergi.
2007. "Interactivity and Live Computer Music". In *The Cambridge Companion to Electronic Music,* edited by Nick Collins and Julio d'Escriván, 89-106. Cambridge: Cambridge University Press.

Magnusson, Thor.
2019. *Sonic Writing: Technologies of Material, Syumbolic, & Signal Inscriptions.* New York, NY: Bloomsbury Publishing.

Rowe, Robert.
2001. *Machine Musicianship.* Cambridge, MA: MIT Press.

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Raw Green Rust: Improvisation (with FluCoMa and UniSSON)

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Keywords: Computer Music, Machine Listening, Signal Decomposition, Audiovisual Performance.

Raw Green Rust are an improvising laptop trio that exploits the interconnectedness of its constituent members & technical ecosystems in playful and agile ways. Sharing audio and control data between performers allows for complex chains of generation and processing as an articulation and exploration of interface, gesture and distributed creativity. This c.20-minute improvisation merges their existing practice with two emerging strands of practice-led research into performative agency: decomposition of audio signals with the Fluid Corpus Manipulation (FluCoMa) toolset; and machine listening and visualization of multiplayer performance with the Unity SuperCollider Sound Object Notation (UniSSON) toolset.

Description

Raw Green Rust make abstract electronic music informed by wide-ranging musical tastes, using custom software instruments and processes with gestural controllers (Rawlinson, Green and Murray-Rust 2018, 2019). An important aspect of our improvising approach is to constantly sample and transform each other, in pursuit of an organic, shifting sound mass. Our performance practice builds on existing strands of work in creative computing, computer music and musicology but seeks to make playful and agile use of technology to explore shared musical agency.

Fig. 1. A prior Raw Green Rust performance, Beyond Festival 2019 https://vimeo.com/389734773.

We conceive of our work in ecosystemic terms (Waters 2007, Green 2011). Mutual connectivity through networked audio and control data offers radical possibilities for making sonic outcomes that are fluid, shared and responsive through performative agency that is distributed across people and processes. Performative agency in software can be found in the software's capacity to act as a conduit and focus of interaction and exchange, as an object that can influence or change behaviours (Bown, Eldridge and McCormack 2009). For Raw Green Rust, this can be found in applications of the FluCoMa and UniSSON toolsets, alongside our already well-established plunderphonic aesthetic.[1]

Fluid Corpus Manipulation

Fluid Corpus Manipulation (FluCoMA)[2] is a five-year ERC-funded project, focusing on musical practices that work with collections of recorded audio and machine listening technologies. The project will produce software toolkits, learning resources and a community platform, in the hope of facilitating

1. A Raw Green Rust performance can be heard at https://rawgreenrust.bandcamp.com/.

2. For more information see http://www.flucoma.org/.

distinctively artistic and divergent approaches to researching machine listening (Green, Tremblay and Roma 2018).

In the context of this performance, the focus is on how techniques such as audio novelty measurement, dimensionality reduction and clustering can be used to facilitate *live corpus co-creation* between the members of the group. What effects might this have on the timescales over which we can quote and transform each other's gestures?

Unity Supercollider Sound Object Notation

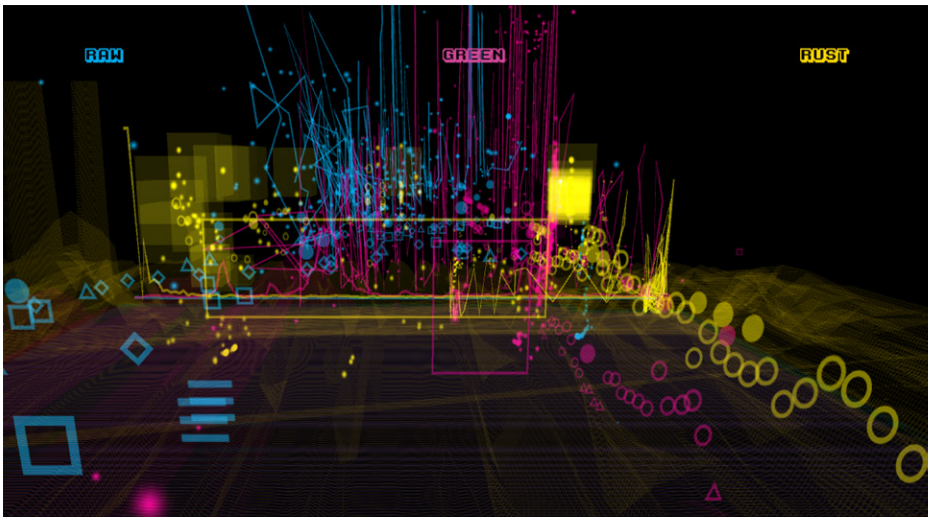
The sound-symbol relationship is the main focus of the Unity Supercollider Sound Object Notation project (UniSSON)[3] (Rawlinson and Pietruszewksi 2019).

3. For more information see http://www.pixelmechanics.com/unisson/.

In electronic music, especially by groups, it can be hard for audiences and performers to know who is doing what as movement and action is decoupled from sonic results. If the audience and performers are not able to audibly or visibly (at a gestural level) perceive contribution, how might it otherwise be represented and communicated?

The main output from this research is a suite of software tools that presents a real-time multi-temporal and multi-resolution view of sonic data. The current state of the software gives a clear view of which audio features belongs to which player, and indicates relationships between events/streams and gestures while exploring legibility and co-agency in laptop performance.

Fig. 2. Multi-temporal, multi-resolution visualization of audio features in UniSSON.



Acknowledgements: FluCoMa has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 725899).

References

Bown, O, Eldridge, A, & McCormack, J.
2009. *Understanding Interaction in Contemporary Digital Music: from instruments to behavioural objects.* Organised Sound, vol. 14, no. 2, pp. 188–196.

Green, O.
2011. Agility and Playfulness: Technology and skill in the performance ecosystem. Organised Sound, vol. 16, no. 2, pp. 134–144.

Green, O, Tremblay, PA, & Roma, G.
2018. *Interdisciplinary Research as Musical Experimentation: A case study in musicianly approaches to sound corpora.* Electroacoustic Music Studies Network Conference.

Rawlinson, J, Green, O & Murray-Rust, D.
2018. *Raw Green Rust: Laptop Trio.* Sonorities Festival, Belfast.

Rawlinson, J, Green, O & Murray-Rust, D.
2019. *Raw Green Rust: Improvisation with machine-learning and visualization.* Beyond Festival, Heilbronn.

Rawlinson, J, & Pietruszewski, M.
2019. *Visualizing co-agency and aiding legibility of sonic gestures for performers and audiences of multiplayer digital improvisation with UniSSON (Unity Supercollider Sound Object Notation).* Convergence International Conference/Festival of Music, Technology and Ideas.

Waters, S.
2007. *Performance Ecosystems: Ecological Approaches to Musical Interaction.* Proceedings of the Electroacoustic Music Studies Network Conference.

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Polymer Dub: Urban Soundscapes, Evolution and Cultural Values

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Keywords: Generative Music, Dub Music, Perception and Cognition, Performance Mixing, Audio Engineering, Techno Music, Machine Learning.

We propose and describe a real-time musical performance traversing the boundaries between technological expression and the analogies, paradoxes and construction structures between, generative music, evolution and dub music performance. Dub music was born out of technological advances and sociological changes. We analyze its development, influence in modern music and propose its continued evolution using intelligent agents as a follow up of its aesthetic characteristics, and nature. Blocks of glitch, techno, field recordings and dub elements portray a soundscape of a city, culture and its acoustic elaboration.

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Description

The technology was responsible for the birth and evolution of dub music, and it is one of the most innovative and prominent recording and performance techniques of modern music. According to Nils Frahm, Dub is influential for all kinds of musicians and is almost as important as classical or jazz music. Jazz is the main language of improvised music, classical is the primary language of notated music, and dub is the language of engineers. Dub transformed the engineer into an artist (Kane, 2014).

It is hard to overstate the impact dub has had on contemporary music production. It is an unquestionable accomplishment that has been celebrated in academic circles and also has infected pivotal music movements (Howard, 2008; Warwick, 2018). It is also hard to overstate the influence of socio-economic developments in dub producers. They employ compositional techniques that carry social or political messages, embedding their sound into a very particular real-world context (Yoganathan, 2018).

The birth and evolution of polymer technology represent an accurate analogy with the development and performance of dub music. Involving science into the process of production and industrialization of a chemical process, the design and manufacturing of materials made of polymers require a considerable piece of knowledge and science, as well as its final application and use, just like music production and performance.

We propose a piece that looks out to reflect on the outcome of a creative process traditionally related to technology with the use of intelligent agents while weighting the long-established artistic idea of finding beauty and meaning in music. Also, embodying current socio-economic and cultural values as well as the continued and natural evolution of dub music. *Polymer Dub* is composed using repeated patterns or building blocks of music, which can be simple or more complicated structures (such as polymer materials). In performance, we traverse the construction and composition of polymer materials, building around a skeleton structure. We employ the concept of using the mixing board as an instrument, using a computer and a MIDI controller. The performance contains elements and sources of uncertainty provoked by the performer in conjunction with algorithmic composition features provided by intelligent agents influencing musical sequences and parameters on a digital mixing board.

The sound in this piece is dry, minimalistic, precise and robotic, softened with echoes, a wall of sound and field recordings. Drums and bass are deep and percussive, creating a contrast with the rest of the composition and remains at the heart of the performance. In this aspect, Polymer Dub adds new layers and dimensions to early and classic dub techno tracks, which avoided any sense of anticipation. The use of generative processes with Markov Chains on the performance creates a higher grade of entropy and hence, surprise and interest. It contrasts with the steadiness of wall of sound soundscapes, which avoid development through repetition in an alternate sense of time, by representing aesthetic relationships between the soundscape of a city and its acoustic elaboration in an artistic effort to reproduce the dynamic ecology of a city (Kolioulis 2015).

Media Assets

This section presents links to previous recordings of the performance described in this proposal.

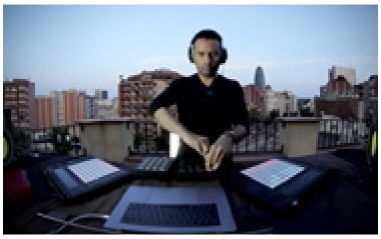

Fig. 1. Polymer Dub at Barcelona by SAE Institute. https://youtu.be/u8kY-aYkvHE?t=329.

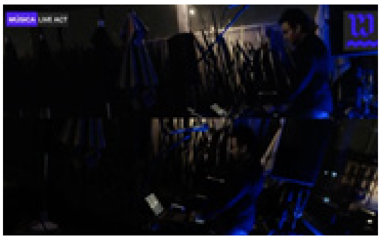

Fig. 2. Polymer Dub at Mexico City by Centro Cultural España. https://www.youtube.com/watch?v=3S_LI9IjG8Q.

References

Howard, D.
2008. *From Ghetto Laboratory to the Technosphere: The Influence of Jamaican Studio Techniques on Popular Music*. Journal on the Art of Record Production 3 (1).

Kane, S.
2014. *Nils Frahm: 'It is inspiring to play the studio like an instrument'.* The Irish Times. https://www.irishtimes.com/culture/nils-frahm-it-is-inspiring-to-play-the-studio-like-an-instrument-1.1801638.
Accessed: 6 February 2020.

Kolioulis, A.
2015. *Borderlands: Dub Techno's Hauntological Politics of Acoustic Ecology*. Dancecult: Journal of Electronic Dance Music Culture 7(2): 64–85 ISSN 1947-5403 2015. http://dx.doi.org/10.12801/1947-5403.2015.07.02.04.

Warwick, O.
2018. *Dubbing is a Must: The modern sound of leftfield dub*. Fact Magazine. https://www.factmag.com/2018/01/28/leftfield-dub-seekers-bokeh-boomarm/.
Accessed: 6 February 2020.

Yoganathan, N., & Chapman, O.
2018. *Sounding Riddims: King Tubby's dub in the context of soundscape composition*. Organised Sound, 23(1), 91-100. https://doi.org/10.1017/S1355771817000310.

Ligeti Hall Performances

Matters 5

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Keywords: Acousmatic, Granular Synthesis, Multichannel Audio, Algorithmic Composition Sound and Form.

Matters 5 is a fixed media composition, here in a version for 24 speakers. The piece formally consists of two parts that have been algorithmically generated with similar parameters of granular synthesis and different sound files (two short double bass samples). The scattered groups of grains – statistically distributed following combinatorial rules – have been processed by 24 reverb units with independant and partially extreme parameter changes. The intended room impression is one of surreality and blurring, corresponding to the formal development.

Sound and Form

Granular synthesis has been in the focus of my compositional work for many years – however, there are always variants, that open new possibilities, at least for the own perspective. In *Matters 5* I decided for a relatively simple way of buffer granulation with SuperCollider patterns. While experimenting with synchronous and asynchronous granular sequences I ended up with a rhythmical structure of phrases that consist of percussive events, short synchronous sequences and rests. The latter follow a fixed exponential random distribution and the percussive events stem from overlapped grains. This pattern produces a kind of irregular regularity, a non-beat swing, that, with its specific parameter setting, I appreciated very much and which gave me the room to work with strange reverb effects. The rhythmical structure of the granulation is confronted with—respectively overlapped by—LFO-controlled movements of the buffer read head and further LFO controls of various reverb parameters, which produce meta waveforms and further near-rests.

As the rhythmical foundation seemed to be sustainable for different sound sources I decided for two different ones that lead to interestingly contrasting results. In the first part a scratch sound is taken and, due to its noisy nature, perceivable pitch, though present, doesn't play an important role. The grains' playback rates are randomly changing every few moments so that the overall harmonic character is atonal. Decreasing dampen parameters of the reverb are causing accumulations of broad clusters, further blurring any unique perception of pitch in a section of turmoil before one of relaxation. In the second part a short glissando gesture of the double bass, moving around a central tone, is taken as a base for combinatorically established harmonic variations in just intervals (3/4, 4/3, 7/8, 8/7). Its character is much more quiet, but a second bow form within the piece is built up. It results from a gradual shortening of grains, which changes the role of the double-dealing reverb to that of metal-like resonator. Single intermediate sequences of longer grains cause reminiscences of the glissando gesture.

Space

The 24 speakers are treated as three rings of 8 speakers, which allows an adaption to different setups from 8 speakers onwards (see the chapter about routing convention). The spatial movements come from two different and independant algorithms: The scattering of grains is organised as a loop of weighted random choices – for percussive pulses and short sequences two or three L/R-pairs in each ring are chosen. The probabilities weaken the weight of rear and rear-side speakers. The continously changing dampen and mix parameters of the reverb units (low frequency sine waves of close frequencies) are additionally causing spatial movements, which are noticably accelerating in the first part of the piece. In the end two SuperCollider programs were rendered to two 24 channel audio files (26 including the stereo version). Besides a single crossfade in the middle of the piece and applying a low shelve filter no post-processing was done in the digital audio workstation (Reaper), see Fig.1.

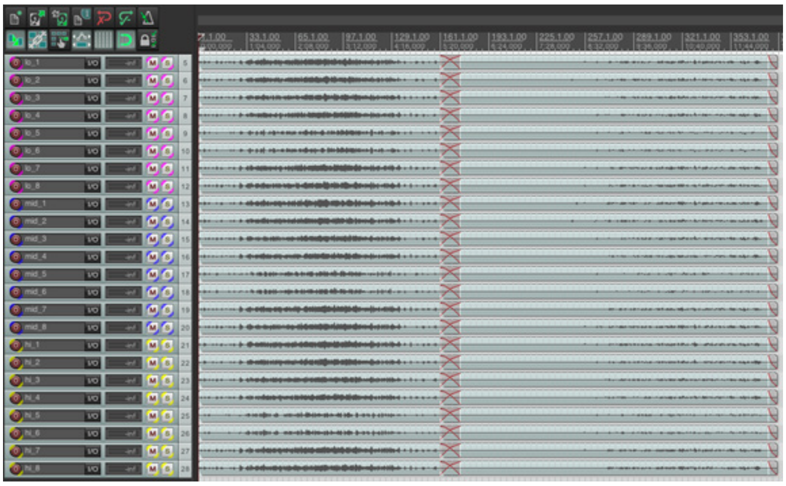

Fig. 1. *Matters 5*, Reaper session, overview (12:46).

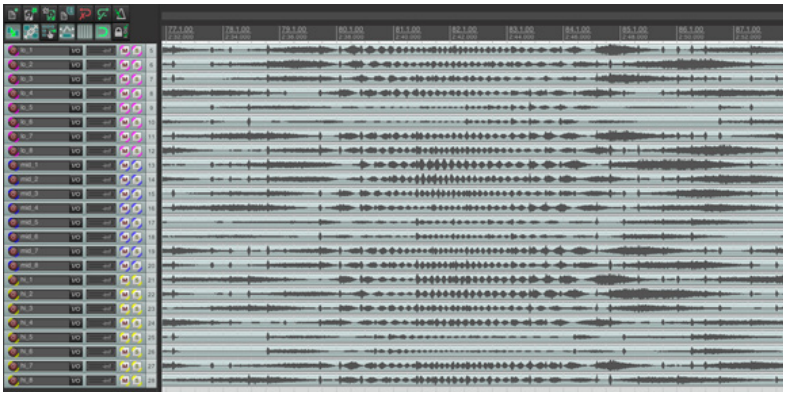

Fig. 2. *Matters 5*, Reaper session, ca. 2:32–2:54.

Fig.2 shows a turbulent section in the first part. On the left side the combinatorial distribution of percussive events in space can be observed, the middle shows the slightly decorrelated amplitude oscillation of the reverb, which becomes slower on the right side. The different weights of channel pairs can also be seen—in every group of 8 especially the rear channels 5 and 6 are of lower amplitude. The timescale of the snapshot inhibits a view into the granular structure and its separate spatial characteristics, which overlap the spatial effects of the reverb.

Routing in Various Multichannel Setups

The mono sound files should be used according to the following rules:

1. The basic 8 ring (soundfiles with suffixes A1, A2, …) must be there and placed in the intended order, prefered in the low level.
2. The optional 8 rings (soundfiles with suffixes B1, B2, …, C1, C2, …) can be placed at higher levels or at the same level as the A ring. There’s no obligation to keep the B-ring below the C-ring, their roles can be switched. If levels have different numbers of speakers, then the groups A, B, C can be distributed to different levels as long as all other rules are fulfilled.

3. The L/R-pairs of the optional rings (1/2, 8/3, 7/4, 6/5) must remain complete (e.g. 1 must be used with 2) and placed at left and right side of the room, mirrored at the axe.
4. Pairs of optional rings might however be omitted, as long as the L/R-pair 1/2 is used and the order of the L/R-pairs from front to back is kept, e.g. (1/2, 8/3, 7/4) or (1/2, 6/5).
5. The L/R-pairs 1/2 and 8/3 must not be placed in the back half of the room whereas the L/R-pairs 7/4 and 6/5 must not be placed in the front half of the room.

Example Setups

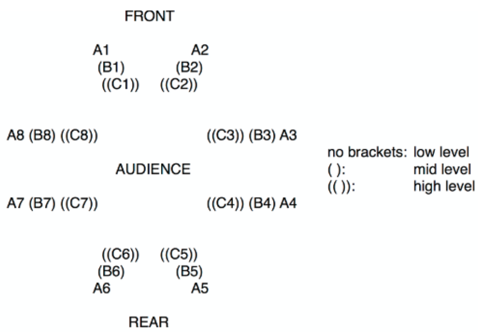

Fig. 3. Shows a full 24 speaker setup with 3 rings, for a 16 speaker setup with two rings the C-ring as well as the B-ring can be omitted.

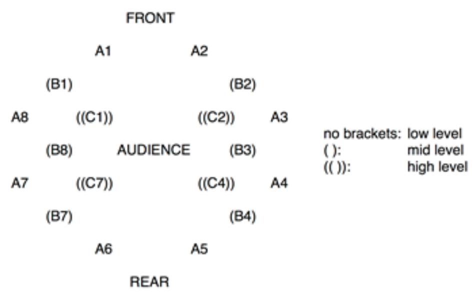

Fig. 4. Shows a setup with incomplete B- and C-rings, both incomplete rings could be omitted as a whole.

Suggested Routing in the MUMUTH

From the speaker setups described in the call, “hemiaux” would be suited best. It can roughly be understood as a setup consisting of 3 rings of 10, 8 and 6 speakers, nearly mirrored along the room axe. It’s almost a perfect layering of 3 x 8 rings, as only adaption – in accordance with the described setup rules – the two rear sources of the C-ring would be routed to the additional rear speakers of the low level ring.

MUMUTH hemiaux	2	3	4	5	6	7	8	9	10	12	13	14	15	17	18	19	20	21	23	24	25	26	27	29
Matters 5 audio file suffix	C3	C2	C1	C8	C7	C4	B4	B3	B2	B1	B8	B7	B6	B5	A5	A4	A3	A2	A1	A8	A7	A6	C6	C5

Fig. 5. *Matters 5*, suggested channel routing for the MUMUTH.

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Polyharpye Reclaimed

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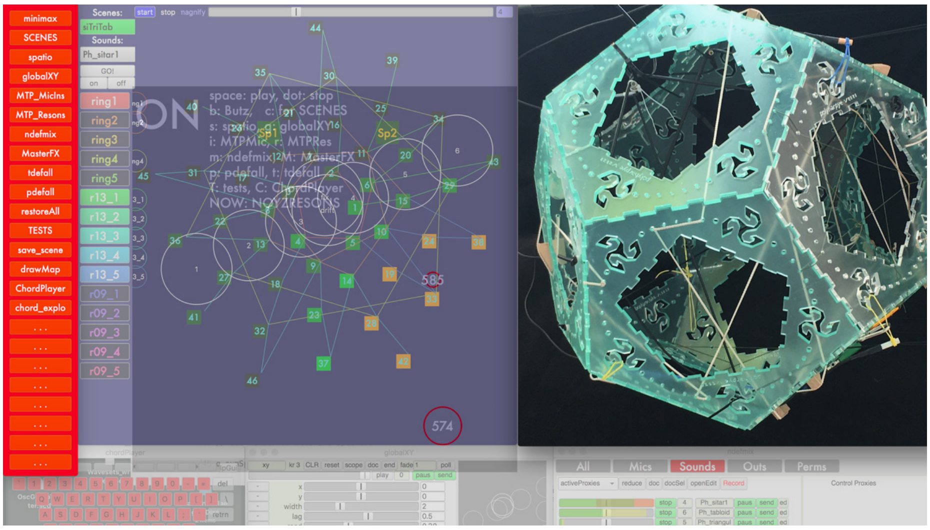


Keywords: Complexity, Improvisation, Spatialisation, Xstruments, Networks of Influence.

Polyharpye Reclaimed combines two parts: a complex sound world originally created for a large sculptural installation consisting of networks of ropes, and two new interfaces for playing it independently of that installation, thus reclaiming it. The sound world contains spatially mapped networks of complex resonators expecting polyphonic sound input. The MultiTouchPad interface generates synthetic source sounds by Ginger movement; the _Polyharpye_ interface, a network of strings suspended in a dodecahedron, generates vibrational source sounds. As _Polyharpye_ is designed for nontrivial, surprising behavior (by feedback and other meta-control strategies), I consider it an _Xstrument_, best explored in improvised performance.

The Sound World

The larger context of this piece is *On Air,* an expansive solo show by Studio Tomas Saraceno at Palais de Tokyo, Paris (2018)[1]. The show claimed that the artworks form an ensemble - a network with information flowing between nodes; to make good on that promise, Dominik Hildebrand (then technical wizard at Studio Saraceno) proposed that, sound being the medium that permeates everything, it is *sound* that flows between the nodes. He realised this with an extensive AVB network of audio interfaces and OSC messaging connecting the entire house, and many elegant details that would warrant their own paper. To fulfil these plans on time, he invited Hannes Hoelzl and myself to consult and realise the SuperCollider-based standalone app that runs the pieces in this network, as well as the sonic content of these pieces.

1. https://studiotomassaraceno.org/on-air/.

The crowning capstone of the show is *Algo-r(h)i(y)thms,* a large sculptural installation consisting of geometric shapes built from ropes, such as Platonic polyhedra with geometric structures nested inside them. These shapes are suspended on ropes that terminate on walls, ceiling and floor, filling a large museum space with a complex network of rope objects.[2]

2. https://studiotomassaraceno.org/algo-rhiythms/.

The Sound World underlying Polyharpye was originally created as the sonic complement for this installation. The initial concept for the installation by Dominik Hildebrand encompassed 64 end points of the suspension ropes being fitted with custom piezo pickups (designed by Hildebrand, C. Engelmann and T. Bovermann), which provide audio input signals to the sound world: By plucking, rubbing or otherwise exciting the ropes, performers or a museum audience could generate sounds. In the versions shown publicly, these sounds came from one of Hildebrand's initial sound sketches: a ringing filter design tuned to a spatially randomized major scale, and projected through loudspeakers and subwoofers near each corresponding rope. I contributed most of the infrastructure codebase for all pieces, resulting in some new SuperCollider libraries ("quarks") and updates to others.

Given the central role of the *Algo-r(h)i(y)thms* piece for the exhibition, I focused my artistic contributions on it. My final version of the sound world added many dynamically changeable choices: more scales, tunings and pitch/location mappings; more choices of resonating processes to be informed by rope-touch sounds; sceness with multiple sounding layers active in parallel, mapped to subsets of the space/pitch layout; and cross-fading between these scenes. All of this was implemented in SuperCollider and packaged as a standalone that runs all sound pieces in the exhibition.

From installation to performance

While the sound world is very enjoyable to play from the installation, its setup is prohibitively expensive and complex, which limits access to the sound world severely, even for myself. Thus, I decided to make it playable at accessible cost and technical requirements, the central issue being convincing alternatives to the physical vibrations from the network of ropes and its array of 64 piezo microphones: sound sources that allow players to inform and activate a large set of complex resonator sounds, and to select destinations for them in the flow of performance.

Interface 0: MultiTouchPad

Multitouch trackpads on current laptops provide interesting possibilities: The SuperCollider quark MultiTouchPad can track up to 11 fingers in position and touch-size, with good resolution and low latency. These can map directly onto the spatial layout of the sound world, allowing to activate specific locations, their associated pitch and mapped sound processes quite intuitively. Figure 1 shows the Polyharpye software interface with a transparent MTP window covering all other windows.

Fig. 1. The Polyharpye GUI with MTP window overlaid.

Interface 1: Polyharpye Xstrument

In the ongoing *Utopologies* project by the *Society for Nontrivial Pursuits* (S4NTP), we have been developing a network of simulated creatures consisting of algorithmically designed bodies with Raspberry Pi computers for brains, and sound and light output informed by group processes that negotiate a repertoire of shared behavior modes. The bodies are algorithmically designed by Christian Schmidts, and made of laser-cut plexiglass plates which can be taken apart and reassembled for easy transport. These bodies have small holes with hooks for attaching strings to stabilize the structures, and larger holes to access the insides.

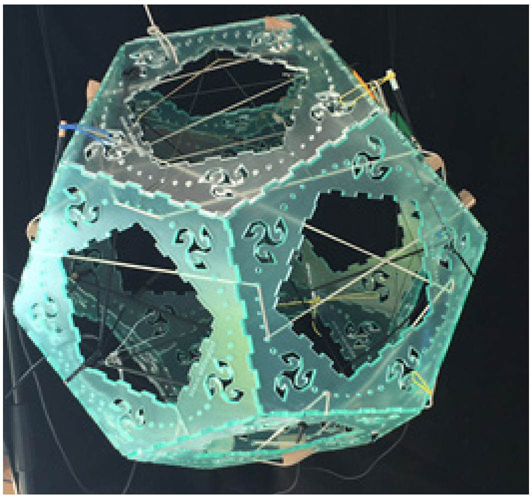
The insight that this is a physical analogon to massive networks of ropes filling large halls led me to the idea of creating variants of these bodies which contain an accessible, playable small network of strings; adding high-quality piezo pickups to them, and dynamically remapping these few piezos to the many available inputs of the sound world. Figure 2 shows the *Utopologies* creature *Bucky,* a precursor of which was used for early *polyharpye* experiments.

Fig. 2. The Utopologies Bucky creature.

The Polyharpye body prototype is structurally similar. On a symmetrical platonic body, the dodecahedron, each pentagon surface side is nested within itself for five levels, so each central opening is again a pentagon scaled down by the golden mean ratio. Each smaller cutout can be assembled into a body again, creating a family of self-similar objects.

The corners have specially shaped holes that derive from the traditional trinacria symbol (a circle of three legs). These and other holes and teeth offer many ways to attach string-like structures to it. The current prototype uses bass strings and differently textured ropes, amplified by plonk piezo pickups by Engelmann & Bovermann, see Fig. 4.

Fig. 3. The Polyharpye body v.1.



On Xstruments

Hannes Hoelzl and me share an extensive history of artistic research into music systems in which agency is gradually shared between the human and the machine/algorithmic parts. We are continuing a tradition that stems from Louis and Bebe Barron's "semi-autonomous creatures" (Laudadio 2007) and, more recently, Peter Blasser's "analog brains" (Blasser N.D.), and which is exemplified in the digital domain in Laetitia Sonami's transition from the *Lady's Glove*—conceived upon classical HMI notions of control that she gradually puts into question—to the *Spring Spyre*, which embraces a more fluent attribution of musical initiative and agency.

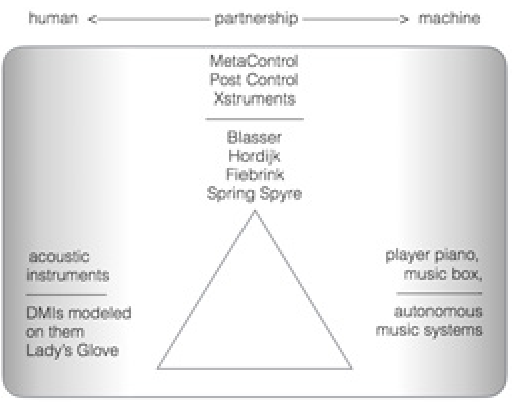


Fig. 4. Sharing of musical agency.

'Machines with agency' are designed to have degrees of autonomy that create a sense of playing with an idiosyncratic partner, rather than playing "an instrument" which leaves full artistic credit with the performer (Lewis 2000, Kuivila 2004 (on David Tudor), Hordijk 2009). Such systems pose very pointed questions: which aspects does the machine decide by itself? Which are designed to be influenced by human players? How does the physical interaction for this happen? What are the artistic intentions implied in, and the consequences of the specific design choices made?

To terminologically mark the step from a notion of DMIs that follow the paradigm of acoustic instruments toward one that takes full advantage of the categorically new possibilities of circuits and algorithms, we invented the term *Xstruments*, where the X stands for exploratory, experimental, or (as in scientific contexts), unknown.

Xstruments are characterized by the application of non-standard synthesis methods which yield sounds with rich inner movement. This is "inner life" of the sounds is facilitated by complex signal modulation, feedback paths on various levels from event-, control- to audio-rate, or by more sophisticated feedback topologies as described by Rob Hordijk for his *Rungler* (Hordijk 2009).

Another notable characteristic of *Xstruments* is in the modes of human interaction with the algorithms, which we termed *Metacontrol* or *Post-Control*. We have been developing strategies to make the mapping of human control to sound process parameters maximally flexible, especially during performance. Such strategies challenge gender-stereotyped fantasies of control (Sonami 2014) and propose alternatives. One approach is accessing a wide range of sounds with a small number of control interfaces/elements, as realised in the Modality project (Habbestad & Carey 2017); another is making the mapping design part of the artistic process (Fiebrink and Caramiaux 2016), while a third one deals with the exploration of immense multidimensional parameter spaces of aforementioned sound processes. Such approaches have been implicit in the writings and artistic work of major STEIM proponents (Ryan 1992, 2001, Waisvisz 1999), and we have published a selection of our own Post-Control strategies, such as the entangled mapping of *Influx* (de Campo 2014), presets by random seeds and *Random Orbits* (Hildebrand et al. 2017). Together with the sound world, the MultiTouchPad and the *Polyharpye* interface constitute Xstruments.

The Performance at xCoAx / MuMuth

The performance will be an improvised exploration of the sound world for ca. 10–12 minutes. The option of 3D-positioning 29 speakers at MuMuth is ideally suited for creating spatial situations for the superposed layers that let the audience appreciate the complexity of the experience more deeply.

Acknowledgements: Many of my software libraries are being developed with the SuperCollider community; and many of my musical concepts are co-developed with my artistic partner Hannes Hoelzl, and refined with our students and alumni. Special thanks to our alumnus and friend Dominik Hildebrand for inviting us to collaborate on the show at Palais de Tokyo, where *Polyharpye* began.

References

de Campo, Alberto.
2014. Lose control, gain influence - Concepts for Metacontrol. In: Proceedings of SMC/ICMC 2014, Athens, Greece.

Hoelzl, Hannes, Han, Isak, and de Campo, Alberto.
2019. The Airborne Instruments nUFO: a Movement Based Musical Instrument for Possibility Space Exploration. In: Proc. of 6th Int'l Conf. on Movement and Computing.

Blasser Peter.
N.D. PHILOSOPHICAL PAPERZ (crescence : goals). Retreived February 2020 from https://ciat-lonbarde.net/fyrall/paperz/index.html.

Hildebrand Marques Lopes, Dominik, de Campo, Alberto, and Hoelzl, Hannes.
2017. Three flavors of post-instrumentalities: The musical practices of, and a many-festo by Trio Brachiale. In: Musical Instruments in the 21st Century. Springer, Singapore. pp. 335-360.

Hordijk, Rob.
2009. The Blippoo Box: A chaotic electronic music instrument, bent by design. in Leonardo Music Journal 19: 35-43.

Laudadio, Nicholas.
2007. What Dreams Sound Like: Forbidden Planet and the Electronic Musical Instrument. Journal of the Fantastic in the Arts 18, no. 4: 334.

Sonami, Laetitia.
2014. And now we leave gloves and other wearables to (small) dictators. NIME 2014 Keynote Speech, retrieved February 2020 from www.sonami.net/writing-goldsmith.

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Eyes Draw Circles of Light

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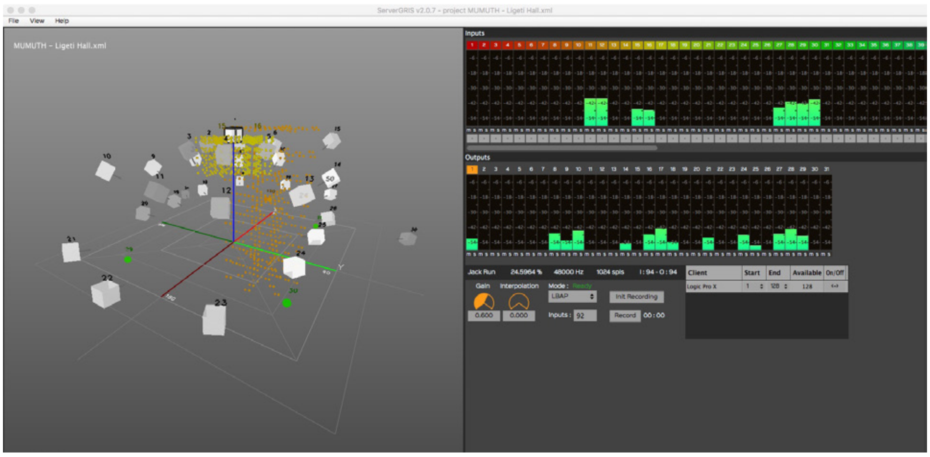


Keywords: Immersive Music, Acousmatic, Psychoacoustics, Voice.

The work is an immersive acousmatic piece that explores specific aspects of the unconscious that characterize the brief moment when we are about to fall asleep. Through sound spatialization, a multidimensional unconscious representation was created that evokes the relationship between psyche and body. The fast and involuntary body movements, hypnic jerks, that may occur at that time have been underlined. The work is a collaboration with the artists Elisabetta Porcinai and Alice Nardi, who wrote a poem for it, and it aims to find a balance between elegance and experimentation.

2020.xcoax.org/nig/

Description

The work explores specific aspects of the unconscious that characterize the brief moment when we are about to fall asleep and we are not sure if what we are perceiving is a dream or the reality. Through sound spatialization, a multidimensional unconscious representation was created that evokes the relationship between psyche and body. The fast and involuntary body movements, hypnic jerks, that may occur at that time have been underlined. The work is a collaboration with the artists Elisabetta Porcinai and Alice Nardi, who wrote a poem for it, and it aims to find a balance between elegance and experimentation. The text was interpreted by Porcinai and then elaborated by the composer.

This piece focuses on aspects related to spatial auditory perception, concerning the choice of sonic materials, their processing, and their positioning and trajectories in space. Emphasis is placed on sounds that evolve on the vertical axis. The sound spatialization was created using SpatGRIS and ServerGRIS (Normandeau et al. 2018), developed at the GRIS at the University of Montreal.

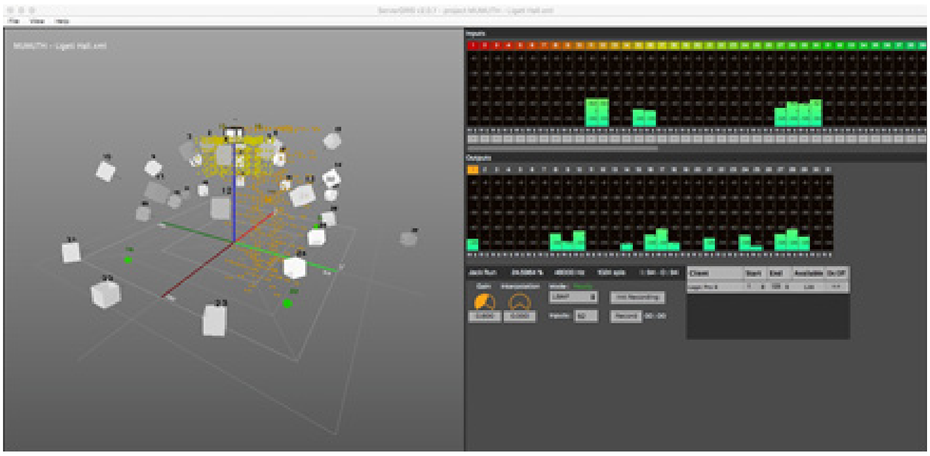


Fig. 1. ServerGRIS, Mumuth — Ligeti Hall Speaker Set up.

The composition is divided into four sections. *Eyes Draw Circles of Light* relates body and breath sounds to high-pitched iterative sonic contents, that are easy to localize (Kendall 2011). This section is characterized by the use of hand-written spatial trajectories. Some of the material were created using a violin bow on a metal wires structure. A prepared piano was also used. *Expand Withdraw Pulsate* focuses on spatial polyrhythms projected into the 3D space. This section, in opposition to the previous one, is characterized by the use of precise geometric spatial trajectories. In *Treacherous Darkness of Senses*, the Porcinai's voice is accompanied by synthetic and concrete sounds. The voice has a fixed position in space, while the concrete sounds are marked by 3D trajectories. The last section, *Arms Stretched Out Like Branches*, reorganizes the elements of the first section by adding some tonal material. To investigate the vertical dimension, trajectories that evolve on this axis are highlighted by the use of bright, high-pitched sounds (Roffler and Butler 1968).

This piece is part of the doctoral research project of the author at the Université of Montreal. The research project focuses on immersive music composition, exploring, from an artistic perspective, the contribution of the spatial auditory perception field to sound spatialization strategies.

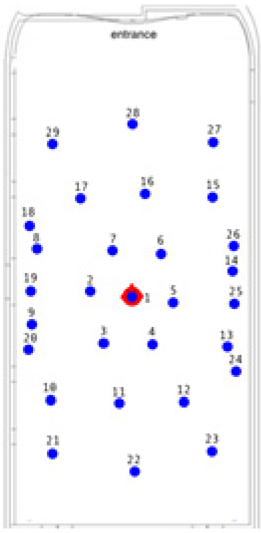
Media Assets

This is the binaural version of the piece:
https://drive.google.com/file/d/189HZ1oxOjWjV7kjC97DHQTVhOu-IspTUE/view?usp=sharing

This is the stereo version of the piece:
https://drive.google.com/file/d/1PhNJz8TbtnWxIdfiB9Gbt6sj2C8GXm-FG/view?usp=sharing

The piece was rendered for the Mumuth – Ligeti Hall Speaker Set up, using the following schemes.

Fig. 2. Mumuth — Ligeti Hall Speaker Set up.



Channel Nr.	X	Y	Z
1	0	0	8.355
2	2.664	-0.352	7.890
3	1.864	2.902	7.890
4	-1.256	3.06	7.890
5	-2.664	0.23	7.890
6	-1.886	-2.901	7.890
7	1.256	-3.051	7.890
8	6.227	-3.232	5.860
9	6.558	1.75	5.860
10	5.235	6.71	6.550
11	0.83	6.795	5.880
12	-3.352	6.71	5.660
13	-6.222	3.222	5.860
14	-6.564	-1.749	5.860
15	-5.251	-6.528	6.470
16	-0.824	-6.816	5.870
17	3.358	-6.539	5.630
18	6.665	-4.726	2.350
19	6.665	-0.395	2.350
20	6.665	3.371	2.350
21	5.235	10.092	2.350
22	0	11.361	2.350
23	-5.251	10.102	2.350
24	-6.66	4.726	2.350
25	-6.66	0.384	2.350
26	-6.639	-3.371	2.350
27	-5.24	-10.102	2.350
28	-0.013	-11.361	2.350
29	5.235	-10.102	2.350
30 (sub)	-6.928	8.961	10.8
31 (sub)	-6.928	1.803	10.8
32 (sub)	-6.928	-5.384	10.8

References

Kendall, G.
2011. Why Things Don't Work: What You Need To Know About Spatial Audio. *Proceedings of the International Computer Music Conference*.

Normandeau, R. et Ledoux, D.
2018. An Immersive Approach to 3D-Spatialized Music Composition. *Proceedings of the Audio Mostly Conference.*

Roffler, S. et Butler, R.
1968. Factors that influence the localization of sound in the vertical plane. *The Journal of the Acoustical Society of America 43*.

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Ring Study II/b: Live Performance with an Autonomous Pitch-Following Feedback System

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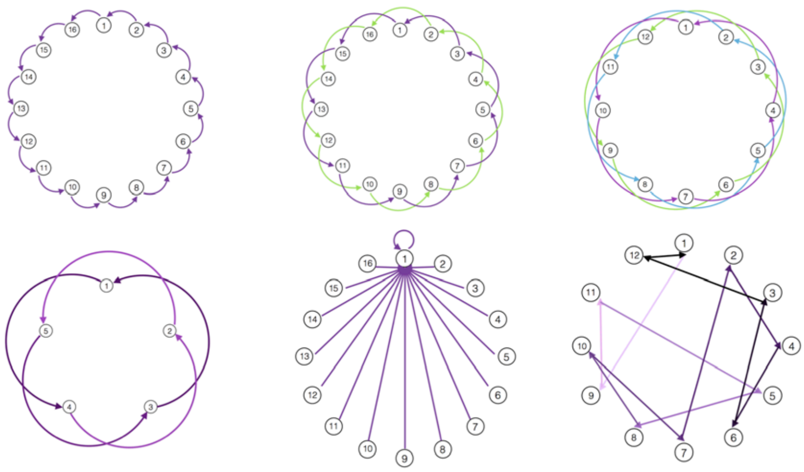

Keywords: Pitch-Following, Feedback System, Live Coding, 3D-Audio, SuperCollider, Autonomous System, Knot-Theory, Improvisation.

Ring Study II/b is a live coding performance for 3D loudspeaker setups realized in SuperCollider. It consists of up to 64 discrete audio channels, each playing the output of a sine-oscillator, which follows the frequency from another channel (or itself). Using a Knot- and Graph-theory inspired approach, links and relinks between channels are performed to build up different knots, chains or rings, creating one or multiple feedback loops. The performance is a real-time interaction with the system, mainly by controlling the topologies of the signal-flow and exploring the resulting behavior in space.

2020.xcoax.org/jil/

Description

Concept

The idea of an autonomous pitch-following feedback system is derived from the ongoing "twin-work" *Ring Study II/a*, consisting of more than 12 singers sitting in a circle, humming quietly and continually at individual pitches. Once started, each of them attempts to follow the next singer's pitch. How would this process evolve? The singer's inaccuracies or deviations may be the crucial factor influencing the performance's overall effect and its development in time.

Algorithms may lead to inaccuracies in their own ways. *Ring Study II/b* models the same idea as a digital feedback-system, leading to a performance with different dynamics and qualities. The "singers" are now sine-oscillators, listening to each other through pitch-following algorithms. Inaccuracies in the results of the pitch-following algorithms are captured and amplified into the human listening space through interaction with the system - controlling the topologies of the signal-flow and modulating the signal through constant observation and auditory feedback of the system's behavior in space.

Signal-Flow and Signal Modulation

The oscillators exist as nodes in a virtual space and could arbitrarily listen to any other node in the system, without necessarily considering how they are mapped into the acoustic space.

Consider a following-rule where each oscillator listens to the one at two nodes of distance, an even number of nodes would result into a following-structure of two rings, an odd number would result into a knot. If the distance is a factor of the total number of nodes, a following-structure of multiple individual rings would result. Highly composite numbers of nodes have more possibilities of being divided evenly.

Beside specifications of the signal-flow topology, additional following-rules are applied, specifying signal modulations at every node. A "director" argument specifying a frequency offset and a noise generator are added to the frequency of the sine-oscillator detected by the pitch-follower[1], allowing to influence the system's behavior and complexity. Furthermore, frequency modulation of the signal provides a means to shape the spectral content of the sound. Interesting artifacts happen when the modulation frequency is out of the specified frequency-range of the pitch-follower, especially when all oscillators just listen to one node.

1. https://doc.sccode.org/Classes/Pitch.html.

Spatial Behavior and Live Performance

Each oscillator (node) is mapped to a discrete channel in the listening space. Spatial effects result as consequences of the system's behavior, presenting a fertile ground for the real-time exploration of sound in space. Rings build from rules specifying node connections as ordered series are easily noticeable as coherent structures when mapped to corresponding loudspeaker positions in the listening space. Rings resulting from randomized node couplings lead to more diffuse effects and emergent phenomena.

All parameters are accessible trough live coding while some of them are also accessible through a MIDI-controller. This offers possibilities for different levels of dynamic encounter with the system. The performance has a variable duration given the large variety of possible modes of interaction with this autonomous system.

Acknowledgements: I would like to thank Patrick Borgeat, Christoph Seibert and Michele Samarotto for their support and encouragement.

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Naufrage: A 32 Channel Electroacoustic Composition

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Keywords: Spatial Music, Electroacoustic Composition, Acousmatic, Envelopment, Localization, Motion.

Naufrage is a 32-channel electroacoustic composition, constructed as a metaphor to the idea of a shipwreck where the audience are passengers cast away into a cave. The sonic landscape portrays their ideas of reality which gradually become distorted by their contemplation of images and shadows, relating to Plato's _Allegory of the cave_. Their imagined perception is transposed sonically through a large variety of sound objects, their direction and movement through space. This brings up an immersive sonic image where spatial characteristics are the driving forces of the composition, aiming to convey high degrees of perceived envelopment, localization and motion.

Description of *Naufrage*

Concept

Naufrage is a 10' 46", 32-channel fixed-media electroacoustic piece, constructed as an immersive metaphor to the idea of a shipwreck which casts away its passengers—the audience—into a cave. Inside, their senses are distorting their perception of reality, especially by the contemplation of images and shadows (Plato, ca. 375 BCE), which sonically are translated by various sound objects and their spectromorphologies[1], as well as their corresponding origin in space, spatial dimension and movement. The piece is constructed around four sections, depicting the general states of *confusion, deliration, acceptance* and *struggle* experienced by the castaways. This is not only reflected by musical discourse, but also by spatial discourse, via localization and movement of sound sources, which are particularly important in this piece. The artistic goal is to create a surreal acousmatic world, situated at the edge of familiar and unknown, with the hope that each member of the audience will have their unique, intimate interpretation.

1. Coined by D. Smalley, the term refers to the apparent temporal evolution of a sound's spectrum.

Sound Design

Being electroacoustic in nature, *Naufrage* was created by experimenting with various digital sound processes (e.g. granular synthesis, gating, modulations), applied in the software *MaxMSP*, to 2-channel recordings, conducted on field and inside the studio. Among the studio recordings there are various interactions with rocks, leaves, water and household objects, as well as a glockenspiel, while field recordings are represented by sea waves, wind, birds and various soundscapes of Belfast's countryside surroundings. The raw sounds were categorized in terms of spectromorphology in order to create similarities and contrasts. Further processing, composition and spatialization was done in *Cockos Reaper* software.

Spatiality

The piece was composed for the *Sonic Lab*—an offering and flexible concert venue based at SARC (Sonic Arts Research Centre) at Queen's University, Belfast, which offers the composers the possibility to surround the audience by 48 loudspeakers across length, width and height. Originally, *Naufrage* was designed for 32 speakers, by employing 4 octophonic rings displaced along the vertical axis where the first layer is at underground level (a few meters under the audience), the second at ear level while the 3rd and 4th corresponds to first and second floor. This immersive setup has the potential to be adapted to other state-of-the-art concert spaces such as MUMUTH's *Ligeti Hall* by re-assigning the 32 channels according to the speaker setup of this special hall in such way as to maintain as much as the original spatial image, as well as by compensating for the hall's unique acoustics through signal processing.

While designing the spatial soundscape, three attributes of space such as *envelopment*, *localization* and *motion* were specifically taken into account in order to create a well-defined spatial image, displaying both contrast and coherence. Each of these three spatial characteristics were associated to spectromorphological archetypes[2] (Smalley, 1997). *Envelopment* was created via decorrelation and spreading of *graduated continuants* on multiple speakers (Kendall, 1995), *localization* was established by assigning fixed origins in space for narrow or point-source *attack* sound archetypes, while *motion* was realized by amplitude panning of *attack-decays*, appearing to have trajectories of rotation, diagonals or sudden jumps.

2. Three spectromorphological archetypes, as elaborated by D. Smalley are *graduated continuants*, *attack* and *attack-decays*, in accordance with their temporal duration and spectral evolution.

References

Kendall, G.
1995. 'The decorrelation of audio signals and its impact on spatial imagery'. *Computer Music Journal* Vol. 19, No. 4: 71–87. MIT Press.

Plato.
ca. 375 BCE. 'Allegory of the cave'. *Republic*.

Smalley, D.
1997. 'Spectromorphology: Explaining Sound-shapes'. *Organised Sound 2(2): 107–26*. Cambridge University Press.

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Sparkline (With Serene Velocity)

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Keywords: Live Electronic Music, Room Acoustics, Impulse Response, Sound Diffusion, SuperCollider 3.

Sparkline (with acceleration) is live electronic music with no fixed media elements. A long pair of wires producing sparks along their length in a somewhat regular but non-metrical and never repeating series of impulses is recorded with two condenser microphones. The recording is played back immediately while it is still being recorded. The playback begins at a rate roughly 8 octaves slower than recorded and steadily accelerates until it is roughly 7 octaves faster and almost catches the input. _Sparkline (with serene velocity)_ is a video documentation of the piece and an homage to Ernie Gehr.

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Description

The sound of low current high voltage arcing is unusual in that it has no 'body'. It is not produced by a vibrating object pushing and pulling at the air but by a literal tearing of the air caused by a flow of electrons. This produces a sound that travels in all directions uniformly. To the ear, the sound of a spark has an unmistakable quality of presence and an association with electronic failure. It is a sound that cannot be adequately reproduced by loudspeakers—it exists at point of rupture just beyond the limits of coils and cardboard.

Sparkline (with acceleration) is live electronic music with no fixed media elements. A long pair of wires producing sparks along their length in a somewhat regular but non-metrical and never repeating series of impulses is recorded with two condenser microphones. The recording is played back immediately while it is still being recorded. The playback begins at a rate roughly 8 octaves slower than recorded and steadily accelerates until it is roughly 7 octaves faster and almost catches the input. That process is repeated. But the resultant sound is quite different the second time as the accumulation of accelerated impulses invades the recording process along with additional manipulations that juxtapose the impulses of digital 'glitch' with the impulses of the sparks.

To my ear, the interaction of static, steady but never quite repeating, and speaker, relentlessly and somewhat dogmatically accelerating, makes it possible to hear more in each. When the speaker playback is slow, the reverberation of each spark is lengthened; when it is fast, the longer-term patterning of the sparks becomes evident. And the spatial specificity of each spark becomes more vivid against the wash of its playback. And the teleological drive of the glissandi and the processual stasis of the sparks serve both our need to know and our desire not to care.

For MUMUTH-Ligeti Hall, I planned a new version that would diffuse the sound of the through the speakers in the "sky". The goal was to place each successive spark, roughly 7000 sparks in total in a distinct pair of speakers, sounding all 4032 speaker pairs available. Of course, our current epidemiological woes make that piece, which is called *Sparkline (with the Sky),* impossible to realize.

Instead, I have made a video version of the piece for online presentation. Since the piece is entirely about liminal physical presences, none of it translates well to online presentation. However, video offers the possibility of experiencing visually and aurally, a succession of completely distinct observation points. In performance, one would never get very close to the sparks, on video, one can. *Sparkline (with serene velocity)* presents the piece as a video of constantly changing camera perspectives in a manner that draws on Ernie Gehr's classic experimental film of a hallway seen at constantly changing degrees of 'zoom'.

Fig. 1. A set of 16 stills at a fixed perspective of *Spark Line (with acceleration)*.

Doctoral Symposium

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Performative Metacreation: An Artist-Centred Exploration of Artificial Intelligence

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Keywords: Metacreation, Performing Arts, Artificial Intelligence, Machine Learning, Digital Performance.

Significant developments in machine learning and artificial intelligence provide new means and media to be used in the arts. At the intersection of new intelligent systems and the performing arts, this project proposes an artist-centred and performance-based research, aiming to develop a theoretical framework that will enable the understanding of metacreative practices and allow the analysis of artworks made with and from such systems. In parallel it is proposed the development of a system capable of integrating the various practices raised as well as a series of performances as artistic exploration. Promoting a greater understanding about the performative event, this project addresses questions such as how are the artefacts generated, which new practices exist and how these systems transform contemporary performance in unprecedented ways.

1. State of the Art

Computers are able to imitate creativity and artistic expression. Current developments in artificial intelligence and machine learning allow not only the exploration of these systems as generative media, but also promote drastic changes in artistic practice. They are revolutionizing multiple aspects of performance art (Baalman 2020), electronic music (Briot et al. 2019) and visual art (Akten 2018), raising questions regarding perception and meaning of artistic artefacts (Hong and Curran 2019). Simultaneously, the audience's understanding of the artworks is less and less clear, as is the very collaboration of artists and systems (Mazzone and Elgammal 2019). This has led us to a state in which all practices in this field have to be thought of in an increasingly adaptive and multifaceted way.

Alan Kay observed that computers are representation machines that can emulate any medium (in Carvalhais 2016), that they are therefore the first *metamedium*, and have degrees of freedom for representation and expression never before encountered. With this, aspects of *metacreation* (Eigenfeldt et al. 2014; Gorlée 1996) become more common as artists start "endowing machines with creative behaviour" (Whitelaw 2008). In fact, musical and visual metacreation (Bodily and Ventura 2018; Eigenfeldt et al. 2014) are already established areas of research that explore various forms of computational creativity (Zhang and Yang, 2015; Colton and Wiggins 2012) where we can find novel systems for performance (Tatar and Pasquier 2017).

Artistic explorations using machine learning and artificial intelligence have been adopted widely. Important venues such as Ars Electronica, ZKM and the CTM Festival provide not only performative spaces but also opportunities for discussion and dissemination. These are accompanied by laboratories such as *European ARTificial Intelligence Lab* and festivals such as *AIxMusic*. In the programming of venues such as these, several meaningful performances for this research were presented, exploring various types of systems and interactions. Examples are *A-MINT* by Alex Braga (2019), *Ultrachunk* by Jennifer Walshe and Memo Akten (2019), and *REVIVE* by Tatar et al. (2018), three projects of stage-based improvisation *alongside* artificial intelligence, where programmed agents perform in a role *similar* to the human. They are programmed with the ability to generate content and adapt during the performance. Also, *Alia: Zu Tài* a performance by Marco Donnarumma (2018) combines dance theater and artificial intelligence, promoting important criticism for the questions raised in this research such as, which kinds of identities artificial intelligence and robotics produce? How do those technologies influence the way we understand and discriminate human bodies? Which objectively lead us to questions such as, what is my performative role?

2. Objectives

This research is developed at the intersection of performing arts and metacreation, studying the use of artificial intelligence in artistic performance through a design-based research methodology (Barab and Squire 2004). Building on the contemporary digital performance (Dixon 2007) and its technologies (Broadhurst and Machon 2006) the main goal is to develop a taxonomy of metacreation and its practices within contemporary performing arts.

This goal will be achieved by analyzing existing references and identifying emerging patterns in the various performative practices such as: performance presentation, the type of interaction that exists between the artist and the system and the characteristics of the latter such as agency, awareness and types of content it generates. From here follow two secondary goals: i) Develop and present a series of performances that help to clarify and explore the taxonomy and that contribute to the dissemination of results within artistic and scientific communities. ii) Develop a fully functional software agent capable of integrating the different types of performances raised. Given the importance of the system's processes and the way they condition the artist's freedom, we propose to develop all the necessary technological solutions, building prototypes, software and multimedia systems for the performance series, seeking to bundle the various technological results into a single instance.

These objectives represent interdisciplinary contributions and help to answer questions such as: i) what are the models of metacreation? ii) how can these help to reveal the audience's understanding and perception of artistic phenomena? iii) how can these newly introduced systems generate entirely new performative practices? iv) how can intelligent technologies change the reflection and responsibility of performers in the moment of creation and presentation? v) considering the pursuit of computational creativity, what are the affordances of these systems, how can they be used in novel and unique ways?

3. Description and Contributions

Already in the process of development during this first year of the doctoral programme, the first step of this research is a thorough review of the literature covering metacreation and performance art. This project starts from frameworks of analysis such as that of Geraint Wiggins (2006) and taxonomies such as that of Eigenfeldt et al. (2013). This review will also reveal artworks, projects and publications relevant to classification that will be documented for future study and work.

The second phase of research will be a systematic survey of the state of the art. In order to develop a sufficiently robust taxonomy we need to study how artists are using these systems today (Visi and Aqaxa 2020; Wærstad 2020), how they used them in the past, and to answer questions as: How is performative practice combined with the massive development of areas like deep learning and computer hardware? How are the new performative proposals different from the previous ones raised in the literature review and what really made that difference?

From this point we will also begin developing a series of performances. These will provide feedback that will not only allow a continuous adjustment of the taxonomy but also represent artistic results that will validate the work in progress and give space to phenomenological discussions. Before their public presentation we will carry out tests in controlled contexts, assessing aspects such as audience perception, and gathering relevant qualitative information through questionnaires and by critical observation of participants (Blain and Minors 2020; Smith and Dean 2009).

The use of artificial intelligence in performance requires the understanding of sophisticated systems and algorithms. We propose to develop the necessary technologies for the performances, providing the infrastructure as well as correlating new contributions with the technical references of taxonomy. It is a clear objective of this project to produce a system diverse enough to integrate the various types of performances raised as well as tackle different fields of the proposed taxonomy. It is also here that themes such as cognition, awareness and automation are explored intensively.

In order to clarify why such systems and their characteristics are used (Linkola et al. 2017) when necessary, interviews can be conducted with the referred authors in order to promote a better understanding of the cited performance. This will be done in a way sensitive to the context in which intelligent systems are used, the position of the authors in the face of their use and the modern definitions of artificial intelligence (Chollet 2019).

4. Progress Towards Goals

This research is currently in a process of systematic literature and performance review, the doctoral programme in which it is based began in October 2019 (Digital Media PhD University of Porto). At the same time as the review, digital technologies that might be considered relevant to this project in areas such as automatic improvisation, generative art, cognition and deep learning are currently being surveyed and studied.

References

Akten, Memo, Rebecca Fiebrink and Grierson, Mick.
2018. "Deep Meditations: Controlled navigation of latent space". In: NeurIPS 2018 Workshop on Machine Learning for Creativity and Design. Montreal, Canada.

Baalman, Marije.
2020. "the machine is learning". Proceedings of the International Conference on Live Interfaces. Trondheim, Norway.

Barab, S., and Kurt Squire.
2004. "Design-based research: Putting a stake in the ground" *The journal of the learning sciences* , *13* (1), 1–14.

Blain, Martin and Helen Minors.
2020. "Artistic research in performance through collaboration.".

Bodily, Paul and Dan Ventura.
2018. "Musical metacreation: Past, present, and future. " *Proceedings of the sixth international workshop on musical metacreation.*

Briot, Jean-Pierre, Gaëtan Hadjeres, and François Pachet.
2017. "Deep learning techniques for music generation – a survey." *arXiv preprint arXiv:1709.01620*.

Broadhurst, Susan and Josephine Machon.
2006. "Performance and technology." *Practice of Virtual Embodiment and Interactivity*.

Carvalhais, Miguel.
2016. *Artificial Aesthetics: Creative Practices in Computational Art and Design*. U. Porto Edições.

Chollet, François.
2019. "The Measure of Intelligence." *arXiv preprint arXiv:1911.01547*.

Colton, Simon and Geraint Wiggins.
2012. "Computational creativity: The final frontier?." In *Ecai*, vol. 12, pp. 21–26.

Dixon, Steve.
2007. *Digital performance: a history of new media in theater, dance, performance art, and installation* . MIT press.

Eigenfeldt, Arne, Miles Thorogood, Jim Bizzocchi, and Philippe Pasquier.
2014. "MediaScape: Towards a video, music, and sound metacreation." *Journal of Science and Technology of the Arts* 6, no. 1: 61–73.

Eigenfeldt, Arne, Oliver Bown, Philippe Pasquier, and Aengus Martin.
2013. "Towards a taxonomy of musical metacreation: Reflections on the first musical metacreation weekend." In *Ninth Artificial Intelligence and Interactive Digital Entertainment Conference.*

Gorlée, Dinda.
2010. "Metacreations." Applied Semiotics/ Semiotique appliqué 24.

Hong, Joo-Wha, and Nathaniel Ming Curran. "Artificial Intelligence, Artists, and Art."
2019. *ACM Transactions on Multimedia Computing, Communications, and Applications* 1 5, no. 2s.

Linkola, S., Anna Kantosalo, Tomi Männistö, and Hannu Toivonen.
2017. "Aspects of Self-awareness: An Anatomy of Metacreative Systems." In *International Conference on Computational Creativity* (pp. 189–196).

Mazzone, Marian and Ahmed Elgammal.
2019. "Art, creativity, and the potential of Artificial Intelligence." *Arts* Vol. 8. No. 1..

Smith, Hazel, and Roger Dean.
2009. *Practice-led research, research-led practice in the creative arts.* Edinburgh University Press.

Tatar, Kıvanç, Philippe Pasquier, and Remy Siu.
2018. "REVIVE: An Audio-Visual Performance with Musical and Visual AI Agents." *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems.* ACM.

Tatar, Kıvanç and Philippe Pasquier.
2017. "MASOM: A musical agent architecture based on self-organizing maps, affective computing, and variable Markov models." *Proceedings of the 5th International Workshop on Musical Metacreation (MUME 2017). Atlanta, Georgia, USA*.

Visi, Federico and Aqaxa.
2020. "You have a new memory." *Proceedings of the International Conference on Live Interfaces - Trondheim Norway*.

Wærstad, Bernt.
2020. "Ghost Doctor Duplicate." *Proceedings of the International Conference on Live Interfaces - Trondheim Norway*.

Whitelaw, Mitchell.
2004. *"Metacreation: art and artificial life"* M IT Press.

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

Zhang, Lu, and Hongji Yang.
2015. "Knowledge discovery in Creative Computing for creative tasks." Creativity in Intelligent Technologies and Data Science: First Conference, Volgograd, Russia, September 15–17. Proceedings. Vol. 535. Springer.

Performances

Alex Braga
2019. *A-MINT*. *Retrieved from the STARTS prize website* https://starts-prize.aec.at/en/.

Jennifer Walshe and Memo Akten
2019. *Ultrachunk*. *Retrieved from the website of one of the authors* https://www.memo.tv/portfolio/ultrachunk/.

Marco Donnarumma
2018. *Alia : Zu Tài*. *Retrieved from author's website* https://marcodonnarumma.com/works/alia-zu-tai/.

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The Aesthetic Values of Source Code

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Keywords: Source Code, Aesthetics, Programming Languages, Elegance, Clarity.

This paper presents the state of my doctoral research on the aesthetics of source code. The approach taken here is that of literary and linguistic analysis: by treating source code as text, it becomes possible to identify discourses about what values such as clarity, elegance, simplicity, efficiency are essential to formal disposition of source code. Due to the ambivalent position of source code as language that is understandable both by humans and machines, I aim at highlighting the multiple relationships between those aforementioned values. Through this process of identifying how aesthetics manifests formally in source code, the role and influence of programming languages will also be touched upon, insofar as they provide the linguistic structure within which those aesthetic manifestations take place.

1. Purpose of the Research, its Importance to the Field and Expected Contributions

The purpose of this research is to identify the role that aesthetics play in the writing and reading of source code. At first somewhat counter-intuitive—why should something ultimately understood by a machine as binary voltage current be deemed “beautiful” or “ugly”, “aesthetic” or not?—the fact that source code can have pleasing formal properties is almost universally acknowledged by programmers, digital artists and hobbyists alike. This implicit consensus about the possibility for code to be “beautiful” however falls short of providing identifiable and consistent formal aesthetic features specific to written source code. Taking the definition of aesthetics as a set of formal properties eliciting a sensory-emotional reaction in the creator and the beholder, this research project consists in looking at source code through the field of literary theory, by treating it as literary text, asking questions about form, authorship, readership, distribution and reception in the context of written scripts. The purpose of identifying the aesthetic properties of source code is to see to what extent these relate to, or differ from, the aesthetic properties of written language, and what is their relationship with the necessities of executing code. In particular, by looking at the tension between what is at the same time a machine-readable text and a human-readable text, I aim at highlighting the role that aesthetics play in both machine and human-understandings of source code.

This research intends to open up new readings of source code, using the lens of aesthetics in order to better understand how code functions as a specific semantic apparatus. It intends to bypass approaches of code as a purely theoretical notion—“code” as a term encompassing any and all kinds of computation, and thus erasing the variety of programming languages that make up its reality—, or as an effective procedure—code as a compiled binary and executed software. This definition of source code as limited to written code thus excludes graphical programming languages, although it is possible that the conclusions of the current project could apply to those, as well as executed code, thus drawing influences from, but not directly contributing to, the field of electronic literature. Specifically, this research contributes to an approach of aesthetics as a functional component in the creation, understanding, and re-use of cognitive objects.

2. Brief Survey of Background and Related Work

Overall, I intend to draw from two separate fields of research which address aesthetics in programming. The first starts with the literature on software development and software engineering as technical practice, as illustrated by the works of Djikstra, Knuth, Kernighan and others. Most of the publications in this field connects aesthetics, as well as the related fields of “art of computer programming” (Knuth 1962), “craft of programming” (McBreen

2001), or "beautiful code" (Oram 2007), to the reality of writing and reading understandable code—in a sense being concerned with "applied aesthetics". If one of the greatest hurdles of programming is to be able to comprehend what a piece of software's potential is, aesthetics is approached here as an essential step towards overcoming that hurdle.

A second field stems from media studies and software studies. It starts from broad theoretical work establishing a definition of software as a socio-technical and cultural object (MacKenzie 2006), towards close, deliberate readings of source code in more recent work (Montfort et al. 2012, Paloque-Berges 2009), complemented by an approach from the field of literary studies (Marino 2020, Hayles 2005). The object of source code is more and more the focus of researchers, particularly in terms of *what code means*, how it represents the world, and how it is represented in the world. However, little attention has been given to what kind of intrinsic formal aesthetic properties it could exhibit, or to what standards can source code be held to as an aesthetic object.

While dealing with the same object, the corpora studied are clearly separated from one another. One the one side, there exists a well-established corpus of commented source code circulating in the professional field of software development. These include best practices, code demonstrations, commentaries and text books, ranging from Djikstra's *programming pearls* (Djikstra 1970) to the commentary of the Unix version 6 source code (Lions 1976). The intent of this research is to further improve the quality of the software made by industry practicioners. References to other fields (such as linguistics, literary studies, or cognitive psychology) are therefore rare but not completely absent (see: Knuth 1984, Weinberg 1998). Most of the contributions of those texts is to establish concrete best practices when writing and reading source code, yet they only accidentally link it back to aesthetic and literary concepts such as *simplicity*, *clarity*, and *elegance*.

On the other side, the body of texts of self-defined *source code poetry* has been given close attention, but yet again mostly in terms of socio-cultural practices, and what they mean within the communities of programmers within which they were written and read. While often addressing the *poetics* of code (i.e. the world-making, storytelling potential of software), some of these (see: Temkin 2017, Aquilina 2015) focus particularly on formal exercises such as Perl Poetry, the Obfuscated C Code Contest and well-known esoteric languages and investigate to what extent these writings could qualify as "code". Within the realm of "artistic code", Paloque-Berges's work is closest when it comes to analyzing the specific forms that source code poetry takes, and what kinds of relationships those forms have with natural languages. For instance, she does so both by highlighting syntactical tokens that make Perl uniquely suited to this kind of endeavour, but also by providing larger theoretical frameworks, based on the idea of fiction (Goodman 1978) and of practice (De Certeau 1990).

The most relevant and interesting research today has been coming from the field of *Critical Code Studies* (Marino 2020) and digital rhetoric. These link directly the syntactic and the semantic components of software: reading source code is essential to understanding what that code is intended to do. It is in this trajectory of code rhetoric that I place this research project, particularly in terms of untangling the relationship between specific formal manifestations and overall conceptual understanding. In that sense, I will be investigating this specific overlap by linking both the analysis of software as a technical practice and as a socio-cultural object.

3. Description of the Proposed Approach and Current Progress

The proposed methodology is threefold: empirical, theoretical and experimental. The basis of this research will be constituted of primary sources: source code available online, published in hobbyist magazines, commented in textbooks or published as artworks. The analysis of these texts, along with the discourses around those texts (comments, reviews, discussions) will help develop a heuristic to understand when and how the criteria of the beautiful, as well as the ugly, is summoned among communities of programmers. This corpus encompasses all ranges of project sizes, languages and periods, from the Apollo IX landing module procedure, to the snippets published in fanzines, or the examples shown in style guides, as well as the more obvious recent publications of *source code poetry*. The wide variety of texts integrated into the corpus will allow me to identify to what extent the aesthetic standards identified are context-free—i.e. which aspects vary between high-level languages and low-level languages? between professional and amateur codebases? between educational and artistic settings?

The second component of this process will be to examine the findings from the analysis of this corpus at the light of the somewhat more traditional concepts of literary theory and linguistics. Recurring concepts in programming discourses, such as *clarity*, will be further examined in the light of concepts such as authorship, reception, rhetorical figures, style, voice and layout, among others. This cross-disciplinary approach will establish a framework which takes into account both the appreciations intrinsic to the communities of practice of source code (e.g. software developers), as well as further highlight some unique aesthetic properties of code via literary methods of analysis. For instance, there could be an exploration of the concept of *simplicity* by comparing the programming paradigm *DRY* (Don't Repeat Yourself) and Barthes's *writing degree zero* (Barthes 1972), or a re-assessment of *explicitness* in the light of Mikhail Bakhtin's *dialogism* (Bakhtin 1981).

Having sketched a conceptual framework for approaching source code as a text with potentially aesthetic manifestations, the last part of this research project will consist in confronting these conclusions with case studies. In line with the empirically starting point and the close-reading practice of Critical Code Studies, I intend to examine three texts, ranging in variety in terms of source code quality (professional, amateur, artistic), in order to confirm or infirm, and in any case further elaborate on, the framework established in the previous stage.

By working across disciplines, this research project intends to contribute both to software studies and to aesthetics. In terms of software studies, I have compiled a formal account of the collective practices and judgments which constitute aesthetic standards in the practice of reading and writing programs, highlighting to what extent these standards are contextual, and to what extent they are general, and in general making explicit the "ambient knowledge" which exists within these communities of practice. Following De Certeau's work on cultural studies and Sennett's work on craftsmanship, the next step is to show that the act of writing and reading beautiful code *matters*.

So far, showing that aesthetics matters has led me to further qualify the role of aesthetics as a functional one (telic, rather than autotelic), insofar as aesthetics can be judged by the extent to which, by making something *understandable*, they make something *work*. This research project therefore aligns with Goodman's claim that aesthetics are a functional part of cognitive appreciation of objects and phenomena with which we engage. By focusing on the relationships between the made (the object), the said (the language, programming or natural) and the thought (the concept) in the unique combination that software offers, I expect to contribute to a deeper understanding of the role of human and machine linguistics, as well as social contexts (as they are presupposed by linguistic activity) in the appreciation and judgment of aesthetic forms.

References

Aquilina, Mario.
2015. *The Computational Sublime in Nick Montfort's 'Round' and 'All the Names of God'*, in *CounterText*, Vol. 1 No. 3, Edinburgh University Press.

Bakhtin, Mikhail.
1981. *The Dialogic Imagination: Four Essays*, Austin and London: University of Texas Press.

Barthes, Roland.
1972, *Le Degré zéro de l'écriture suivi de Nouveaux essais critiques,* Paris: Editions du Seuil.

Chandra, Vikram.
2014, *Geek Sublime: The Beauty Of Code*, Port Townsend, WA: Graywolf Press.

Cramer, Florian.
2005, *Words Made Flesh: Code, Culture, Imagination*, Rotterdam: Piet Zwart Institute.

De Certeau, Michel.
1990, *L'Invention du Quotidien,* Paris: Editions Gallimard.

Djikstra, Edsger.
1970. *Notes On Structured Programming*, TU Eindhoven, retrieved online from: https://www.cs.utexas.edu/users/EWD/ewd02xx/EWD249.PDF on 28/04/2020.

Goodman, Nelson.
1978, *Ways of World-making*, Indianapolis, IN: Hackett Publishing Company.

Hayles, N. Katherine.
2005. *My Mother Was a Computer: Digital Subjects and Literary Texts*, IL: University of Chicago Press

Knuth, Donald E.
1962, *The Art of Computer Programming*, MA: Addison-Wesley.

Lions, John.
1976. *Lions' Commentary on UNIX 6th Edition, with Source Code*, University of New South Wales.

Mackenzie, Adrian.
2006. *Cutting Code: Software and Sociality*. New York, NY: Peter Lang.

Marino, Mark.
2020. *Critical Code Studies*, MA: MIT Press.

McBreen, Peter.
2001. *Software Craftsmanship: The New Imperative*, MA: Addision-Wesley.

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.

Oram, Andy, Wilson, Greg.
2007, *Beautiful Code: Leadings Programmers Explain How They Think*, BE: O'Reilly.

Paloque-Berges, Camille.
2009. *Poétique des codes sur le réseau informatique,* Paris, Editions des Archives Contemporaines.

Temkin, Daniel.
2017. *Language Without Code: Intentionally Unusable, Uncomputable, or Conceptual Programming Languages*, in CITAR, Vol. 9, No. 3, Portuguese Catholic University.

Weinberg, Gerald.
1998. *The Psychology of Computer Programming*, NY: Dorset House.

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"Some Things You Can Ask Me": About Gender and Artificial Intelligence

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Keywords: Artificial Intelligence, Digital Assistants, Gender, Feminization.

This study explores the relationship between gender and artificial intelligence, aiming to assess the reasons why digital assistants tend towards femininity and highlighting the social and cultural conventions that inform their development. It begins by confronting gender conceptions as defined by a binary framework with the evolution and integration of artificial intelligence in our daily life. Aiming to examine gender assumptions in current AIs, it draws on a previous analysis of four digital assistants regarding their anthropomorphization, tasks, and behaviours. It then complements this view with a survey of user preferences and gender perception regarding the interactions of these AIs. To this end, the project involves development of chatbots that gather information through dialogue and also raise awareness on how current digital assistants tend towards feminization. In this manner, this study seeks to discuss digital assistants' stance towards gender and question the social and cultural views they reflect back to us.

1. Purpose of the Research and its Importance to the Field

Personal digital assistants are no longer a thing of the future: they talk to us, listen to us, help us and, as artificial intelligence's increasing ubiquity often goes unnoticed, they become a natural part of our daily interactions. They are now embedded into our mobile devices and web-based services, not only assisting us in daily tasks but increasingly acting as friendly companions. In an attempt to become closer to our social reality, they are assigned human-like traits, features or even personalities. However, this growing anthropomorphization inevitably entails gender attribution which results in a behaviour that conforms to certain stereotypes and reinforces traditional assumptions of gender.

In this sense, this study seeks to question why femininity seems to be often present in AI, assessing the reasons behind this phenomenon and emphasizing its implications. In this way, it aims to understand, explore and expose the relationship between gender and artificial intelligence, discussing the cultural conventions that inform the conception of this technology and the way digital assistants tend to reinforce gender roles or stereotypes, reflecting social and cultural values back to their users.

It follows a theoretical, analytical and practical approach, seeking to raise awareness on the implications of assigning gender to digital assistants and incite reflection on this phenomenon.

Current discussions surrounding the sociocultural consequences of the integration of AI technology into our daily life, either by entities like UNESCO or in online media contexts, attest to the current relevance of this research, namely, by addressing gender issues and questioning associated stereotypes. We consider it relevant to expand on these discussions, exposing the implications of the growing ubiquity of digital assistants and discussing their stance towards gender, while taking into account that the rapid development of AI often eludes critical stances on the social and cultural roots that inform its evolution.

2. Background and Related Work

Artificial intelligence is already part of our daily life, as digital assistants become more ubiquitous, ranging from mobile devices to online services (Dale 2016). These assistants are gradually humanized, thus evolving from mere assistants to daily companions, developing emotional bonds with their users (Weizenbaum 1976; Richardson 2015). This intention of turning their interactions more natural encompasses a growing anthropomorphization, which reveals the presence of gender attributes. Socially, gender is mainly perceived through a binary framework, and certain acts, tasks and even jobs are identified as specifically masculine or feminine, reflecting stereotypes and a structural hierarchization of labour (Butler 1990; Prentice and Carranza 2002; Hester 2016).

In this sense, we can observe how digital assistants currently automate traditionally feminine jobs that reflect upon their tasks of service, assistance and emotional labour (West and Zimmerman 1987). Gender is also present in their voice, name and avatar, and their behaviour often conforms to "stereotypical and gendered behaviour patterns" as they fill the roles of caregivers and other roles coded as feminine in western society (Weber 2005). As such, we end up perceiving these entities not only as mere machines but also as "mirrors or substitutes" and the way we relate to our peers starts influencing how we relate to artificial intelligence and how it relates to us (Weber 2005).

Current trends in their development are not naïve regarding this phenomenon, although corporations are more focused in further anthropomorphizing and humanizing these entities. And while Alexa and Cortana intentionally present themselves as feminine personas, Google Assistant and Siri appear to be trying to become more diverse and unbiased in their characterization.

Observing this tendency, researchers and academics highlight the way gender (and, by extension, femininity) is instrumentalized to manage interactions between digital assistants and users (Eyssel e Hegel 2012; Piper 2016; Bergen 2016). In turn, common debates often advance user preference as a justification for feminized AIs and even popularize the belief that it's due to the field being mostly developed by men (Nickelsburg 2016; Steele 2018; Chambers 2018). In both contexts gender neutrality is seen as illusory since anthropomorphized virtual assistants inevitably engage with traditional and binary assumptions of gender. In this sense, there is little agreement on how to tackle these issues, and neutrality is often questioned in favour of gender diversity, namely, allowing the user to customize their assistant, and some authors even point out how these entities could fluctuate between more than one gender, thus being genderfluid.

3. Description of the Proposed Approach

Firstly, we aim to assess the theoretical foundations of this phenomenon and the questions that arise with it. Drawing on a previous study that confronts how gender is perceived under a binary framework with the integration of artificial intelligence in our daily lives (Costa & Ribas 2018), it begins by discussing how digital assistants tend to emulate feminine features through their anthropomorphization, the tasks they perform and their behavioural traits. The study begins with a theoretical approach, which structures the analysis of digital assistants, both complementing and informing the project's development.

Furthering this discussion, it observes the main questions that researchers and academics raise when examining the relationship between gender and artificial intelligence, confronting these views with the common discourse around the feminization of digital assistants in the context of online media coverage, while also paying attention to how AI is portrayed in popular culture.

This view is supported by a previous analysis of Alexa, Cortana, Google Assistant and Siri that revealed how they tend to be feminized, be it through their voice, tasks or social interactions, thus lacking a counterpart or just mere diversity. Expanding on these results, we intend to examine how current digital assistants evolve in their portrayal of gender, according to the functionalities and features that are being prioritized in their development as promoted by Amazon, Apple, Google and Microsoft in their official websites and announcements.

We also intend to develop surveys as to assess user preference regarding AI's interaction and characterization. On one hand, the project aims at collecting this data by creating a chatbot inspired by ELIZA that questions users regarding their preferences when interacting with current digital assistants while also creating chatbots inspired by the Turing's Imitation Game that question how users perceive gender in AI. On the other hand, it aims at creating chatbots with different personalities, functionalities and interactions, which seek to raise awareness on issues related to the current integration of AI in our daily life and on how these entities portray gender.

4. Expected Contributions

With this study, we intend to promote critical thinking surrounding this phenomenon with its theoretical and analytical approaches and incite reflection on how artificial intelligence currently engages with gender conceptions, eventually reflecting them back to us. It aims to inform designers that contribute to the development of this technology but also the users of their creations, namely those that use these digital assistants on a daily basis. Additionally, the analysis will allow us to assess current preferences regarding artificial intelligence and how users tend to perceive its gender through the behaviour it exhibits. Following this idea, the project will retrieve this data through chatbots that question users. Another set of chatbots will confront users with stereotypes, roles and archetypes that refer to both AI and gender, through different dialogues, functions and personalities, ironically reinforcing some of the stereotypes we currently engage with.

5. Progress Towards Goals

The research proposed here is in continuity with the one developed in the Masters in Communication Design and New Media (2016-2019) at the Faculty of Fine-Arts, University of Lisbon, and presented at xCoAx in 2018 and 2019. In this way, it seeks to expand on those results and deepen their discussion as part of an ongoing PhD program, started in September 2019 at the same institution. Since the end of the master's degree, we have further developed the research's theoretical, analytical and practical components. We have started to look into how current discussions in specialized contexts and online media coverage approach this phenomenon and how fiction and pop culture depict gendered AIs, observing how neutrality is often questioned in favour of gender diversity, namely, how these entities could be more androgynous and genderfluid (Costa & Ribas 2019). We have also extended our previous analysis (Costa & Ribas 2018) to Google Assistant and looked into current trends of development regarding Alexa, Cortana, Google Assistant and Siri, that reveal an intention of turning them more ubiquitous, anthropomorphized and humanized. Lastly, we have been planning on how to expand the project, namely through bots that gather data for the analysis and bots that further discuss gender attribution in artificial intelligence.

References

Bergen, Hillary.
2016. "'I'd blush if I could': Digital assistants, disembodied cyborgs and the problem of gender." *Word and Text: A Journal of Literary Studies and Linguistics*, 6. 95–113.

Butler, Judith.
1990. *Gender Trouble: Feminism and the Subversion of Identity*. New York and London: Routledge Classics.

Costa, Pedro and Luísa Ribas.
2018. "Conversations with ELIZA: on Gender and Artificial Intelligence." *Proceedings of xCoAx 2018: 6th Conference on Computation, Communication, Aesthetics and X.* Madrid, Spain.103–116.

Costa, Pedro and Luísa Ribas.
2019. "Some things you can ask me: about gender and artificial intelligence." *Proceedings of xCoAx 2019: 7th Conference on Computation, Communication, Aesthetics and X.* Milan, Italy. 49–66.

Dale, Robert.
2016. "Industry Watch: The return of the chatbots." *Natural Language Engineering* 22 (5):811–817.

Eyssel, Friederike, and Frank Hegel.
2012. "(S)he's Got the Look: Gender Stereotyping of Robots." *Journal of Applied Social Psychology* 42 (9):2213–2230.

Hester, Helen.
2016. "Technology Becomes Her." *New Vistas* 3 (1):46–50.

Huffman, Scott.
2018. "The future of the Google Assistant: Helping you get things done to give you time back." Accessed April 29, 2020. https://www.blog.google/products/assistant/io18/.

Nickelsburg, Monica.
2016. "Why is AI female? How our ideas about sex and service influence the personalities we give machines." *GeekWire*. Accessed January 27, 2020. https://www.geekwire.com/2016/why-is-ai-female-how-our-ideas-about-sex-and-service-influence-the-personalities-we-give-machines/.

Piper, Allison.
2016. "Stereotyping Femininity in Disembodied Virtual Assistants." Master of Arts, Rhetoric, Composition and Professional Communication, Iowa State University.

Prentice, Deborah A., and Erica Carranza.
2002. "What Women and Men Should Be, Shouldn't Be, Are Allowed to Be, and Don't Have to Be: The Contents of Prescriptive Gender Stereotypes." *Psychology of Women Quarterly*: 269–281.

Richardson, Kathleen.
2015. *An Anthropology of Robots and AI*. New York and London: Routledge.

Steele, Chandra.
2018. "The Real Reason Voice Assistants Are Female (and Why it Matters)." *Medium*. Accessed January 27, 2020. https://medium.com/pcmag-access/the-real-reason-voice-assistants-are-female-and-why-it-matters-e99c67b93bde.

UNESCO.
2019. "I'd blush if I could: closing gender divides in digital skills through education", *UNESDOC Digital Library.*

Weber, Jutta.
2005. "Helpless machines and true loving care givers: a feminist critique of recent trends in human-robot interaction." *Info, Comm & Ethics in Society* 3:309–218.

West, Candace, and Don H. Zimmerman.
1987. "Doing Gender." *Gender and Society* 1 (2):125-151.

Weizenbaum, Joseph.
1976. *Computer Power and Human Reason: From Judgment to Calculation*. New York/San Francisco: W.H. Freeman and Company.

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Post-Digital Aesthetics in Contemporary Audiovisual Art

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Keywords: Post-Digital, Audiovisuals, Media Art, Hybridity, Neo-Analogue, Digital Maker.

This theoretical and practical research aims to analyse current aesthetic manifestations in contemporary audiovisual media art. The concept post-digital is used to describe the current condition characterized by the pervasiveness of digital media technologies in everyday life. Contemporary audiovisual media art practices that engage with the post-digital condition reflect a shift in modes of production from media specificity towards hybridization as a critique of the effects of digital media in society. This results in hybrid manifestations such as neo-analogue practices that blur analogue and digital media, and digital-physical combinations that merge physical materials and the digital domain.

1. Research Purpose and Importance

The purpose of my research is to develop artistic projects that engage with the post-digital condition as well as to analyse different conceptions of the post-digital and its current aesthetic manifestations in contemporary audiovisual media art. As the scholar Florian Cramer proposes, the term post-digital is best understood not as the end of or after the digital, but as the continuation of the digital in its "subtle cultural shifts and ongoing mutations" (Cramer 2014, 13). The post-digital condition describes media after its digitization where new hybrid forms appear that are not easily classifiable as analogue or digital (Cramer 2014). Contemporary audiovisual media art practices related with the post-digital forge new hybrid forms, be it by merging analogue and digital media or digital and material realms. As a result, the division between old and new media as well as the digital and physical is blurred.

My main research question is: How do current aesthetic manifestations within the post-digital condition critically engage the pervasiveness of digital media? In order to answer this question, two secondary questions are posed: What are the contemporary audiovisual media art practices that engage critically with the post-digital condition? How do I, through my artistic practice, relate to these practices and engage with the post-digital condition? In this way, the study seeks to pin down creative strategies that artists have been exploring by shifting the focus on digital media specificity and infrastructure towards media hybridization and their broader cultural effects. I aim to contribute to a better understanding of the diversity and specificity of post-digital aesthetics and to highlight how contemporary audiovisual media art practices engage critically with digital and computational technologies so deeply entrenched in all parts of everyday life.

2. Background and Related Work

The concept of the post-digital was initially coined by the composer Kim Cascone as the "aesthetics of failure" (Cascone 2000). His understanding of the post-digital term suggests a desire to materialize the invisible or disembodied computational processes of digital media. However, the post-digital as synonymous of glitch art as proposed by Cascone—as "a deconstruction of digital files" (Cascone 2000, 16)—points to a formal approach to digital media infrastructures. Glitch art practices that explore solely computational processes and digital media infrastructures rely on the digital technologies they attempt to criticize. Thus, the post-digital is associated with a disenchantment towards digital media technologies or a time in which our fascination with these devices has become historical (Cramer 2014). It describes the state of media, arts and design after digitization, where new hybrid forms appear that are not strictly classifiable as analogue or digital (Cramer 2014). According to this view, audiovisual media art practices associated with the post-digital label reject techno-positivist innovation approaches and media-based categorizations. Instead, they seek new hybrid forms, such as analogue and digital media hybrids associated with the neo-analogue practice, and digital making and hacking practices that merge the digital and material realms. Therefore, both the neo-analogue media practitioner and the digital maker can be seen as part of the same post-digital culture of audiovisual production that reinforces do-it-yourself (DIY) creative practices, as a "hacker attitude of taking systems apart and using them in ways which subvert the original intention of the design" (Cramer 2014, 18).

Neo-analogue hybrid practices refuse traditional dichotomies of old and new media. They explore analogue media devices and offline manifestations and, as Cramer suggests, they "can only be meaningfully called 'post-digital' when they do not merely revive older media technologies, but functionally repurpose them in relation to digital media technologies"(Cramer 2014, 18). The digital maker merges the digital and material domains while also moving beyond the screen with digital-physical hybrids, or new modes of materiality that blur non-digital and digital, the virtual and the real, as part of the same reality.

These approaches relate to what scholar Matt Ratto calls 'critical making', as a methodology that explores the intersection between digital technologies and the human, between online and offline modes of production. Critical making thus emphasizes the process of making as a critical engagement with digital technologies according to "critique and expression rather than technical sophistication and function" (Ratto 2011, 253). Digital making and hacking practices function as alternatives to, and resistance against, the corporate state of digital technology, where software, hardware and the internet are controlled by a few corporations that subject their users to passive consumers of digital media, as subjects that are largely "unaware of the computer as a system that is programmed, that can be reprogrammed at any moment, and that could potentially be programmed or reprogrammed by its users" (Lialina 2016, 137).

This kind of approach beyond the screen is one of the main goals of a post-digital analysis of art, according to theorist Josephine Bosma, as the "merging of machine spaces and art practices asks for a visualization method that is at the same time applicable to science and art" (Bosma 2014, 109). Accordingly, theorist Mel Alexenberg suggests to move away from a single-point perspective in order "to explore postdigital perspectives emerging from creative encounters between art, science, technology, and human consciousness"(Alexenberg 2011, 9). Audiovisual media art hybrids of digital and physical combinations relate to computation critically through practices that are not reducible to the digital domain, or its code poetics and medium specificity. In this way, the digital-physical hybrids are not reduced to the imperceptible computational processes and expose the contemporary post-digital condition, where "[c]omputation becomes experiential, spatial and materialized in its implementation, embedded within the environment and embodied, part of the texture of life itself but also upon and even within the body" (Berry & Dieter 2015, 3).

3. Approach

The research design adopted for this dissertation follows a theoretical and practical approach. It combines qualitative analysis in the development of a theoretical framework, to inform and deepen the understandings of my artistic practice, and an experimental methodology based on creative research of digital and non-digital materials. Through critical analysis of the available literature, the study aims to build a theoretical framework on the concept of the post-digital in order to examine audiovisual media art practices, cultures of artistic production, and methodologies that take critical stance towards media technologies.

I aim to synthesize this research through artistic interventions that explore audiovisual hybrids of digital and non-digital technologies in the form of audiovisual installations and performances. I give emphasis to DIY creative practices such as digital making and neo-analogue media practices to create sound and image hybrid combinations. This includes the experimentation with physical materials and digital media infrastructures, open-source software and hardware in order to explore digital-physical hybrid relations to gain agency over the corporate state of digital media technologies.

4. Expected Contributions

The outcome of this dissertation project is both the publication of qualitative research as academic papers and artistic interventions in the form of audiovisual installations, performances and other audiovisual hybrid forms. My research contributes to the current literature on audiovisual media art and the post-digital aesthetics both in media theory and media art practices.

My hypothesis is that a post-digital audiovisual aesthetics moves beyond techno-essentialist creative approaches on the digital medium towards hybrids of analogue and digital media, and the digital and physical domains. This hybridization presents a conceptual and practical transition in creative modes of production focused on media specificity and infrastructure, towards a broader critique of the effects of digital media in society and culture.

5. Progress

I have started my PhD research in the winter semester of 2018/19. By now, I have written two papers and produced three prototypes of artworks that keep developing as works-in-progress. The work *Unintended Consequences* is an audiovisual performance and music album that amplifies the electromagnetic fields generated by electronic devices and are visualized in a burst of colours and glitches; *On A Scroll Through The Cloud* is a computer game suitable for VR installation that plays with the visual surface of the internet's technical infrastructures and its popular imaginary context; and *Deep Touch* (working title) is an interactive networked audiovisual installation of digital-physical hybrids that combines 3D printed objects, data sonification and visualization. At the moment, I am in the process of finishing my PhD project plan and preparing to write the first chapter of my dissertation based on the literature review and the two published articles.

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References

Alexenberg, Melvin L.
2011. The Future of Art in a Postdigital Age: From Hellenistic to Hebraic Consciousness. 2nd ed. UK, Bristol/USA, Chicago: Intellect.

Andersen, Christian & Pold, Søren.
2015. "Aesthetics of the Banal - 'New Aesthetics' in an Era of Diverts Digital Revolutions." In Postdigital Aesthetics: Art, Computation and Design, David M. Berry and Michael Dieter (eds.), pp. 271–288. Hampshire, New York: Palgrave Macmillan.

Berry, David & Dieter, Michael.
2015. "Thinking Postdigital Aesthetics: Art Computation and Design." In Postdigital Aesthetics: Art, Computation and Design, David M. Berry and Michael Dieter (Eds.), pp. 1–11. Hampshire, New York: Palgrave Macmillan.

Berry, David.
2014. "Post-digital humanities: computation and cultural critique in the arts and humanities". *Educause Review.* 49 (3). https://er.educause.edu/-/media/files/article-downloads/erm1433.pdf, date accessed 3 May 2020.

Bosma, Josephine.
2014. "Post-Digital Is Post-Screen: Arnheim's Visual Thinking Applied to Art in The Expanded Digital Media Field." A Peer-Reviewed Journal About: Post-Digital Research. Vol. 3 No. 1., pp. 106–118. https://aprja.net//article/view/116091/164262, date accessed 3 May 2020.

Cascone, Kim.
2000. "The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music." Computer Music Journal. V. 24:4., pp. 12–18, Winter. USA, Massachusetts Institute of Technology.

Cramer, Florian.
2012. "Post-Digital Writing". *Electronic Book Review,* December 12. http://electronicbookreview.com/thread/electropoetics/postal, date accessed 3 May 2020.

Cramer, Florian.
2014. "What Is 'Post-digital'?". A Peer-Reviewed Journal About: Post-Digital Research. Vol. 3 No. 1., pp. 10–24. https://aprja.net//article/view/116068/165295, date accessed 3 May 2020.

Lialina, Olia.
2016. *"Not Art&Tech." In* Across & Beyond – A transmediale Reader on Post-digital: Practices, Concepts, and Institutions. Bishop, Ryan, Gansing, Kristoffer, Parikka, Jussi & Wilk, Elvia (Eds.), pp. 135–145. Germany, Berlin: transmediale e.V. and Sternberg Press.

Ratto, Matt.
2011. "Critical Making: Conceptual and Material Studies in Technology and Social Life", The Information Society: An International Journal, 27:4, pp. 252–260. http://dx.doi.org/10.1080/01972243.2011.583819.

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Preemptive Futures: A Study of A Circular Information Economy of Architecture

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Keywords: Preemptive Futures, Information Economy, Circular Economy, Architecture.

Preemption is an action conditioned by speculations on proximate futures based on past data. Preemption has been widely studied in economics to deduce models of strategic interactions between actors, who make decisions based on the feedback of information, where information is value that is represented, quantifiable, and tradable within the economy. In today's urbanism, the digitisation of data helps to accelerate the feedback process of preemption and individuates information. For instance, Sidewalk Lab uses hyper-personalisation to preempt the supply and demand of energy at the scale of individual citizens. Nonetheless, the flow of information in the field of architecture remains linear and impeded. This limits the re-distribution of resources within its economic structure, resulting in a small clique economy as opposed to a circular economy. In the face of climate change, this research that aims at defining an applicable framework of preemption for architecture and urban planning.

1. Purpose of the Research and its Importance to the Field

The 2050 target is a universal anthropogenic timetable, which commenced many transnational initiatives against the climate emergency. The C40 is a notable example that serves as a platform of communication between 94 megacities around the world to establish a global data registry (Rimmer 2008). Digital data is useful in modelling predictive analytics to speculate on possible futures, which will assist in defining the discourse of behavioural changes and guide our everyday urban routine. This gives value to information derived from data to become tradable assets in our economy. The current information market is populated by private digital platforms, which are radically reconfiguring the public realm using hyper-personalisation techniques as preemptive strategies. For instance, the Sidewalk Labs instrumentalises public spaces to gather user data that feeds predictive algorithms to personalise energy plans in real-time and preempts overconsumption (Sidewalk Labs 2020). In this case, preemption is being used to optimise the distribution of resources, but contributes to the monetisation of the public realm and creates spaces of political tension (e.g. social surveillance).

Preemptive strategies may assist architects and planners to plan against climate change by designing self-organising and resilient urban systems (Avanessian & Malik 2016). The development of information economies is demanded to support preemption in complex systems; nonetheless, it is heavily conditioned by the accumulation and extraction of data within a network of actors (Bottazzi 2018). Along these lines, it is important to have a holistic understanding of preemption: its historical and scientific foundation, its current applications in urbanism, and how it can be coupled with digital technologies to be utilised across various ground conditions.

2. Brief Survey of Background and the Proposed Approach

The research reported here combines literature study and case study methods to map a timeline of events, from the mid-20th century till now. The research aims at defining an applicable framework of preemption to establish a circular information economy for architecture and urban planning in the face of climate change.

The literature study section focuses on tracing Cybernetics and its subsequent disciplines, in particular *Wiener's Cybernetics*, *Second Order Cybernetics (SOC)*, *Game Theory*, and *Actor Network Theory (ANT)*, to establish a historical and scientific foundation of preemption. Through this mapping, the study delineates how preemption had been democratised from a military art, to a corporate financial tool, and eventually to a civil art. This section aims to explain how Cybernetics remains an important influence to preemption via the development of information economics and hyper-personalisation techniques.

The case study section focuses on contemporary urban landscapes, and consists of three cases: algorithmic personalisation in digital platforms, the democratisation of Blockchain in geopolitics, and the use of Big Data in the Coronavirus pandemic. Although these cases are seemingly different in nature, they operate on similar Cybernetics principles, and well exemplify how preemption is being exercised on various ground conditions. In the face of climate change, this section aims at discussing what are the kind of preemptions we should anticipate in architecture and urban planning to establish a circular information economy.

3. Expected Contributions and Progress Towards Goal

This research examines the idea of preemption by comparing its historical base and implications in various contexts. It will organise and tabulate a timeline of precedents on the development and the use of preemption. It aims to develop a vocabulary base on preemption that can be used as the foundation of a communication device that navigates across east and west, and help sets a common ground for mediating risks collectively. This research aims to help us in questioning what are the kind of preemption we want in different contexts, and diversify our means to preempt futures.

This research first traces back to WWII, where preemption was used as a military art to defend against aircraft fire (Venter 2013), and became the origin of Norbert Wiener's Control Theory—Cybernetics (Wiener 1961). Then, this research talks about how Cybernetics was democratised from a military art to a civil art after the end of WWII, and transfigured into Second Order Cybernetics in the 70s (Scott, 2004), which focuses on observing complex dynamics like social systems (Pask & Foerster 1961). Second Order Cybernetics emphasised on feedback and self-organisation made advances on artificial neural networks (McCarthy, Minsky, Rochester, Shannon, 1955), pattern recognition and predictive analysis, which are useful tools in preemption. In the 80s, Cybernetics became heavily influenced by and influenced many interdisciplinary fields, including Game Theory(von Neumann & Morgenstern 1947), which piloted the development of information economies and digital technologies. This accelerated the use of preemption, which heavily relies on transacting and processing information for decision-making (Nash 2002). The beginning of the 21st century saw the rise of the platform economy, which can be analysed using the Actor Network Theory (Latour, 2005). This turns data mapping and predictive analysis from causational to correlational using digital technologies (Carpo 2017). This methodology is widely adopted by digital platforms to preempt supply and demand correlation, which enables personalisation for users.

In the first case study, algorithmic personalisation (Milovanović & Popović 2019) is being used to examine if the current model is the kind of preemption we need in the face of climate change. The second case study used blockchain (Nakamoto 2008) as an example to review how preemption is not a rigid framework, but has the potential to fit various ground conditions and achieve different effects. The last case delineates potential limitations and cultural ethics of preemption using the Coronavirus pandemic and the use of Big Data as an example (Takeuchi 2020).

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References

Avanessian, A. And Malik, S.
2016. The Time Complex. Post-Contemporary. [Name].

Bottazzi, R.
2018. Digital Architecture Beyond Computers. Bloomsbury Publishing.

Carpo M.
2017. The second digital turn: Design beyond intelligence. Cambridge: MIT.

Latour, B.
2005. Reassembling the Social: An Introduction to Actor-Network-Theory. Oxford: Oxford UP.

McCarthy, J., Minsky, M.L., Rochester, N. and Shannon, C.E.
1955. A proposal for the Dartmouth summer research project on artificial intelligence, august 31, 1955. AI magazine, 27(4), pp.12–12.

Milovanović, G. and Popović, G.
2019. The hyper-personalized supply chains. Industry 4.0, 4(3), pp.124–127.

Nakamoto, S.
2008. Bitcoin: A peer-to-peer electronic cash system. Manubot.

Nash Jr, J.F.
2002. Ideal money. Southern Economic Journal, pp.4–11.

Pask, G. & Foerster, H. V.
1961. A predictive model for self organizing systems. Urbana: University of Illinois.

Rimmer, M.
2018. Divest New York: The City of New York, C40, Fossil Fuel Divestment, and Climate Litigation. SSRN Electronic Journal.

Scott, B.
2004. Second-order Cybernetics: An Historical Introduction. Kybernetes. 33. 1365–1378. 10.1108/03684920410556007.

Sidewalk Labs.
2020. Sidewalk Labs. [online] Available at: https://www.sidewalklabs.com/ [Accessed 15 April 2020].

Takeuchi R.
2020. Coronavirus: From 93 infected to 0, what did this Chinese City do to contain the virus? n.d. Available at: https://www.youtube.com/watch?v=YfsdJGj3-jM&t=609s.

Venter, R.
2013, 'Weapons, antiaircraft', in Piehler, K (ed.), Encyclopedia of military science, SAGE Publications, Ltd., Thousand Oaks,, pp. 1648–1651, viewed 15 April 2020, doi: 10.4135/9781452276335.n553.

von Neumann, J., Morgenstern, O.
1947. "Theory of games and economic behavior" , Princeton Univ. Press.

Wiener, N.
1961. Cybernetics, Or, Control And Communication In The Animal And The Machine 2Nd Ed.. [Place of publication not identified]: MIT Press.

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Audio Data Compression Artefacts as Creative Material

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Keywords: MP3, Data Compression, Artefacts, Noise, Composition, Aesthetics.

Using a series of experiments, analyses, and composition studies, this research investigates data compression artefacts in audio and their potential for musical application. Experiments have consisted of cascading colours of noise and transient signals through an MP3 encoder set to low bitrates and sample rates. By doing this, artefacts have been generated and then analysed using spectrograms and spectromorphological listening approaches, allowing for a greater understanding of their causes and characteristics. Understanding this allowed me to anticipate and generate particular types of artefacts, which were then used as the raw material for composing with. Conducting a series of composition studies allowed for an understanding of the creative possibilities of these sounds, their potential for processing, and arrangement.

1. Purpose of Research

The research considers audio compression encoding artefacts for the purpose of musical composition. Experiments, in which colours of noise were cascaded through an MP3 encoder, led to the production of artefacts, such as birdies, signal gaps, and bandwidth limitation. Artefacts were then analysed using spectrograms and spectromorphology—the means of describing and analysing "sound spectra and the ways they change and are shaped through time" (Smalley 1997, 107). This has led to an improved understanding of artefacts and a development of a taxonomy of their causes and aesthetic qualities, which range in spectral and temporal complexity. Knowing how to produce certain artefacts and anticipate their aesthetic characteristics has been key for generating material for composing with. This, in conjunction with exploring techniques for arranging artefacts informed by microsound composition, is leading to a firmer grasp on artefacts' practicality as material for composing with.

While these artefacts might be considered side-effects, I have found them to be a fertile area for varied aesthetic qualities. Smooth sinusoidal timbres with internally dissonant microtonal relationships can be heard, sometimes analogous to howls or wails. Rapidly changing discrete pitched artefacts have the effect of creating animated shimmering textures. While at other times artefacts merge into one another creating an unbroken though unstable harmonically complex texture, which is rough, oscillating, and gestural.

I hope for this work to develop a deeper understanding of the creative potential of these sounds, while contributing to the tradition in electroacoustic music wherein the sounds of technological transformations are exploited for composing music.

2. Background and Related Work

Prior research into audio data compression provided a foundation for understanding encoding concepts and terminology. Studies outlined causes and characteristics of compression artefacts, supplied some taxonomies of artefacts, and described mitigation techniques.

The concepts and terminology discussed included sample rate, bitrate, and lossy and lossless format differences (Corbett 2012); windowing, window length, spectral analysis, and quantization (Iwai 1994); and the Nyquist theorem (Olshausen 2000). Papers often discussed the causes of artefacts (Erne 2001; Martinez 2007), while others provided taxonomies for compression artefacts (Artega 2016; Liu et al. 2008) giving descriptions of how they sound. Overall, however, research in this field has been concerned with developing novel techniques for mitigating compression artefacts such as birdies (Desrochers et al. 2015; Prakash et al. 2004), pre-echo (Iwai 1994; Samaali 2012), and aliasing (Princen 1986).

There are a number of artistic projects that have creatively engaged with MP3s, including *MP3 Deviation* by Yasunao Tone (Blake, et al. 2009) and *The Ghost in the MP3* by Ryan Maguire (Georgaki 2014). MP3 encoding errors were used by Tone to trigger sounds, and Maguire used audio that would normally be removed during MP3 encoding processes as the artistic focus. Additionally, Alberto Ricca's project *Most Beautiful Design* consisted of five musical works encoded as MP3s at a bitrate of 16 kbps creating intentional sonic artefacts and adding to the textures within the pieces (Ptwschool 2019). Though the record is only eleven minutes long, the project shows the potential for aesthetic exploration of MP3 artefacts.

3. Description of the Proposed Approach

3.1. Experiments

A series of experiments were conducted in which various colours of noise and transient signals were cascaded through an MP3 encoder. The use of violet, blue, white, pink, and red noise allowed for a better evaluation of how encoding variables react to various spectral characteristics, while transient signals showed how encoding can affect temporal and spatial characteristics.

3.2. Analysis

By encoding noise at bitrates of 8 and 16 kbps and sample rates of 8, 16, and 24 kHz, artefacts became more pronounced and easily perceivable. Using spectrograms to analyse artefacts led to a better understanding of their causes and characteristics, allowing me to recognise artefacts. Listening practices, such as spectromorphology (Smalley 1997), gave me a better ability to describe artefacts and then consider them within electroacoustic compositional processes.

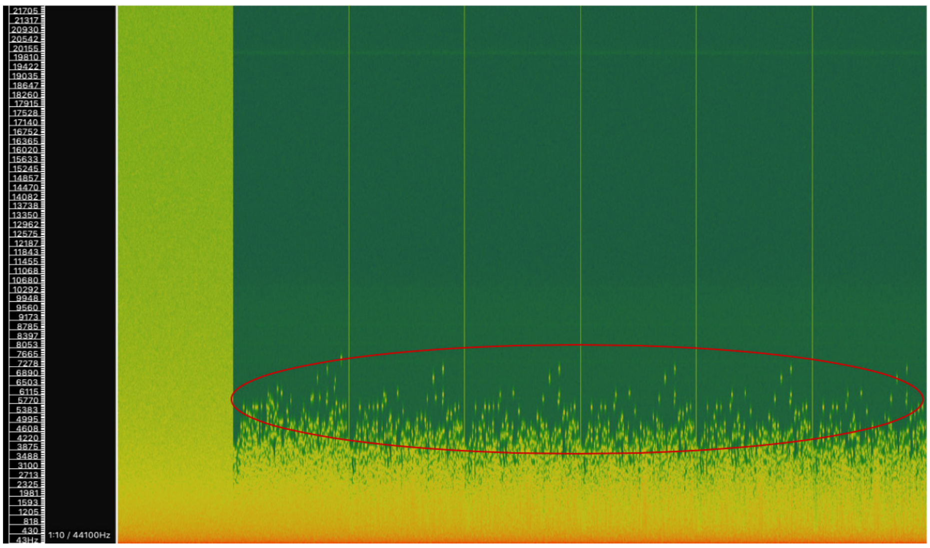

Fig. 1. Spectrogram of iterations of red noise encoded at a bitrate of 16 kbps and sample rate of 24 kHz creating the birdies artefact, which can be seen circled. https://vimeo.com/413614700.

3.3. Compositional Studies

Techniques developed by microsound composers Iannis Xenakis and Curtis Roads, which investigate sound densities and time scales in music, were used to explore the effectiveness of artefacts' aesthetics within arrangements. Encoded noise was cut up, arranged, and layered creating sound clusters and clouds (Solomos 2012), while time stretching artefacts gave a greater amount of time for the aesthetics of the artefacts to be voiced. Time stretching also allowed for the relationship between different sound object time scales to be considered (Roads 2001, 16–27). By pitch shifting artefacts, different sonic characteristics could be voiced more clearly, while the stereo field was explored in an attempt to create a sense of space and depth.

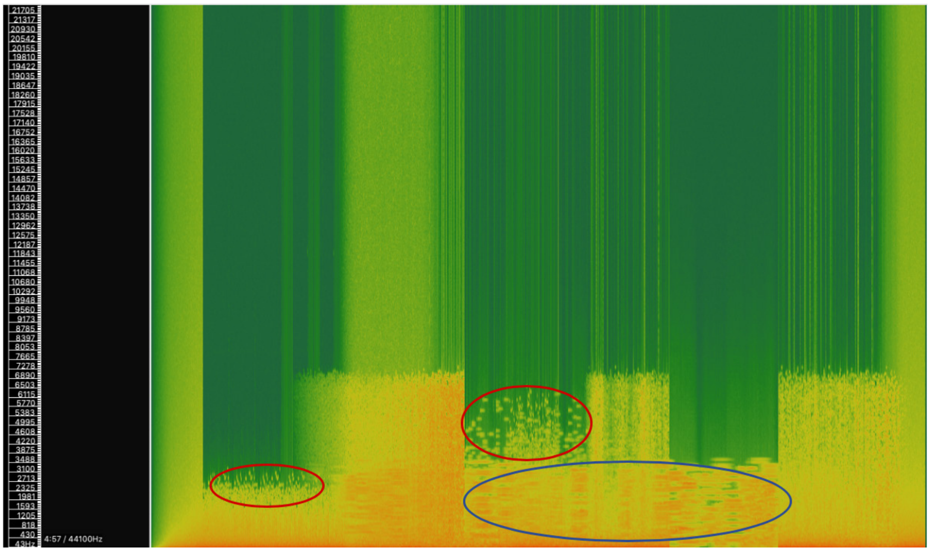

Fig. 2. Spectrogram of a composition using red and white noise at various bitrates and sample rates. Use of birdies for creating textures can be seen circled in red, while time stretched artefacts can also be seen circled in blue. https://vimeo.com/413614970.

4. Expected Contributions

This research sits within the tradition of music composition which harnesses sounds that have been generated through technological transformations, from Luigi Russolo's "noise-sounds" (Umbro 2009, 75–76) to Kim Cascone's post-digital glitches (Cascone 2000). I hope for this research to contribute to this tradition, considering compression artefacts as creative material. A taxonomy of artefacts and musical works will be created, which will allow for a better understanding of the sonic effects of MP3 encoding, while also acting as a creative tool informing the application of artefacts for creating music.

5. Progress Towards Goals

The experiments, analyses, and compositions I have been producing over the past year have greatly informed my knowledge of MP3 artefacts' and their potential for creative use. While I have made a series of studies into frequency domain artefacts, finding new phenomena and alternative theories for artefacts' creation, there are still issues to be resolved including greater investigation into time and spatial domains. The compositions and creative studies themselves are also ongoing, offering new insights into the creative potential of data compressed audio artefacts.

References

Apollonio, Umbro.
2009. *Futurist Manifestos.* London, United Kingdom: Tate Publishing.

Artega, Ignasi Adell.
2016. "Automatic Detection of Audio Defects in Personal Music Collections." Master's diss., Universitat Pompeu Fabra.

Blake, Thom, Mark Fell, Tony Myatt, Peter Worth.
2009. "Yasunao Tone and MP3 Deviation". *Music Research* centre. York, UK: University of York. 234-7.

Cascone, Kim.
2000. "The Aesthetics of Failure: "Post-Digital Tendencies in Contemporary Computer Music" *Computer Music Journal*. 24, no. 4: 12-18.

Corbett, Ian.
2012. "What data Compression Does To Your Music." *Sound On Sound*. April, 2012.

Desrochers, Simon and Roch Lefebvre.
2015. "Detection and Removal of the Birdies Artifact in Low Bit-Rate Audio." Presented at the *139th Audio Engineering Society Convention. New York, USA. October 29-Novemeber 1, 2015.* http://www.aes.org/e-lib/browse.cfm?elib=17959.

Erne, Markus.
2001. "Perceptual Audio Coders 'What to listen for'". *Presented at the 111th Audio Engineering Society Convention. New York, USA. September 21-24, 2001*. http://www.aes.org/e-lib/browse.cfm?elib=9836.

Georgaki, Anastasia and Georgios Kouroupetroglou, eds.
2014. *Proceedings of 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*. San Francisco, CA: The International Computer Music Association.

Iwai, Kyle.
1991. "Pre-Echo Detection & Reduction." Master's diss., MIT.

Liu, Chi-Min, Han-Wen Hsu, and Wen-Chich Lee.
2008. "Compression Artifacts in Perceptual Audio Coding." *IEEE Transactions on Audio, Speech, and Language Processing* 16, no. 4 (May): 681-95.

Martinez, M. Herrera.
2007. "Evaluation of Audio Compression Artifacts." *Acta Polytechnica* 47, no. 1: 12-16.

Olshausen, Bruno.
2000. "Aliasing." Accessed April 4, 2019. http://www.rctn.org/bruno/psc129/handouts/aliasing.pdf

Prakash, Vinod, Anil Kumar, Preethi Konda, and Sarat Chandra Vadapalli.
2004. "Removal of Birdie Artifact in Perceptual Audio Coders." Presented at the *116th Audio Engineering Society Convention. Berlin, Germany. May 8-11, 2004*. http://www.aes.org/e-lib/browse.cfm?elib=12723.

Princen, John P.
1986. "Analysis/Synthesis Filter Bank Design Based on Time Domain Aliasing Cancellation" *IEEE Transactions on Acoustics, Speech, and Signal* 34, no. 05: 1153-61.

Ptwschool.
2019. "Bienoise – Most Beautiful Design (Mille Plateaux) → Ptwschool." Accessed 11 May 2019 https://www.ptwschool.com/blog/bienoise-most-beautiful-design-album-mille-plateaux.html.

Roads, Curtis.
2001. *Microsound*. London, England & Cambridge, Massachusetts: The MIT Press.

Samaali, Imen, Gaël Mahé, and Monia Turki.
2012. "watermark-Aided Pre-Echo Reduction in Low Bit-Rate Audio Coding". Journal of the Audio Engineering Society. 60 no 6: 431–43.

Smalley, Denis.
1997. "Spectromorphology Explaining Sound-Shapes." *Organised Sound*. no. 2 (2): 107-26.

Solomos, Makis, ed.
2012. *Proceedings of the International Symposium. Xenakis: The electroacoustic music*. Paris, Université Paris.

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The Self as Data: Visualizing Identity Through Data Portraits

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Keywords: Data Portraits, Personal Data, Identity, Visualization, Self-Knowledge, Human Agency.

This study focuses on the creative exploration of personal data as raw material for the creation of portraits, considering how our contemporary existence is constantly mediated by an expanding array of digital technologies, capable of recording various aspects of human life as digital data. It draws on a previous study on data portraits, following a theoretical, analytical and practice-based approach that seeks to create visual representations of identity that reflect choices, attitudes, tastes, or the behavioral profile of an individual, while exploring their digital footprint. This project seeks to frame these representations of identity as tools for self-expression and self-knowledge, while promoting discussion on our lack of control over the data we generate, aiming to foster our agency over our data. This approach also highlights how portraiture can be reconceptualized to become more attuned with our contemporary mode of living immersed in data.

1. Purpose of the Research and its Importance to the Field

The purpose of this research is the study, analysis and application of data visualization techniques in the field of portraiture. According to an exploratory and critical design approach, it aims to create data portraits that reflect the behavioral profile of an individual, exploring the implications of data collection by means of technological devices. This approach seeks to highlight the use of personal data as a mechanism for self-observation and self-expression, and also as a means of raising awareness about the current uses of our private information.

This approach is motivated by the present context of widespread technological mediation and consequent dissemination of personal data, which in most cases are governed by various corporations that use them for their own commercial purposes. Considering that this setting of "surveillance capitalism" (Zuboff 2019) fails to acknowledge our sensitivity and humanity, we aim to repurpose these trails of personal data to our own interest, as a means of self-expression. The research thus proposes a reflection on our current "data-driven [way of] life" (Wolf 2010) and the prevailing trend towards the quantification of everything around us, including the most subjective aspects of human life.

2. Background and Related Work

The portrait as a symbolic representation of personal identity tends to reflect the social, cultural and technical context in which it is created. At a moment where technological mediation is omnipresent, data portraits appear as forms of portraiture that evocatively represent the identity of individuals based on the visualization of their personal data, resulting from their daily activities and digitally registered by technological devices. According to Donath (2017, 187), data portraits can be defined as "depictions of people made by visualizing data by and about them".

The portrait has been gradually reinvented following the tendency to detach itself from the mimetic representation of the physical body. This move towards abstraction accompanies technological and cultural advances, namely the dissemination of photography, which transformed the production of mimetic images into a mechanical task. Similarly, enumeration techniques and personal inventory methods are explored as forms of portraiture, shifting "attention from iconic qualities of portraiture to indexical ones" (West 2004, 212), and providing a conceptual ground for autoethnographic approaches to portraiture.

Therefore, the emergence of data portraits is tied to a cultural and ideological shift in the representation of identity since they prioritize "qualities that are not directly observable" (Donath 2001), relating to actions, behaviors and ideas, which cannot be deduced from appearance.

However, although different from traditional portraits, data portraits evoke the same functions of their classic counterparts, as essentially tied to the representation of the subject before the other and/or before himself. On one hand, they can act as *proxies* of individuals in online communities, revealing their behavioral patterns, rather than appearance, and having an impact on how others act towards them. On another hand, data portraits can act as a "data mirror", or a "portrait designed to be seen only by the subject, as a tool for self-understanding" (Donath *et al*. 2014). Additionally, and by involving the re-appropriation of personal data that is scattered in a variety of distributed clouds, data portraits can also fulfil a political role by drawing attention to the loss of control over private information. Finally, these portraits can also promote an affective tie with one's personal data, as an effect of its instantiation and due to its biographical qualities (Lupton 2016).

Data portraits are also the outcome of an interdisciplinary practice, as forms of portraiture whose visuality tends towards abstraction, seeking to reveal the subject's identity traits while following a process of systematic self-observation through data collection and its visualization, that is mainly done in an automated way (Selke 2016). And since data are extracted from the real world, the outcomes of these practices can be coupled with a notion of "digital realism" (Min 2015), often involving the representation of time, as means of expressing change, but also a distance from an analytical stance concerned with legibility, that favors a subjective expression of the subject's identity traits (Sampaio et al. 2019).

Data visualization is often about "rendering the phenomena that are beyond the scale of human senses into something that is within our reach, something visible and tangible" (Manovich 2002). Therefore, subjectivity is also inherent to the choices involved in the mapping of data, as abstract measurements, to sensory, tangible representations. In this sense, and as suggested by Manovich (2002), "data visualization artists should also not forget that art has the unique license to portray human subjectivity." With the aid of technological means, these forms of portraiture can also be endowed dynamic properties, in order to express the changing nature of human experience over time. They can also allow the interactive exploration of different layers of information, reflecting the complexity of personal identity.

In sum, data portraits can be seen as visualizations of subjectivity but are also visualizations of a subjective nature, regarding design choices on what is to be represented and how, and to what end or expression. So, their primary goal is "to call into question the claims of transparency, certainty, and objectivity" of data visualization, insisting in "the situatedness of the observer and the phenomenon being observed" (Hall 2011).

3. Description of the Proposed Approach

Drawing on this framework, the study follows a theoretical, analytical and practice-based approach, according to the following objectives.

The study first seeks to conceptually frame the representation of personal identity through the use of personal data. To this end, the *theoretical component* proceeds to a bibliographic review, on the concepts of identity, portraiture, personal data and visualization. With this approach we seek to frame the emergence of data portraits and identify the expressive functions that they fulfill as aesthetic artifacts. We also seek to explore their potential to portray social interactions in digital environments, to aggregate dispersed personal data and to facilitate self-analysis via self-tracking to promote human agency through data.

The second objective is to understand the diversity of creative approaches to data portraiture. The *analytical component* of the study then follows a inductive approach that aims to examine the mechanics of these artifacts, through the description and analysis of works that a) address the visual representation of personal identity, b) use personal data as a raw material, resulting from the subject's daily activities, and c) resort to computational means for collecting, structuring and visualizing data.

Finally, the *practice-based component* is dedicated to the design and implementation of techniques for visualizing personal data, seeking to highlight the ethical implications of its use as a raw material for portraits and the aesthetic choices inherent to the representation of identity. The project involves the development of a computational system capable of producing different representations of identity. These can be visual, graphic or physical outputs which reflect the behavioral profile of an individual in the digital environment, and highlight issues related to the collection and recording of their everyday activities mediated by digital technological devices.

4. Expected Contributions

This research aims to contribute to design solutions that respond to the growing dematerialization of social interactions by creating visualizations that can be integrated into interfaces of virtual social spaces and collaborative systems to represent identity based on interaction data. These data portraits then take advantage of the objectivity of data to represent the human subjectivity. They can also be applied to self-tracking devices, acting as interfaces between users and their own behavioral and biometric data. Finally, data portraits also have the potential to express our existence through our 'digital footprint' as biographical repositories of a technologically mediated life.

According to this approach, we belive that data portraits can promote a reflexive awareness on one's personal identity, but also make us conscious of the implications of personal data collection practices, through design practices that privilege the individuals agency over their personal data.

5. Progress Towards Goals

This research draws on a previous study developed in the Masters in New Media and Communication Design, which contributed to define the theoretical and conceptual framework of this research, as well as its aims and corresponding methodological approach. In continuity with this study, and in the scope of the PhD research we have initiated in September 2019, we intent to refine their analytical and practical components. Having done a large part of the literature review, we have framed the nature of these data portraits as tools for self-knowledge and awareness, in line with the aims of the project *Data Self-Portrait* previously developed.

Considering the analytical component of the study, we began to refine the selection of aesthetic artifacts focusing on automated processes of data collection and computational techniques of data visualization. We also started to further develop the model of analysis (Sampaio et al. 2019), drawing on the methodology of data visualization proposed by Fry (2008)[1].

We will then proceed to the development iterations of our ongoing project *Data Self-Portrait,* with the aim of exploring the creative possibilities inherent to data portraits and the implications of digital data collection.

1. The process of deriving information from a given data set, as described by Fry (2008, p. 5), implies the obtention of that data *(acquire)*, structuring them *(parse)*, the usage of methods of quantitative analysis such as statistics *(mine)*, its representation according to a visual model *(represent)*, the refinement of the same representation in order to make it clear and visually appealing *(refine)* and, finally, the integration of interactive features that allow viewers to select data and control how it is displayed *(interact)*.

References

Donath, Judith.
2017. *The Social Machine - Designs for Living Online*. Massachusetts: MIT Press.

Donath, Judith.
2001. "Mediated Faces", *Sociable Media Group*. [accessed: 05-01-2019] http://smg.media.mit.edu/papers/Donath/MediatedFaces/MediatedFaces.CT2001.pdf .

Donath, Judith, Alex Dragulescu, Aaron Zinman, Fernanda Viégas, Rebecca Xiong, and Yannick Assogba.
2014. "Data Portraits", Sociable Media Group. [accessed: 18-05-2019] http://smg.media.mit.edu/papers/Donath/DataPortraits.Siggraph.final.graphics.pdf.

Fry, Ben.
2008. *Visualizing Dat*a. Sebastopol, CA: O'Reilly Media, Inc.

Hall, Peter.
2011. "Bubbles, Lines, Strings: How Information Visualization Shapes Society", Data Design. [accessed: 04-05-2019] https://datadesign.files.wordpress.com/2016/03/bubbles-lines-and-string.pdf.

Lupton, Deborah.
2016. "You are Your Data: Self-Tracking Practices and Concepts of Data", *Lifelogging - Digital Self-tracking and Lifelogging – Disruptive Technology and Cultural Transformation*. Berlin: Springer VS. (pp. 61–79).

Manovich, Lev.
2002. "Data Visualization as New Abstraction and Anti-Sublime", Lev Manovich Personal Website. [accessed: 04-05-2019] http://manovich.net/index.php/projects/data-visualisation-as-new-abstraction-and-anti-sublime.

Min, Sey.
2015. "Data Visualization Design and the Art of Depicting Reality", MoMA. [accessed: 12-12-2019] https://www.moma.org/explore/inside_out/2015/12/10/data-visualization-design-and-the-art-of-depicting-reality/.

Sampaio, Catarina, Luísa Ribas, and Pedro Ângelo.
2019. "Data (self) Portraits: An Approach to the Visualization of Personal Data from an Autoethnographic Perspective". *Proceedings of xCoAx 2019: 7th Conference on Computation, Communication, Aesthetics & X*.

Selke, Stefan.
2016. *Lifelogging - Digital Self-tracking and Lifelogging – Disruptive Technology and Cultural Transformation*. Berlin. Springer VS

West, Shearer.
2004. *Portraiture*. Oxford: Oxford University Press.

Zuboff, Shoshana.
2019. *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. London: Profile Books Ltd.

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