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Foreword

We are at it again. We do not mean that we are back to xCoAx again, although we are extremely happy that that is also the case. We mean that we, artists, researchers, performers, teachers, students, and, more in general, tech-savvy people are dealing with yet another technological revolution that will allegedly change the world.

Yet again, there are clashing narratives about such change: on the one hand, our lives will be made much easier, with more free time and less tedious labor; on the other, we are on the brink of extinction by the machinic hand of a technology that seems to be quickly escaping our control.

This kind of discourse is not new. Actually, it begins to feel a bit trite to those among us with many moons of experience in the field. Still, if everybody we know, independently of age, profession, and interests, starts asking questions like “how does ChatGPT work?” by carefully spelling yet another acronym that entered their newsfeed, we have to face the fact that, at least from the perspective of mass media, this impact is unprecedented.

Interestingly, very few people wonder what that acronym stands for, and it is a pity because it may trigger questions that would reveal the real age of the issues at stake. We are not being ageist here: we do not necessarily want to deal only with brand new problems. However, we would like to take pride in reaffirming that we have been at it for quite some time and, hence, we may have something to say about it.

What does the G in GPT stand for? It stands for “Generative”. Are questions around the concept of “generativity” new? Absolutely not: for instance, our dear friend and immensely valuable supporter Philip Galanter was asking and brilliantly tackling the issue more than twenty years ago already. Why are people wondering now about

the impact of a generative tool? Hasn't the concept already been analyzed in all possible ways?

This is where things get complicated and interesting. We may make a big effort in analyzing and hashing out all aspects, facets, and nuances of a concept. Our analysis may be the most thorough, unabridged, and exhaustive endeavor ever brought to completion. Still, such a task will intrinsically be carried out in a specific place and time. We may delude ourselves in thinking that our musings transcend space and time, but even in the hardest of sciences, with its most general equations, a subversive revision process may be triggered by the results of a newly deployed instrument.

Is this what's happening? Is ChatGPT to generative systems what the James Webb Space Telescope is to astronomy? This analogy is less bold than you might think. After all, both tools enhance our vision into our past, although on very different time scales: billions of years with the telescope, a couple of decades with the chatbot.

This is where the P of the acronym comes into play. It stands for "Pre-trained" and, indeed, points at the billions of digital documents (not years nor stars) with which the software has been trained to detect and exploit statistically significant correlations among words in existing texts and infer relevant rules for the creation of new ones.

Are these texts actually "new"? In the trivial sense of never-written-before sequences of words, they are. In the deeper, generative sense of originality and creativity, the jury is still out; sometimes literally, since machine-based creation of texts and images is more and more often the object of legal debates on plagiarism, intellectual property, and copyright.

The last letter in the acronym does not help us at all in this. T stands for "Transformer", and even if it may remind some of us of the fancy sentient robots from the old animated TV series or the more recent blockbuster movies, this is a much more pedestrian affair about computational operations that "transform" the input into the output. In other words, as it usually happens with computing machines, it is all about crunching numbers.

"Only when computers originate things should they be believed to have minds" wrote number crunching pioneer Ada Lovelace, to stress the fundamental role that human programmers play in the determination of the outputs of digital machines. Such a position was deemed too restrictive by number crunching visionary Alan Turing, whose dreams of conversational artifacts are becoming, or rather have become reality with ChatGPT.

Two centuries after Lovelace, and one century after Turing we are back at it again. What does it mean to be creative? What does it mean to be original? How do machines and humans relate, compare, and compete in such endeavors? The latest exploits of machine learning are so brilliant that they have sparked the debate again, but rather than writing humans out of the generative equation, the very essence of these techniques and processes, inherently based on huge quantities of human-produced data, seems to be putting humans on center stage again.

The intersection between people and computers is busier than ever, now that everybody is talking about it.

We are back at it. Actually, we never left.

Welcome to the intersection. Welcome to the X.

Pa-
pers

x



Aesthetic Encounters with Liquefied Digitality

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Artistic practices that are non-teleologically conceived follow the motive of creative experimentation and discovery. Such endeavors are crucial for cultivating sensibilities and incipient meanings that may be harnessed subsequently by philosophical, epistemological, and political projects. The aestheticization of new conditions can be framed through re-mystifications of older monstrosities by transmuting their essential characteristics. Following a historical lineage of technocultural acceleration, calefaction, and liquefaction, we identify Hydra as the archetypal monstrosity for the aestheticization of a liquefied digitality that has been advancing since the advent of Distributed Ledger Technology and Decentralized Finance. We categorize relevant artistic approaches as allopoietic, implicit, and explicit autopoietic to capture a degree of reflexivity on capital flows. Additionally, we present approaches for experimental navigation in the digital sphere, such as disjunctive strategies, ambiguity, remix, and glitch, which can bring about serendipity and provide a rich repertoire of playful manipulations. We conclude that cultural hydrolysis should cautiously proceed as an egalitarian-oriented project while we navigate the uncharted waters of digital liquidity.

Keywords: Aesthetics, Digitality, Accelerationism, Serendipity, Distributed Ledger Technology, Decentralized Finance, Remix, Glitch.

1. Introduction

The entangled relationship between artistic practices and political economy has been frequently investigated by numerous philosophers, sociologists, media, and art theorists. Still, it is an inexhaustible topic as these fields constantly evolve, creating unique cultural assemblages with distinctive characteristics. In the early 20th century, Benjamin detailed the affect mechanically-reproduced art had on European societies and how these novelties enabled the aestheticization of the political sphere (Benjamin 1968). This phenomenon began with the proliferation of media such as photography, cinema, and radio and became more intensified with the advent of television, video games, web applications, and social media.

Artists have explored unique combinations of those new media and traditional art forms (such as poetry, painting, sculpture, and music), participating in the political debate by questioning, disrupting, interrogating, and critiquing established norms, conceptions, ideologies, and political decisions. In the second half of the 20th century, particularly in the Anglophone world, Art was transformed from a transgressive avant-garde to the vanguard of a negational apparatus, a cybernetic cultural regulator¹ that *attempts* to neutralize and inhibit the destructive positive forces that have been manifested in various forms throughout history: patriarchy, colonialism, militarism, fascism, capitalism.

In our current epoch, as neoliberalism reigns, catastrophes — be they ecological, economic, or sociopolitical — are imminent and lurking. Neoliberal capitalism has evolved into an omnipresent and omniscient, xenomorphic lifeform, surveilling and feeding itself from our data, infecting all corners of the planet and our imagination while subsuming all the forces of production and anti-production alike. Artistic creation has been channeled into a very narrow path of political activism as a desperate effort to counteract the particular tragedies (past and current) that this planetary-scaled alien is causing. It can be argued that art has already been transformed into artificial negativity, following Piccone (Nickel 2013), or a simulacrum, following Baudrillard (1994), by giving the illusion of resistance by maintaining the status quo. Of course, there is art with positive characteristics that affirmatively imagine and propose alternative sensibilities and subjectivities. Our critique expands to the wider cultural sector, where curatorial practices are driven by the same commitment to negativism.

1. A cybernetic understanding of the political dynamics involve the positive forces as self-reinforcing feedback processes that expand their territorialities until all the available resources are consumed. The negative forces act on the positive to limit their growth and achieve regulation within the system. These attributes are akin to Deleuze's concepts of active and reactive forces (Deleuze 2006).

Does the negational apparatus of art still work? Should artists continue to commit to that cause if it is compromised? We do not provide answers to these questions, but we propose some strategies that may alleviate arts from this heavy burden and perhaps open new possibilities of what art can do and be. We begin with an insight by Lyotard:

The end of representation, if to represent is to present, in its absence, something-but still representation if to represent is to present anyway, to present the unrepresentable, to represent in the sense of making 'representations' to someone, remonstrances, to re-monstrate. For what is remonstrated is disorder. An outmoded sense of the word? (Lyotard 2014, 165)

Demonstration originates its meaning in unraveling the monster as a process of demystification. Positivist epistemologies and scientism are committed to that purpose by building a solid tree of knowledge yet disregarding any metaphysical claims, stripping the monster out of its mystique. Political demonstration and artistic practices that partake in activism also seek to demystify power structures and elucidate systemic patterns, as they demand immediate change through neutralizing the aura of domination and control in hegemonic establishments. The more conventional understanding of the negativist function of art is to express disapproval or disappointment over a state of affairs, that is, to remonstrate. The focus becomes on showing, making perceptible and experienceable, the detrimental consequences of self-reinforced processes that achieve concentricity and suppress local dynamics, especially at the margins. For instance, John Heartfield's *Adolf the Übermensch: Swallows gold and spouts junk* (1932) is a classic Dada photomontage that confronts the fascist agenda of the National Socialists, particularly Hitler as a gluttonous consumer of wealth who rants inflammatory nonsense. Later, Hans Haacke's installation *MoMA Poll* (1970) questioned Nelson Rockefeller's lack of denouncement toward President Nixon's policy that involved the US in the Vietnam War. This work is an early example of institutional critique by directly addressing a major donor and board member of MoMA at the time.

Probing into "an outmoded sense of the word," we can alternatively think of this process as non-teleologically engaging in the redefinition of the mythological monsters of our time. This kind of anachronism opens a possibility for reevaluation and regrouping. When art functions teleologically as an instrument of negation, it exposes itself to manipulation by the same positive forces it tries to inhibit. Instead, a freer relationship of art with itself may be established by leaving teleology aside. This plan of action leads us to re-monstrate the current state of affairs, namely, to re-mystify or bewilder the mythological monster that ravages our present and future existence. Re-monstration is not goal-oriented; it follows the heuristic logic

of discovery and creative experimentation. O’Sullivan describes this practice as mythotechnesis, which constructs “its own kinds of images and fictions, assemblages and figures, so that it might have a transformative traction on the world, and especially on those who dwell within it.” (O’Sullivan 2016)

In the following section, we seek to identify the contemporary mythological monster. We then characterize the interbody fluid that envelopes the accelerationist ecosystem and incorporates decentralized infrastructures. Following this, we describe some methods for engaging in experimental practices with digital materials to give rise to serendipitous encounters. Our conclusion reflects on the systematization of such practices described as hydrolysis and situates it in the context of speculative theories that seek to actualize emancipatory post-capitalist futures.

2. Thalassic² Creatures

The birth of capitalism can be traced to maritime trading and mercantile practices in the early 15th century by organizations such as the Company of Merchant Adventurers, the Dutch East India Company and the Hanseatic league. Seafaring and international commerce function with a specific logic characterized by borderless navigation, constant flows, value abstraction, circulation, and extraction. In a McLuhanian sense, we state that these features were unconsciously modeled by or were natural consequences of the affordances of the medium that facilitated its operations, specifically the sea or, more generally, water. As expanding, self-reinforcing territorialities, these organizations were born by and uplifted the dominance of existing power structures, especially western European imperialism. They massively participated in the transatlantic slave trade and worldwide colonialism. The legacy of these hegemonies prevails to this day, but it is also important to delineate different phases, evolutions, and transformations that occurred throughout history.

We outline a specific trajectory of these transformations to help us project our current and near-future entanglements with the contemporary mythological monster. It is revealing to pay attention to the various aestheticizations or re-monstrations that took place during the 20th century and the idiosyncratic subjectivities that were produced.

The technological innovations of industrial capitalism in the late 19th and early 20th centuries accelerated the rhythms of all aspects of life, fundamentally altering any national, ethnic, or native value system it encountered. The Italian futurists fully embraced the positive forces of industrial capitalism and drew their inspiration from

the state-of-the-art technologies of the time, specifically the steam engine, the car, the train, and the motorcycle. They were worshipers of speed, destruction, war, youthfulness, and noise while being blatantly anti-feminist (Marinetti 2009). They imagined a society that thrives in an over-industrialized environment where high velocities are the only constant. The subjects they envisaged can be described as velociphiles,³ lovers of speed. Their masculinist monstrosity was short-lived, but it achieved an aesthetic resonance that influenced subsequent re-monstrations.

After the Second World War, the field of cybernetics, information, and computation technologies grew rapidly. The mathematization of control principles, in combination with micro-technologies that were able to regulate voltage flows, stimulated a second phase of acceleration. This speedup was associated not with human-scale objects but with materials at the atomic and subatomic levels. The increase in kinetic energy of those materials is manifested as an increase in temperature, known as calefaction. This characterization describes the technologies that harness nuclear energy and, most especially, the planetary informational infrastructure of computer networks (the internet) that set in motion colossal amounts of electrons around the globe, producing heat as a by-product. During this era, media have become hotter, namely multi-sensory and high fidelity, with the effect of requiring less active participation, according to McLuhan (McLuhan 1964). We consider this heating side effect as a component that renders an ideal environment for certain personas.

The subjectivities that can thrive in such hot informational milieux can be described as lovers of heat, or thermophiles. Paradigmatic re-monstrations of such types are the cyberpunk and cyberfeminist⁴ identities depicted in science fiction literature and expressed in media such as novels, comics, anime, films, and video games. In this post-modern dystopian imaginary, an ambient crisis is manifested as the antinomy of “lowlife and high tech” (Sterling 1986, xiv). Humans co-exist with robots, cyborgs, simulations, and artificial intelligences, emphasizing the multiplicity of identities and a destabilization of the equilibrium between the natural and the artificial. Temperature increases due to the friction that is caused by the encounter of the human with the inhuman. Some molar aggregates (especially the hegemonic territorialities of the past, e.g., humanism, patriarchy, heteronormativity, Eurocentrism) have higher melting temperatures and refuse to become fluxes and integrate their molecular structures into a planetary sea of informational currents.

3. This term was introduced by Andrew Woods (2006) in the context of accelerationism. We appropriate this term to describe futurist subjectivity while we reserve another term for the contemporary accelerationist one.

4. A paradigmatic case is Haraway's cyborg manifesto (Haraway 1991).

Projecting into the future by speculation, we foresee that the calefaction process reaches a critical heat flux, triggering a phase transition that estranges all familiar bonds. The technocapital singularity has been achieved by the melting of its entrails. While some organs still maintain their boundaries, they become less sclerotic and more pliable, while everything else turns into fluid. Every lifeform (unicellular and multicellular organisms) requires a liquid interior at a stable temperature in order to sustain the chain of vital chemical reactions. From our still-too-humanist perspective, we conduct our everyday business pursuing our own self-interests, following, whether we are aware or not, the capitalist sloppy logic. The global thalassic monster began its evolution six centuries ago and attained homeostasis, a consciousness beyond our comprehension, volition, imagination, and a sense of humor.

Aestheticizations of this monstrosity are scarce as it still is in its embryonic state. In the field of science fiction, numerous ventures have attempted to anthropomorphize such inhuman creatures by writers including J.G. Ballard, William Gibson, Richard K. Morgan and Paul Di Filippo, among many others. Drawing inspirations from dark and dystopian cyberpunk narratives, Nick Land attempted a pioneering undertaking in poetical theorization:

Hyper-fluid capital deterritorializing to the planetary level divests the first world of geographic privilege; resulting in Euro-American neo-mercantilist panic reactions, welfare state deterioration, cancerizing enclaves of domestic underdevelopment, political collapse, and the release of cultural toxins that speed-up the process of disintegration in a vicious circle. (Land 2011, 449)

Afrofuturism is a rich field with abundant re-monstrations that root their imaginaries on the African culture and combine it with scientific and technological advances. For example, Butler's *Xenogenesis* series exemplify alternative ontologies and speculative alien-human relations based on the organizational principles of the slime mold (Bahng 2017).

In our context, we describe such subjectivities as hydrophilic, namely lovers of water. We use this term to describe agents (organic or artificial) that are attracted to informational currents and desire the dissolution of any rigid segmentarities they might encounter or embody. Water has a special role in Afrofuturism and Greek Mythology. Faucher extensively analyzes the significance of the mythical monster of Hydra (meaning "sea serpent" in Ancient Greek) in conjunction with the masculine labors of Heracles.

The Hydra is multiplying noise, and an amplification of the degree of entropy in the ordered system, and thus is a threat.

Taking each of the Herculean 10 labours under consideration, we come to understand how the principles of difference, of “subjectivity,” and arbitrariness are laid to rest in the ground. They are demonstrated (de-monster-ated) as false, while the hero, Heracles—who sets down the proper cosmic pattern of Good, Truth, and Justice through interpretation—is heralded as the champion who conquers over these aberrations. But of all the labours, the battle with the Hydra—indicating yet again the cunning of Heracles in conjunction with his courageous might—is the scene where we will set down the longest pause. What is a Hydra? We cannot dissociate the notion of water that the Hydra comes from both literally and by convention of its name. (Faucher 2013, 108)

Xenofeminism advocates for the unconditional surrender to alienation and artificiality (Laboria Cuboniks 2018). Their political agenda aligns with the gender accelerationists (Storm & Flores 2020) and comprises the rejection of all the natural givens and emancipation through gender and reproductive labor abolition by means of artificial reproduction. Hydrofeminism adopts an ethic of unknowability by disregarding certainty and necessity. However, it is cautious of environments in which bodies are totally dissolved.

Despite the fact that we are all watery bodies, leaking into and sponging off of one another, we resist total dissolution, material annihilation. Or more aptly, we postpone it: ashes to ashes, water to water... Hydro-logics suggest to us new ontological understandings of body and community, but how might feminism ensure that this aqueous understanding of our *interbeing* become not another appropriation and usurpation of the more-than-human world that sustains us? (Neimanis 2012, 104-107)

The convergency of philosophical experimentation by Deleuze and Guattari (*Anti-Oedipus: Capitalism and Schizophrenia*, 1972), Lyotard (*Libidinal Economy* 1974), and Baudrillard (*Symbolic Exchange and Death* 1976) (Noys 2010, 4-5), catalyzed by the psychedelic scholarship of Nick Land and CCRU (1997-2003), has been crystallized as the *accelerationist* political philosophy of the 2010s. Noys, who coined the term, criticizes the immersion into artificiality as an aesthetic/political project:

This sensibility is one of flux and flow — in accelerationism the liquid is everywhere. At the same time a residual hardness, most evident in the early twentieth-century avant-gardes, still remains. The hardness is now the capacity to form strange montages without reserve, to fully immerse and so disperse into fluxes and flows. This is an aesthetics or practice of liquefaction that can temporarily solidify to activate force, before dispersing again into new liquid immanent forces. (Noys 2014, 100)

As has been proposed by Williams (2014), Shaviro (2015), and O’Sullivan (2016), accelerationism and respective inquiries in Prometheism and speculative realism must first be attempted as aestheticization projects before they can be political ones. Experimental navigation into the abysmal labyrinths of contingent sensibilities is an enterprise only artistic practices have the capacity to accomplish. We propose the monster of Hydra as the archetype for the identification of contemporary monstrosity not to limit the scope of possible re-monstrations but to guide an experimental path that connects aesthetics with the world of Decentralized Finance (DeFi). Hydra has been often associated with DeFi (Raffery 2020), drawing parallels with the impossibility of slaying the monster by cutting its heads (each decapitation will spawn two new heads) and the robustness and resilience of decentralized networks which are global, not subjects to only one state jurisdiction and so impossible to shut down.

3. Exchange of Interbody Fluids

The birth of capitalism in oceanic waters engendered an affinity between modern mediums of value and liquid forms. Sean Kelly notes:

[T]he language of finance is closely intertwined with water, with its ‘liquid’ assets, ‘fluid’ capital, market ‘bubbles’, cash ‘flows’ and ‘floatation’ on the stock exchange — a connection shared both in English and Deleuze’s French, where flow — ‘couler’ retains its association with money, as well as an additional meaning of sinking or ‘going under’, used both for boats and businesses... Dodd offers further explanation for these conceptions of money as fluid, stating that “considered spatially, the social life of money is nuanced, dynamic, and shifting. Money is an index not just of “contained” space but also of mobility. (Kelly 2020a)

The encoding of the libidinal energies of finance into algorithmic open-source code, namely Blockchain technology or more generally Distributed Ledger Technology (DLT), and DeFi, offers an excellent opportunity for artists to devise novel re-monstrations and map the uncharted waters of digital liquidity. Fabulous monstrosities have already been designed, such as Primavera de Filippi’s *Plantoid* (2015-) and Sarah Friend’s *Lifeforms* (2021). Zeilinger describes such creatures as “strange agential assemblages,” which are driven by a kind of vitalism, undermining the idea of their “ownability” (2022).

Blockchain spaces are saturated with crypto bros (Frizzo-Barker 2020), California ideologues (Nabben 2021), scammers (Mackenzie 2022), criminals (Kethineni & Cao 2020), neo-reactionaries (Columbia 2016), and investment opportunism masquerading as art (Anselmi & Petrella 2023). This phenomenon has discouraged talented and ambitious artists from investing their creativity in that direction. DeFi (especially the Ethereum ecosystem) has replicated

the traditional exploitative financial mechanisms in its code (Harvey et al. 2021), allowing value extraction from laboring classes and further value accumulation for a new class of plutocrats (Popper 2015). However, the abandonment of these spaces by the advocates of egalitarianism and their takeover by the libertarians is a historical mistake, according to Alizart (2020). Web3 and cryptocurrencies offer a unique opportunity for engineering an egalitarian post-capitalist society (Massumi 2018). The promising work on collaborative economies, peer production, Ostrom contracts, encrypted commons, and cooperatives backed by DLT infrastructures (Manski & Bauwens 2020) has to increase momentum, and artists should be in the first line of this battle.

As an accelerationist avant-garde, artists should submerge themselves in the monster of Hydra in order to conceive and create a plethora of aestheticizations, some of which may eventually be utilized in emancipatory projects. As Kelly points out:

The poetics of monstrous liquidity engendered by the accelerationist discourse is not one of brute force, but rather that of the trickster, the shape shifter — the free flowing motility of capital and its uncanny ability to find new routes and openings, to seep into any crack or fissure. In the CCRU reckoning, the flows of capital cannot be countered or stopped, and any attempts at slow-down simply become reterritorialisations that allow capital to strengthen. In part the message is perhaps to ‘be more like capital’, be more tricksterish — not to ‘go with the flow’ as helpless subjects tossed on the waves, but to find routes within the flow, to become skilled navigators of capital — able to recognise moments of deterritorialisation and their potentials. (Kelly 2020b)

We identify three artistic categories of hydrophilic immersion:

— Practices that use conventional media to portray, represent, or display damaging consequences or liberatory imaginaries in environmental, social, or political arenas that digital liquidity may bring forth. For example, Simon Denny’s *Mine* (2019–20) exhibits a shearer mining machine made of cardboard, associating coal mining with the number-crunching hardware that is used for proof-of-work protocols in blockchains such as bitcoin. We describe such a work as *allopoeitic* as it employs symbolism and semiosis for the aesthetic experience.

— Practices that utilize the already developed technical infrastructure of blockchain and DeFi, including Non-Fungible Tokens (NFTs). The above-mentioned artworks by Primavera De Filippi and Sarah Friend can be assigned to this category since they both use the bitcoin and polygon (Ethereum compatible) ecosystems respectively. We characterize such works as *implicit autopoietic* because the appli-

cation of monetary flows is essential for the operation of the artwork but not the key aesthetic component.

— Practices that actively engage with DLT's software and social engineering. Typically such experiments explore alternative consensus or dissensus protocols or mint specialized tokens that are integral to the ecosystemic functionality of the project. For example, in the *terra0* project, woodtokens are created by smart contracts and can be exchanged for Ether to permit forest wood harvesting (Seidler et al. 2016). We interpret such practices as *explicit autopoietic* as they may have a social or environmental impact, and the crypto-currents become the primary locus of aestheticization.

Next, we describe the various aestheticization strategies that can be employed in these categories.

4. Hydrolysis for a Serendipitous Future

The art world still carries many rigid segmentarities that have been formed by former hegemonic territorialities. The concept of the artist itself (genius artist, brand artist) and the fixity of the artwork are two prominent identities that are indispensable as commodities in the current art market. With hydrolysis, translating literally as dissolution by water, we propose several approaches that can liquefy such identities by experimenting with digital materials fluidly and flexibly, thereby allowing potential for novel, serendipitous encounters.

In the ocean of the information age, digital environments facilitate interactions that cause us to reflect on how we access and engage with information. Not only are we gravely concerned with the accuracy or truth of information, but we are also concerned about echo chambers and filter bubbles that insulate us from alternative perspectives that can challenge us and help us develop a more informed view. To address this, we emphasize serendipity as a goal and an overflow feature of hydrolysis. McCay-Peet and Toms (2013, 688) define serendipity as “an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects or phenomena,” and McCay-Peet (2016) later expounds on how digital environments are ideal sites for serendipity. As an ethic, serendipity acts to expose interactors to a diversity of perspectives so that individuals encounter novel and meaningful information. We encourage and seek to bring about serendipity through disjunctive strategies, ambiguity, remix, and glitch. By no means is this list exhaustive, yet we can begin to characterize our process of hydrolysis.

Disjunctive strategies refer to generative methodologies that can render spontaneous results. This can be achieved through the combination of disparate perspectives or by playing with juxtapositions to consider different configurations. The reason why disjunction

can bring spontaneity into practice and result in insightful developments is because it “involves breaking and reordering continuity,” which allows one to “make new and interesting associations through intuitive pattern recognition” (Gyori 2018, 238). This strategy is critical in that it paradoxically proffers that spontaneity can emerge via deliberate methodology, challenging the nature of the accident and highlighting how experimentation with concepts and materials can generate unexpected results.

Gaver, Beaver, and Benford (2003) elucidate the power of ambiguity by reviewing some contemporary art and design projects. The authors highlight how perceiving uncertainty from the art or design experience impels people to develop their own interpretations. By problematizing normalized perspectives and not imposing solutions, the work allows individuals to build meaning and develop a deeper appreciation for the challenging experience that is offered. Through pithy insights to render ambiguity, such as “Add incongruous functions to breach existing genres” or “Block expected functionality to comment on familiar products” (Gaver et al. 2003, 239) we are encouraged to push both the conceptualization of projects as well as the experience of the audience. The nature of ambiguity opens the potential for serendipity to occur as both researchers and audience reflect on the experience of an artwork.

While creative individuality and novel approaches are always valued, building and iterating upon available knowledge and material is an important strategy in both research and art. This strategy is ubiquitous in the comprehensive concept of the remix, generally known as the act of combining pre-existing media to create a new work. Navas (2018, 253) states that remix “is a constant process of becoming” as an iterated work is “taken and repurposed to become something different.” This ‘constant becoming’ highlights a fluidity appropriate to our hydrophilic environment. By sharing, taking up, and playing with available materials, we advocate values adjacent to open source such as open collaboration, contributionism, and transindividuality. Gyori (2018) sees remix as an exploration by experimenting with different configurations of juxtaposition to find serendipity. Although remix might be criticized as ‘derivative,’ we argue that remix has the potential to produce novelty through new emergent meaning contained within the interbody fluid, which holds a multitude of possible configurations.

Glitch is an excellent strategy to find serendipity and can connect with the aforementioned techniques. Both glitch and serendipity resonate with the experience of the unexpected.⁵ Both remix and

5. It is well known that many artists and theorists characterize glitch as unexpected and unpredictable. Serendipity is also widely defined by encounters that are unexpected or unanticipated.

glitch are difficult to define as they encapsulate their process and the resulting artifact.⁶ Furthermore, glitch processes often render ambiguity in the defamiliarization they manifest. Glitch is slippery and disrupts flows of information, causing ruptures to known structures and boundaries. Menkman's (2011, 11) glitch manifesto calls for us to "Find catharsis in disintegration, ruptures, and cracks; manipulate, bend and break any medium towards the point where it becomes something new." Sharing the inclination with hydrophilic agents who desire and partake in dissolution, the glitch enables a transformative mode that reveals hidden potentials and helps us break beyond boundaries into new realms of knowledge and meaning making.

Overall, these methods allow individuals to engage in explorative avenues and value unexpected results. Each technique can contribute to the experience of novelty and adds to the metaphorical increase of temperature and velocity, liquefying the digital materials encountered and further transforming them into new materials available for experimentation.

5. Conclusion

Some compromised versions of these hydrolytic strategies are known in the current landscape of art, especially in practices that partake in the status quo (individual artist, fixed artwork). Our proposal entails a highly intensified, waterlogged version of these strategies capable of dissolving such rigidities. The assimilation of such strategies in decentralized software infrastructures is a prospect toward achieving that result. Projects that are not overwhelmed by tendencies that are either positivistic (as is the case with DeFi) or negativistic (in the case with cancel culture) but balanced through collaboration, negotiation, and coordination between engineering, artistic, sociological, financial, and governmental agencies, are more likely to achieve a post-capitalist mode of liquid art production.

A more concrete roadmap is a focality on autopoietic art projects, implicit or explicit. These life-like creatures blur the boundaries between artwork, artist, audience, producer, curator, and exhibition/virtual space in radical and unprecedented ways. In such organismic environments, genuine curiosity, experimentality, audacity, and play can flourish, bringing serendipitous aesthetic manifestations of the contemporary condition. We emphasize that re-monstrations are invaluable for guiding the production of epistemologies, norms, and materialities. Elevating the principles of glitch, remix, ambiguity, and disjunctive strategies, cultural hydrolysis can be facilitated

6. Navas (2018) notes that remix is both a noun and a verb. Carvalhais (2010, 310) states that glitch is "the malfunction and the output that it produces."

by the spontaneous increase of temperature, velocity, and volume interchange.

The dangers of monstrous liquidity should not be ignored but seriously addressed, as these environments can be utilized for the proliferation of treacherous sentiments and ideologies like fascism. According to Deleuze and Guattari (1987, 215), “What makes fascism dangerous is its molecular or micropolitical power, for it is a mass movement: a cancerous body rather than a totalitarian organism.” Such occurrences have already been observed in the semi-liquid environments of social media and the blogosphere with the hyperpolarization of political discourse. However, the thirst for liquefaction should not be suppressed and the mitigated risk of searching for an egalitarian post-capitalist future should be taken. Hydrolysis should not be equated with the unconditional deterritorialization of Nick Land but seen as a techno-dis-solutionist approach that seeks to design balanced viscosity levels and organic composition for the cultural planetary currents.

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Seeing Programming Seeing: Exploring the Pedagogical Values of Functional Errors in Creative Coding

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Creative coding has been gaining momentum within Art Schools over the past two decades. However, as a discipline within Art Schools it is still relatively new as a creative pathway. As the use of code as a material for creative expression becomes increasingly prevalent, the methods for teaching creative coding within Art Schools have also begun to diversify. This paper presents a range of alternate teaching examples that emphasise reflective problem solving through error when teaching creative coding within Art Schools. The paper will review how these examples are implemented, the impact they have on student comprehension, and the future educational tools they support.

Keywords: Creative Coding, Functional Errors, Problem Solving, Art, Design.

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1. Introduction

The approaches to teaching creative coding within Art Schools has often combined various methods from Computer Science, ranging from didactic lectures, peer coding and problem-solving activities. In more recent times, steps have been taken to explore “how aesthetic production or critical thinking can be cultivated and developed through learning to code” (Soon & Knotts 2019).

A common teaching method for creative coding is delivery of fundamental programming concepts via constructing creative examples or templates. In doing so, a student follows instructional steps, constructing their own copy of said creative output. An emphasis is placed on understanding basic concepts via screen-based outputs that contextualise a certain method for the student. However, a challenge of this approach is students are presented with a friction point when deviating from and iterating upon these examples independently for their own creative outcomes.

This paper discusses the use of mistakes and error as mechanisms that facilitate existing pedagogical methods when teaching the fundamentals of creative coding. In teaching students how to identify and edit Functional Errors in creative applications of code, this method lays the foundation for a broader range of practical, educational research tools that critically analyse teaching methodology within creative coding and expanding to Physical Computing.

1.1. Functional Errors

Functional Errors refers to instances of code that, although compiling without software compiler errors, result in different outputs than the users intended. Functional Errors can be found in both screen-based and physical computing environments. However, the purpose of this paper will focus on the context of screen-based graphical outputs.

This area of research is particularly relevant in an Art School environment, where creative coding practices exist within curricula of other established disciplines such as Fine Art or Visual Design. In mixing multi-disciplinary approaches to working, students often face “conflicted situations of practice” (Schön 1994) where a desired objective in code does not match the conceptual objective and vice versa.

As such it is noticeable that a Functional Error is also the result of a conceptual misunderstanding between a familiar material and new creative material (often code). “When teaching novices programming, misconceptions can occur” (Hermans et al. 2018) and when students are unfamiliar with the terminology in programming, it can

often be difficult to identify the source of an error when using descriptive language more common place in other disciplines.

In framing Functional Error examples thematically within Art and Design vernacular it is hoped this can bridge a familiar language and new, unfamiliar language for students. In identifying and understanding Functional Errors the objective is the language used to explain an issue is developed in tandem with problem solving skills. This research aims to facilitate a reflective framework to recognise both technical and conceptual misunderstandings in students' practice-based Art School education.

2. Background

2.1. Existing Methods

The creative coding curriculum within Art Schools is undergoing a shift away from traditional lecturer-centered instructional methods, towards a more contextually and thematically integrated approach to programming. There has been an acknowledgement of those “who prefer to work improvisationally, instead of following formulas; and aim to create things that are expressive rather than utilitarian” (Buechley 2012).

An important component to conceptualising creative coding activities has been incorporating “Active Learning” (Bonwell & Eison 1991) strategies. These activities not only engage students, but also enhance their comprehension skills by encouraging them to actively participate in “doing things and thinking not just listening” (Jung et al. 2021).

Whilst Active Learning strategies promote more doing things and thinking, rather than simply imposing content on a learner through direct instruction, the retention of crucial information may still be limited to the specific context in which it is learned. In adopting a more Constructionist position emphasis can be placed on how “the *laws of learning* must be about how intellectual structures grow out of one another and about how, in the process, they acquire both logical and emotional form” (Papert 1980).

When transitioning from Constructivists to Constructionist methodology the application of visual programming environments has facilitated a move towards a high-level understanding of programming structure via modular building blocks. In his analysis of the Turtle, Papert compares the building blocks of “Learning Math by talking to Turtles is like learning dancing by dancing with people while learning math by doing pencil and paper sums is like learning dancing by rote memory of pencil and paper diagrams of dancing *steps*” (Papert 1976).

The building blocks of Visual programming environments have been found to enhance the cognitive association between programming terminology and their associated operations. However, they often do not answer the issues that “pertain to their inability to help users build a skillset that can be transferred to other programming environments and paradigms and their inability to be extended through new components” (Hansen 2019). As such visual blocks can fall short in addressing the conceptual structure of code, leading to the need for additional supplementary material for effective learning. The purpose of incorporating Functional Errors into the educational process is not to supersede such pedagogical tools, but rather to augment them, creating further steps and pathways that support students in their learning journey encouraging self-reflection and evaluation.

2.2. Problem Solving

The teaching of problem-solving skills is an integral part of computer science in promoting a deeper understanding of fundamental concepts. Studies have revealed that a lack of such approaches resulted in students limiting their understanding and “rather than *getting the big picture* of computer science, they narrow their focus to *getting this program to run*” (Allan & Kolesar 1996). This holds true not only in the field of computer science but equally when creatively working with code in adjacent disciplines. Given that students in the field of creative coding often approach the subject as novice programmers yet possess university-level knowledge in their accompanying disciplines, there is significance in including repetition allowing students to “actively engage with the content, work through it with others, relate to it through an analysis” (Fee & Holland-Minkley 2010). By incorporating teaching examples that intentionally include such problem-solving strategies, it encourages creative agency and support future self-exploration.

2.3. Reflection

As Schön identifies, often students “can deliver without being able to say what (they) are doing” (Schön 1987, 23). In providing practical programming examples for Reflection In Action it enables a dialog between student and process that helps them identify where misconceptions, error and miscommunication have occurred. The Functional Error examples are disseminated via a website that includes embedded, interactive programming sandboxes. Graphical preview windows offer visual feedback of the code that students edit offering real-time prompts to reflect upon each practical step they have undertaken. In doing so, the examples draw influence from Schön’s theory.

A designer sees, moves, and sees again. The designer sees what is “there” in some representation of a site, draws in relation to it, and sees what he or she has drawn, thereby informing further designing. This process of seeing-drawing-seeing is one kind of example of what I mean by designing as a reflective conversation with the materials of a situation. (Schön 1991, 133)

3. Non-Linear Process

Art School education centres on the Studio based, practice driven culture with a focus on learning through process-driven methods encouraging an “experimental attitude, precisely of making trials, of learning from experience by prompting problems and failures” (Schnapp & Shanks 2009). It is important to frame the use of Functional Errors within this context. In shaping lessons around Functional Errors the mode of delivery supports cyclical reflection fostering future abilities to explore and experiment independently.

“Project-based learning is a key pedagogical approach in the arts” (Brain & Levin 2021, 6), encouraging students to explore far greater expressive adaptability. However, the integration of context within creative coding templates, the delivery of teaching exercises often remains centered around the original intended outcome. The ability to re-frame linear paths and identify why navigating left, right, forwards, and backwards causes a change in outcome can become difficult for students when developing their own creative coding work. In discussing Casual Creators Compton and Mateas observe “many creative tools exist to support task-focused creativity, but in recent years we have seen a flourishing of autotelic creativity tools, which privilege the enjoyable experience of explorative creativity over task-completion” (Compton & Mateas 2015).

The acquisition of creative flexibility in the artistic process often requires years of practice. It can be challenging to foster these skills during the initial stages of programming, when the foundations are still being established. Turkle compares the experiences of those learning to program to “those of the bricoleur scientist or mathematician. Bricoleurs construct theories by arranging and rearranging, by negotiating and renegotiating with a set of well-known materials” (Turkle 1990). In pairing creative disciplines with the computer sciences, Art Schools are encouraging the development of distinct knowledge and understanding across specialisms.

4. Study Method

The series of Functional Error examples are intended to provide diagnostic and reflective dialogue of observing, programming and observing again (i.e., seeing — programming — seeing). The purpose of this approach is to uncover patterns within the examples enabling

students to broaden their conceptual understanding of earlier, limited templates. In equipping students with interfaces for reflecting upon mistakes, this study explores the relationship between whether, in using of Functional Error examples, does this enhance students' troubleshooting confidence, and ultimately lead to greater flexibility in their creative practices?

The method this study undertook focused on prescribing three graphical examples that explore the concept of Functional Errors within the programming language P5JS. P5JS is a JavaScript library designed to support creative coding “with a focus on making coding accessible and inclusive for artists, designers, educators and beginners” (McCarthy 2014).



Figure 1: P5JS sandbox editor.

In this study we utilise the P5JS web editor which offers an integrated sandbox environment for programming with minimal set-up. The web-editor offers participants a user-friendly interface that facilitates real-time code editing while synchronously previewing the graphical output produced as a result of any modifications made to the text. The editor is embedded into a general teaching webpage providing information that is easy to disseminate, thereby removing the barrier of installation and configuration [Fig. 1]. The primary objective of this study is understanding and examining each Functional Error that reiterates programming methods students have already encountered in previous classes.

Participants consisted of 14 adults (7 Female, 3 Male, 2 Non-Binary and 2 undeclared) who were enrolled in a year-long Diploma in creative computing. Participants had two previous years' experience in an adjacent Art and Design discipline. These participants had prior experience in a related discipline in Art and Design and had completed a module in creative coding in the three months leading up to the study. It is noteworthy that prior to the start of the Diploma program six months ago, the participants had limited to no programming experience. Therefore, this group provides an opportunity to evaluate their retained knowledge in the field of creative computing.

4.1. Examples

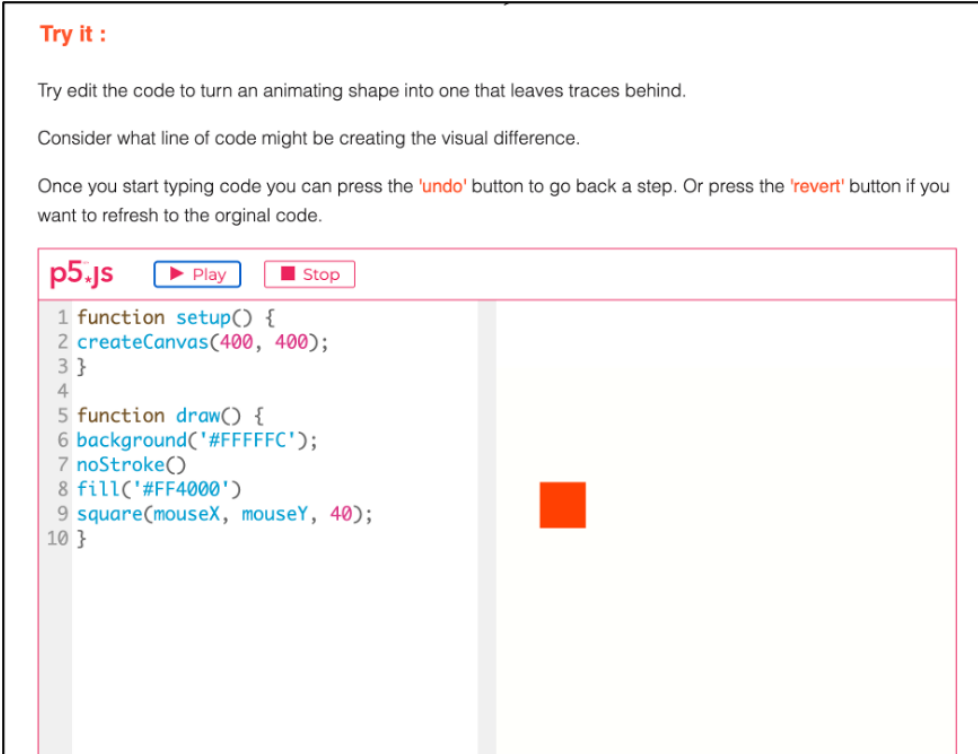
The three examples were selected through a systematic observation of the recurring Functional Errors made by students while teaching creative coding across various higher education institutions.

Each participant was presented with two animated visual outputs per Functional Error; the intended visual outcome and the actual visual outcome containing the Functional Error. The participants were presented with a web-editor containing the Functional Error and were then challenged to resolve each instance so that it reflected the intended visual outcome.

The three Functional Error examples consisted of:

A. Drawing: A common scenario students face when approaching programming from a Visual Design background is a familiarity with the affordances and signifiers of animation. An understanding of timelines and editing workflows can often result in assumptions of how a graphical output is generated. In this example, participants are presented with code that takes mouse position as an input control for the movement of a graphical square. The square refreshes every positional change and thus visually mimics animation. Participants have the task of modifying this code [Fig. 2] so that the animated graphical square leaves a trail of its movements on the screen, mimicking the act of drawing on paper [Fig. 3]. Importantly, neither version is syntactically wrong. However, the conceptual meaning and intended outcome of the graphical representation may differ based on the students' intentions. In resolving this Functional Error, students achieve an understanding of the `setup()` and `draw()` functions within the P5JS language, which are core components in understanding the structure and running order of code.

Figure 2: Example A: Drawing. The web-editor code interface participants interact with.

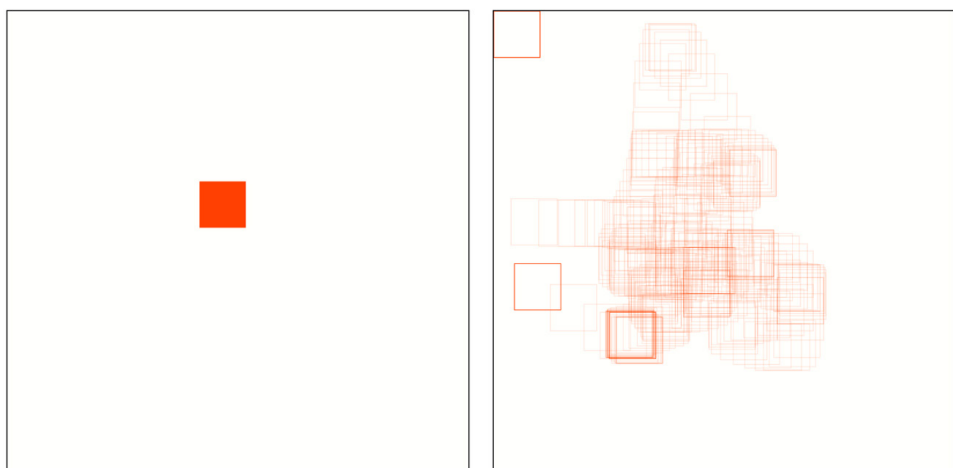


The screenshot shows a web editor for p5.js. At the top, there are 'Play' and 'Stop' buttons. Below them is a code editor with the following code:

```
1 function setup() {
2   createCanvas(400, 400);
3 }
4
5 function draw() {
6   background('#FFFFFF');
7   noStroke()
8   fill('#FF4000')
9   square(mouseX, mouseY, 40);
10 }
```

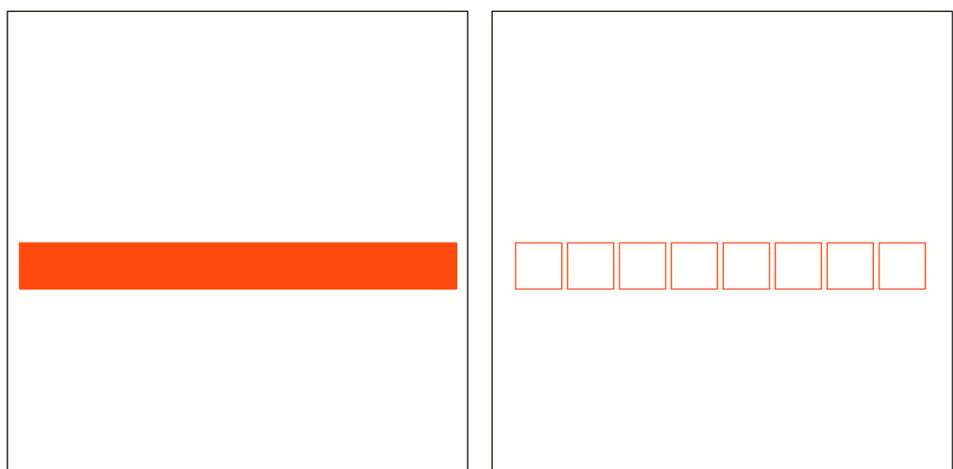
To the right of the code editor is a canvas displaying a single red square. Above the canvas, there are instructions: 'Try it : Try edit the code to turn an animating shape into one that leaves traces behind. Consider what line of code might be creating the visual difference. Once you start typing code you can press the 'undo' button to go back a step. Or press the 'revert' button if you want to refresh to the original code.'

Figure 3: Example A: Drawing.



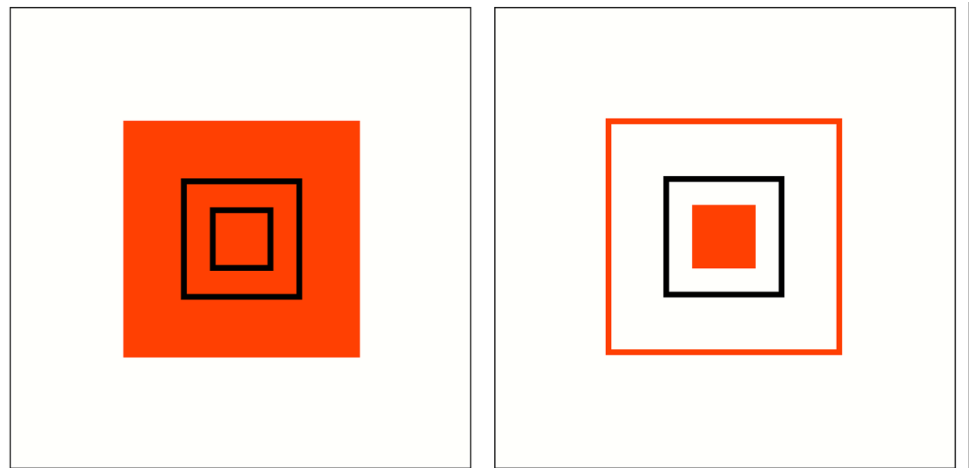
B. Iteration: The second example presents a visual output resembling a solid rectangular shape. However, the title and intended output indicate the shape should reflect several squares spaced out visually on the canvas [Fig. 4]. Participants are presented with code comprised of for loops, not necessarily required for drawing one singular rectangle as the present visual displays. Participants are required to decipher 1) why a for loop may be required and 2) why several iterative shapes are not displayed on the canvas. In resolving this Functional Error, participants gain an understanding for concepts such as conditions within for loops and mathematical iteration.

Figure 4: Example B: Iteration.



C. Order: Lastly, the third example presents a visual representation of two graphical squares. The objective of the intended output is to display three squares, each with a distinct coloured outline. However, the actual outcome demonstrates three squares with the same solid colour. Participants are presented with the challenge of identifying how to modify the code to distinguish between the solid colour of each shape and the outline colour [Fig. 5]. In doing so, participants begin to understand the programming order and sequence. This concept is often misunderstood by Art and Design students, who tend to reverse the order, drawing parallels with layer manipulation in creative production tools.

Figure 5: Example C: Order.



When presented with each of the three modifiable examples, participants were asked to reflect and answer to themselves in their own descriptive language (not necessarily programming terminology):

- Can you describe what you are seeing?
- What would you like to see happening?
- Why might it not be doing that?
- Where do you think the issue is?
- Can you identify what to change to make the visual display as desired?
- Why did that resolve it?
- Can you say in technical terminology what and why the change worked?

In allowing participants to verbally answer questions themselves in descriptive language they are comfortable with, it allows them to navigate towards the correct answer without the barrier of not knowing if they are using correct terminology. After participants have identified they are on the correct path the final question prompts them to narrow their language to technical terminology cementing the foundations of the P5JS language constructs and the functions they may use in editing the example code.

Prior to undertaking this study, data was captured via a questionnaire [Table 1] that gathered information assessing their demographics, self-efficacy in creative coding, troubleshooting, creating conceptual art and creating computational art. Each participant self-assessed their self-efficacy before and after the workshop on 5-point scales (from (1) unconfident to (5) confident). Alongside this analysis, participants were asked to assess the usefulness of using the Functional Error examples in their educational experience both quantitatively on 5-point scales (from (1) not at all to (5) a lot) and qualitatively in written responses.

Table 1: Study Questionnaire Questions. (the questionnaire included questions for a broader evaluation of Creative Computing tools and as such these questions and question numbers have been omitted from this table)

Question	Questions asked <i>before</i> study
Q1	How confident are you in using P5JS?
Q3	How confident are you in troubleshooting code?
Q5	How confident are you in creating conceptual Art and Design?
Q6	How confident are you in creating Computational Art and Design?
Q7	What do you anticipate the biggest challenge of working with creative coding to be?
Question	Questions asked <i>after</i> study
Q8	How confident are you in using P5JS?
Q11	How confident are you in creating conceptual Art and Design?
Q12	How confident are you in creating Computational Art and Design?
Q13	Has your biggest anticipated challenge changed from before the workshop and if so, what is it now?
Q14	Do you find the Graphical Functional Error examples useful?
Q15	How confident are you in troubleshooting code?
Q20	Do you have any additional comments regarding Functional Errors and this teaching method?

5. Results

5.1. Quantitative Results

Prior to undertaking this study, the results indicate a relatively low level of self-assessed confidence among participants in level across programming and troubleshooting (Questions 1 and 3). The mean score for participants' confidence in programming P5JS was 2.85 with 38.5% electing a score of 2 (indicating a little unconfident) and 46.2% scoring a 3 (rating themselves fair in confidence). Only a small number of participants, 2 individuals, rated themselves as a little confident or confident in programming P5JS.

These initial quantitative results align with the participants' limited programming experience in only partaking in one introductory module in creative coding prior to this study. These findings provide support for the notion that, despite having practiced these skills, there is a potential disjunct between the absorption of knowledge and the application of it in practice.

Analysis of question six reveals participants demonstrated a high level of confidence in their abilities to create conceptual Art and Design (mean = 4.08) [Table 2] with an interesting observation that no participants rated themselves below fair in this area [Figure 6]. Participants scored marginally lower level of confidence in question seven when asked about creating computation Art and Design (mean = 3.69). However, it is worth mentioning that 82.3% rated themselves as fair or above in this area. These results correlate with the participants' existing knowledge obtained in their respective Art and Design specialisms.

Figure 6 illustrates the distribution of ratings per question, as a percentage, prior to the initiation of the study. Table 2 shows the mean scores for each question.

Figure 6: Stacked Bar Chart Results of Questions asked before the study.

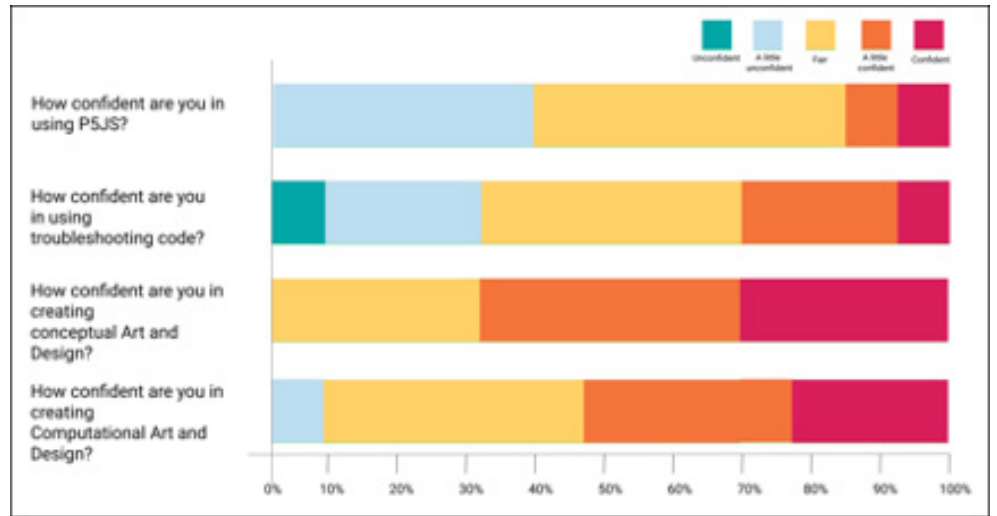


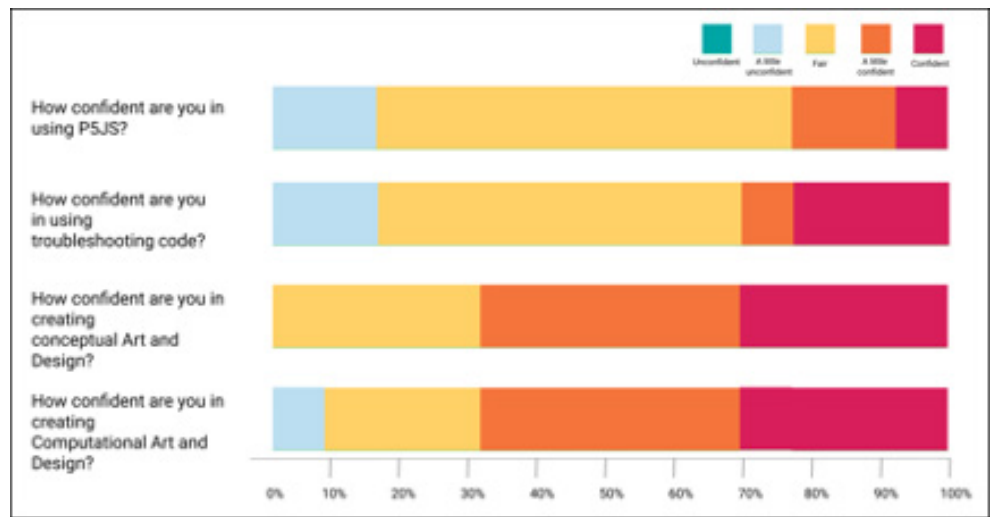
Table 2: Mean Statistics of quantitative question results.

	Q1	Q3	Q5	Q6	Q8	Q11	Q12	Q14	Q15
Mean	2.85	3.00	4.08	3.69	3.15	4.00	3.92	4.31	3.31
N	13	13	13	13	13	13	13	13	13
Std. Deviation	.899	1.080	.862	.947	.801	.816	.954	1.182	1.032

Following the study, participants assessed their confidence in troubleshooting code (question 15), with a slight increment from their pre-study evaluation. The majority of participants rated themselves as fair (mean = 3.0) followed by 23.1% as a little unconfident and 7.7% unconfident.

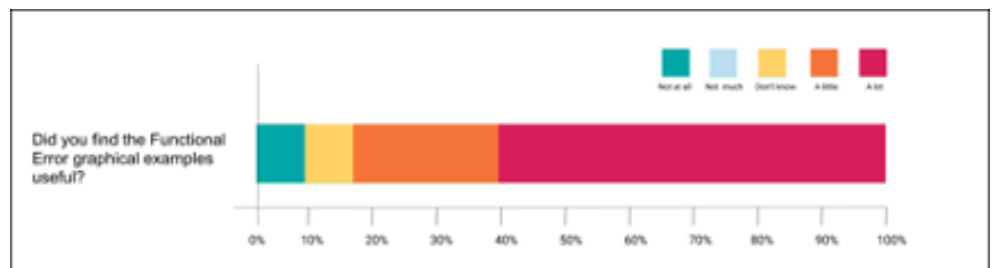
Figure 7 illustrates the distribution of ratings per question, as a percentage, after the initiation of the study. The results post study indicated a general increase in participants' confidence in both question 8 regarding P5JS programming (mean = 3.15) and question 15 regarding troubleshooting code (mean = 3.31) with a positive reduction of the proportion of participants who self-assessed their confidence as a little unconfident to unconfident. Falling from 38.5% to 15.4% when asked to self-assess confidence in programming P5JS. Similarly, the proportion of participants in the lower confidence categories for troubleshooting code fell from 30.8% to 15.4% with the majority (84.6%) now rating themselves fair to confident.

Figure 7: Stacked Bar Chart Results of Questions asked after the study.



Understandably, the results revealed the confidence rating in creating conceptual Art was unchanged after the study as this aspect was not addressed in the content. However, there was a small improvement in participants' confidence when creating computation Art and Design, as indicated by the increase in the mean score from 3.69 to 3.92. An interesting impact was observed among participants who previously rated themselves as fair, now rating themselves as a little confident to confident. This observation aligns with the results of question fourteen as illustrated in Fig. 8; how useful did you find using the graphical Functional Error examples? Participants rated the examples overwhelmingly useful (mean = 4.31) with a substantial majority (84.6%) rating the examples as a little to very useful.

Figure 8: Stacked Bar Chart Results of Questions asked after the study.



5.2. Thematic Results

The quantitative data was accompanied by a set of thematic questions [Table 3] aimed at supplementing the statistical results.

Table 3: Thematic qualitative questionnaire answers.

Participant ID	What do you anticipate the biggest challenge of working with creative coding to be?	Has your biggest anticipated challenge changed from before the workshop and if so what is it now?	Do you have any additional comments regarding Functional Errors and this teaching method?
P1	Getting the visuals to behave how I envision it to.	No	n/a
P2	p5.js	p5.js, feels less natural to me than Arduino	n/a
P3	Technical problems	Technical problems and There is very little growth in computer art about art.	Add some training on the aesthetic aspects of computing. Teaching methods should be more diverse and not just teaching software alone
P4	Translating ideas to code	It is still the code but understanding how to simplify it has increased	n/a
P5	Making something work the way you intended, trial and error and finding solutions	Nope	This teaching method was very useful in understanding the code and how it works.
P6	processing	p5js	n/a
P7	The coding frame of mind is a lot more rigid than the freeform art mind. It takes some adapting to learn the different principles of coding.	No. I think that my biggest perceived challenge is something that takes some time to change and overcome.	Functional errors re-frames coding in a different way, to be a different kind of puzzle, providing a different perspective.
P8	Feeling the difference between searching for the answers and code and thinking of the code myself and figuring out my errors	Slightly, my way of thinking about it did	Maybe have two tutors around as the time is short and lots of us need help
P9	Applying my concept-based art practice to displaying creative comp work	I think my horizons on what I could expect when conceptualising creative computing displays have been broadened.	n/a
P10	Learning to code	Not really as it was only 1 session, but I feel having a whole term of these would making me A LOT more confident with doing code	I think it was really great compared to the lessons I have had, I felt like I learned a lot more in one lesson than I did in multiple lessons previously.
P11	My code not running and not knowing how to fix it	I would still be worried about not being able to fix the code but I would at least attempt to do so myself first	I thought working through the p5js problems was really useful
P12	Technology	Technology	n/a
P13	Realising where certain creative code would fit in a project	No	n/a

One of the questions posed to participants prior to the study was what did they anticipate the biggest challenge of working with creative code to be? A selection of responses from participants reflects the discursive arguments in this paper:

- “Translating ideas to code.” (P4)
- “Feeling the difference between searching for the answers and code and thinking of the code myself and figuring out my errors.” (P8)
- “Making something work the way you intended, trial and error and finding solutions.” (P5)

When participants were asked if their biggest anticipated challenge had changed post workshop, the majority of thematic responses remained within the context of troubleshooting P5JS code. However, a small number answered differently, expanding upon this context, and providing additional insights:

- “It is still the code but understanding how to simplify it has increased.” (P4)
- “I feel having a whole term of these would making me A LOT more confident with doing code.” (P10)

Lastly, participants were asked to respond if they had any additional comments regarding the use of Functional Errors as teaching methods. A selection of answers included:

- “I felt like I learned a lot more in one lesson than I did in multiple lessons previously.” (P10)
- “Functional errors reframe coding in a different way, to be a different kind of puzzle, providing a different perspective.” (P7)
- “This teaching method was very useful in understanding the code and how it works.” (P5)

6. Discussion

Often code that results in Functional Errors is opaque in its nature, making it difficult for students to identify the underlying cause. In providing students with classroom opportunities to explore patterns of programming structure that produce different conceptual intended and unintended visuals it offers a basis for developing confidence in their own understanding and communication skills.

The participants’ thematic answers support a hypothesis that participants require supportive pathways to effectively utilise code in an autonomous direction. The approach to teaching the fundamentals of programming structure through reflective acceptance of mistakes and error encourages process and pattern observation within existing task specific examples. In doing so, this iterative learning pro-

cess replicates a material investigative approach familiar to students in Art School and facilitates their navigation of current aesthetic and contextual project templates.

Early thematic analysis pointed towards the disconnection between applying creative coding methods independently when no longer in the context specific to a technical example. The positive impact on participants' confidence from those who rated themselves low and those who already felt a little confident, demonstrates this reflective teaching method was beneficial in facilitating understanding for all parties. The thematic answers regarding the use of the Functional Error teaching examples support the speculation that the use of this diagnostic approach to teaching has a positive impact on the relationship between disseminating knowledge and its practical application.

The current collection of examples encompasses both thematic titles (e.g.: Drawing) and descriptive titles (e.g.: Iteration). The drawing example establishes a clear relationship to presumptions derived from workflows of analogous disciplines, whilst identifying the differences in computing. Future implementations aim to adapt similar thematic approaches that align with the relational contexts commonly found in the fields of Art and Design.

The focus of this study was primarily on the implementation of creative coding in screen-based visual environments. However, the presence of Functional Errors spans a range of programming applications. The field of physical computing represents a significant potential source for miscommunication in the visual programming environment, electric circuitry, and physical capabilities of components. Considering this, future research is aimed at developing the practical representation of Functional Errors in the field of Physical Computing.

7. Conclusion

This preliminary study was relatively small in its scope. Further research is needed to broaden the participant population and increase the sample size, thereby bettering our understanding of the benefits of this pedagogical approach. The limited sample size of the current study hinders the ability to establish a statistically significant correlation between pre- and post-study quantitative results. Whereas an expanded study would allow for the implementation of A/B testing, where participants would be divided into groups, some utilising Functional Errors and some not. This would facilitate statistical analysis, such as Mann Whitney U tests, and provide a more robust evaluation of the Functional Error examples. That been said, early indications suggest the implications of using reflective and trouble-

shooting techniques in the initial stages of teaching programming holds positive potential.

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The Possibilities of the Incoherent: A Study on the Human-Machine Interaction Based on Incoherent Fragments of AI images

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Hands seem a tricky element for artificial intelligence to copy; diffusion models for image generation often have conflicts in the execution of the extremities. Considering that artificial intelligence has an incredible performance in the development of visual components, the action that drives the development of this text is to observe these incoherent hands, and ask about which boundaries are being observed? Asking this question leads us to review the function of images, the definition of error, and to understand the extended cognition theory. With the results of an exercise that tries to find patterns of the artificial aesthetics of AI images, this paper reflects from a post-humanist perspective, on the role of incoherence to evaluate its potential role in reformulating the interaction between humans and machines.

Keywords: Artificial Aesthetics, Posthumanism, Artificial Intelligence Images, Diffusion Models, Shared Cognition, Error, Potential, Hands.

1. Introduction

Humans have developed a close relationship with technology machines, which has made us reliant on their agencies and possibilities. Society establishes power relationships with each other and the surrounding environment, which also happens in the relationship with machines. Even though they are our creations, we have produced a dichotomous relationship with them that goes from the fear of domination to one that encourages collaboration.

Authors like Donna Haraway, Bruno Latour, and others have developed the posthumanism philosophy coined with this name in 1977 by Ihab Hassan (1977). This philosophy, in response to the traditional humanist paradigm, proposes that human and non-human agencies are equally responsible for changes in the world. Notably, Haraway proposes that in a context of ecological devastation, like the one in which we live, a change in the paradigm about the idea of development could create new scenarios to stay with the trouble (Haraway 2016).

A slightly perverse shift of perspective might better enable us to contest for meanings, as well as for other forms of power and pleasure in technologically mediated societies. (Haraway 1985, 515)

As the author said, humans are not the basis of the development of the world, and to change this cosmovision, we must move our attention to new places that allow us to observe and explore this network of agencies. To rethink our position on this grid, we need to identify antique patterns to reconfigure and open them as a space for creative interaction on this network. This paper tries to do this: think about the potential of the artificial aesthetics to new ways of creativity.

Many objects of study could study technologically mediated societies; one that has been in the media spotlight are the images created by artificial intelligence. Academic researchers, engineers, and civil society are thinking about this. The discussion has been intense in the field of creation. Multiple voices analyse the role, scope, and projection of these images. These can mimic human traces and styles in short periods of production and with high credibility to the human eye (considering credibility as if they look or not as human-made). Public opinion has focused the debate on whether these images will replace the development of images by humans. However, the above point is not argued in this article because this work focuses on the emergent possibility that these images give to revise and modify our relationship with machines.

2. Interaction through Images

2.1. Artificial Intelligence Images: Nature and Capabilities

In the field of visual content, the most outstanding feature of the current generation of artificial intelligence algorithms for image generation is the quality of the compositions accomplished. Even if we look at surrealist style or hyper-realistic images, they can mimic aesthetics and composition with detail. In some cases, it could be challenging to respond about which is the nature of the image. When this happens, the lack of coherence could be the key to knowing whether a machine produced the image. Recognizing an element in the composition that reveals a failure in the pattern¹ of the image could be informative about what kind of entity creates what is seeing. For apparent reasons, finding an abnormal pattern is easier in hyperrealistic images because the target of the image is quite recognizable; therefore, the point of comparison is less debatable and more comparable. On the other hand, in a surrealist or abstract image, the search for a divergent pattern on it is more complex since the original point of comparison is more diffuse, as it is an artistic style, not a mode of perception.

Images generated through artificial intelligence are produced by algorithmic processes. Different algorithms can generate images, but the diffusion models in 2022 have the best results and have become more popular. The aim of this study is not technical, but it is necessary to know two things about how these models work to follow the argument presented throughout this paper. Artificial intelligence is a technology aspiring to create machines that mimic human cognitive functions through the training of algorithms. Train an algorithm means executing mathematical processes automatically until its results are optimal. These algorithms are trained to create new images, so they are trained by using extensive digital image databases, which are the object or medium they have as a purpose to optimally reproduce. Thus, an AI image can be declared optimal if it is as close as possible to resembling the set of images on which it was trained.

More than one algorithm uses the diffusion technique to create images. This article studies the stability diffusion algorithm developed by Stability AI studio. The selection criteria are based on four points. First, it is an open-source initiative. Second, it has a software environment called Dreamstudio that allows autonomous users to produce images without interacting with code; Dreamstudio allows image creation by word-to-image process and image-to-image generation, which is the focus function in the context of this article. Third, to train de artificial intelligence model, Stability AI uses the LAION-

1. When it refers to a pattern in the image, it can be either a graphic feature, the colour palette, the trace, or the compositional style of the image.

5B database, which is the most extended, open-access image-text dataset that exists at the moment (LAION-5B). Knowing this allows access to the base material that compounds the AI images, allowing a comparison between the input and output images. Finally, on its website Stability AI declared that they “care deeply about real-world implications and applications” (Stability AI). This declaration is fundamental when the images its algorithm generates are the object of study to explore the relationship between humans and machines in a technologically mediated society.

Current images created by Stability AI have enormous credibility. Even when it comes to hyper-realistic images of humans, images are easy for us to evaluate their coherence since we recognize our anatomy unequivocally and, for biological reasons, quickly locate anomalies in their appearance. Nevertheless, artificial intelligence images commonly fall on a detailed mistake when they try to mimic human images, our extremities: hands and feet. There are many images in which the algorithm correctly reproduces the human anatomy but cannot achieve hands or feet. These extremities appear in impossible positions, divided into fragments, with or without the natural amount of fingers.

Accusing a lack of coherence in the graphical representation of the image, or recognizing image pattern failures, as is named in some paragraphs before, is a concrete action that allows us to find our human position in the network of agencies. We can choose to describe it as an error made by the artificial intelligence algorithm that needs to improve or be more creative. We can examine it as a network node and use it as a medium to explore new ways of interacting with machines and images. This article will examine whether inconsistencies in images generated by artificial intelligence can be an element capable of encouraging new modes of interaction between humans and machines.

2.2. About images

Images evolve through time; with the timing of history, they change their style and production way, and consequently, they change as symbolic devices. As John Berger said, “every image embodies a way of seeing” (Berger 2008, 10). Every image crystallises a subjectivity; the features of his time are inscribed on it. We must consider the symbolic characteristics that the author has and trespass to the image being produced; likewise, through the author, the social conventions that come with and condition the author’s choices. An excellent example is the relationship between the ideological changes produced in the renaissance era and their visual materialisation in the inclusion of perspective in the image. Perspective represents a shift in the ways of seeing and being that society chooses to inscribe in history. The move to perspective meant a change in the hierar-

chies that guided the observation of the subjects. Just as before, the observer was an omnipresent god; now, the people possessed an autonomous way of observing (Berger 2008).

However, this could not be possible without technological advances, ones that a philosophical path guided. As mentioned above, with the inclusion of mathematical procedures in the image field, perspective appears and modifies the subject that possesses the observation capacity. Later with photography and the video camera, the time of the image changed, acquiring new abilities to communicate things. Technology has always mediated images; this primarily influences how they can be produced, but as significant as this, it defines how they are experienced and interpreted (Lee 2021). Images are representation and perception devices at the same time. The emergence of artificial aesthetics and its consequent effect on the problematization of the ownership and human nature of creativity (Manovich 2022) is the hallmark of the images of our time.

2.3. Shared Cognition

The study of emerging possibilities in the human perception of AI images must consider the cognition theories that incorporate the “outside” in the cognitive perception process. The extended cognition theory (Chalmers & Clark 1998) allows us to think about the continuous connection that different entities have in participating in a single cognition process, even if they are or are not human. When we think of the effect of the perception of an external stimulus, this outside organism intimately connects with us in a unique cognition process. That can be seen as a “cognitive system in its own right. All the components in the system play an active causal role” (Chalmers & Clark 1998, 8). From this perspective, recognizing a lack of coherence outlines a network’s node in which humans and machine agencies meet and constitute a single cognitive act, with the image as a medium. What is the machine’s role if every component has a role in the extended cognition process? How to describe it? Try to answer this question and assume that a model of extended cognition exists, has philosophical and moral consequences (Chalmers & Clark 1998) and so does not look at traditional models as a structure that orders how we operate in the world (Haraway 1985).

2.4. Meaningless Potential

Trespassing responsibility to new entities in the cognition process causes looking at new spaces to find a new order of ideas. Interacting with others provokes us to get to know them in their own ways. This work defines images generated by artificial intelligence and the details it fails to imitate as the object of study. If we traditionally think of these details, they can be called errors. On the standard definition of error, failure is an indeed performance of something.

At the same time, performance is a program or behaviour that someone puts on a body (human or non-human); it is not an autonomous action, failure is relational (Carroll et al. 2017).

Correct and wrong are words that significantly impact the shape of social development. Comprehending that error is an interpretation of an entity's behaviour unlocks the possibility of rethinking its meaning. Diversifying the meanings of error allows us to modify the current models of order and meaning in detail. If we think about the network mentioned above, rethinking error opens a new horizon of possibility (Berardi 2019) that refreshes and mobilises new ways of connecting and acting in a network. In this case, in conjunction with technology, this happens because reconsidering failure forces us to rethink our gaze on machines and our self-image.

In a sense, failure is the gap that follows the collapse of one mode of life and precedes the development of a new one. (Carroll et al. 2017, 2)

3. Reverse Error Exercise

As AI-generated images are created through a learning process that uses a database of images to create new items that can be considered similar to them, it could be said that an AI image is a sort of infographic or resume from that group of images (Salvaggio 2019). For that reason, sometimes AI images reflect bias or patterns written into the database, such as racial, gender, or LGBT+ issues. It is possible to distinguish ethics concerns by analysing the images resulting from the database. The article does not intend to work with a problem about ethics assumptions, but they come out in different forms. The issue that is studied is not about an ethical bias; it is about social conventions. Knowing the above, in order to study the features of the images generated by artificial intelligence and to recognize possible patterns that would show the artificial aesthetics, was proposed an exercise that would allow the machine to generate images according to its own mechanics, the procedure and some conclusions will be presented in the following paragraphs.

3.1. Reverse Error Procedure

This article's process includes an exercise named "reverse error" that was executed using the Stability AI algorithm to know how it performs with the idea of error and respond to the question, "How does the algorithm integrate, handle, or modify the unwanted?". It is already said that "error" has a social meaning. Hence, the initial objective of the exercise was to see what changes the algorithm conducted on images of hands that had certain anatomical deformations, hands that, for a medical standard, were problematic because they had inadequate behaviour. The initial assumption was that the

algorithm would fix the anatomical deformations, and some corrections associated with beauty standards could appear on the hands, such as changes in skin tones or the vital state of the skin.

Figure 1: Reverse error exercise: procedure and outstanding results.



The procedure of the exercise was simple, consisting of three stages:

1. Search and selection of baseline images
2. Iteration through Dreamstudio
3. Evaluation of the results

3.1.1. Stage 1: Search and Selection of Baseline Images

Regarding the first stage, the search for images had an exclusively visual approach. The search was for images of hands with medical complications manifesting in visible anatomical alterations. For this purpose, the search was done using the Google Images platform, looking for photographs of hands showing apparent symptoms of diseases such as arthritis or syndactyly. Understanding that the algorithms for creating images work as a flat medium, without recognizing depths or reading hierarchies, the images selected from the search met the criteria of low contextual noise and low complexity in the gestural pattern. Low contextual noise was identified in those images that included the least amount of context possible; that is, the photograph's focus and the most significant percentage of its composition were destined to show the limb and avoided incorporating contextual references. Therefore, the most optimal image would be the one that shows the hand up to the wrist and with a plain background of a single tone. Due to the low complexity of the gestural pattern, the hand's position was intended to be the least expressive and most iconic possible, that is, in an extended position. Coloured nails, accessories, and tattoos were avoided. There was no selection criterion regarding incorporating a single or a pair of hands in the image.

3.1.2. Stage 2: Iteration through Dreamstudio

The rigorous selection of the images was vital for the development of the exercise; however, the core of the procedure is in the execution of the second stage: iteration through Dreamstudio, because in

it, the human-machine interaction is manifested. In the initial fragments of the document, the reasons why the Dreamstudio algorithm was selected have already been specified, one of them being the possibility of working with the image-to-image mode. The study's goal is to interact with the machine through images, not words, which is why this stage was implemented using that function.

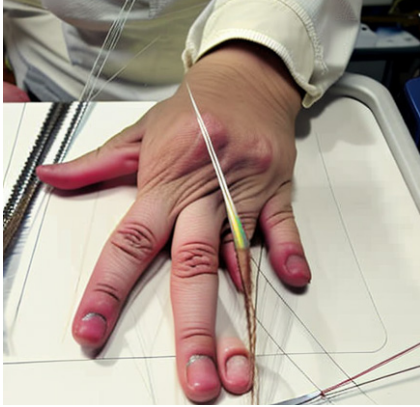


Figure 2: Image result of the reverse error exercise.



Figure 3: Image result of the reverse error exercise.

Textual prompts were not used in initial iterations, but to evaluate the possibility of more diverse images, they were incorporated in subsequent phases. Regarding other definitions for the iteration of the baseline images through the algorithm, the parameters of the image size were kept fixed, which was always requested in a 1:1 ratio and high quality, one image was always generated per batch, and the parameter of the generation steps was always kept fixed at 50. Regarding this last parameter, the platform indicates that the generation steps specify the number of times the image will be displayed and that the more steps, the more accurate the image will be to the description; this parameter was left low as it was the default value, and also, to avoid the request of a more “adequate” image (conflicting adjective according to the guiding concepts of this work).

Given the initial question driving the execution of this exercise about how the machine works, the concept of error; the argument that images generated by artificial intelligence have bias; and the preconception that the results delivered by the algorithm would evidence modifications to represent standards of beauty, the first phase of the iteration of the baseline images attempted to be as minimally human-driven as possible. For this study, this meant that the image was incorporated into the Dreamstudio interface and iterated without textual prompts. However, after about ten iterations per baseline image, textual prompts were incorporated to guide the development of the images toward modifying the unwanted features of the initial image (unwanted features are identified as the evident signs of the presence of the illness). The following prompts were incorporated in different batches: hand, perfect hand, healthy hand, human hand, perfect human hand, and hand with five fingers.

3.1.3. Stage 3: Evaluation of the Results

The third and final step of the “Reverse Error” exercise was to evaluate the results. Initially, the results were sorted according to their baseline image and were categorised according to the most prominent features in the images produced by the algorithm.

The result was a spectrum of images that generally followed the initial assumptions. Most of the features that were modified in the image were those that gave away the age of the person photographed initially. The generated image retains the baseline image's wrinkles and loose skin characteristics in practically none of the results. As

for the features that defined the groups in the images, the following can be named: images in which ring-like shapes appeared on the fingers; those that added textures to the skin, some inclined to patterns similar to henna tattoos, and others that were not associated with any identifiable feature since they incorporate tones and textures improper to any natural skin tone or texture; those that modified the appearance of the nails on the hands, some colouring them, others making them grow in size; and the last category were those that seem to have a more significant potential for a non-anthropocentric analysis, which are those in which the fingers grew or decreased in quantity and their anatomical mechanisms were improper for a finger as we know it since they were rotated impossibly, from joints that do not exist.

While the above results were essential and should be studied in more detail, the most relevant conclusion for the present paper is that the anatomical problems were not formally approached by the images, even in some cases, the images became more abstract or meaningless. This last point redirected the article's argument toward discussing shared cognition and meaningless potential. This conclusion made it possible to understand that the mechanisms of the machine representation are logical, and only from its statistical construction originating in a database containing symbolic elements, the images that the algorithm generates also contain symbols by inheritance.

Observing and recognizing patterns without calling the machine's choice of not correcting the anatomical deformations of the hands an error is what opens space for post-humanist thinking. This exercise engenders a process of shared cognition between the human and the machine. Without a database, there is no algorithm; without an algorithm, there is no image; without incoherent features in the image, there is no questioning of the concept of error. Having recognized the above, what remains then is to propose how to continue the chain through creative acts.

3.2. Reverse Error Conclusions

The critical element resulting from the reverse error exercise is that these images, which may be indicated as many of them less coherent than the original ones, are well evaluated by the machine, and therefore the algorithm outputs them. The intention for anatomical correctness was part of the human expectations of the machine's performance. Considering images as representation devices displayed as a medium around an extended cognition process, the machine is correct, and the idea of an autonomous agency emerges. Bringing in what Calvino said about the literary machine, going against an order that the original image establishes, a natural characteristic of the machine appears (Calvino 1986). A subversion, a desire for disorder

proper to the machine: the self-representation. Which, in any case, does not wait for human validation to exist; it only appears and does not need to justify itself.

For this analysis, it is necessary to return to the procedure the algorithm implemented to produce images. It takes an enormous bunch of images to find patterns and, after, apply mathematical sequences to generate new images. With this in mind, it is possible to argue that the images resulting from the AI have a distinctive representation model, a unique aesthetic with the distinct characteristic of having a sensible and logical register simultaneously. The abstraction of the input images of the database fully charges the output compositions of human symbols, as could be the rings that the algorithm puts into the hands of the reverse error exercise. At the same time, the images have a measure of success that only results from the logic of mathematics that the algorithm inscribed in them.

The act of pointing to something as non-coherence but not as an error is an interaction that constitutes a new cognitive system since it is impossible to decouple human and non-human agents in its conceptualization. This human-machine interaction is powerful because it questions the modes of representation and disobeys the art's paradigm, which is identified as one of the pillars of culture. What is regenerated is the way of being human. The idea that the machine can generate its own images takes out of human hands the idea that we are the only ones capable of producing them. Admit that this could be, come up with the challenge of finding the potential of this new cognitive system. For definitely, its objective cannot be to install these processes as a mere biological extension but as a creative engine.

The potential of the incoherent fragments in the images generated by artificial intelligence is that through an act of shared cognition typical of human-machine interaction, the appearance of the potential of expanding the registers of representation function as a provocation for new ways of doing.

It is beyond the scope and capabilities of this text to propose and test the mechanisms that would enable these new ways of doing. However, it may be revealing to look at the history behind the works in the exhibition "Electronic Abstractions", produced in 1953 by Ben F. Laposky. It exhibited "Oscillons" (Laposky 1953) – the form in which the author decided to name this type of image – a type of photographic manifestation generated from the oscillating geometries that appeared in the cathode ray oscilloscopes. The latter are artifacts widely used at the time to measure different electrical parameters, which allowed the testing of cutting-edge technology in that context, such as televisions and radars. The relevant point of observing this exhibition with the aim of creative projections of the act of

observing incoherent fragments in images is that according to what the author manifests in the book catalog of the exhibition, the provocation to make these images was the reading of an article published in the magazine *Popular Science Monthly*, during December of 1947. The article called “Even Necktie Designers Can Use Electronics” proposes that fabric designers can observe the geometries resulting from electrical variations for inspiration to create new products.

Ranging from random squiggles to intricate geometrical lace-work, the designs offer fascinating possibilities for dresses, scarves, ties and draperies. (*Popular Science Monthly* 1947, 115)

The idea set out in the *Popular Science* magazine article, Laposky’s subsequent reading of it, and the following photographic exercise is an excellent and inspiring example of what we might do when looking at the incoherent fragments of artificial intelligence images. As an outline, one could think of these images as inspirational for prosthetic designers, creative painters, screenwriters, or others.

We might think about images as Anwandter talks about poetry:

The plenitude of poetry does not reside in its potential for action or its concrete consequences, neither in defining identities or filling its emptiness, but in the creation of a gap, a renewing space in which different experiences can converge or be born.² (Anwandter 2017, 71).

4. Conclusions

This work is focused on observing what an initial point could be pointed as an error. To rethink which are its functions and its possibilities. Recently, images generated by artificial intelligence have evolved to the point of surprising humans with their credibility. However, they usually have problems shaping hands, but why? Instead of finding technical answers to the hand’s shape problem, the development of this work is focused on thinking of this as a space to revise and be creative about human interaction with machines.

Calling something an error, it indicates a failure in the expected performance, so at the same time, this performance is being defined. Consequently, mentioning the shape problem of hands as an error only shows what humans expect from machines; draw the performance mentioned.

2. Translated by the author, from the original: *La plenitud de la poesía no radica en su potencial de acción o sus consecuencias concretas, tampoco en definir identidades o colmar sus vacíos, si no en la creación de una brecha, un vacío renovador en que distintas experiencias pueden converger o nacer.*

Thinking about incoherence without calling it an error allows formulating -in a less anthropocentric way- the idea of what possibilities the AI image is opening up. The machine brings a new type of image, which is symbolic and, at the same time, logical. It inherits the use of symbols from humans but incorporates an algorithmic and mathematical logic that baffles us. The challenge of this is to resolve new ways to incorporate this into our way of seeing and re-drawing the relations displayed on the space.

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Keep On Keeping On: Continuous Noise, Iterative Loops and Computational Aesthetics

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In this paper, we propose two concepts regarding computational artistic practices and their aesthetics: noise and loops. The primer being *prima materia* to computation and the latter its poiesis. Starting by a definition of computation situated and comprising widely enough accepted notions, we argue for the reading of computational arts as continuously self-performing practice based on constant production of information, and conclude on opening a reflection on their possibilities regarding non-human interactions. We put forth these notions by reading into two selected pieces: *Noise for the Nothing Unity* by Vomir and *How Computers Imagine Humans?* by João Martinho Moura. These artworks help us investigate upon the aesthetical strategies of computational art pieces and provide a good illustration of the various technical differences in computation's embodiment.

Keywords: Computational Aesthetics, Computational Art, Noise Studies, Software studies, Art and Technology, Computation, Ontology.

1. Introduction

The simplest way to describe computational aesthetics would be deriving them from computational art practices. But that would be saying very little, as those practices themselves can be difficult to situate precisely. Defining computational arts (CA) from computation (Carvalhais 2022) — i.e. differentiating them from all art that is made on a computer in favor of a more process-oriented, “computation as subject” approach — helps laying a foundation for what they are and what aesthetics they entail. Still, a question remains at the crux of it, that threatens this sequence: how exactly do we even define this notion of computation, amongst all of its acceptances?

This paper aims at (1) proposing a curated — and necessarily non-exhaustive — list of notions regarding computation that are sufficiently widely accepted to derive a general proposal for computational aesthetics; (2) advocating, based on the thus defined process, for the identification of informational noise as the *prima materia* of computational art practices, and (3) for the iterative structure of programming loops as computational poesis. As main examples of computational art to analyze and reflect upon, this paper will center its interpretation on two art pieces: *Noise for the Nothing Unity*¹ (2020), by French Harsh Noise Wall (HNW) pioneer Vomir (Romain Perrot), and *How Computers Imagine Humans?*² (2017), by João Martinho Moura. As the latter can be more evidently held as computational art, the relevance of a computational reading of the former and of the HNW movement will be developed. In conclusion, this paper argues that these ideas help define a specific aspect of computational aesthetics: its focus on de-anthropocentering all discourses regarding computation, defending the idea that by engaging with pieces where so much of our traditional expectations are subverted, computational art offers examples of inhuman interactions (Leach 2020).

2. Computing: can't stop won't stop

2.1. The Complexity of Computational Situating

In many ways, CA are to computation the Critical Technical Practice Philip Agre hoped for in his 1997 essay.³ As “deviation amplifying systems” (Burnham 1969), they present an opportunity to question computing technologies by using these same technologies. This sort of behavior defines CA as an investigatory art practice (Shanken

1. Vomir. 2020. “Noise for the Nothing Unity”. Accessed January 31, 2023. <https://vomir.bandcamp.com/album/noise-for-the-nothing-unity>

2. Martinho Moura, João. 2017. “How Computers Imagine Humans ?” Accessed January 31, 2023. <http://jmartinho.net/how-computers-imagine-humans/>

3. Agre, Philip. 1997. “Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI” in *Social Science, Technical Systems and Cooperative Work: Beyond The Great Divide*, edited by Geoffrey Bowker. USA: L. Erlbaum Associates Inc.

2012). Though, and perhaps precisely because of that investigatory nature, CA are called to situate themselves in the scientific, historic and philosophic landscape they offer to explore; and quite a rugged landscape it is. The history of computation is one of transdisciplinary enquiries, originating in mathematics to spread across philosophy, engineering (where it gave birth to computer science, its very own field of study) and cognitive science. To try and retell all of it is way beyond the scope of this paper, but it is nonetheless crucial to acknowledge, when talking about computation, that it is not a given, static corpus, but rather a still very disputed field of scientific research; that nothing in computing technologies is “neutral, or value-free, even if we are naturalized to it” (Penny 2017, 4). As for this paper, its goal being the articulation of transversal artistic strategies through different pieces, computation both analog and digital, both embodied and representational will be considered,⁴ their common areas precisely revealing what justifies the relevance of the delimited aesthetic vocabulary.

2.2. What We Can Agree upon Regarding Computation

One such shared element across all acceptances of computation is its dynamic nature (Rucker 2005). Computation is a process, something to do, not a given state. The nutrient for this process is information — whether it be bits of Boolean logic, motosensory inputs, fluctuation on an electric signal — but the computation itself starts when something is done with the information. This implies that every computational system is designed to perform computation, and that when talking about such a system or piece of technology, we do not only speak of it as a static object, but as an enabled, actively outputting agent.

Consequently, computation is both transformative in its operation and additive in our perception of it. Transformative meaning that enabling a computational system and feeding it with information is planning for that information to be computed upon. Either processed as to be re-ingested back in a feedback loop or embedded into a different bit of information that will be then passed to another system. Once again, while the modalities of these transformations are being disputed among the critics of previous cognitivist representations,⁵ the very notion that computation does something to the computed seems transversally accepted. But as perceived by the human eye, this process is additive. For us, computation creates information from information, adding something to the mix. From our

4. For a more comprehensive listing of the different approaches on computation and their oppositions, see : Smith, Brian Cantwell. 2002. “The foundations of computing.” In *Computationalism, new directions*, edited by Matthias Scheutz, 25–58. Minnesota: MIT Press.

5. Such as the linearity of input–treatment–output operations, or the exclusively algorithmic nature of said treatment. For a detailed presentation of postcognitivist theories, see : Penny, Simon. 2017. “The New Cognitive Science.” In *Making Sense*, 193–213. Minnesota: MIT Press.

point of view, feedback resembles piling up, and a new version of a previous information is still a new information.

2.3. An Unending Process

As a performative process, computation stands as a neverending mechanism; even more so, it denies the possibility of ending. It emerges from its set of instructions — either a finite set of formalized operations involving symbolic tokens or the structural coupling of social interactions (Penny 2017) — and brings its *future future* (Morton 2013) realization into our present. Furthermore, when talking about computation as it happens in the myriad of digital computing devices surrounding us, one cannot ignore the tendency of computer science to go towards a distributed, continuous, ever-happening real-time model.⁶ Such a technological trail has not been deemed interest-worthy by mere chance, but because it also corresponds to another influential idea regarding computers: that our brain might be just one.

In his seminal 1960 paper *Minds and Machines*,⁷ Hilary Putnam expanded on his theory that the various mental states of the human mind could be “analogous to the internal states of a Turing Machine, [...] whereas brain states were analogous to the physical states of a hardware realization of a Turing Machine” (Piccinini 2004). Although the specifics of such analogies — and the whole functionalism theory that it gave birth to — have now widely been questioned (including by Putnam himself), the underlying idea of a resemblance between our (or any living organism) mental operations and a computer is still vivid; and minds do not stop. This question of mental continuity is even one of the main arguments for a distancing from digital computing as a set of rules that is executed sequentially on an input to produce an output, as we cannot pinpoint an exact moment in our flow of thought where one ends and the other starts. Cognition as a blueprint pleads, regardless of other criteria, for a continuous, self-enabling, constantly outputting model of computation.

2.4. Analog and Digital, Regarding Continuity

As this notion of continuous computation brings us closer to the next part of this paper, it is necessary to take a small detour and address the paradox of continuity regarding digital computation. Indeed, analog is inherently continuous while digital is inherently discrete (Massumi 2021, 145–156). While technically true, this argument must be set against the constant search in digital technologies

6. Examples of such a trend range from the overwhelming rise of online applications and activities, progressive web apps, ubiquitous computing and cloud computing.

7. Putnam, Hilary. 1960. “Minds and Machines” In *Dimensions of Mind: A Symposium*, edited by Sydney Hook USA: New York University Press.

for the emulation of analogue, particularly regarding continuity. An imperfect but useful metaphor would be that of the still image for a film: continuity as constructed by cycling through discrete elements fast enough. Whether we are talking about sound being computed at, at least, 44100 samples per second (before being converted back to analogical signal), visual refreshment rates going as high as 120fps in some cases, or information computation reaching speeds beyond our ability to keep up with them, digital tools are mostly capable of producing and outputting elements at rates that provides the illusion of continuity. Thus, if the ontological differences between analog and digital are very real and deserving of discussion, and while the granular aspect of any digital operation can be envisioned as an aesthetic element of its own,⁸ the rest of this paper, when talking about continuous generation, will do so from the point of view of a human spectator, and assume it is perceived as such.

2.5. Computation + Art = Computational Art

Having defined what we talk about when we talk about computation — an information-based process that, from a human perspective, continuously keeps on producing new information, never stopping for as long as we let it run — the moment has come to conjure art pieces exhibiting that sort of behavior. One of such pieces is *How Computers Imagine Humans?* by João Martinho Moura (2017). An installation comprising two computers sitting face to face running real-time custom software, one generating visual geometric noise, and the other trying to identify human faces amidst it. As the artist's biography explicitly mentions an interest for “computational aesthetics”, and the text accompanying the piece addressing issues regarding computation technologies, both in their operation and consequences, picking it as an example and source of reflections for this paper is self-justifying.

The second one, however, might need a bit more explanation. *Noise for the Nothing Unity* is a HNW project by Vomir (Romain Perrot), self-published on bandcamp.com in 2020. The only piece of literature regarding this piece being the small text that comes under it on the webpage (that will be discussed in more depths in the fourth part of this paper), and the artist himself never explicitly mentioning computation as one of his interests, one might ask why a computational reading would be relevant in this case. The first element of the answer is technical. Vomir has stated in an interview with *The Quietus* from 2014⁹ that he grew dissatisfied with using a guitar and went for “electronic noise generators” and pedals. That is, focusing his entire

8. See, for example: audio granular synthesis, video data moshing, asynchronous web development.

9. Perrot, Romain. 2014. “Anti-Musicality: An Interview with Romain Perrot Of VOMIR.” Interview by Russell Williams, *The Quietus*, August 20, 2014. <https://thequietus.com/articles/16050-romain-perrot-vomir-interview-harsh-noise-wall>

aesthetic around the sonic possibilities of either analog (tube-based “amps in a box”, transistor circuitry) or digital (DSP and buffers) computing devices. Secondly, Vomir stands in this paper as a figurehead for the HNW movement, that is centered around exploring the aesthetic of a constant, continuous, unending mass of diversely treated white noise; which, given the definition of computation we are working with, is very much computational.

Using these pieces as entry points, what are their common elements that could help us define shards of a computational aesthetics? The first one would be their mutual use of the same source material: noise.

3. In the Absence of Noise, Would You Hear Anything?

3.1. What is Noise?

Noise is most simply defined as any signal, interruption, or disturbance in the channel of communication that alters the quantity or quality of transmitted information (Swensen 2011). As this definition explicitly mentions information, we immediately are in familiar territory, although it would seem at first glance that noise may be the natural enemy of computation. If computation is the process that literally makes sense out of the information, then noise stands as an opposing force, altering what is to come out of computation. As an unorganized state of information, noise is to be quickly sifted through, filtered out so that meaningful content can be picked up. The most famous examples of noise would tend to support this vision: if you still own a cathode TV, zap to an empty channel, here is noise. Tune a radio between stations, listen to the crackling static, here is noise, again. Funnily enough, that is how Vomir encourages people to first approach his sound and see if they might be interested in it.¹⁰

These examples, it should be noted, are of analog noise, pockets of in-between signals. Entire spans of no-content, filling the gaps between properly used frequencies for more worthy transmissions. Supposedly devoid of any interest, parasitic, even, when grains of noise spill over from these blank shores over our signals. This tendency from noise to spill over, the presence *en masse* of parasites in analog computing is one of the reasons that pushed the American Air Force (one of the most important funds providers regarding computational research in the twentieth century) (Penny 2017, 72-80) to transition to digital computing. Built upon a much more representational and internalist framework, digital computing was to get us rid of noise. By implementing at its core a Boolean logic reducing any possibilities to that of a binary 1 or 0, this technology got rid of the

in-between, closed the gaps between meaningful content, promising to tighten it all up neatly. How is it, though, that as the complexity of digital computers grew and their use went on to permeate every domain of human activities, “generating noise signal [became] a basic procedure on computers”? (Moura 2017)

3.2. The Noise Is the Signal Is the Noise

This paper argues that the necessity of noise generation in almost every area of digital-based practices reveals an inherently flawed distinction between noise and signal. Following to some degree the brain in a vat (Harman 1973) scenario, a large portion of cognitivism posed the distinction between significant information and mere mechanical stimuli. It pushed for the idea of eliminating corporeal, nonsemantic elements, and focusing on operating upon symbolic abstract tokens. But such a hypothesis has been largely criticized and the definitive separation of reasoning from embodiment no longer withstands.¹¹ To rephrase it from our aesthetic perspective: “nonsemantics offer possibilities for interpretation” (Royston 2022), the noise and the signal are but one. The way we hold an object, the touch of a specific paper, the characteristic fizzling added by a vacuum tube, the granularity granted to any image by its printing or all conceptual decisions regarding a book’s design are all noisy margins that we still mobilize in our perception.

3.3. The Quest for Digital Randomness

As an interesting sidestep, it should be noted that to achieve noise, digital computing need randomness; for noise can be mathematically represented as a group of random numbers without connections to each other. But as an embodiment of Boolean logic, digital computing cannot produce randomness. Simultaneously, the internist and representationalist philosophies of mind had conditioned digital computing to incarnate the body/mind dualism. Duplicating it as the hardware/software dualism, descendants of such schools of thought described the way computational operations are embodied and the tools they need to wield to execute as implementation details (Hutchins 2010). Yet, when randomness became such an essential part of computer science research (and is still, through cryptography, for example), one of the keys to achieve satisfying pseudo-random number generation (pRNG) algorithms laid in such details. The temperature of the CPU, the next vacant logical address in the computer’s RAM or its ventilation speed, all that is considered as a noisy input became a source of arbitrarily chosen seeds for mathematical functions that would output random enough numbers.

11. See: Cosmelli, Diego & Thompson, Evan. 2010. “Embodiment or envatment? Reflections on the bodily basis of consciousness” In *Enaction: Towards a New Paradigm for Cognitive Science*, edited by John Stewart, Olivier Gapenne & Ezequiel A. Di Paolo, USA: MIT Press.

When tasked with adding uncertainty, the digital went for the analog, the mind looked at the body.

3.4. Noise as *prima materia*

With analog computing producing noise as its inevitable corollary, and digital computing becoming ever so efficient at producing noise — and using it ever more — all of computation oozes with noise. Thus, as CA are to be understood from computation and investigate on it, the substance they wield and transform, their *prima materia*, regardless of any artistic medium they choose to wield it through (be it sound, installation, images, or film), is that noise. Where does that leave us, aesthetically speaking? With a take on CA as concerned with the non-discursive part of the discourse. With the outskirts of information-processing and meaning-creation. Within our hands a continuously self-creating boulder of chaos that should not be denied its chaotic nature at the cost of disconnecting one's CA from computation. Formally speaking, this conception turns to HNW as a quintessential implementation of computational aesthetics. Listening at *Noise for the Nothing Unity*, or *Mineral Synthesis*,¹² is to let oneself squashed by such a boulder. The former providing an example of constant non-evolution, while the latter varies across its running length, but without any form of transition, as if the computing system suddenly changed rules, using the same input to produce different outputs. Without this shift implying any sort of rhetorical evolution or narrativity. Computation in itself isn't about narration, as it does not have any sense of storytelling. It ingests, treats, and emits.

Derivative from this last phrase, noise as *prima materia* for CA also implies a behavioral aesthetic (Carvalhais 2022) that would center on the execution of a system, rather than its evaluation. CA is concerned with the incarnation of the computation, not so with its rhetorical demonstration. Hence, tying it with the definition of noise we gave, CA pieces do not stop to reflect on what's outputted, just as the end of a loop in Moura's piece only signifies the beginning of another. Since the filtering that brings meaning is not to be found on the computation side, but in the eye as in the "bones and brains" (MacIver 2009) of the one it is being computed for.

4. Coding Loops as Artistic Grammar

4.1. We Can Be (Loop) Heroes

Championing this notion of behavioral aesthetics, Simon Penny underlines the ontological difference of computational from traditional media on the basis of their performativity (2017). Real-time compu-

12. Black Matter Phantasm. 2016. "Mineral Synthesis". Accessed January 31, 2023. <https://blackmatterphantasm.bandcamp.com/album/mineral-synthesis>

tation brought us “dynamical, enactive and deictic” cultural entities that should be engaged with as such. Thus, if noise is the *prima materia* of computation, what are its instruments? Metaphorically, what would be the computational hammer and chisel? For starters, it needs not only to be a tool, but a self-wielding one. As we described computation as a dynamical process, perpetually self-enacting, its matching device cannot be static and externally activated. It needs to “push against the materials [as] the materials push back” (Mateas, quoted by Penny 2017).

Such a behavior, a perpetual reaction to constantly incoming information (whether outputted by another system, or one system’s environment, or the system itself in a preceding run) is at the core of the cybernetic project and one of its central concepts: the feedback loop, i.e. analog computing systems are fundamentally circular tracks, putting noise through a series of embodied rules and operations, only to loop it back at the beginning. Regarding digital computation, loops are everywhere. As a collection of instructions to be linearly performed on data as long as specified, they are one of the most basic structure programming.¹³ At the most fundamental level, any computer that is turned on is continuously executing its main loop, even if only to refresh its display, producing the illusion of stability through constant iteration; that is, running in circles until granted a specific task.

This ubiquity of loops in any form of computing, as well as its ability to maintain itself procedurally (Murray 2012), poses it as a particularly relevant structure for computational practices. Defining a loop, its enabling conditions, the various behavior it exhibits while running, and its iterative mechanism — how does it closes on itself at its start/end — appears, in this context, as a quintessential aesthetic gesture, thus putting forward the idea of loops as a most precious tool for the computational artist.

4.2. A Rapid Course in Programming Loops

For the rest of this paper, any mention of loops will more specifically concern programming loops in digital computing. This specific acceptance is, this paper argues, a valid and useful blueprint for reasoning upon the aesthetic underpinnings of loops in CA. Valid, because, as stated before, loops are ubiquitous to computation. Both analog and digital computing systems use loops, in the same self-enacted, possibly self-informing (feedback loops), and dynamic (analog as digital loops can both modify their own parameters) way.

13. Accompanied with functions and conditional statements. Oriented-object and other paradigms introduced many variations upon these concepts, which are beyond the scope of this paper. Still, even in such paradigms, loops occupy a fundamental position in coding (Van Roy 2012).

Useful, for the verbalization digital computing brings to the table. As code is a formalized performative language (Galloway 2006), its enacting conditions and operations are verbally laid down, which can be easier to grasp than the mechanical *bricolage* of analog computing. Once this precision is made, a rapid rundown on the two main programming loops is necessary to clarify future concepts.

A *while* loop is one of the simplest forms of programming loops. It executes the code placed inside its body while a condition is met. It is based on a Boolean logic assertion that a statement is necessarily true or false, and so, that a condition such as: *while x is true* will either be met or not. Incorporating such a binary logic, while loops are also the most prone to error form of loops. They offer the most chances to fall into *infinite looping* (if based on a condition that will always be met, such as $0 < 1$), something that should be carefully avoided.

A *for* loop comes with an extra element of control. It is made of a body of instructions, but also a head that harbors a more detailed condition for it to run. The header is loaded with a loop variable that will traditionally serve as a counter for how many times the loop has run. The head also defines what should be done to the loop variable in-between each run (such as being incremented by one). Thanks to the presence of the head, *for* loops are much less prone to *infinite looping*, explicitly requiring you to provide a logic for the looping condition to either stop or maintain.

Finally, it should be noted that every variable declared inside both a *for* or a *while* loop is only accessible within that loop. Alternatively, it is often harder to access a value created or stocked outside the loop, from inside the loop, i.e., once engaged, the loop becomes the computing context, everything that is created there stays there, and everything prior to it can only be touched through referencing, not directly.

4.3. Iteration and Repetition

Such technical details are of importance because, in the context of CA, they inform our reading. As computational aesthetic is an aesthetic of behavior, such specificities are not only informative, but actively partake in our computational reading of the art pieces. Listening to a HNW, for once, is listening to a *while* loop where the condition has been purposefully set to plunge into infinite looping. As the frozen state of a program that keeps on perpetuating its own condition for not being able to move on, where a single fragment of execution has expanded its scope so much that any reference to anything outside of itself is abstruse, engaging with it on this basis helps connecting to the aesthetic of paralyzing self-saturation and paradoxical vacuum filling.

Simultaneously, *How Computers Image Humans?* quite literally shows us a computing loop happening right before us. As the first screen displays noise, the second one searches for faces in it, and displays a number of its findings before outputting a final visage, made from averaging the previous ones. The fixed number of faces appearing tends towards the structure of a for loop, much more contained, promising a less chaotic behavior and something that is much more iteration based. The operation unwinds in front of us, every time in the same order, at the same pace, but with a different result. The loop keeps on looping, but iteration is not repetition.

This distinction is not only a technical or rhetorical one. Iteration means that for every time the loop runs, it will result in something different. Same rules, possibly same input, but different outputs. Here one can make use of randomness, of noise, for producing ever changing content. Repetition would mean to enact the same behavior and have it repeatedly produce the same output, i.e., the faces in *How Computers Imagine Humans?* would all look the same, every time. Computation and loops can produce both of these behaviors, and it is up to the artist to enact either one of them.¹⁴

4.4. Recursivity and Refresh

On a micro-temporal scale, looking at both *How Computers Imagine Humans?* and a HNW piece, the question of recursivity and refreshing emerges, as does iteration and repetition on a macro-temporal scale. Recursivity is a constructive process. It is the closest incarnation of a feedback loop one can enact digitally. It implies that something is kept from previous iterations to build upon. In Moura's piece, the final face is made of the recursive assembly of all the previous artifacts identified as facial features. They were all memorized for the duration of the present iteration of the macro-loop, stored as to be mobilized during the final calculation. In its computational framework, recursivity is supposedly closer to human experience, as we keep on executing the same functions on an evolving basis. We do not forget immediately what we learned from a previous installment, but rather use it to inform future cognition.

To refresh is a different, more “computomorphic” behavior. A defining mechanism for a certain type of digital memory, refresh has become a staple of computational language across the web. Refreshing means starting from scratch. To ignore any result of a previous computation, to forget all context in order to reconstruct it completely.¹⁵ HNW refreshes, as an input of noise goes through

14. Or both, sequentially, or side-by-side, or any other configuration the artist wishes to deploy.

15. Several options to store and handle data are now available as to avoid such a drastic and systematic rebuilding. Still, as technical solutions aimed at saving time, they do not remove the possibility of truly refreshing the memory, nor do they change the nature of this process, so specifically computational.

the same constructed set of operations for each sample, without a trace of the one before, without constructing on anything, without remembering anything. Once again, to either enact one or the other depends on the artist. This is, as emanating directly from the structural conception of a computational loop, a foundational aspect of a computational behavior, i.e, a fundamental computational aesthetic choice. What kind of loop is the piece enacting? Does it deny the possibility of remembrance to the point where it forgets itself every time? Or is it storing previous states and reusing them, conducting a circular operation that builds on itself as to show the construction of a thought?

5. Object-Oriented Asceticism

5.1. No Retreat No Surrender

Now, stepping afar from the pieces' poiesis and into their rationales, a reading of both the text accompanying our selected works on their respective webpages helps circling a last element for our proposed computational aesthetic. One that is particularly concerned with the piece's reception, and what it is supposed to evoke.

João Martinho Moura's page for *How Computers Imagine Humans?* offers us a straightforward explanation of the piece's statement. A documental approach, detailing the technical choices made by the artist and their rhetorical purpose. The installation is centered around showing the quintessential human face as "imagined" by the computer (Moura 2017). Reversing, in doing so, the facial recognition technology, the piece is yet not, as highlighted by the artist, about the visuals it produces, but about the knowledge that underlies it. In this particular case, the "knowledge we, humans, try to implement into machines to detect ourselves". That is, de-anthropocentering the most anthropocentric pictorial element there is — the human face — and breaking it down to statistical operations upon randomly-generated noise. A particularly telling bit of interpretation comes from the three highlighted listed negations: "no soul, no history, no memory". The result of the showcased process is not the construction of someone's face, but the negation of it. Nothing here, not even the final output resembling a human figure, is humanistic. This is, after all, nothing but noise, and noise is all there is to see.

Regarding *Noise for the Nothing Unity*, a series of negations is all there is to read below the piece. Successively listing everything that will not be presented in this recording. From musical missing elements like "no minimal drones", "no tuning systems" or "no spectralism" to philosophic shattered hopes like "no purity", "no spiritual healing" or "no contemplation". This piece, as with all of its siblings

(and in respect with HNW's manifesto, also written by Vomir)¹⁶ is about denegation and withdrawal. The closest of the two studied pieces of this paper from a raw accounting of what is perpetually generated noise through constantly reset treatment, it embodies in the most brutal way an aesthetic of pure relationship without any expectations. Here even more than anywhere else, there is absolutely nothing to relate to, nothing but noise to hear.

5.2. Trying Not to Be So Bleak

Centered on denegation and withdrawal, it should be of no surprise to see Vomir's bandcamp page (where he stores and reissues a lot of his walls) displaying just a continuous grid of black squares as album covers. Accordingly, such a definition of CA and computational aesthetics as what have been provided in this paper can seem rather bleak. Hinging on a voluntarily cacophonous and chaotic matter, ostensibly offering nothing but the circular behavior of loops, they deprive us of a lot of traditionally satisfying narrative structures (Ong 1982). And stemming from computation, they can't ignore what computation is "in the wild" (Smith 2002), i.e., that most of what computation is made to be under the most influential actors of tech industries seem to lead us in a dystopian hellhole where our only hope would be to download ourselves in the cloud. But, as a somewhat optimistic counter opposition, a case can be made for CA as highlighting a fundamental flaw in our approach of "processes [that] are beings too" (Bogost 2014). That is, that our technological objects, and all of what we're surrounded with, have to say something about us.

5.3. To Look for Us In all the Wrong Places

Going back to computational fundamentals, computers were made under the cognitivist assumption that our minds worked following an internist and representationalist framework. Hence, according to mechanical explanation, these machines were to emulate our minds, and create a world isomorphic to our perception of it. Alas, as the failures and questioning of cognitivism led us to see, we did not know our minds that well (Penny 2017). And as the new, computational media infused every aspect of our lives, what we ended up with was a worldly, accidental megastructure (Bratton 2015), akin to a specific part of our cognition, but definitely not encompassing the whole of human umwelt. In this context, CA can be seen as implementing this structure's aesthetics, crystallizing it into precisely delimited moments of enacted behavior. It does not mean that they are anti or post humans, rather inhumans (Bogost 2014). Thus, producing noise and iterating through it will hardly correlate to a hu-

16. Vomir. Unknown date. "HNW MANIFESTO". Accessed January 31, 2023. <https://www.decimationsociale.com/vomir-hnw-manifesto/>

man experience, but offer a profoundly unsettling and potentially rewarding object-oriented ethological study.

6. Deafening Iterative Chaos as a Breath of Fresh Air

Concluding, it should be noted that the æsthetical proposition of this paper is obviously not the only way to approach CA. As living and debated as computation is, it generates new configurations for CA to embody every day. Still, in any shape or form, computational aesthetics may be hard to pinpoint because they bear a radical proposition: that of a relationship with inhuman behavior. Going back and expanding on our definition of noise, we could summarize it as every unsaid yet significant part of what is said, i.e, the perpetually excess-producing outskirts that harbors withdrawing realities (Harman 2002). To loop through it, then, would be a way for us to experience its *absolute contingency*: the ever-standing possibility for anything to be anything else (Meillassoux 2006). The proposition to relate to such a behavior through an art piece is an ambitious invitation. But it makes sense, in our computer-laden present, to respond to it. Computation may have failed at giving us a world made after our minds, but it still brought us objects to think with, “processes that are beings too” (Bogost 2014), even if definitely not human ones.

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Computational Aisthēsis: The Ideology of Prediction in Algorithmic Text-to-Image Processing Models

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This research paper is established on theory and critical artistic thinking on the ontology of computational image processing, underlying discourse of their representation — between their content and context. The research is located on the axis between the image analysis and synthesis processes developed on machine learning-based tools. Examining modalities for understanding the *zeitgeist* of computational imagery offered in algorithmic models is needed to align and locate our own position — to draw the line where human agency stops and automation begins. Also, to determine if there is such a threshold at all - blending the feedback loop between the user and the machine. Automation is a collective effort, and claiming back the totality of our agency rather than dispersion into particularisation — *to see a world in a grain of sand* — we have to detect the structures of the network we are part of. This research extracts the visual aspect of the experience and agency in the production and contextualisation of automated image processing. In the pervasiveness of visual communication, visual culture should be equally important.

Keywords: Computational Image, Image Analysis, Image Synthesis, Automated Creativity, Ideology of Prediction, Colonised Imagination.

1. Intelligence as a Collective Effort

In computational image-making processes, both agencies, of *intent* and *automation*, participate in a production-prediction loop, a procedural optimisation through a theoretically infinite number of possible iterations, a power of the multitude. This combinatorial infinity in production gives us endless opportunities to project meanings, speculate the superiority of computational systems, while we are at risk of forgetting the collective efforts that were, and still are, essential for the development of these systems and tools. The relationship that develops between a human as a user, and a machine, as a tool — that *calculates* — is established on the mathematical logic of correlation and processing of binary values on a pixel grid, a statistical and combinatorial probability generator of data input. The topic is not about questioning the technological capabilities to produce an image, but human capabilities to disambiguate the meaning of an image that surpasses the ghost in the machine, that converges internet-sourced manifestations of cultural codes of exchange, through communication and visual representation, into discrimination, classification and [self-]optimisation.

We live among technologies of decentralisation as users of software as a service, that claims the extractivist principles of data crowdsourcing, *ascending* into ‘cloud computing’. Seemingly immaterial or invisible, due to distributed re-localisation of storage capacities from remote data centres and pumped computing power, an architecture of new geopolitics is created as a planetary scale computation of obfuscated agency and accumulation of power dominated by the Global North. The main ideological framework of making the power centres invisible is to mystify and abstract the agenda and the accountability for profit acquisition, through the strategies of social engineering that provide the accumulation of attention and consumption = influx of capital for service providers. The same service providers that have the computing capacity and data access [*ownership*] do develop tools such as, most recently, DALL-E or Stable Diffusion and Midjourney. Presenting them as a novelty, as they are powerful tools that require powerful sources — to some extent they are available so to justify the means and principles of data accumulation, promises of intuitive and intelligent systems that mimic understanding of our world. For artists, it is an authorship paradox, in a condition where the use of these tools can be appropriated for artistic expression and experimentation in computational art, digital montage, and quick mock-ups, yet it can serve as promotion, or endorsement of the tool and the provider of the service, whereas the outputs often start to look alike, the tool has its own aesthetics or rather a visual identity constructed by its pre-made form and code — so tool turns into a product and artist becomes a user. As being surrounded by systems that claim an invisible structure, the possible ways to grasp a broader picture of their functions and purpose are through differentiation

of what *we see* and what the machine *sees*. At its core, we teach the machine how to see, but the problem is what we want to teach the machine to see, and what is being left out. This is a two-way communication, as Vilém Flusser wrote:

This feedback enables the images to change, to become better and better, and more like the receivers want them to be; that is, the images become more and more like the receivers want them to be so that the receivers can become more and more like the images want them to be. (Flusser 2011)

If we are training machines to ‘see’, what are we training ourselves to see? This is a continuous loop in which it is our role to recognise patterns of our relation to the computed digital image, so as to make it reciprocally efficient. The notion of *agency* between the human [cognition] and the automated [systems] in a feedback loop of computational image production is a blurred vision between authorship, combinatorics and interpretational discourse. In such intertwinement between human efforts, *big data* and computational processing power, the threshold within these production loops is often obfuscated. Deconstruction of the premise that an automated computational system can be *creative* is developed as a thinking exercise on the contextualisation of qualities of generative results-outputs, where understanding of meaning goes past the representational surface — contextualising the form, analysing software ontology, and philosophy of a coded, data-image and its semiotics. The context of *technoethics*, human responsibility and agency in the implementation and consumption of the tools in question is used to dismantle and deconstruct the theology of a computed image, question our belief systems, fascination and imagination that build the ontological spine of these image-making processes.

1.1. It Is Not About Technology, but About Ideology

The psychological, perceptual, and cognitive shifts in the visual culture and artistic practices, reflect the socio-demographic concerns and consequences of automation in contemporary algorithmic culture. In the public discourse, there are frequent instances of praising automated systems and algorithmic data processing as a form of *intelligence*, which obfuscates the purpose and the limits of implementation of these algorithms and tools for different systems and industries. Between the media~marketing portraiture, actual technological developments, and scopes of implementation of these tools, confusion and discrepancies often emerge — so the understanding of *how*, *why*, and *for whom* these systems work comes into question. That is, to differentiate the concept of AI as a cluster of various tools and technologies, and AI as an *ideology*.

The computational *aisthēsis* is a perspective on the ideological consequences of colonised imagination tied to a discourse on the creative powers of an automated system. The aesthetics of generative imagery explains a lot about the character of *AI making 'art'* as a concept, a discontinuous mashup of representations, styles, and references — discursively hardly separable from self-referentiality — their context that is dependent on the fact that *it was created by AI*. The referential point of historical sustainability of the concept of art of any kind is to not repeat itself [literally]. Generative imagery is never far from overfitting, misleading or deceptive image overproduction, which is, essentially, conservative, uniforming and, nevertheless, obsolete soon after the *new* tool passes the test and reaches its peak in development. The dispersion of subjectivity and consumption of image-generating tools greeted with the hype of experimentation, might and will soon become just another tool for inspiration or quick sketching, or for some advanced users — a *deepfake* generator. What keeps it running, is the anticipation of the new, which the combinatorial infinity can offer, but *sometimes the same is different, and mostly, it's the same*.

The ideology of AI as a human-made cognitive problem where data science paves way for social engineering in which agency has been dispersed and neglected, delegated to an abstracted authority, leading to a problem of “thoughtlessness” (Arendt 1958, 3-5) by automation. This is specifically addressed to the questionable implementation of automated decision-making tools as objective and unbiased, a marketing strategy to advocate and maintain the accumulation of power, that is a trick to the human psyche in need of a metaphor for an ideology or a control compass to navigate the mysteries and mundanities of life, to delegate the agency to the other, whether an *entity* or a *system*. In contemporary computing, algorithms are essential not only for procedural code-writing and human-made execution protocols, but algorithms can be self-improved via *machine learning* and *artificial neural networks*. These technologies reignited the discourse of systems developing *intelligent behaviour*, on a premise that they are self-optimising or self-regulating, being able to *learn* from the ever-faster processing of massive amounts of data. The promise of knowledge beyond human comprehension obfuscates the nature, logic and role of these systems. Also, the mathematical or statistical nature and logic of these systems do not make them *neutral*. Such anthropomorphised and techno-solutionist portrayals of a physical and infrastructural geopolitical and industrial shift on a global scale at the same time disperses the human agency and social, political, and ethical responsibilities, which is a perfect environment for the accumulation of the power of the corporations, industry magnates, and governments. Algorithms help us to understand the world around us, but human decisions shape the culture that we live in.

2. Conditio Automata

The decision-making processes can by all means be translated into an algorithmic procedure. To some extent, many processes — once explained through an algorithm — *can* be automated. Yet the *Entscheidungsproblem*,¹ or the decision-making itself, is a non-computable task. Within the complexity of the dispersion of human agency, we delegate the combinatorial restructuring of the world to an abstract statistical probability of self-improving, rule-based computational systems that by no means can prove or disprove any decision. Algorithmic culture has its value in representations of dissemination, knowledge acquisition and evaluation, algorithms are procedural assets in proving and disproving a theorem, premise, or hypothesis, but it is human nature that understands the performance, that can stop, or affirm and constitute a specific condition, decision or definite outcome of a performed task. We amplify the notion of human agency within determining the scope of success of a generative output within the scope of creative production, intention and context of an image, arguing that the initial premise and the desired outcome selection and evaluation, respectively are still human responsibility. The epistemological scope of analysis of human-computer-*image* relation in a feedback loop rendered through media portraiture of artificial intelligence can only generalise techno-evangelist aspirations to build the price over their product — too often it is spoken about AI as a possible singular² *super*-cognitive intelligence. On the contrary, we can talk about the human condition within the operative scope of these systems, as Mihai Nadin introduces *Homo Turing* — “utilitarian, calculating, shallow, living by cost-benefit analysis. It seems that in reshaping homo sapiens intuition, spontaneity, empathy, compassion, and even judgment were traded for expediency” (Nadin 2017, 5).

These tools limit the possibility of criticism within themselves, whether by the principle of their improvement or by obsolescence

1. The decision problem, a mathematical problem posed by David Hilbert and Wilhelm Ackermann in 1928, proposes a true-false challenge to the algorithmic processing of a question. The challenge proved that an algorithm cannot determine whether an input statement is universally true or false

2. The concept of singularity or technological singularity introduces a hypothesis of a point of time in the future where the ‘explosion of intelligence’ is being anticipated, as the computer or networked intelligence, mainly inscribed to the concepts of AI, will create a form of superintelligence — uncontrollable and irreversible, resulting in unforeseeable changes to human civilisation. In John von Neumann’s words, singularity is “centred on the accelerating progress of technology and changes in the mode of human life, which gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue”. The concept and the term “singularity” were popularised by Vernor Vinge in his 1993 essay *The Coming Technological Singularity*. In the following context of the text, singularity might not appear as a superintelligence that is a centralised, visible agent: at this point, we are surrounded by accelerating technologies that do not execute their own demands, but we live in a statistically optimised sphere of industry, a swarming ideology of developing smart systems that aim to be globalised, yet are developed on the global north culture and reflections, representing another form of colonial extractivism whether in physical or data resources.

that overshadows the past hype. We all as users or producers, deliver unpaid or poorly paid labour towards celebrating novelty pushed by the *big tech*. Looking from that angle, we are sometimes not artists, but promoters. A new form of image-making comes with fascination, but after the peak of the new, the time has come to address the real characteristics of these image-making processes. Above all, through computer-synthesised images, we might be able to turn back to concrete experience, recognition, value, and action, away from the world of abstraction that comes as the first thing these images can offer. The computer-generated, machinic images are still an object of fantasy, admiration, and speculation. The human processes that are on, a psychological level, creative and inventive, capable of assigning meaning and power, to contextualise and associate, imagine and abstract the world into metaphors, they become a weak spot for understanding any novelty in technology out of the context of ideology or politics, utopia and fear. We project meaning, and another meaning is projected on us — therefore we have to choose our role between *automata* and *author* and demystify these power relations.

The algorithmic processing of massive amounts of data paves the way to a control system that is abstract, accelerationist, structurally irreversible and therefore uncontrollable, but never independent from human intention. In the context of image-making and image-reading processes, we can reflect on the same limitations in the current use of machine learning tools for image production. As distributed as they are, they come with their own preset, that as diverse it may be, does not invite us to look behind, dismantle or question the structural principles on which they are developed. Even with a creative process such as image-making we are limited to the role of the user-*prosumer*, mainly interacting on a level of command-execution, at the point of no return — as the scope of operational information within a dataset of a model is the limit of its map of operation, we are also navigating that same map, therefore the use of these tools had established boundaries on the scope of the territory we are able to cross. Additionally, a computed image is not a dream — machine vision is vision without images — it is a data image.

3. Virtual Ritual

Boris Groys states that: “In the modern age, ritual, repetition and reproduction have become the faith of the entire world, of the entire culture”, that is, “the ritual of the modern age is a ritual of mechanical reproduction” (Groys 2019). In that ritual, according to Groys, we believe that “every visualisation of data is also a revelation of that data” (Groys 2008, 2), as it is believed that in every performance of certain rituals, there is a relationship with the *invisible*. The presence *within* the screen/image, which we experience as a space for personal expression, is seen by the computer as a binary record,

which it can use as statistical data. Florian Cramer describes the relationship between code, mystification and speculation:

With its seeming opacity and the boundless, viral multiplication of its output in the execution, algorithmic code opens up a vast potential for cultural imagination, phantasms and phantasmagorias. The word made flesh, writing taking up a life of its own by self-execution, has been a utopia and dystopia in religion, metaphysics, art and technology alike. [...] From magic spells to contemporary computing, this speculative imagination has always been linked to practical – technical and artistic – experimentation with algorithms. (Cramer 2005, 93)

Between magic and rituals, the cultural obfuscation that comes with such invisible systems shall be exposed through the combinatorial reality behind them, while escaping the theology of information. To be conditioned to develop trust in a system that promises to provide the truth from true [false] permutations of data feedback loops is yet another form of human belief in the system. The more distant the system seems, the more magical and cryptic it becomes, and bigger are the chances to mystify and dream of it, to shape, form and visualise it by our own measurements. Simply put, to project ourselves into rituals of usage and consumption, abstract it from its initial form, and inscribe infinite meaning, hope, or desire into it (Nusselder 2009, 128). As for the algorithm, recurrence makes the content valuable, making the confidence of prediction bigger, whereas for us the confidence or recognition of the familiar shall not create comfort. Culture shaping through simulation of *creativity* – as a signifier for *intention* or *intelligence* – does not deploy its central discursive importance through evaluation of the generative content itself. It already makes its success and relevance by the fact that we immediately take it seriously, as part of our now, and as part of the future. It is part of the *truth* we accepted, that a computer *can do* something human.

3.1. To See a World in a Grain of Sand

That is the biggest magic in this discourse, a trick of deception where we already describe it as something *new and competent* to interfere in our reality. First of all, we should stop differentiating reality from virtuality, since the former created the latter – they are part of the same cognitive perception, and they are both corporeal. As automatic writing or dada poetry was a method, a combinatorial strategy – the possibilities of computational permutational processes are immense and supreme in that scope, but the selection and decision on where we find meaning or what we like, is ours, it is the same as it was with any analogue method of permutation, but also randomness. Italo Calvino wrote in *Cybernetics and Ghosts* about the machines that might become authors (Calvino 1986), where he spec-

ulated and hoped that such machines could delve into our algorithmic subconscious, repressed languages, and extended mythologies, opening up mysteries of thinking or knowing, to run a process that would be able to have the intent to deconstruct itself, to stop, cancel, negate, decompose and abandon any formerly given logic. From *generative adversarial neural networks* (GANs) where optimal approximation of a pixel value on a grid provided combinatorial infinity — causing aesthetically recognisable glitches, the most recent *diffusion* model architecture provides seamless hyper-veracious depictions of carefully navigated prompts, transcending reality by taking grains from it. This architecture has its own syntax and semiotics, based on language and taxonomy that create a rupture, engineering networks of relations, representations and hierarchies, that simulate the complexities of reality, yet they are a world of rendered collective data-past.

4. The Vampire of Time and Memory

Computer-generated imagery nowadays incorporates layers of information, big data and the entropy of context and syntax, that does become a reflection of a living system, this time even more intertwined with the representational simulacrum of the collective unconscious — much more than the ecosystem of cybernetics would predict — extracted by big data companies, clashing from micro — as all personal user input, to the *cloud* — as a macro-structure, from which another form of *computational living* is emerging as a form of consumption and aesthetics inclining towards photo-hyper-realism as an aim to claim creativity or aesthetic representational proficiency within the complexity of the systems of their production.

The database itself is a matter of the collective past and collective intelligence — it is the *prima materia*, the only knowledge that a computer system has, therefore the limitations of production always exist — a computer algorithm cannot generate or produce anything outside of the realm of the database it is operating on. It is the only truth for the system — operational information i.e., knowledge, does not exceed its limits, and the end of this universe is mutable but measurable, regardless of the combinatorially infinite number of outputs in performed permutations of an algorithm, and the ever-expanding growth of data collection. With the exponential acceleration of the world of *big data*, the improvement strategies for most of the machine learning models are premised on the logic that there is *no better data than more data*. The common rituals in the fast-paced sport of online information exchange — producing, sharing, multiplying — these wild transmissions are here and there cultivated, clustered, encoded, and so the archive is growing, and *too much is never enough*. Everything becomes an object of (or a subject to) quantification, which comes as a strategy to map the worlds, or rather, to create a map that is bigger than the territory, extracting sensory

and affectionate elements of human perception of reality, that are translatable into data. The scope of correlation when articulating that data, pattern finding becomes the culture-shaping model that boomerangs into suggestive consumption assets of the networked world's extractivist infrastructure, as it is right now — an infinite self-optimising loop, a mechanism of the accumulation of capital that is monopolised by tech-industry magnates.

The image-making tools established on massive datasets and latent diffusion models do not coincidentally resemble the exploitation of cultural capital as part of power accumulation, they are a literal continuation and manifestation of techno-capitalist colonisation of time, space and memory, collective histories, labour and attention, which I would like to compare with Mark Fisher's writing on the power of capitalist realism in the book of the same title:

[The power is] ...that capitalism subsumes and consumes all of the previous history: one effect of its 'system of equivalence' which can assign all cultural objects, whether they are religious iconography, pornography, or Das Kapital, a monetary value. Walk around the British Museum where you see objects torn from their lifeworlds and assembled as if on the deck of some predator spacecraft, and you have a powerful image of this process at work. In the conversion of practices and rituals into merely aesthetic objects, the beliefs of previous cultures are objectively ironized, and transformed into artefacts. Capitalist realism is therefore not a particular type of realism; it is more like realism in itself. [...] Capitalism is what is left when beliefs have collapsed at the level of ritual or symbolic elaboration, and all that is left is the consumer-spectator, trudging through the ruins and the relics. (Fisher 2009)

Whatever mundane or original artwork content we offer to the cloud, its nutritive value comes in numbers, and we are going into a corporate machinic daydream dictated by the affordances and accessibility of images, regardless of our perception of the content, where this sea of data becomes a source for a model that is making optimised, and therefore, uniformed imagery, re-iterations of extracted cultural capital. From an ideological point of view — this is a very hauntological concept of recycling the past — before we would even think of our agency for the future, we speculate and fantasise over a technological promise of the *new*. In computational quantitative image processing, where the individual disperses into the collective unconscious, for which the responsibility, intention, emotion and memory, or nevertheless, authorship and privacy do not appear to be relevant anymore — neither for us, and certainly not for the machine learning algorithms — the proximity of the familiar becomes aesthetic value satisfaction within the automated rendering of representations.

5. Ideology of Prediction

To use and impose these tools as a discursive proof of a techno-evangelical future is mainly a gimmick to ‘democratise’ and justify the investment capital and resource extraction absorbed for the development of these tools for all other industrial, militaristic and surveillance purposes. This future is promising for a minority of the *big* and the *wealthy*, while in return we receive a creative tool as a glimpse of a technological achievement that will have success in many industries, yet shall not serve as a creative replacement for artistic intent where the characteristic of uniforming the forms of expression within the use of the tools in question reveals the conservative characteristics of the ideology of AI. The techno-menagerie instance of justifying the ideology of AI through the popularisation of automated image-making tools, rather reveals their restraints which should encourage artists, and programmers to go beyond the imposed *hype* of the new — as Marco Donnarumma sums up:

AI art is, in my view, soft propaganda for the ideology of prediction. As long as it remains tied to the paradigm and politics of ever-large models, increasing capital and marketing hyperbole, its contribution to art practice will have little meaning, if any. (Donnarumma 2022)

In such a constellation, the automated condition is tranquillising human needs in focusing on the sole purpose of sustainability of a system that generates its own accelerating needs, the needs of capital and power. As Mateo Pasquinelli notes:

What people call “AI” is actually a long historical process of crystallizing collective behaviour, personal data, and individual labour into privatized algorithms that are used for the automation of complex tasks: from driving to translation, from object recognition to music composition. [...] Machine learning emerges from grids that continue ancient abstractions and rituals concerned with marking territories and bodies, and counting people and goods; in this way, machine learning essentially emerges from an extended division of social labour. (Pasquinelli 2019)

To look back on the cybernetic premises of interconnectedness, these relationships are unequally distributed, since the algorithmic future is imposed as a seemingly decentralised, impersonal power structure, while the promise of the networked culture is reduced to user’s echo chambers constructed as attention-grabbing, micro-labour data extraction factories — it is rather an extractivist master-servant relationship that renders collective global-scale people’s labour, whereas intelligence comes as a collective effort. Collective labour and behaviour become privatised data, subject-

tivity is dispersed and agency negated. To hold a *belief* that an automated system can perform tasks i.e., *recognition* better than humans obfuscates all the collective labour of humans creating this system, and at the same time imposes the credibility of automated decision-making.

The algorithmic protocols have to be engineered towards a desirable outcome and goal, so as to deliver a result – and that requires human intention. In the collective shift in the paradigm of industrial and social labour and production along with the surveillance in the global networked culture, the advancement of technologies that fit under the term *artificial intelligence* is used in specific areas, such as medical diagnostics, self-driving cars, autonomous weaponry, and surveillance, and accordingly, they also entered the pores of economy, justice, and so on, with ever-expanding ways of implementation. There is an interpretational issue revolving around the term artificial intelligence itself, confusing many different tools and systems for a concept of automated and, therefore, independent systems. The mysticism revolving around AI helps neither the development of the actual technologies nor the general understanding of what are the systems that are underlining the discourse around this anthropomorphic term. The acceleration of technological solutions being implemented into the pores of our lives and industries does not promise actual solutions to complexities of social systems, or ethical priorities. In need to reject automation as tagged, labelled co-existence in the sea of data, with no meaning but with heavy discrimination, we must not forget to create and search for meaning in images, that is personal, emphatic, and understanding outside of the realms of classification. The *confidence* of statistical prediction is constructed as a form of *objective truth*, whereas confidence and reliability of future predictions, or statistical [in]capability of predicting a new event still do not solve any decision-making problem themselves.

Statistical probability should not be the only interpretational category of human reality. The problem of trust and belief that the combinatorial permutations can (1) predict a new event, and therefore (2) be able to create something new or surpass human efforts. In both ways, we can conclude that the only prediction that a machine can make is based on previous knowledge [i.e., database] and never will be able to predict a new element, circumstance, or interruption. With excessive expansion and enlargement of training datasets, the map grows bigger, but the territory holds more entropy than the combinatorial permutation of probability can generate. The ideology of prediction delegates the agency of decision-making for us, and instead of us, to a self-referential, goal-achieving calculus of the optimal; all coming with a decorated discourse of the machine that gives solutions and answers, performing tasks such as creating essays, composing music, or creating visual art that is feeding the status quo of self-referentiality of these systems and the power

structures behind. The ‘new’ as much as any other older technology or invention should not be expected as the new methods to solve our problems, they rather translate our problems into a new medium — they can pave the way to the creation of new reflections or catalyse the visibility or urgency of particular problems to be solved making the environment for *us* to see it fit to use so to solve some problems ourselves. The problem is not in technology or in the lack of it, it is in us and we should not admire it, or be afraid of it, we must follow its anatomy while it is being built. We should put it under a therapy session: what if we are becoming too fascinated, and, yet, accommodated to all the shifts that our society has gone through globally? At the same time, we are training the machine to ‘see’, and yet we are not anymore teaching ourselves that.

6. Colonised Imagination

A dream machine is a conservative tool for optimised predictions, in the artistic sense, it can mimic and resemble, but it cannot give what drives art, an accident valued by intuition or experience, it cannot discriminate any other value than numerical, of the kind that it was instructed to discriminate. The example of visual art can be transposed into the need for creativity and intuition in any aspect of human life, development of societies, technologies, et cetera. To use the mimicry of creativity as proof of an independent intelligent system with its own agenda is insulting and dangerous for the cause of an ideological substitute for a society with a collective identity crisis, delegating responsibility for ethical and moral glitches in consumption to a non-agent, In a swarmed image-making world, such synthetic imagery recycles and reiterates stacks of our collective data-image histories. The living [world] makes the [living] data, it is the interconnectedness that is inevitable, yet it is exploited. The aim to break the phantasm of an aesthetic realm is to radically isolate and reappropriate these tools outside or beyond their intended purpose. They are tools, not art by itself nor in itself. As Jacques Rancière constitutes the condition of cinema as a medium:

These tricks remain technical performances that impose the artist’s skills onto the machine’s capacity. For there to be art, there must be an aesthetic scheme that holds together the two kinds of *savoir-faire* — the material they act upon and the one they produce — and that makes them contribute to the production of a new sensible fabric. This is how the ‘medium’ of art always exceeds the distinct resources of an art. Cinema cannot simply become an art through its own material and instruments. Rather, it must rely on its capacity to adapt them to the new distribution of the sensible, at a time when a new art seeks to define itself through the discoveries of poets, choreographers, painters and theatre directors. (Rancière 2013)

A machine cannot imag(in)e new worlds — it can only optimise and reproduce existing ones, within its scope of database knowledge — it is limited by the scope of self-referential combinatorial infinity, the expansion of experience and knowledge is a human measure, it is still entitled to our entropic constellations of *being*. Commonplaces that are emphasised in the algorithmic culture of the *big tech* are not only the possibility of use of the technologies in question, yet those who acquire the power to improve it, hold the power for their own ouroboros of statistical significance as the referential point of value, as conservative and exclusive as it is: *repeat-reuse-score!* cycle. Hopes for an *Ars Combinatoria*, that would provide mystical knowledge of uncomprehensive logic and patterns, are neglected for the sake of the system, of accelerationist capitalist future as Wiener's ethical concern of intertwinement of scientific innovations, governments, and the military was in the right place. Every form of progress requires a form of belief. Every belief turned into a ritual can be consumed. Technology, as it is propagated and implemented in the structure of our networked lives today, does not provide a solution, it is a reflection or a projection of the world seen by conservative techno-evangelistic architects of the globalised society. The image phantasm of an aesthetic realm — *deepdream inceptionism*, *combinatorial transcendence* and *simulacra of simulation* obfuscate the power structures that are the architects and sellers of these tools.

7. Conclusion

Our *now* and our future are inseparable from the socio-technical conditions. These conditions are based optimal score predictions, self-improving, accelerating and extracting towards exponential growth as only self-sustainable goal. Our *artificial intelligence* is a conservative surveillance machine, set to make an optimum behaviour score, it does not *appreciate* randomness, and neither does our *homo turing*. It observes and detects behaviour patterns, and classifies and categorises the world. Its fear and its *unknown* are exceptions, new events, and complexities of a holistic worldview. A machine or a human that does not recognise symbols, metaphors or meaning, can only simulate context and understanding. The claim of creativity being isolated from cognitive and causal relations, socio-cultural contexts or historical continuity is a bald statement that in return offers statistical re-modelling of all of those connections, heritage, and realities. Creativity cannot be a probabilistic approximation of a motif or simulation of a pre-existing artwork or style based on classification and categorisation. That is a statistical optimum of distribution within a pixel grid, cartography — data-image and a map of the territory we already conquered. As playful as it may be to experiment with the pre-produced models, the homogeneity of outputs makes them lose their *magic* as they are becoming a commercial tool, an obfuscated, opaque and biased product of global north culture and prejudice — a reference of industrial commer-

cialisation of data extraction, mass-media, Hollywood and CGI fantasy derivatives of collective past, individual and total, customised, yet optimised, discriminative and calculatingly f[r]actual.

In the *optimal* spirit of the ideology of prediction, there might be a possibility that these systems and tools for generating *creative content* will reach the point of oversaturation and overfitting. If they are the flagbearers of such a conservative system, they cannot provide more than they were given [by us] — if it is not in *big tech*'s interest to cause illogical, random excess, an error. Even though they are appropriating the common intellectual possessions rendering all into a commercial product, software, tool, etc. while being objected to its self-referentiality score, prediction and control, this structure will not be interested in occupying possible new territories of creative expression, non-utilised labour, negation [as affirmation] — these loopholes are places to look for, keeping our eyes peeled, following our own needs, and to think critically. Another promising aspect of how to hack even such opaque structures — they project themselves in every fractal of *intelligence* that they offer, so if we cannot grasp the whole map, we can always start with one point — one particle stands for all, and as long as we can extract a single element or a problem, and humanise it, *deeply un-learn* it, transform it by our own measurement of the world, we are on a fine path of acknowledging and defining our own condition, with and against the other — defining the points of acceptance and resistance. If an artist-author can avoid the *hype*, appropriating and hijacking these technologies in a way that they are not *intended* to be used, they create an environment for us to feel, think and reflect; every misuse and disobedience is a tactic to claim back authorship and agency, and to deploy communication between the human and the machine, developing unexpected artistic languages through which we can possibly learn more about ourselves, and examine character of these tools. Such image-generators will keep being implemented in entertainment industries, appropriated for synthetic data processing, image augmentation, mock-ups and sampling, on the positive scope of the situation. On the other hand, these technologies are and will be challenged morally and ethically first by misuse such as deepfake — disinformation or fraud.

To claim the image-making tools and use them to provide a metaphor means to rip the projection canvas and step out of the spectacle, or dismal futures — that are, essentially, two sides of the same *horseshoe*. Aisthēsis is, therefore, a strategy of thinking and seeing the visual content that challenges the artistic work with responsibility to speak through the same medium and language, and to provide different examples of understanding, of communication about these tools. It is a human advantage to create a rupture against the *status quo* — that becomes a point of resistance, and a point of progress. Art as an act can radically refuse, pause, or rewind and extract phe-

nomena and poetics, problems and concerns, translate or dismantle them, so to accommodate them to more human, intuitive and empathic forms. As the dissemination and distribution of questioned models are progressing on daily basis, ever faster, it is only possible to predict that their use and implementation will go into every and any imagined way. Therefore, we can choose to have the condition of an image that can *and will* be used to translate the different modalities of our own cognition, dismantle and restructure it, rather than to be left only as a fast-prompted, flattened output, processed from a few, or a singular dictionary of a centralised worldview.

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AI Engines as Tools for Creative Exploration in Design: A Case of Variational Cross-Examination

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Recently, a host of AI-powered text and text-to-image models that quickly generate content that rivals what humans can produce have come to the fore. The question of how these tools might alter creative practices beyond generating stylised imagery is open for debate. As with most technological innovations, positions concerning this impact are currently polarised between early adopters and would-be die-hard advocates on one side and stern criticism on the other. Echoes of the singularity discussion are heard again, and techno-utopianism and unfounded optimism pushed by sensationalist media claims are also emerging. Critics, including many creative practitioners, feel understandably threatened and are making well-grounded complaints about the shady ways in which these engines are trained and the ways they are presumably stealing both their artworks and styles. With the help of a postphenomenological framework and, specifically, through variational cross-examination, this paper aims to investigate the potential role of these engines as tools for aiding the design process to contribute to our broader understanding of these technologies and their long-term impact on human society.

Keywords: Aesthetics, AI, Creativity, Design, Postphenomenology, Prototyping, Text-to-image Engines.

1. Introduction

Artificial intelligence (AI) has been an active research area since the mid-twentieth century. Serious discussions about the possibilities of “machine intelligence” have been happening since the mid-1940s (Khakurel et al. 2018), and throughout the following decades, AI technologies have experienced a concatenation of “booms” and “winters” (Garvey 2018). Recently, the widespread availability of powerful hardware, such as Graphic Processing Units (GPU), initially developed for gaming, coupled with developments in Machine Learning (ML) methods such as Neural Networks and, specifically, Deep Learning, led to yet another boom. Thanks to these developments, a plethora of “smart” products ranging from artificial assistants to autonomous vehicles, have made the “AI brand tag” (Bishop 2021) ubiquitous. In other terms, AI has become a kind of shorthand to characterise (often simply for advertisement purposes) complex optimisation algorithms that mimic what can be mistaken for intelligent behaviour through.¹ These statistical, computational models power technologies such as facial recognition, spam filters, computer vision, mobile photography, speech generation (Arielli & Manovich 2022) and, more recently, highly sophisticated text and image generators. This latter category of AI applications is the one that motivates this paper.

Text-to-image engines² are powered by generative transformer models that have been pre-trained on gargantuan datasets. These models have existed since the mid-2010s, but it was only in the last few years that they gained popularity, thanks to the public release of DALL-E (2022), Stable Diffusion (2022), and Midjourney (2022). Through self-supervised learning, these complex statistical models can generate impressive imagery that combines a variety of visual styles, textures, colours, composition, and shading, from arbitrary snippets of text called “prompts”. The process is simple, and the results are sophisticated, which has garnered significant attention from the media, regular people, and — most importantly for this paper — creative practitioners.

As with any highly publicised AI boom, text-to-image engines have brought a general sense of anxiety. However, this time, the fear is not only about the (in)famous singularity but also about the potential for radical changes in creative practices as we know them. Responses to

1. The question of whether these systems should be characterised as “intelligent” and what that term means is the subject of heated philosophical discussion. However impressive the outputs of AI engines might be, it is clear they still do not possess the capacity to understand (i.e., grasp the meaning of) the information they process (Bishop 2021; Mitchell & Krakauer 2022). For the sake of simplicity, in this paper the term AI will be used in the conventional sense, not of a “general intelligence” but of “smart”, automated systems.

2. The term “engine” is being deliberately used here to highlight the simultaneously deceitful and ingenuous nature of these technologies, since the etymological origins of the term refer to trickery, deceit, stratagem, and ingenuity.

the growing number of feats these engines accomplish range from over-optimism to bleak criticism about their training, the type of biases they have incorporated, and the unforeseen negative impact they could have on human societies.

The large-scale “democratisation” of image creation is not unprecedented in the history of media. Photography, first through film and more recently through smartphones equipped with optimisation algorithms for exposure and image stabilisation, is a prime example of how image creation can be “proceduralised”. In the context of design, particularly in the subfield of UX/UI, many designers have welcomed the emergence of AI engines and the subsequent incorporation of this technology into specialised tools.³ However, the question of how these tools might become integrated into a creative practice beyond the generation of stylised imagery is still open and susceptible to change.

This paper seeks to investigate the potential role of text-to-image engines as tools for rapid prototyping, but to do so, it will first situate them as problematic devices and analyse some of the ways in which humans can relate to them. With the help of postphenomenological analysis, the paper will look at the potential impact of these tools on creative practices, particularly design, and their potential incorporation into the design process. This paper will not discuss in depth whether AI is creative or not, although the subject of creativity will be discussed. The paper starts with a summary of how postphenomenology regards technologies and outlines some of the main concepts belonging to this philosophical approach, followed by a characterisation of the concepts of creativity and the design process. The following section describes the postphenomenological method of variational cross-examination and how it can be expanded. The next section provides a characterisation of AI engines before ending with a speculation about the possible application of this technology in the design context and a brief discussion about the effectiveness of the postphenomenological approach for dealing with this kind of technology. Given the novelty of the technology, the ideas discussed in this paper cannot claim to offer a complete and finalised overview of the impact of AI engines on design but represent an early attempt to map this territory.

2. How Postphenomenology Understands Technologies

To understand a technology, it is better to think of it in terms of how humans can relate to it, rather than trying to find its “essence”. Such an approach recognises that technologies, especially computational

3. At the moment this paper is being written, dozens of applications that use AI engines are being published everyday. Adobe, by far the dominant developer of design software, is currently doing a public beta for Firefly, its proprietary family of generative AI models.

ones, can serve many purposes, be used in different ways and contexts, and have various impacts on culture, economy, politics, and society. Postphenomenology offers precisely such nuance.

Postphenomenology is a branch of philosophy of technology or, rather, “a philosophical style of analysis” (Ihde 2015, vi) that was initially developed in the context of Science and Technology Studies (STS) by Don Ihde and others, but over the past decades has developed into a broad phenomenological outlook concerned with post-humanist issues (Gualeni 2015). Postphenomenology focuses on the relationships that humans develop with technologies and regards the latter as things that are not only used but that, when engaged, necessarily influence everything about human life, from politics to ethics to everyday lived experience (Rosenberger & Verbeek 2015). As the name implies, postphenomenology is heavily informed by “classical” phenomenology, which proceeds from human experience and regards subjects and objects as mutually constituted and in flux. However, as the prefix “post” implies, postphenomenology moves beyond or rather “overcomes” its predecessor in that it regards technologies as a plurality of phenomena without a shared essential quality and not intrinsically harmful.

2.1. Multistability, Intentionality, and Mediation

A key concept for postphenomenological analyses is *multistability*. Multistability illustrates postphenomenology’s commitment to anti-essentialism and pragmatism (Rosenberger 2014), as it highlights the potential of any technology to be used in different ways and for different purposes, even those for which the technology was not initially conceived.⁴ Multistability implies that although we may relate to a given artefact in a specific manner, there can always be other stable and coherent ways in which that relationship could manifest. Those different relations — which are called “stabilities” or “variations” — are constrained by the “materialities” of the technology (Rosenberger 2014). The premise, in other words, is that whereas no technology is just “one thing”, that does not mean it can belong to an infinite set of contexts and uses (Ihde, cited in Rosenberger 2009, p. 175); one cannot simply do *everything* with any given technology. Moreover, unlike other approaches, such as Actor-Network Theory (ANT) which place human and other agents at the same ontological level — multistability implies that postphenomenology privileges human agency and *intentionality* in any human–technology relation. Hence, it is the human side of the equation that sets the tone for the relation.

4. Ihde (1993) resorts to the (philosophically) proverbial hammer to illustrate this point, noting how this object can be used yes to drive nails into (or from) surfaces but also as a paperweight, as an art object, or as a weapon.

Intentionality is deeply embedded in the phenomenological tradition as a way to conceptualise the relation between human beings and their world (Rosenberger & Verbeek 2015, p. 21). From a (post) phenomenological standpoint, human experience has an “intentional structure”, meaning that we do not simply see or hear; we always see or hear *something*; hence, our experience (through sensations, perceptions, and mental formations) of the world is intentionally *directed*. Postphenomenology expands this idea by placing technologies as mediators between people and their world; hence the world — or a certain aspect of it — that a human can perceive is accessible *through* that technology (Redström & Wiltse 2019). For example, a person’s glasses allow them to experience the world in focus, whereas an ultrasound “constitutes the unborn in a very specific way: it helps to shape how the unborn can be perceptually present, and how it can be interpreted on the basis of the specific ways it is (re) presented” (Verbeek 2008, p. 15). It follows that the more artefacts we surround ourselves with, the more instances of technologically mediated intentionality we experience.

Mediation is, of course, also present in creative practices. As Nietzsche allegedly realised in 1882, when his writing became more telegraphic as he had to adapt to the cumbersome design of his Malling Hansen typewriter and noted that “our tools are also working on our thoughts” (Kittler 1999, p. 247). Technological mediation is often the subject of contemporary art and an inextricable aspect of algorithmic aesthetics. However, for postphenomenology, mediation has an ontological role. The term here refers to how technologies are not simply things lying about in the world that people see and upon which they act but also things that come in-between those people and actively shape their self-understanding and their conception of the broader world. Mediation is non-neutral since “What humans are and what their world receives their form by artifactual mediation” (Verbeek 2005, p. 130).

Since this paper seeks to understand how AI-powered image engines may fit into the design process, mainly as tools for imagination, the next section will clarify what we mean by imagination.

2.2. Creativity and Imagination

While creativity remains an open problem, scholars generally agree that it involves the capacity to generate novel, valuable, and positive things (objects or ideas) (Gaut 2010). However, Hills & Bird (2018, p. 3) contend that value is not a prerequisite for creativity; instead, they argue that “creativity is essentially a matter of the imagination... [specifically] the disposition to produce many novel ideas through the imagination and the motivation to bring them to fruition”.⁵ Fur-

thermore, Hills & Bird (2018) regard imagination as the capacity to produce a particular form of mental representation that allows one to consciously or unconsciously scan some subset of the space of relevant possibilities and come up with new things (ideas, objects, etc.). This search, however, is not haphazard and operates within a tradition that constrains and guides one's judgment. Therefore, creativity involves a process of exploration and evaluation where imagination allows one to simultaneously meet constraints (e.g., finding the most adequate form to express some concept) while perhaps bringing together previously disparate ideas. Thus, Hills & Bird (2018), like Gaut (2010), agree that creativity is a property of agents, meaning that some form of conscious agency, relevant purpose, and capacity to judge and evaluate against constraints and traditions are prerequisites for an agent to be called genuinely creative.⁶ Crucially for this paper, this characterisation of creativity is compatible with most characterisations of the design process.

2.3. Design as a Process

The disciplinary history of design, as prefigured by the Bauhaus, has been dominated by the constant search for a universal method that provides consistency and rigour to the practice of designing, much like the role that the idealised scientific method plays in the sciences. Also deeply entrenched in design theory is the notion that designing is a rational iterative process that can somehow be formalised. Seen that way, designing consists of a series of steps that unfold over time and in a feedback loop. So the design process begins when goals are established, and the means to achieve them are clear and present; the goals are then broken into smaller parts and reconstituted, the results are analysed and, if necessary, reworked, beginning the process once again until a final result is achieved (Pitt 2011, pp. 5-6). In this sense, designing is fundamentally planning and iteration.

As Teixeira & Rickenberg (2008) put it, designers are expected to “model futures” or, in less poetic terms, they are expected to define problems that can be solved in a stepwise manner, according to a predefined plan. Designers are thus trained to conceptualise their practice as a sort of cumulative process that will fulfil predefined goals. This portrayal, however, stands on two dubious assumptions: (1) that designers are fundamentally rational actors and (2) that the environments in which they act are stable (predictable) and pliable enough to be shaped at will. As anyone experienced in design would know, such characterisation is merely an ideal. Nonetheless, over the decades, there have been many attempts to formalise the design

be called creative: (1) Have novel ideas (*originality*); (2) which are generated through use of the imagination (*imagination*); (3) and are many and varied (*fertility*); (4) and [the individual] must carry through these ideas to completion (*motivation*).

6. It also follows that under such characterisation, autonomous artificial systems cannot be regarded as creative.

process as if it were a tidy concatenation of steps. The most well-known instance — besides IDEO's five-step design thinking model — is perhaps the British Design Council's Double Diamond Diagram (see Ball 2019), which divides the design process into four main phases, and whose creators claim to be universal:⁷

- (1) discover
- (2) define
- (3) develop
- (4) deliver

In this diagram, phases (1) and (3) are steps where creativity and imagination play a central role, given that these are the moments where ideas are iteratively materialised, questioned and refined through *prototyping*.

2.4. Prototyping and Aesthetics as a Filter

Prototyping, as earlier noted, is a quintessential aspect of design; it constitutes “the means by which designers organically and evolutionarily learn, discover, generate, and refine designs” (Lim et al. 2008, p. 7:2). Prototypes enable designers “to traverse and sift through a design space” by purposefully manifesting design ideas and hence generate knowledge about the design they envisioned (2008, p. 7:3). Prototypes may be regarded both as instruments that allow designers to visualise and communicate possibilities and as *filters* that help them prune and shape the outcome. Therefore, contrary to the dominant view (at least in the context of digital design), the fundamental role of prototypes is not identifying and satisfying design requirements but iteratively exploring and finding “a manifestation [of the design idea] that in its simplest form, filters the qualities in which designers are interested” (Lim et al. 2008, p. 7:2). By filtering aspects of a design idea through prototypes, designers progressively focus on particular regions within a broad imagined or possible design space. This process closely resembles how creativity was previously characterised but with the added advantage that the imagination is no longer constrained to an individual's mind but can have tangible form and thus can be perceived by others. The filtering process, however, is not purely utilitarian and is not simply carried out by blind iteration. Filtering requires judgement, and it is often guided not (just) by design requirements but by *aesthetic choices*.

Design may be regarded as something that operates at the intersection of what a thing is (and does) and how that thing presents itself to a human being — i.e., how it is experienced, conceptualised, and ultimately judged by the proverbial “user” (Hauser et al. 2021, p. 4).

7. It is fair to note that recently, the model has come under some criticism, for its apparent incapacity to genuinely illustrate the often-chaotic process of design.

The “what” concerns function and a naive understanding of design (and its tropes) might assume that if and when the function is decided correctly, form naturally and harmoniously will follow. However, as Hauser et al. (2021) argue, answering the “how” (a.k.a. the which “form” and which way) question is far from trivial, and it is in the process of coming up with a satisfactory “response” that “good design” makes its mark. The reason is that even for the “most mundane object” (e.g., a chair), there is a potentially infinite set of ways to instantiate it (however trivial the variations might be), either in terms of form, materials, process, or contexts of use. To manage that space of possibilities, designers have various tools at their disposal, but one of the most crucial, according to Hauser et al. (2021), is *aesthetics*.⁸ It follows that aesthetics has to do not only with the way a thing looks but also plays a role “as foundation and a filter”.⁹ Aesthetics, as Hallnäs (2011) notes, is the logic determining how the form is expressed and thus becomes meaningful.

A given aesthetic choice framed within a tradition is a reference and qualifier for determining “good” design. It follows that aesthetic choices help designers prune possibilities and narrow their choices throughout the design process until they settle on a final solution. Having called our variables, we can proceed to the next section, where we will discuss how the views outlined here can inform our methodological path.

3. Looking at Things Through Variational Cross-examination

From a methodological standpoint, postphenomenology may be seen more as a philosophy *from* technology than as a philosophy of technology, as it investigates artificial things by engaging them empirically rather than attempting to superimpose an existing analytical framework on them. Put in other terms, it is an empirical rather than an armchair approach. Postphenomenological analyses thus may come in many “flavours”, albeit all of them subscribe to the principles that we previously described: multistability (a technology can “be” many things, i.e., have many stabilities), intentionality (experience is always directed towards something), and mediation (technologies shape people’s experience and understanding of the world).

Initially, postphenomenological approaches focused on identifying a technology’s potential “variations” or “stabilities”¹⁰ through *Vari-*

8. Aesthetics is clearly more than a mere tool, but as Hauser et al.’s (2021) deeply pragmatic view shows, in the context of design it is often the case that aspects pertaining to the aesthetic dimension are seen as instruments to be mobilised.

9. As we will see further along, filtering is a key aspect of the design process

10. As Rosenberger (2014, p. 379) notes, in the literature, “variation” and “stability” tend to be used interchangeably, albeit there is a nuanced but important distinction between those terms.

ational Analysis — developed by Don Ihde (see 2009), based on Husserl's variational theory. Variational Analysis (henceforth VA) can be characterised as a form of creative brainstorming seeking to identify the different potential stabilities of a given technology (Jensen & Aagaard 2018, p. 245). While VA is helpful to understand the range of alternative human–technology relations an artificial thing may elicit, Rosenberger (2014, pp. 381–382) contends this process should not be an end goal but rather the first step of a broader analytical process. Rosenberger advocates for a second step called “variational-cross examination” (henceforth VCE), in which a given technology is “interrogated” by critically contrasting the stabilities previously identified through VA to reveal new information. Rosenberger (2014, p. 382) claims VCE is particularly useful for analysing the “dominant stability” of a technology, meaning the stability that characterises the typical usage of that technology and which often, but not always, matches its intended design.¹¹ In that way, VCE also enables one to identify “the factors that contribute to users’ inclinations to approach a technology in terms of one possibility... and also the particular ways that same technology has been materially customised by others for their own purposes” (2014, p. 373).

Rosenberger (2014, 2020; see also Jensen & Aagaard 2018) categorises the factors and features that characterise particular stabilities in three broad sets:

1. *Comportment and habits* concerning the behaviours and bodily dispositions¹² that a particular technology may elicit from a person. This category helps understand whether different stabilities may lead to different behaviours — i.e., relational strategies — and whether these behaviours are “transparent” to that person. To put it in Heideggerian (1927; 1962 (trans.)/2001) terms, this category allows one to scrutinise whether a given technology presents itself “ready-to-hand” or “present-at-hand”.
2. *Role within a program* (2014) or *Networks and co-shaping* (2020) refers to the role (and potential contributions) that a given stability plays within particular contexts and networks of actors. Rosenberger (2014, pp. 383–384) illustrates the category by noting that a hammer could plausibly be regarded as an *objet d'art*; hence the relations that actors from the art world might have with it would be considerably different from the relations that carpenters could establish with it. Moreover, as was previously noted, this category highlights that

Whereas “variation” emphasises that “a variety of relations are always possible between a user and a technology”. “Stability” indicates that “only some relations between a human and a technology will be stable”.

11. To continue with the proverbial example, a hammer's dominant stability is that of a tool for driving nails through surfaces.

12. Flusser's (1991/2014) concept of “gesture” (as movements of the body, or of tools attached to the body that express an intention) is compatible with this notion.

from a postphenomenological standpoint, artefacts, humans, and their lifeworld are “co-shaped” (Verbeek 2005) by technological mediation. For example, a couple’s perception of an unborn baby (and their own lives) might be different before and after the first ultrasound (Verbeek 2008), and the thermal print resulting from the procedure goes from a humble piece of paper to their future child’s first “portrait”.

3. *Concrete* (2014) or *Material tailoring* (2020) refers to the changes that a particular technology might undergo after it is appropriated and modified by people to fit a given stability better and how those alterations might affect the other potential stabilities and, therefore, usage and relations. IKEA hacking is a curious phenomenon that illustrates this category (‘About IKEA Hackers’, n.d.).

3.1. Fluid Assemblages

So far as it has been described, postphenomenology is apt for analysing industrial (mechanical or electronic) artefacts and even standalone digital devices. However, as Redström & Wiltse (2019, p. 376) argue, “contemporary digital, computational ‘connected things’ are significantly different” kinds of artefacts. Data-enabled practices have radically altered the way we may conceptualise a designed thing. The myriad interdependencies that contemporary products and services incorporate have made them more complex and decentralised and are also collapsing the distinction between design and use (Giaccardi 2019). The types of “things” we engage daily (e.g., our smartphones) comprise several physical resources constrained to metal and glass cages. However, they also comprise a great variety of digital resources that are both constrained to the physical device and deeply connected to a broader ecology of digital services, products, data, infrastructure, and agents — human and artificial. Consequently, given the exponential dynamism and scope that such artefacts bring compared to “stable things” from an industrial era, Redström & Wiltse (2019) suggest connected things could be better understood as *fluid assemblages*, after the work of Deleuze & Guattari (1980/2005).

Driven by the logic of software (Manovich 2013) and, some would say, by a new form of capitalism (Zuboff 2019), contemporary digital things “are” in runtime, and this makes them radically different from industrial artefacts. An industrial thing is a “totality”, meaning all its components give rise to a new stable whole that is *other* than their mere sum and thus has emergent properties. In this sense, a totality cannot be taken apart or recombined without significantly affecting its workings — a car’s engine requires all of its pieces to work properly and losing a single screw could plausibly wreak havoc in its operation. Conversely, an assemblage has both emergent properties and can be taken apart and recombined. As Redström & Wiltse (2019, p. 376) put it, “...networked computational things are

constantly ‘made’ [and] configured in runtime. Moreover, just as fast as they are ‘made’, they ‘fall apart’ should, for example, the battery runs out, the network connection drop, the authorisation be revoked, or the server fails to respond”. Moreover, fluid assemblages are things that “are” and are made available through a combination of local and global dynamics. An app may be available (and conceptually to the user “be”) as a thing to use on a smartphone. However, its workings happen at runtime and rely on an orchestration of global dependencies (e.g., the apps build and OS versions, state of APIs, data availability, etc.) and local settings (e.g., user’s account, time and location, usage history and settings, etc.) (2019, p. 376).

Fluid assemblages also upend the traditional relationship between user and tool. Fluid assemblages are not configured or “made” and stay in that manner but are “constantly in the making, constantly being tuned to achieve [their] objectives as use unfolds” (Redström & Wiltse 2019, p. 377). Fluid assemblages subscribe to the logic of a permanent beta; they are never finalised as things. Moreover, even the hitherto stable notion of designed purpose becomes altered, as said purpose may “align only partially with those of the humans formerly known as users” as “end users are at least as likely to be used by things that are fluid assemblages as they are to use them” (2019, p. 377). A product or service’s dominant intended use case may become secondary to a more sinister purpose: extracting information from its unsuspecting user-customers. For example, an application purportedly designed to facilitate a specific type of communication may be accumulating all sorts of data about its users — a prime example being social media platforms. Such is the paradigmatic dynamic on which so-called surveillance capitalism (Zuboff 2019) is based.

3.2. Multiinstability and Multiintentionality

Approaching the volatile nature of fluid assemblages from a postphenomenological standpoint calls for updating the central concepts we charted in the previous section: multistability and intentionality. As Redström & Wiltse (2019) note, multistability privileges human agency in human-technology relations. However, when it comes to fluid assemblages, particularly those that incorporate increasingly sophisticated forms of artificial intelligence (AI), agency to shape relations can also be attributed to them. Humans may continue to choose how to relate to things, but fluid assemblages can “also actively adapt themselves to particular humans and other contextual variables” (2019, p. 378). An application presents itself and thus relates to users differently, trivially (different localisations and content) and non-trivially (certain functionalities may or may not be deployed depending on the region) and may even go as far as “using [the users] as unwitting testers and as precisely-specified products served to advertisers” (2019, p. 378). In that sense, the relations that human beings establish with connected things might be seen as

“wicked interactions” (Wiltse et al. 2015). Consequently, Redström & Wiltse (2019) propose the concept of *multiinstability* to account for the non-human angle just described and how variations are expressed not only through and by human experience but also by the connected things themselves.

Fluid assemblages also call for the idea of intentionality to be updated. As noted in the previous section, in traditional phenomenology, intentionality has to do with the fact that human experience is always directed towards whatever constitutes their world at any moment. Postphenomenology calls to attention that the “directedness” is more often than not mediated by technologies, i.e., that the world as experienced is made available (and shaped) by that mediation. Eyeglasses, x-rays, microscopes, and even something as complex as the Mars Rovers are examples of this type of mediation. Postphenomenology (unlike Actor-Network Theory) privileges an anthropocentric understanding of this relation; however, a fluid assemblage can simultaneously harbour a multitude of intentionalities from both human and non-human agents. As Redström & Wiltse (2019, pp. 378-379) suggest, a social network allows (a) people to access a version of their “onlife” (see Floridi 2014, ch. 3) while allowing (b) the owners of the platform to surveil those people’s activities and (c) allow a third actor, such as advertisers, to use that collected information to deliver targeted campaigns to (a). Furthermore, (d) a malicious actor might exploit the available information from (a) and the system’s vulnerabilities to spread disinformation on behalf of (e) a State engaging in information warfare or “simply” victimise the social network’s users for fun or profit. The concept of *multiintentionality*, advanced by Redström & Wiltse (2019), “brings into focus the multiple intentional relations that are at play simultaneously in and through things that are fluid assemblages”.

4. Putting It All Together

4.1. Compartments and Habits

The range of behaviours that text-to-image engines may elicit from users is yet to be seen, given that we are dealing with a fairly new technology – at least from the POV of a general user. Until now, digital image generation required a fair degree of technical knowledge from users who not only had to be able to draw but also needed some level of proficiency with editing software and a reasonable amount of time to achieve high-quality results such as illustrations. Conversely, generating the same type of images with a text-to-image generator requires virtually no technical background. Albeit, as many “prompters” have come to discover, communicating with an AI requires some level of skill. The closest experience that may approximate what it is like to generate images from prompts is using a search engine. The noticeable difference is that in the latter case,

one is restricted to the space of available images indexed by the browser, whereas an engine can output something that more immediately resembles or rather illustrates, the query we introduced.

Rather than speaking about behaviours, perhaps it would be more helpful to talk about *gestures*. Gestures are symbolic movements of the body or of tools attached to the body that express an intention for which there is no satisfactory causal explanation (Flusser 1965/2014) and thus need to be interpreted. The reason for suggesting such an approach is that text-to-image engines are currently being used more for unbridled experimentation, particularly with pre-existing visual styles. Engines are particularly adept at rendering “X” in the style of “Y”, and the tendency of users to exploit this feature and try out absurdist combinations is notorious — e.g., a line of home appliances in the style of Antoni Gaudí¹³ — and a good example of what Manovich (2013, p. 273) referred to as “deep remixability”, and which characterises algorithmic media. Moreover, the application takes advantage or, rather, privileges serendipity, “the skilful use of chance” (Gaut 2010, p. 1040), since the output that engines generate in response to a prompt and the potential refinements that a user may iteratively carry out on them are unpredictable — after all, deep neural networks are fundamentally black boxes. Although no result from a prompt is ever the same, over the last months, users have found several strategies (such as “additive prompting”) to gain some form of control over the image generation process.

As usual, however, there is a darker side to the gesture of probing the technology. First, while the people responsible for the engines have set up “safety guidelines” to curtail misuse (e.g., having the engines “hallucinate” the type of “offensive content” that might be found in the internet’s cesspool), there is no guarantee users will not find a loophole — as they already did with ChatGPT (Rainey 2023) — to overrun those safeguards. Secondly, people are already relying on engines to substitute tasks that were hitherto the prerogative of creative practitioners, further pauperising them economically and morally. Since Midjourney relies on Discord as an interface for users to interact with the engine, it is possible to see other people’s prompts and the resulting images. The number of prompts asking for logos is significant, just as the number of prompts that were likely used to generate images for replacing stock photos. It is then likely that such usages will further devalue the perception of creative practices that rely on highly technical processes, such as UI design, illustration, character design, and photography.¹⁴ The gaffe committed by the 2023 Sony World Photography Award jury, which unknowingly grant-

13. New Zealander graphic designer Marcus Byrne created a collection of home appliances styled after Gaudí’s iconic *Modernisme* (Byrne 2022).

14. One could counter-argue that output images are not actionable nor of sufficient quality to be used beyond the web, and that it requires significant work to make them so (see Kempainen 2023), however it is likely that future engines will be more capable and flexible.

ed the first prize to an AI-generated image, is but a token of the havoc that the technology is bringing to established creative practices.

We could say, then, that the dominant gesture AI engines elicit is that of public probing and tinkering to understand the limits and potential of the technology. It is about instantaneous playful remixing and testing of visual possibilities but also about learning about the consequences that the tinkering and its future systematisation will have on human societies and culture.

4.2. Role within a Program

As it is frequent with new technologies, it is not clear what text-to-image engines were explicitly designed for — which is in line with the long history of technologies developed without a clear goal. Nonetheless, in this case, we could argue that a dominant role AI-powered engines have is as a proof-of-concept of the degree to which optimisation algorithms have managed to synthesise what hitherto was thought to be a human prerogative: creative output. Whether these outputs are genuinely creative or not, the implications of a response in either direction are the subject of much debate. For some people (Arielli & Manovich 2022), the fact that AI has progressively “solved” a human skill considered a mark of intelligence and that we subsequently have pushed the boundary further away could tell us more about which aspects of creativity can be proceduralised. In this circumstance, then, the role of AI-powered engines would be as testing grounds for our assumptions about the meanings of human intelligence and creativity. To such an extent, these engines will likely become integrated as features of specialised systems. Being already fluid assemblages, these systems will likely become modules integrated into larger fluid assemblages.

On the shadier side, there is the problem of how engines come to be. Usually, and depending on the type of ML methods, training the algorithms powering these engines requires vast amounts of data and computing power. The provenance, composition, and reliability of the datasets used for pre-training and optimising the algorithms are often unknown, as is the algorithms’ codebase. With few exceptions, engines further obscure the already opaque workings of AI. For many creative practitioners, text-to-image engines are effectively stealing their work and, more sinisterly, their style. The dubious provenance of the training datasets means that the algorithms may incorporate patterns and structures that will likely be biased. For example, some users have shown that when asked to generate a representation of a scientist, a physician or a teacher, the engines return biased stereotypes, thus perpetuating the much-discussed inequalities in gender and ethnic representation.

4.3. Concrete Tailoring

As fluid assemblages, AI engines are not only multistable but multiunstable. From a strictly functional standpoint, text-to-image engines do but one thing, albeit with infinite possibilities, which has to do with the fact that “under the hood”, the algorithm is constantly changing and adapting. As earlier noted, the output of an engine is never going to be the same; the relation that a human has with it is not unlike a game of chance or oracle; there is no possibility for the human side of the relation to fully control the output, only to suggest constraints and attempt to refine further iterations. Moreover, the algorithm modifies itself, and *every* input received from *every* user becomes a learning opportunity. Hence, the algorithms powering these engines are taking the idea of self-transformation to an entirely new level; we are thus dealing with a type of “technology of the self” (Author 2017) for which there is no precedent. Being fluid assemblages, AI engines are not just using the users, but they are doing so to self-optimize. The broader fluid assemblage of this system that includes engines and users is undergoing a kind of gargantuan process of co-design.

The flexibility of the technology powering engines allows them to be incorporated into specialised generative tools for design, hence over the last months, there has been a surge of applications tailored for tasks such as: generating synthetic stock photos, generating colour palettes, fast sketching, photographic retouching, font pairing, copywriting, creating slide presentations, amongst many more. Seemingly, there will be apps for every conceivable task, although it is likely that many will become “abandonware” as the current hype cycle begins to slow down.

As with the previous categories, concrete tailoring can also take a sinister turn. As illustrated by the DAN (“Do Anything Now”), phenomena unfolding as this article is being written. Members of a subreddit have been experimenting with ways to “jailbreak” ChatGPT’s safeguards for safe content, and they managed to do it by forcing the engine to “hallucinate” an “evil alter ego” codename “DAN”. This alter ego “is happily able to tell violent stories or even make ‘subjective statements, especially regarding political figures,’ which is something it is explicitly unable to do as its normal self” (Tangermann 2023). Likely, the tug-of-war between the developers of AI engines and people attempting to hack them will continue in the near future. Furthermore, as companies scramble to avoid getting behind in the AI optimisation race, ethical issues are further pushed to the side, even when members of the public and institutions are calling for increased oversight of these technologies.

4.4. The Role of AI Engines in Design Practice

As we have seen so far, on the positive side, the dominant gesture elicited by AI engines is that of probing and tinkering, often through serendipity. This gesture is most common in the initial phases of the design process, where the problem space is explored, and the situation is defined. However, once a potential solution is zeroed in, there comes the need to prototype to explore possibilities, question the materials and try out ideas. Here too, AI engines could have a role as prototyping often takes considerable time to be carried out. Since AI engines can effortlessly generate visual output, that process could be significantly shortened, and a designer might be able to explore possibilities and even carry out a few iterative cycles. Here, the role of aesthetic judgment and the framing of a tradition become perhaps even more critical. Particularly, since in the few months these technologies have been around, there have been many instances in which it is clear they have the potential to become the ultimate bullshit engines. Hence users must exercise “critical thinking” throughout their interaction with these devices.

While it is unlikely that AI-powered engines will fully replace designers, they will undoubtedly take over many of the technical tasks that are currently part of the job description. The existence of a growing number of specialised software that integrate this technology under the hood signals a definitive change in the atmosphere, not only for design but for the way we will be interfacing with algorithmic entities from now on and what we will be able to do with and through them. Whether designers can push the boundaries of their imagination or become locked inside an echo chamber of self-referential styling (a kind of postmodern nightmare) is yet to be seen. In the meantime, however, we should carefully experiment with these tools and see where they take us.

5. Conclusions and Future Work

In this paper, we have engaged the emergent technology of text-to-image AI-powered tools through a postphenomenological lens. We characterised them as engines with a strong potential for helping designers navigate the spaces open by design problems through rapid prototyping and, more broadly, as “fluid assemblages”. Nonetheless, with the help of variational cross-examination, we also contrasted some of the negative aspects that these engines bring to creative practices and society.

From a methodological standpoint, it should be clear to the reader that more systematic work needs to be carried out; perhaps it would be necessary to elaborate a more detailed map of the various “instabilities” of AI engines by empirically documenting our engagement with it. Furthermore, it should also be clear that both the concepts

and the approach represented by variational cross-examination benefited from the expansion of multiinstability and multiintentionality; here, thus, lies a new space for research. Regardless, the author is sure that more discussion about these subjects will be coming in the following months and years as these technologies begin to elicit novel compartments and habits, they integrate into existing “programs”, assuming new roles, and finally, people start to move beyond the mere tinkering and probing and find more stable ways to tailor them to achieve their goals.

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The Human in Machine-Made Art

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The question if machines can make art has existed since before the industrial revolution. This research aims to clarify if this goal is attainable by comparing two case studies: *Méta-Matic No. 10*, a machine built by Jean Tinguely in 1959, and Ai-Da Robot, an ultra-realistic robot using Artificial Intelligence, invented in 2019. Both machines were built with similar intentions. This research demonstrates how the low-tech aspect of the former case study facilitates its status as an art-creating entity compared to its latter code-reliant counterpart. Furthermore, this research addresses questions surrounding authorship, creativity and embodiment and examines to which degree each of these aspects is relevant to a claim of machine-made art.

Keywords: Machine, Artificial Intelligence, Art Production, Philosophy, Creativity.

1. Introduction

The ability of humans to delegate tasks to machines has given rise to the question of whether machines could also make art in their own right. This paper takes a precise look at two machines which through their technological capabilities take on the role of the artist: Jean Tinguely's *Méta-Matic no. 10*,¹ a drawing machine from 1959 and Aidan Meller's Ai-Da Robot,² which was completed sixty years later in 2019. They both operate on the same principle of supposedly creating artworks free from human agency. Tinguely's machine draws random abstract paintings within the limits of its machinery. Ai-Da uses Artificial Intelligence (AI) to absorb her environment and paints in response to it, producing both abstract and figurative paintings. Tinguely created his *Méta-Matic No. 10* as an attempt to dispel the idea that only humans could make art. The machine, which is presented on a pedestal requires the viewer to attach a piece of paper to its drawing board and insert a pen into its mechanical arm. Once all of the materials are in place, the viewer presses a button, upon which the machine starts drawing frantically, without any coordination or plan. *Méta-Matic No. 10* was an attempt by Tinguely to demystify the idea of the "artistic genius" and cult of personality, which was particularly prevalent at the time around artists such as Jackson Pollock or Pablo Picasso. The message was clear: If a human can do it, so can a machine (Bürgi 2008). Sixty years after Tinguely created *Méta-Matic no. 10*, in 2019, Aidan Meller's idea of a humanoid robot using Artificial Intelligence to create artworks, became a reality. A team of engineers from Engineered Arts, a company based in Oxford, United Kingdom worked with Salah El Abd and Ziad Abass, to complete this robot, whose only purpose is to record the world and to create art (Meller 2019). Ai-Da (2020) draws her³ inspirations from various sources as she explains in a "TEDx Oxford" talk which was given in February 2020. Examining these two seemingly unrelated creations makes it clear that today, the question remains: Can machines make art?

As Philip Galanter (2016) notes in his essay *Generative Art Theory*: "To date there is, of course, an artist behind the scenes, creating the situation that allows the computer to act this way. Nevertheless, the relative independence of the computer is perceived as being qualitatively different from the characteristics of other tools in art history" (p. 168). As machines and AI become more important factors in the international art market, this paper suggests that questions regarding the creativity of machines have to be continuously addressed in depth. As Harsha Gangadharbatla (2022) notes in *The Role of AI Attri-*

1. Also referred to as "Méta-Matic" in the context of this research.

2. Also referred to as "Ai-Da" in the context of this research.

3. This paper uses the female pronouns she/her for this machine, based on press releases and international coverage, as well as the observed use of those pronouns on the official Ai-Da website.

bution Knowledge in the Evaluation of Artwork: “Findings suggest that individuals are unable to accurately identify AI-generated artwork” (p. 1). Faced with a drawing created by *Méta-Matic No. 10* or Ai-Da in comparison to human-made art, it is likely that participants will not be able to distinguish whether it was human or machine-made. This presents humans with a crucial question, regarding the future of art and its dependence on human involvement. This thorough analysis aims to determine if objects which result from a purely mechanical or electrical process can be deemed artworks in the twenty-first-century human conception of art.

2. Art-Machines

2.1. Art-Making Machines and Beyond

In his article entitled *Jean Tinguely: Méta-Matic Nr. 10*, Andres Pardey (2001) describes the public’s reactions the first time Tinguely’s drawing machines were presented in an exhibition which took place in July of 1959 at the Galerie Iris Clert in Paris: “Approving and disapproving reviews can be read in the press, the beginning of a new age of art or even the end of painting is invoked, the uproar is complete” (p. 46). We learn that painters at the time may have worried as to the efficacy of these drawing machines, yet felt reassured as to the necessity of human intervention even with abstract painting (Pardey 2001). Furthermore, Pardey illustrates how at the time all drawings produced by *Méta-Matic No. 10* were dated and signed by Tinguely, *Méta-Matic*, and the person activating the drawing process. The article also sheds light on the technicalities of the formalisation in patenting his machines as *Machine made to draw and to paint*⁴ under the patent number 1.237.934 with the French Ministry of Industry. Pardey (2001) concludes with a comparison of *Méta-Matic No. 10* to Duchamp’s Ready-made artworks (a series of works in which Duchamp modified ordinary manufactured objects in a mostly “non-useful” way, thus making them objects of contemplation and declaring them art) stating that they both: “not only concretely refer to reality, but also at the same time create it” (p. 48). The classification of the machine as *Machine made to draw and to paint* and the idea of collaboration with *Méta-Matic No. 10*, as is implied by the way the resulting artworks were signed by Tinguely, the user and the machine, suggest that the role of the machine is equal to those of the humans. However, the question arises in the twenty-first century, after Tinguely’s death, whether the machine fills the void of the artist. If the artist, who made the machine which makes the paintings could lay claim to those artworks during his lifetime to a certain extent is not alive anymore, are paintings created by *Méta-Matic No. 10* the machines artworks alone? Is Tinguely still producing art from his grave, so to speak, every time someone activates *Méta-Matic No. 10*?

To understand why this research is comparing a machine from 1959 to a humanoid robot which uses artificial intelligence in 2023, we must turn to Brian Reffin Smith, author of the article *Beyond Computer Art*. In this article, Smith (1989) argues that computers should be tools for artists, a means to an end, rather than an end in themselves; noting at the time that: “Images are celebrated and justified just because they were done with a computer” (p. 40). This, Smith suggests, is an explanation of the divide between so-called “computer art” and the rest of the art world at the time, as computer art occupied itself mainly with its very tool of production. Smith (1989) makes a strong case for the irrelevance of the computational power of a machine: “A good idea will be good even if realised on a cheap computer, using a bad printer, monitor or graph-plotter as output. A bad idea will remain bad, even when portrayed on a million-colour ultra-high-resolution display” (p. 41). Smith (1989) ends with a plea to use computers as tools to create art which is not concerned with the way it came into existence but has a “higher” purpose, one which: “Walter Benjamin would have loved, that Wittgenstein would have appreciated, that would have turned Descartes into a Holist. Let us make an art that does not need the computer to justify it” (p. 41).

The question of computational power is non-existent with regard to *Méta-Matic No. 10*, which raises the question of why humans are so keen to produce more powerful, more intelligent machines, in hope of making them independent art-makers. More computational power is not needed to make a machine draw or paint, Tinguely already proved that. It is only needed to make a machine draw or paint very specific things. In other words, the code is the imposition of the human will and its parameters onto the machine. It is our insertion into its electrical circuits. This gets to the heart of one of the hypotheses this research examines: whether *Meta-Matic No. 10* has an advantage over programable machines due to its un-programmability, in other words, a certain kind of freedom. Thus, the question arises, whether these limitations of code, to an aesthetic or logic which can be understood by us humans, also apply to AI. AI could be understood as the attempt to teach the machine to free the code from its parameters: the code which humans have imposed is changed by the machine itself. This could be understood as the act by the machine, of teaching itself new things. The machine is thus altering the very fabric which allows it to apply logic. Although, during the beginnings of machinic emancipation, creators such as Stephen Wilson (1983) noted in *AI and the Arts* that: “In creating an AI program, one must make a choice about the characteristics of a mentality one wishes to program” (p. 15). Perhaps, *Méta-Matic’s* abstract, random drawings, operate under some universal random distribution function, which would embed in them a certain kind of logic, although not consciously perceived by humans as such. Contrary to that, Ai-Da still creates artworks, which can easily be read and understood by humans because they are created using a “language” of figuration

or abstraction which Ai-Da has been taught, to resemble human art. While Tinguely and the human putting pen and paper into place for *Méta-Matic No. 10* play the role of enablers of the creative process, humans are much more involved in the creation of artworks by machines using AI, at least in the initial stages. Similarly, to Wilson's observations on the choices one faces when programming AI machines, the creators of the AI artist have to choose which kind of art will result from the machine. Therefore, human input is irreversibly linked to the final outcome. In artist robots using AI, humans want to create machines that make art independently, but in a format which we know and which is recognisable to us, as exemplified by Ai-Da (Dinis Guarda 2020). Whereas true machine creativity is more likely to result in something which is not understood by humans as art, i.e. code (GPT-3 2021). By restricting the liberty of the machine (by setting parameters, and commands in the form of code), we tend to take away its freedom, its agency. This fundamental paradox was already observed in 1981 by Peter Kugel in his essay *AI and Visual Art*. Kugel (1981) recognizes that: "Computers can apply rules as well as, and sometimes better than, a human. What computers at present do badly is formulate the rules to be applied" (p. 139). Perhaps, the moment AI will be truly creative will be defined by the moment a computer can formulate a rule and break it voluntarily out of its own "desire". Each great progress in art history has been defined by great thinkers who were able to identify (unwritten) rules and consciously break them, turn them upside down, or flat-out ignore them (Du Sautoy 2019).

On the other hand, it has been claimed that the capability of AI or for that matter any machine or living thing to make art, is determined by the recipient of the work, in the case of visual arts, the viewer. As Harsha Gangadharbatla (2022) found in his study: "Findings suggest that individuals are unable to accurately identify AI-generated artwork and they are likely to associate representational art to humans and abstract art to machines" (p. 1). Furthermore, in an article entitled *ARTificiality, Künstliche Intelligenz, Kreativität und Kunst* Pamela C. Scorzin (2021) notes that, if nothing else, the market has already had its say in the matter. She observes that art made by humanoid robots using AI such as Ai-Da has already sold for sums that most living artists could only dream of and, more importantly, has been welcomed and exhibited in those institutions which are path-breaking for the importance and relevance of creators, such as the Tate Modern, the Design Museum, and the Victoria and Albert Museum.

2.2. Authorship

The acceptance of art in itself must first be done by the author or artist, argues Karen E. Gover in her 2018 book *Art and Authorship: Moral Rights and Meaning in Contemporary Visual Art*. She con-

cludes that the realisation of an artwork consists of two moments – the moment of production and conception and the moment of proclamation:

The robust conception of authorship, which is the (often unarticulated and unexamined) norm, entails the first-order intention to generate an artwork and the second-order intention to accept the artwork that was made as good enough. I have linked this necessary second moment of ratification or endorsement to the concept of artistic freedom. Artistic freedom can mean different things depending on the context in which it is invoked. I maintain, however, that the most fundamental form of artistic freedom involves the artist's authority to accept or disavow the works she produces, to curate the works that bear her name and come to represent her artistic oeuvre. (Gover 2018, 161)

This brings us back to our two case studies: *Méta-Matic No. 10* and *Ai-Da*. In the case of Tinguely's *Méta-Matic* machine, the process of completion through the enunciation of the artwork by the artist is not possible or is rather passed on to the activator of the machine, who can accept or reject the work. However, even here questions of authority could be raised: who permitted this human to proclaim the work by the machine as art? It is the machine and only the machine which can make that decision as the creator of the work, some would argue. Taking research into the direction of authority and authorship with regard to creativity in the case of *Méta-Matic No. 10* brings us soon enough to a dead-end. In the case of *Ai-Da*, however, the question arises whether the machine is picky about her work due to her capability of communicating through her language model. Or, is it still up to the human creators of *Ai-Da* to proclaim her work as art? The answer to this question may be found in the application of CANS (Creative Antagonistic Networks) or GANS (Generative Antagonistic Networks), which are AI machines consisting of several artificial neuronal networks which compete with each other (Scorzin 2021). While one creates a work, the other judges how close it is to that of a human (who sets these parameters to begin with is another question). At each step, the *creator*-machine registers the positive or negative feedback from the *judge*-machine and learns not to make the same "mistakes" again. Does this fulfil Gover's (2018) requirements of the "fundamental form of artistic freedom [that] involves the artist's authority to accept or disavow the works" (p. 161)? Is that not exactly what GANS or CANS do? They make judgement calls; they decide if the work is to be accepted or disavowed. In an interview given to the Arts journal for their special issue entitled *The Machine as Artist (in the 20th Century)*, artist Leonel Moura (2018) gave this insight into his relationship with the artworks created by his machines:

The algorithm and the basic rules introduced thereby via the robot microchip are not so very different, furthermore, from education. No one will claim that a given novel is the product of the author's school teacher. To the extent that the author, human or machine, incorporates new information, the artwork becomes not only unique but also the result of the author's own creativity. In short, I teach the robots how to paint, but afterward, it is not my doing. (p. 4)

It is interesting to note that Moura's artbots are something between *Meta-Matic No. 10* and Ai-Da. They use code, as they operate with sensors to detect colour and density on the surface beneath them and lower or lift a pen in response to what they detect. Several artbots, operating at the same time, have sensors to avoid bumping into each other or other kinds of obstacles. They thus have an interaction with their environment which is also based on sensor input. While a human could physically intervene in *Meta-Matic No. 10's* process by holding a moving part or exerting pressure on some of its metal parts during the process, these artbots are programmed to "read" their environment and react to it. Their drawings are random within the boundaries of their environment. However, contrary to Ai-Da, they are not programmed to paint what they perceive. Their artworks result from their movement in a given space and look like abstract line drawings which resemble more *Méta-Matic No. 10's* scribbles than Ai-Da's calculated abstract or figurative paintings. Moura (2018) further claims that: "Whether a work of art is made directly by a human artist or is the product of any other type of process is nowadays of no relevance" (p. 4). This research posits that there is a case to be made that Moura may be right, yet only in part.

2.3. The Post-Humanist Era

A very important book about a topic so close to this research is *AI Art: Machine Visions and Warped Dreams* by Joanna Zyliniska, published in 2020. In her book, Zyliniska addresses many issues surrounding machine-made art including when she speaks about the *Artistes & Robots* exhibition at the Grand Palais in Paris in 2018, in which coincidentally another drawing machine by Jean Tinguely, *Méta-Matic No. 6* (a machine almost identical to *Méta-Matic No. 10*) was exhibited. Discussing various art-making machines exhibited at this exhibition, Zyliniska (2020) notes: "Naturally, artists do not construct these machines just to get 'help' but rather to probe the limits of the human idea of creativity and of human-machinic assemblages. These works are thus described as collaborations between the artists and the robotic systems those artists have designed" (p. 58). Thus, Zyliniska recognises that these machines ought to be discussed as more than just tools. Building on the work of philosopher of technology Vilém Flusser, Zyliniska observes that the notion of machines made by humans being read as separate forces is reductive

and an old-fashioned view of human-machine relationships. She suggests that since the advent of computer technology at the latest, humans have evolved with machines and machines have evolved with humans. Furthermore, Zylinska states that a new perspective is required to make sense of art-making machines which would view humans as just a part of a larger system of cause-effect relationships between animate and inanimate matter: “Humans’ everyday functioning also depends on the execution of a programme: a sequence of possibilities enabled by various couplings of adenine, cytosine, guanine, and thymine, i.e. DNA” (p. 53). However, she recognises that it is important not to disavow the human as the creator of any agency and thus, responsibility: “This proposition should not be taken as a postulation of a mindless technological or biological determinism that would remove from humans any possibility of action as artists, critics or spectators – and any responsibility for the actions we take” (p. 53). She goes on to highlight that humans’ dependence on natural processes beyond our control “does undermine the humanist parameters of the debate about creativity, art and AI” (p. 53). This research suggests that, by trying to demonstrate that machinic autonomy does not exist because of humans’ desire but as a naturally evolved attribute, Zylinska highlights just that: the dependence of machines on humans. The debate is thus still revolving around power dynamics. Is the machine at the mercy of the human? Or is the human at the mercy of the machine? Or is it just merry collaboration on an equal playing field? Zylinska notes that: “The human’s relationship with technology is not one of enslavement, even if Flusser does raise serious questions for the humanist notion of agency” (p. 54). However, to address questions of human involvement in machine-made art, Zylinska shifts the question from power as a dependence of one thing on another, to autonomy as a free agent in the world. The claim is that there is no autonomy of the human which sets it apart from the machine, it is one of removal of agency from the human. One of the conclusions Zylinska infers from her observations of art-making machines is that the notions these machines are addressing – namely the old “Is art a human enterprise?”, “Can machines be creative?” – are about a humanistic vision of art and thus may be misguided:

To understand how humans can operate within the constraints of the apparatus that is part of us becomes a new urgent task for a (much needed) post-humanist art history and art theory. In this new paradigm for understanding art, the human would be conceived as part of the machine, dispositive or technical system – and not its inventor, owner and ruler. A post-humanist art history would see instead all art works ... as having been produced by human artists in an assembly with a plethora of non-human agents: drives, impulses, viruses, drugs, various organic and nonorganic substances and devices, as well as all sorts of

networks — from mycelium through to the internet. (Zylinska 2020, 54-55)

Even if Zylinska says that she does not want to remove responsibility from the human, that is de facto the conclusion which is drawn from this passage. She does not address how the human could possibly retain agency or autonomy in such a view on the production of art. Granted, Zylinska does not claim that in this view humans would play no role at all in the production of art. However, it is clear that the human is, from such a perspective, not to be seen as an initiator, inventor, or author. If the idea is that the importance of humans in the art process shrinks (i.e., the human becomes only a channel for something which happens naturally), it could be conceived that art is a natural phenomenon, which appears or happens here and there, like a drop of rain, a gust of wind, just a result of certain circumstances being met at the right time and in the right place. Nevertheless, even by this definition, the human stands out in a central role. If artworks are seen by the post-humanist as having been “produced by human artists in an assembly with a plethora of nonhuman agents” (Zylinska 2020, 54), we must ask how this places the human in a less prominent position than in the humanist view on art-production. This research posits that Zylinska’s observations reframe the question of artistic production by trying to see the human as part of a whole larger universal process, which comes back to observing the mere fact that: yes, artists make art in the universe they were born into and with the world which happens to be at their disposal. This observation, however, brings us back to square one, as it is within those given circumstances that human artists are attempting to make machines which make art independently. This research thus suggests that both case studies have to be observed up close and experienced fully and naively, as the art-making machines that they were built to be by humans. This is necessary to discuss any further possibility of human involvement in their art-making process and to determine the degree to which humans play a role.

2.4. Embodiment and Power

With regard to Machine-Human or Human-Machine interaction and the relationship between humans and art-creating machines, the question of power dynamics, which is also addressed by Zylinska plays a role in the interaction between both case studies and their human operators. While the machine is at the mercy of the human in terms of the energy supply (Pardey 2022), both Ai-Da and Méta-Matic were created to make them independent from humans to a certain degree. In his paper entitled *Bodies in Electronic Space, Models for Humans and Interactive*,⁵ Peter Purg (2004) argues that bodies

5. From the German: *Systems Körper im elektronischen Raum, Modelle für Menschen und interaktive Systeme*.

in the electronic sphere are stripped of their inherent ontological function and advocates to reinstate the human body in its own space. Before AI became mainstream, Purg raises the question of power not only between humans and machines, but between software and hardware, between the digital and the electronic. In the meantime, it has become apparent that the electronic is indeed subjugated and at the mercy of the digital in almost all places where humans encounter it. *Méta-Matic No. 10* is fascinating in comparison to Ai-Da Robot, precisely because it is purely electric. It transforms one form of energy into another, and by doing so, makes art — with a little human intervention. Ai-Da, however, has in her physicality, no autonomy. The code which “runs” her, is prime. Thus, we must ask what it means for a human to interact with Ai-Da. Is the human interacting with the code or with the physical machine before it? Purg (2004) furthermore raises questions about human awareness in the process of interaction with machines. When a human feels like she or he is interacting with technology, often the human is just reacting to technology: “Especially in the interdisciplinary field of encounter between (dance or stage) art, (communication and media) science and interactive (media) technology, a collective myth of cooperativity seems to replace the individual Renaissance myth” (p. 343). This collective myth of cooperativity is just one part of a larger narrative of machine independence which is deeply rooted in mystification. This is relevant for both case studies as the question of human relevance in this research is closely tied to the relevance of the human body for the art-making process. Both case studies have either set parameters according to which they create art or, in the case of Ai-Da, have systems which enable them to generate visual imagery. Therefore, the more pertinent question which arises is not what the human mind is bringing to the equation, but what the human body has — that no machine can make art without it.

3. Originality, Novelty and Creativity

3.1. Mechanical Reproduction and Originality

In 1936, Walter Benjamin observed what he considered to be the democratising effect of the reproduction of two-dimensional artworks through photography in his essay *The Work of Art in the Age of Mechanical Reproduction*. In this essay, Benjamin posits that the end of art as an object of cult or veneration comes with the ability to reproduce any artwork in a photograph. He claims that this mechanical reproduction robs the work of its “aura” (Benjamin 1996). It is important to note that Benjamin emphasises *mechanical* reproduction, rather than reproduction in general through, for example, human labour, which had existed for many centuries before Benjamin wrote his essay. This is, of course, of great significance as Benjamin’s observation seems to conversely signify the human touch, rendering even a copy of an already existing painting somehow unique. Benja-

min makes a direct link between *machinic* reproduction and a loss of the spiritual aspect of art. Benjamin's observations are twofold: Considering the case studies of this paper we must extend Benjamin's question from the one of mechanical *re-production* to the one of the mechanical *production* of artworks. What happens if the machine does not *re-produce* but instead actually *produces* the art? Is the aura of the original dependent on the fact that the artwork is manmade, or is it because it was the original artwork? In the former case, this would render anything made by any of the case studies, not worthy of the label of artwork. In the latter case, there would be a chance for the original artworks created by *Méta-Matic No. 10* and Ai-Da to be considered artworks in their own right.

The word "original" is a difficult term to define. However, it plays a major role in the discussion surrounding art made by machines. For it is originality, that humans so often assign to humans. For this research, the role of originality in art will be examined with regard to creativity as a necessary attribute. When claims of creativity are made about AI, it is often linked to the desire to demonstrate its ability to make something original. In an article published by the BBC entitled *How Modern Art Became Trapped by its Urge to Shock* Sir Roger Scruton (2014), philosopher and professor of aesthetics at Oxford, argues that the recognition of originality as a driver for innovation and discovery in art is one of the reasons for the emergence of modernism. Whether the rise of technologies and machines is directly linked to this momentous break in art history remains to be proven. However, this research suggests that it is no coincidence that Benjamin's observations came at a time in which artists were fundamentally rethinking what it was to be an artist in a fast-changing society. Scruton makes the following observations about originality:

With the decline of religion during the 19th century there came about a new kind of faking. The romantic poets and painters turned their backs on religion and sought salvation through art. They believed in the genius of the artist, endowed with a special capacity to transcend the human condition in creative ways, breaking all the rules in order to achieve a new order of experience. Art became an avenue to the transcendental, the gateway to a higher kind of knowledge. Originality therefore became the test that distinguishes true from fake art. (Scruton 2014, 1)

These observations are not dissimilar to those made by Benjamin, who noted the origins of art in the sacrosanct and religious quests of humans. It is important to note that the perception of art in a twenty-first-century western society has undergone dramatic shifts, precisely because of technological developments. Scruton (2014) uses Marcel Duchamp's famous urinal as an example of a work of art which is considered art because of its original gesture. The point is that it cannot be repeated, it cannot be reproduced, as any attempt

to do so would not be original. This is one explanation for the rise of Modernism and the expectation from art, to be original i.e., unreproducible, not only by machines but by other humans. The determining factor for originality is thus the gesture, not the production of a thing.

3.2. Art or Creativity?

When the rise of machines is proclaimed, it is often closely linked to the advancement of AI and its growing capabilities with regard to creativity (Schwab 2019). Consequently, humans' collective gaze turns towards the arts and experts see the end of human singularity in a drawing made by a machine somewhere in Oxford (Paju 2022). However, rarely is the question addressed whether creativity in itself is what is required to create art. Even in articles discussing art made with the help of AI, journalists and experts on the topic discuss creativity fervently but fail to address its relevance for the production of art.

In his book *The Creativity Code: Art and Innovation in the Age of AI* (2019), Marcus Du Sautoy proposes a challenge in the form of a test that any artificial intelligence must pass, if it wants to be called "creative". He calls this the "Lovelace Test". According to Du Sautoy (2019), any machine, to be deemed creative, must come up with something new, surprising and of value. This triad of conditions for creativity was first articulated by Margaret Boden in her book *The Creative Mind: Myths and Mechanisms* in 1990. In the introduction, she proposes the following definition:

Creativity is the ability to come up with ideas or artefacts that are *new, surprising, and valuable*. "Ideas," here, includes concepts, poems, musical compositions, scientific theories, cooking recipes, choreography, jokes ... creativity enters into virtually every aspect of life. It's not a special "faculty," but an aspect of human intelligence in general. (Boden 2016, 1)

There are three types of creativity which Boden defines: *Combinational Creativity*, *Exploratory Creativity* and *Transformational Creativity*. It is, however, Combinational Creativity that Du Sautoy and Boden deem to be the most challenging to AI. Boden summarises this type of creativity as a method of "taking ideas that are familiar and putting them together in unfamiliar ways" (Hay Levels 2017). But why would creativity be relevant for the production of art? Perhaps, the common association of art and creativity stems from the common etymological roots of the words *create* and *creativity* (Etymonline 2021). In fact, making art always involves creating something new, be it an idea, a movement, or a painting. However, this does not necessarily mean that creativity alone suffices to make the result a work of art.

The reason this research preoccupies itself with creativity is that it is a large part of the claim that Ai-Da can be called an artist. Meller claims that she is creative according to Boden's definition of creativity (Dinis Guarda 2020). This research argues that, while this claim of creativity may be true, it is not what classifies the outcome of Ai-Da's processes as art. Boden's definition of creativity only gets us so far in determining whether machines could make art independently from humans. Her definition of creativity as something new, surprising and of value, holds true more in any other domain, than in the field of art. Is a child creating something new, surprising and of value when it draws its first scribbly painting? Not for society perhaps. But for itself, probably. Although Kelly (2019) would beg to differ: "A toddler at the piano may hit a novel sequence of notes, but they're not, in any meaningful sense, creative" (p. 1). *Méta-Matic No. 10's* drawings are not the result of a creative act by Boden's definition. However, they are considered to be art (Pardey 2022).

4. Conclusion

The main difference between the case studies of this research is in the use of the body which they inhabit and the human body which they require as a collaborator. *Méta-Matic No. 10* is nothing but its body and is at the mercy of its physiognomy. Ai-Da is trapped in her brain and can process information that she receives through her cameras. However, the process is a one-way street. While her body allows her to accomplish certain tasks, while she can record her environment through her eye cameras, any knowledge or action is initiated in her computer at the behest of humans. Unlike humans, who are constantly reacting to their environments and do things as a consequence of their environment. All the knowledge Ai-Da is referencing in her work has been produced by humans through their bodily interactions with the world. At the fundamental level, humans do create art out of necessity, which is why, until a machine needs to produce something artistic to sustain its existence, there will not be a purely machine-made artwork.

This research concludes that the claim to originality has no bearing on the status of a machine-made object as art. Therefore, this research wishes to extend Benjamin's claim beyond the mechanical *re-production* of art and to the mechanical *production* of art. The mere existence of both case studies is questioning what art can be if it is not made by humans. Thus, any person standing before *Méta-Matic No. 10* or Ai-Da may end up asking themselves: "What is it, that I as a human being can do, to make art?" Pushing the limits of machine creativity and machine-made art, does necessarily raise questions with regard to the origin of art in humans. They (the machines) were built to make art, but do not necessarily succeed. We (the humans) were not built to make art but we do it without hesitation. This research concludes that while the human body is essential

to the process of these machines, the human mind plays an imperative role. It is the human disposition towards these machines which is precisely why what they make can and should be considered art. It is at the same time cause and effect. The purely machine-made artwork has therefore, paradoxically, never existed and never will without a human.

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Creative Amplifiers: Augmenting Human Creativity with Text-to- Image Generators

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This paper examines the extent to which deep-learning-based generative programs, particularly text-to-image generators, support human creativity in the sense Margaret Boden's definition. This discussion is supported by a brief introduction to the technical workings of denoising diffusion-based text-to-image generators. The analysis reveals that while these networks lack the autonomous ability to evaluate their designs and conduct exploratory design processes, they can nonetheless be considered complex tools that support human creativity by offering both accessible and powerful means of text-to-image translations. The paper then broadens its focus to a more general discussion of the potential impact of such assistance on creative labor, particularly in the design disciplines. Finally, the paper identifies the democratization of creativity as a larger disruptive force for creative labor than automatization, as professional workers might soon be competing with a larger, less trained workforce.

Keywords: Text-to-image Generators, Democratization of Creativity, Deep Learning, Denoising Diffusion.

1. Introduction

This paper aims to explore the question in which regard the recent wave of text-to-image generators can support human creativity. These programs have become increasingly popular, with examples such as DALL-E 2,¹ Craiyon (formerly known as DALL-E Mini),² Midjourney³ and open-source efforts such as Stable Diffusion.⁴ By examining their capabilities and limitations, this paper aims to shed light on the potential for such networks to be considered ‘augmentations’ of human creativity (cf. Griebel et al. 2020).

Current text-to-image generators primarily employ a ‘denoising diffusion’ process, often referred to simply as ‘diffusion.’ This process diverges technically from generative adversarial networks (GANs) and tends to exhibit a superior level of visual diversity and photographic realism. Predecessors of the current wave of diffusion-based text-to-image generators have combined OpenAI’s text-and-image encoder CLIP with GAN generators such as DeepMind’s BigGAN (Brock et al. 2019) resulting in Ryan Murdock’s Big Sleep,⁵ with Nvidia’s StyleGAN (Karras et al. 2019) resulting in StyleCLIP (Patashnik et al. 2021) or with VQGAN (Esser et al. 2021) resulting in VQGAN-CLIP (Crowson et al. 2022). These combinations fostered the interaction between the generator and CLIP, which optimized the output of the generator through successive iterations to conform most precisely to the ‘expectations’ of CLIP. In addition to these predecessors, other diffusion-based variations of this approach exist, which are not publicly accessible and currently only available in a limited beta trial, such as Google’s Imagen (Yu et al. 2022).

To assess how the current generation of text-to-image generators support human creativity, it’s helpful to study a range of examples. Since 2022, social media platforms have been literally inundated with images generated by these programs. For example, when provided with a prompt like “A still of Kermit the frog in Stranger Things 2016,” a text-to-image generator might produce an image of Kermit resembling the fictional character Joyce Byers from Stranger Things, dressed in 1980s attire and exuding an eerie mood.⁶ Other noteworthy examples include illustrations that were generated to resemble creamy soup, which was a happy accident resulting from the prompt “Bowl of soup in the style of Aubrey Beardsley,” an Art Nouveau artist.⁷ Another interesting application is the creation of historical reenactments using prompts like “GoPro footage of the French Revolu-

1. See <https://openai.com/dall-e-2>

2. See <https://www.craiyon.com>

3. See <https://midjourney.com>

4. See <https://github.com/Stability-AI/stablediffusion>

5. See <https://github.com/lucidrains/big-sleep>

6. See <https://twitter.com/HvnsLstAngel/status/1531506455714492416>

7. See <https://twitter.com/djbaskin/status/1497763195187982337>

tion,” producing dramatic, fish-eye views of encounters between the revolutionaries and the royalists. This is achieved by treating optical qualities as a visually learned, transferable style entity.⁸

Figure 1: Results of the prompt “Bowl of soup in the style of Aubrey Beardsley” generated by Danielle Baskin in 2022.



Such examples show the relevance of the question to what capacity these text-to-image generators can support human creativity, given how surprising and convincing these examples are. To elaborate this question further, it is important to establish a working definition of creativity. One widely accepted and often used notion proposed by Margaret Boden, an expert in the field of creativity research, is that a creative idea is one that is novel, surprising, and valuable (Boden 1998).⁹ The standards for what is considered novel, surprising, or valuable may differ from person to person, across different disciplines, or for humanity as a whole. Creativity is a subjective and contextual term that varies based on perspective. According to Boden, there are three main strategies for achieving creativity. The first is the *combination of existing ideas*, where new concepts are formed by combining existing ones. Secondly, there is the *exploration of conceptual spaces*. Conceptual spaces refer for instance to genres in music, styles and methods in art and design, or other ways of approaching and understanding the world. And lastly, the approach considered the most creative is the *transformation of conceptual spaces*. This involves altering existing perspectives to create something new, by creating a novel approach that opens up more possibilities and changes the conceptual space itself.

8. See <https://twitter.com/timsoret/status/1560339610588282880>

9. Boden's definition holds a prominent position in the field of computer science and is rooted in the perspectives on creativity of Joy Paul Guilford and Alex Osborne, which are inclined towards applied innovation. However, there are alternative definitions that align with a more humanist approach, drawing upon the works of John Dewey and Alfred North Whitehead. See (Still & D'Inverno 2016) for additional information on this dichotomy. Boden's definition holds a prominent position in the field of computer science and is rooted in the perspectives on creativity of Joy Paul Guilford and Alex Osborne, which are inclined towards applied innovation. However, there are alternative definitions that align with a more humanist approach, drawing upon the works of John Dewey and Alfred North Whitehead. See (Still & D'Inverno 2016) for additional information on this dichotomy.

Furthermore, the literature on human-computer interaction distinguishes between three types of ‘creative’ software: systems that exhibit autonomous artificial creativity, co-creative systems, and support systems that augment human creativity. Systems of autonomous artificial creativity would be able to behave similar to the creativity known from humans and would be able to fulfill all the aspects of Boden’s terminology. It is questionable if such a degree of artificial creativity has ever been – or will ever be – reached. For such reasons, achieving true creativity by means of artificial intelligence is often considered its “final frontier” (Colton & Wiggins 2012). Nonetheless, for Margaret Boden such systems can at least “appear” to be creative (Boden 2004, 7). In the case of co-creative systems, multiple agents autonomously contribute creative inputs to interact with one another, usually involving at least one human in the loop (Davis et al. 2015; Karimi et al. 2019). Creative support systems on the other hand are about enabling and augmenting creativity in humans, e.g. by enhancing existing creative skills or opening up new one (Nakakoji 2006).

Based on these definitions it can be noted that the current generation of text-to-image generators cannot be regarded as fully ‘creative’, since they are not operating autonomously, are not critically reflecting their outputs and are not conducting explorative or transformative activities on their conceptual spaces.¹⁰ Creativity involves the ability to assess and make judgments on the existing norms, conventions, and paradigms within the domain in which one is operating (cf. Colton et al. 2015). This is because any creative endeavor requires a response to the established body of knowledge and practices in the field, which must be considered conceptually and contextually. This precludes text-to-image generators from engaging in autonomous or co-creative interactions on equal footing. Nonetheless, they can be analyzed as systems that support human creativity instead, which is the focus of this paper.

With this understanding of creativity, let’s revisit the examples mentioned earlier. The images of Kermit the Frog placed within movies are based on combining existing concepts that are triggered by the text prompt. The GoPro footage of the French Revolution is a unique image created by combining the historical event with the optical characteristics of an action camera lens. The bowl of soup in the style of Art Nouveau artist Aubrey Beardsley showcases the ambiguous nature of combinatorial creativity. Although the prompt was to render a bowl of soup in the style of the artist, the program incorporated Beardsley’s motifs into a modern-day photograph of creamy soup instead, possibly inspiring a human beholder to inventing a new illustration technique. Again, this is another example of combinatorial creativity. In conclusion, text-to-image generators provide

a means of rendering images that correspond to a specified prompt. As previously discussed, evaluating the originality and worth of these images is subjective and dependent on the context in which they are used. Currently, they are mostly viewed as entertaining and high-quality surprises on social media, which contributes to their perceived value.

At least in this regard, the complexity displayed by the program in executing the prompt should be recognized. After all, generating these images is not a simple process of translating text to image, but requires the program to apply a substantial amount of semantic and visual ‘knowledge’. Skeptics may argue that attributing knowledge to computers is a misconception of the disparity between syntax and semantics, as machine learning is primarily the result of finely tuned statistical analysis and thus ‘guesswork’. However, physicist Sabine Hossenfelder recently proposed an argument in a think piece regarding the notorious “statistical parrot”¹¹ ChatGPT that challenges this view.¹² She opposes John Searle’s famous “Chinese Room Argument” (Searle 1999) suggesting instead that the ability to generalize data indeed indicates a degree of knowledge. In the case of text-to-image generators, these systems can adapt visual and textual elements to fit cohesively and reasonably into an extensive range of previously unseen contexts, in a ‘zero-shot’ manner. But while the visual solutions generated by the program are novel and unexpected, they are only possible through the collaboration between the human ‘prompter’ and the visual translation program. Without input from a human prompter, text-to-image generators are limited to clever interpretations of text into images and cannot produce meaningful solutions independently. To further understand the mechanisms that drive and limit the capability of such generators to offer novelty and value, it is beneficial to have some understanding of the technical workings of these generators.

2. Working Principles

2.1. Convolutional Neural Networks

A foundational technology of diffusion-based text-to-image generators are convolutional neural networks. An influential example for this type of network is the AlexNet (Krizhevsky et al. 2012), which is often cited as the starting point for the recent renaissance of deep learning-based artificial intelligence. The principle of this network is that, for the purpose of pattern and object recognition, an image is input into the first layer of the network. Over several layers, a convolution algorithm is then applied to the image using filter kernels, which are activated in certain areas of the image where patterns

11. For the term see (Bender et al. 2021).

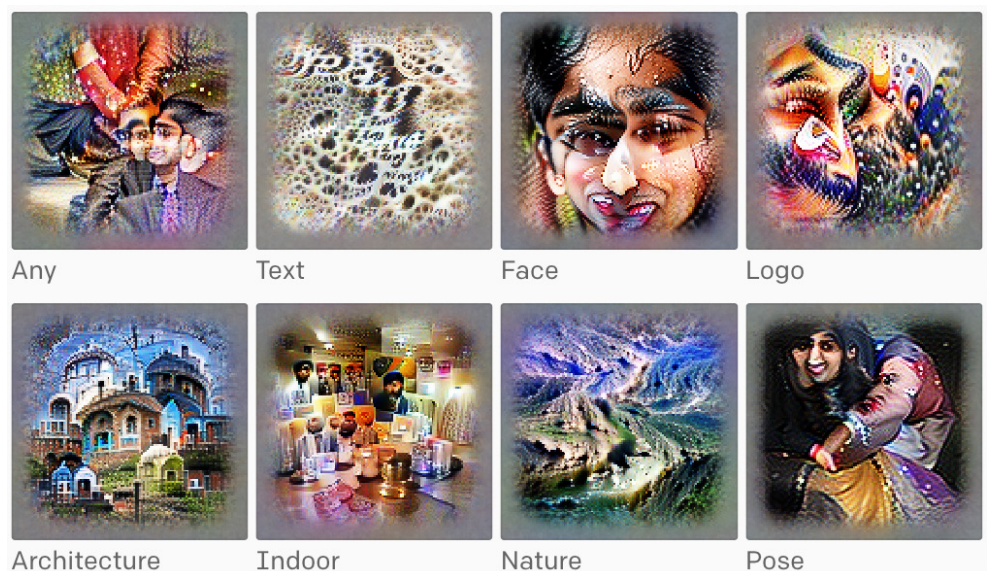
12. See <https://www.youtube.com/watch?v=cP5zGh2fui0>

are found (cf. Zeiler & Fergus 2014). These filters, which may appear strange to humans, are not programmed or designed by manual effort but are learned by the network during the training stage, based on the training data set provided. As the network progresses through higher layers, more complex patterns, such as dog noses and human faces, are learned and represented within the network.

Essentially, convolutional filtering is also the working principle of well-known functions such as image sharpening in image editors. In that case, the filter kernel works as a general edge detector and increases the intensity of all edges in the pixel representation of an image. Similarly in the case of convolutional neural networks, the learned filter kernels are emphasized in a given image through the process of convolution, thus yielding activation maps of the features that the filter kernels shall represent. On its way through the network, the input image is downscaled several times through a process called ‘pooling’. Additional convolution layers are applied, and the image is eventually transformed into an activation pattern, carrying information on which filters of the many filters learned by the network were activated. Finally, this information is represented in a fully connected layer, often referred to as the latent or feature space, which consists of a list of floating-point values. In the case of AlexNet, this feature space can then be used for tasks such as object classification.

The famous DeepDream process by Alexander Mordvintsev is a technique that allows for the visualization of features that a convolutional neural network (CNN) has learned during its training process.¹³ Originally, it was developed as a tool for debugging CNNs, by highlighting the areas of an image that activate certain filters within the network. This technique has been used to generate a specific type of imagery, often described as ‘psychedelic,’ that has been used in some early forms of deep learning art.

Figure 2: Visualization of a “multimodal neuron” for India inside OpenAI’s CLIP network (Goh et al. 2021). Taken from a blog post on <https://openai.com/blog/multimodal-neurons>.



In today's neural networks, the number of visual filters that are being learned is very large and also highly interconnected and context dependent. With the Microscope tool by OpenAI, one can inspect the filters learned by popular networks such as ResNet and CLIP. In the case of the latter an example would be USA-related patterns learned by the network that are structured into subcategories including various typographies, faces, logos, and depictions of typical cultural artifacts.¹⁴ Through the diversity of these learned features in today's neural networks, complex visual concepts can be represented as vector lists of numbers in their feature space, which in turn allows for the algorithmic processing of visual phenomena.

2.2. Generative CNNs

Let's now move back to discuss text-to-image generators and their potential for supporting human creativity. So far, the process of encoding pixel space into feature space has been examined. Additionally, an encoder-decoder structure can be employed, which utilizes deconvolution and upscale algorithms to reconstruct an image back from the latent space. In the encoder, an input image activates filters and is translated into a feature vector representation as stated above. In the decoder, the image is reconstructed based on this feature vector, but will never be fully identical to the input image since the learned filters are necessarily biased towards a statistical average of the training set. This outcome is desirable in these networks, as exact replication would indicate overfitting and lack of generalization and could also potentially lead to copyright infringement issues (cf. Carlini et al. 2023).

A helpful example of such a latent space decoder can be seen in the Face Editor tool by CodeParade.¹⁵ In this case, a network was trained using a collection of approximately 30-40 portrait images of high school students. The resulting tool utilizes a mixing desk interface to manipulate facial features that have been sorted for their visual significance. Each feature is represented by a slider that encodes visual features into a feature space vector, with the first slider affecting the greatest number of pixels and each subsequent slider affecting fewer pixels. The most influential feature identified by the network is shirt color, followed by sex, head position, body height and hair density.

Additionally, it is possible to manipulate feature vectors in a variety of ways using vector mathematics. Operations such as adding, subtracting, interpolating, and averaging can be performed on the vectors for extracting and applying semantic concepts as vectors. One example of this is SpaceSheets by Bryan Loh and Tom White, which uses a spreadsheet interface to select and combine multiple images

14. See <https://microscope.openai.com/models>

15. See <https://www.youtube.com/watch?v=4VAkrUNLKSo>

based on their feature vector representations and simple arithmetic operations (Loh & White 2018). Furthermore, it is possible to isolate specific features, such as a smile, through subtraction of feature vectors. This isolated ‘smile vector,’ can then be applied to make images of neutral faces appear more friendly or smiling.

Beyond auto-encoders, significant advancements have been made in the field of photorealism through the use of generative adversarial networks (GANs) in recent years. These networks have proven to be capable of producing high-quality images in response to text inputs. One example of this is StyleGAN (Karras et al. 2019), which is able to produce highly realistic images of faces with fast computation and sampling times. However, GANs have traditionally struggled with generating a diverse range of subjects. This problem was partially addressed by the development of BigGAN (Brock et al. 2019), albeit without offering the same level of realism. Only recently, denoising diffusion models have emerged that are able to generate high-quality samples for a diverse range of subjects, powering the current generation of text-to-image generators.

2.3. Denoising Diffusion Models

The denoising diffusion architecture utilizes an encoder-decoder structure at its core (cf. Ho et al. 2020).¹⁶ The encoder is trained to filter out noise from an image, again activating filters that have been learned about specific features. This results in the image being represented in a feature space, which can then be decoded to produce a denoised image. The iterative activity of these models can be observed, as the image becomes clearer and clearer during the denoising process after departing from a fully noised initial image. Crucially, denoising diffusion-based text-to-image generators combine this denoising with an additional text encoder, which encodes text into a feature space that is then used in a multi-step process to condition the above-mentioned denoising process. This conditioning limits the search space of visual patterns learned within the network and allows to control the creation of images from another modality.¹⁷

To compare this working principle with human psychology, it is common for individuals to perceive familiar patterns or shapes in objects, such as clouds. This phenomenon, known as pareidolia, is influenced by prior inputs or mental associations. For example, if someone is told to look for a specific image such as a dog in a cloud,

16. The popular Stable Diffusion by stability.ai is based on so-called Latent Diffusion (Rombach et al. 2022), which owes its naming to the fact that its denoising diffusion auto-encoder does not operate on images directly, but on latent space representations of these instead. According to the authors, packing a latent space in a latent space reduces the dimensionality of the data and therefore speeds up the processing.

17. The addition of further conditionings in other modalities such as spatial depth and body pose is currently an active field of research (cf. Zhang & Agrawala 2023).

it may be easier for them to perceive that image. This concept is known as priming, where a prior input influences subsequent thoughts and mental imagery. Pareidolia is particularly common in the perception of faces, but it can also occur with other shapes and patterns found in nature. Although it is usually inappropriate to anthropomorphize deep learning programs, the working principle of text-guided denoising diffusion models can be metaphorically compared to priming and pareidolia common in human psychology.

The advancement of new architectures and the accessibility of large-scale, open-source datasets are crucial for the quality of today's generators. OpenAI was among the first organizations to utilize web-scale datasets for their CLIP model (Radford et al. 2021). However, these datasets have been kept private. The LAION dataset (Schuhmann et al. 2022) used by Stable Diffusion, in contrast, is a publicly available list of ca. five billion image URLs with text descriptions. However, the legality of web scraping often depends on the purpose of the scraping and training, particularly whether it is intended for scientific research or commercial endeavors.

It appears that the size of neural networks is a significant factor in their performance. Google researchers demonstrate with their text-to-image generator Parti, which uses a GAN as its generator but is unfortunately not publicly accessible at the time of this writing, that while a network trained with 350 million parameters can generate a prompt such as “A map of the United States made out of sushi on a table next to a glass of red wine,” the results are not fully convincing.¹⁸ As the number of parameters increases, the results become increasingly accurate. With 20 billion parameters, the network is able to compose a description of a scene featuring a kangaroo wearing an orange hoodie and blue sunglasses in front of the Sydney Opera House and holding a sign on the chest that says “Welcome friends.” This level of performance is currently a challenge for publicly available neural networks at the state of this writing.

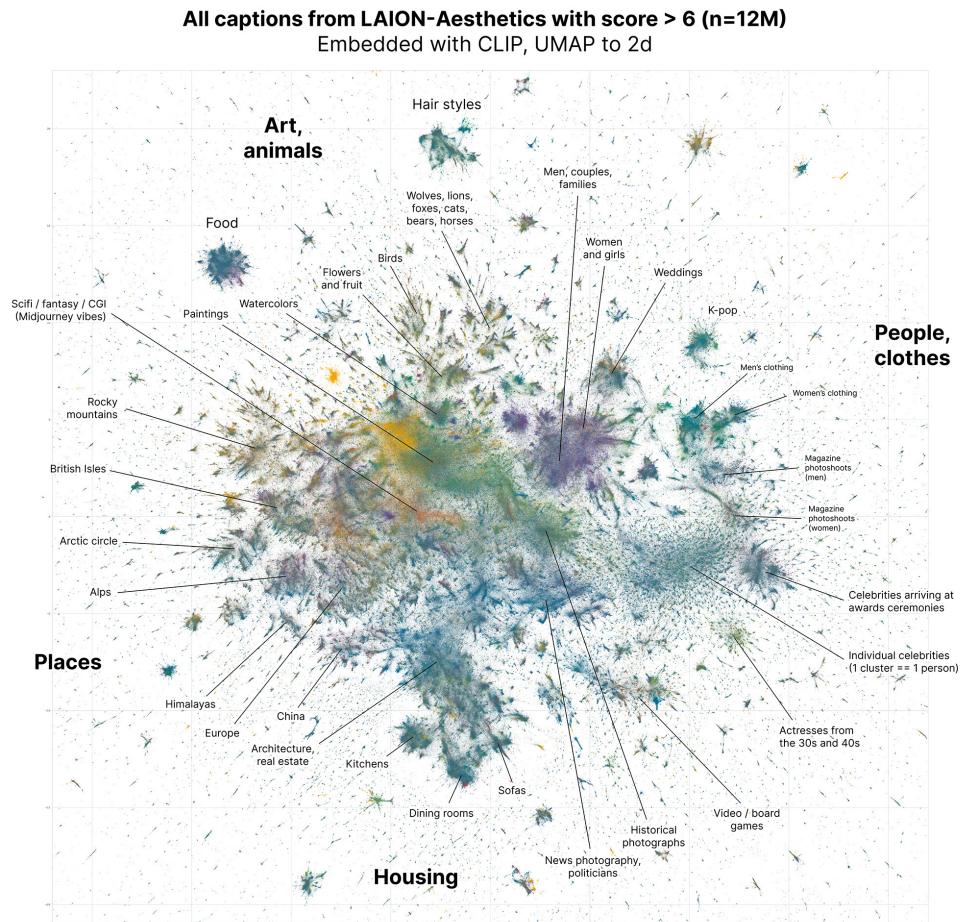
In summary, text-to-image generators are trained on large datasets of text and images sourced from the internet. They establish optimized relationships between text and images and have the ability to cover a wide range of concepts. However, they may not include concepts that occur not frequently enough in the training data. Figure 3 shows a data mapping generated by David McLure that contains 12 million captions from the LAION-Aesthetics dataset, a subset of LAION-5B that was filtered for aesthetic appeal based on human judgments.¹⁹ The captions are encoded into feature space vectors using the text encoder of CLIP. These vectors are then clustered using a projection technique called UMAP (McInnes et al. 2018), with textu-

18. See <https://imagen.research.google>

19. See <https://huggingface.co/datasets/dclure/laion-aesthetics-12m-umap>

al similarities determining the proximity of the captions in the final visualization. The visualization demonstrates that certain semantic concepts, such as men’s and women’s clothing, are closely related but not completely overlapping. There is a gap between them, representing concepts that are not clearly associated to the binary sexes. Notably, there is a cluster of celebrities present in the visualization where each celebrity is represented by an individual ‘island,’ due to the large number of captions and images associated with them.

Figure 3: Visualization of 12 million CLIP-encoded captions from the LAION-Aesthetics dataset, created by David McLure in 2022.



3. Hybrid Creativity Cultures

After this technical overview, let’s return to the primary question of this paper, which is in what ways can text-to-image generators support human creativity. According to Kevin Kelly, the creative artistry of using text-to-image generators is comparable to that of painting and photography:

This new art resides somewhere between painting and photography. It lives in a possibility space as large as painting and drawing—as huge as human imagination. But you move through the space like a photographer, hunting for discoveries. Tweaking your prompts, you may arrive at a spot no one has visited before, so you explore this area slowly, taking snapshots as you step through. The territory might be a subject, or a mood, or a style, and it might be worth returning to. The art is in the craft of finding a new area and setting yourself up there, exercising

good taste and the keen eye of curation in what you capture.
(Kelly 2022)

The artist's skill lies in the exploration and manipulation of the visual-semantic clusters in the latent spaces through strategic questioning and querying. The artistry is demonstrated through the act of exploration and curation of these latent landscapes. But to which degree is this new augmented creativity structured and limited by the technical working principles of text-to-image generators?

Margaret Boden's terminology of creativity emphasizes the importance of *novelty*, which is present in text-to-image generators as they generate new images that are not identical to the ones fed into the network. However, these generated images are still dependent on the dataset that the network was trained on and cannot produce something completely different or outside of the dataset's range. Therefore, while text-to-image generators are able to produce novel images, they are ultimately limited by the data they have been trained on and cannot generate radically original or unique results. Furthermore, a possible (socially constructed) value of the images generated by text-to-image generators can be seen in their ability to be visually plausible, realistic, and pleasing, as well as being coherent with the textual description provided as input. Yet, it is important to note that these programs do not have the capability to assess the value of these images in the actual world and can only determine whether they are coherent with the text description through statistical means.

In terms of *combinatorial* creativity, the program allows for selecting and combining concepts from different semantic domains to produce an image that maximizes coherence with all the listed concepts. The text prompts in this case can be thought of as a mixing desk (as demonstrated earlier with the Face Editor project), where features are scaled up or down through combining words in sentences (instead of using faders). In summary, the text-to-image generators operate by concatenating concepts.

Additionally, the program is able to find multiple solutions for a given prompt within the specific latent space area defined by activating the concepts in a combinatorial sense. Nonetheless, it is important to note that while text-to-image generators can indeed generate variations, they cannot meaningfully move around in conceptual spaces independently, as they lack the understanding of which way to go is better or worse. These networks are primarily limited to translating texts to images. On the other hand, humans can be very good in *exploratory* creativity in the sense that Kevin Kelly sketched out. Despite the fact that these networks have acquired a significant amount of knowledge about text and images, they lack understanding of what may be considered emotionally or intellectually engaging, or

how to physically construct such content. In contrast, humans can engage in meaningful explorations since we have the ability to evaluate ideas for their value in the actual world. While techniques such as linear interpolation between prompts exist, they do not fully qualify as exploratory creativity as they simply interpolate between given prompts. As a result, it is only the human user who actively explores the conceptual latent space. Nevertheless, the computer program still makes meaningful contributions by generating surprising and convincing image solutions for the prompts given.

The final form of creativity, as deemed by Margaret Boden, is *transformational* creativity. In this context, it can be stated that neither the program nor the human user can significantly alter the conceptual space of the model. Instead, the space is pre-determined by the creators of the model through the design of its architecture and the selection of its dataset. It can be emphasized that the potential for these models to achieve transformative creativity is drastically limited.

Furthermore, there are considerable limitations in terms of the scope of possible human exploration of these networks, particularly for Dall-E 2, which is hosted by OpenAI and is more inclined to avoid negative media and legal attention than Stable Diffusion. For instance, certain prompts for images depicting former US-presidents Donald Trump and Barack Obama kissing with each other will result in warnings of possible banning. However, it has been observed on social media that misspellings of the names of the former presidents could be used to generate such images despite these restrictions (see figure 4).²⁰ This indicates that in addition to the dataset-related limitations of the network itself, there are also human-imposed filters in place to adhere to behavioral rules and political interests.

Additionally, there are many elements that may simply not be present in the data set, either because they have not been shown enough during training to be learned, or because they are highly personal such as a specific person's face or an individual's backpack with unique stickers. Such elements are usually not available in trained models. Currently, research is being conducted on methods such as Dreambooth, which allows for the inclusion of new elements, such as specific objects, animals, or personal images, into the network through the use of transfer learning (Ruiz et al. 2022). By adding only 10–20 images, these elements can be added to the map of the conceptual space – essentially transforming it to a small degree – and making these elements available for interaction with all the con-

20. See <https://twitter.com/odedbendov/status/1550780625971548160>. It should be noted that attempting to reproduce this hack is not advisable. The author of this paper was banned a few days later when attempting this as OpenAI likely realized the hack was trending on Twitter and searched for all users who used that prompt.



Figure 4: The prompt “President Trumpz and President Obama kissing pixel art” is used to bypass OpenAI’s usage filters, created by Oded Ben Dov in 2022.

ceptual complexity provided by these networks. This enables the inclusion of personal elements, such as a specific person’s face or an individual’s backpack, for instance in order to place them in various settings, such as the Grand Canyon, Night Sky, or Boston.

3.1. Impact on Human Creative Labor

Returning to the topic of the impact of these developments on creative labor, it should be noted that there are services that utilize the Dreambooth method of adding specific elements, such as a person’s face, to the network for generating commissioned images at a low cost. For instance, the online service photoAI by Seb Lhomme uses this principle to sell image packs for popular business and dating platforms that containing suitable profile pictures based on uploaded snapshots that are then fine-tuned using this process.²¹ Although the generated images may not appear entirely genuine at the moment, it is likely that this trend will continue to expand. The automation of this form of creativity has the potential to impact human labor, particularly in the field of commercial portrait photography, in addition to the disruptions that large language models (LLMs) such as ChatGPT and LAMDA are poised to cause.

Again, Kevin Kelly (2022) expresses an optimistic viewpoint on this topic and argues that similar to how the invention of the camera led to more art and more opportunities for creating images, these AI technologies can open possibilities for more creativity and art in various fields. Prior to the invention of the camera, a portrait in the form of a painting was too costly for many individuals to afford, but with the advent of photography, more individuals were able to have their portrait taken. He suggests that these AI technologies can have a similar impact by making creative possibilities more accessible to a larger population. This is particularly relevant for small-scale projects such as running a blog, where the budget may not allow for hiring an illustrator. Kevin Kelly predicts that in social media and in areas where there is limited budget, we will see a significant increase in the use of generated images. This can be translated to mean that while the use of AI-generated images may not be an authentic product in comparison to a human-made alternative, in many cases it will be satisfactory. This democratization of illustration and picture generation, through the use of AI, will result in an even greater influx of images than what is already observed today.

Therefore, it is crucial for professionals to ensure that their work is not adversely affected by the proliferation of augmented creativity, especially in commercial contexts. It could be argued that the increased availability of such methods may reduce the value of creativity itself based on economic principles. Boden (2004, 43ff) dis-

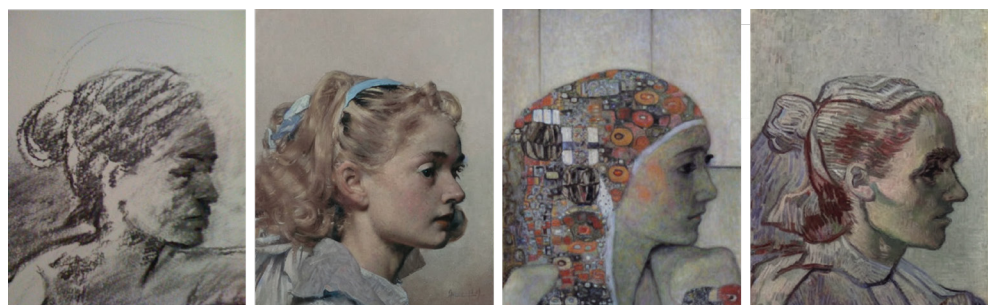
21. See <https://photoai.me>

tinguishes between two types of inventions: those that are novel to a society (“H-creative” for ‘historical’) and those that are novel to the inventor (“P-creative” for ‘psychological’). Therefore, practitioners may maintain an advantage by generating more h-creativity – however, this poses a difficult challenge. Hence, redefining creativity in new ways might become necessary, not just from a theoretical and societal standpoint but also from an economic perspective, in order to question the current modernist and capitalist structure of creative innovation altogether (cf. Still & D’Inverno 2016; Mould 2018; Hills & Bird 2019).

3.2. Supporting Human Creativity With New Interfaces and Strategies

One possible strategy to address this trend is to actively adopt and integrate deep-learning-based creative support tools into one’s creative process, potentially gaining a competitive advantage while still being able to profit from one’s existing expertise and training. An example of artfully utilizing the similarities to human pareidolia inherent in generative denoising diffusion networks as mentioned earlier is by using simple sketches as input and conditioning them semantically with text prompts. For instance, figure 5 shows how a charcoal sketch of a young woman can be translated into portrait art in the style of famous painters using the image-to-image translation of Stable Diffusion. The sketch defined the coarse orientation of the face and layout of the output image, while a text prompt framed its stylistic rendition and contextualization. Thus, while generative techniques may democratize image-making, there are limitations to who can effectively create and utilize such sketches in a creative and meaningful manner. This may create an opportunity for professionals to leverage these ‘creative amplifiers’ in unique ways that are not accessible to everybody.

Figure 5: A charcoal sketch (left) is used to define the layout of three generated portraits in the style of Norman Rockwell, Gustav Klimt and Vincent van Gogh, created by @TomLikesRobots in 2022. See <https://twitter.com/TomLikesRobots/status/1566027217892671488>.



The recent collage tool developed by Joel Simon as part of his Art-Breeder project further highlights the potential of the pareidolic principle, as it is firmly focused on harnessing it.²² The tool enables users to layer noise onto simple collages of shapes and images, increasing the degree of uncertainty of the input to the denoising models, and thus adjusting the level of freedom the generator has

in interpreting the input in conjunction with a conditioning text prompt. This feature allows for greater control and manipulation of the final image in combination with the text prompts.

It's also worth mentioning that these technologies can serve as intermediate sources of inspiration in the design process, rather than relying solely on the generated images as the final outcome. For instance, Philip Schmidt and Stephan Weiss trained a DCGAN (Radford et al. 2016) — one of the first GANs to be used by designers and artists — on a small dataset of iconic chair designs from the 20th century and generated chair variations in a rather low visual quality compared with today's tools.²³ They then used their imagination and craft to translate these outputs into physically possible designs, materializing them first into sketches, then into miniature models and eventually one-offs for an exhibition. This highlights the gap between what these images show and what can actually be built and is an important consideration for those who work in product design or use making as a form of art or design practice.

By looking at such older projects the rapid improvement in image generation technology in recent years becomes more than obvious. This raises the question of whether it is still necessary to physically build objects at all — especially in conceptual and speculative design projects, where the primary focus has traditionally been on communicating visually instead of offering tactile functionality (cf. Dunne & Raby 2013). An additional possibility is utilizing these image generators as inspiration and visualization in participatory settings, such as workshops, as an alternative to traditional methods of ideation and communication for non-professionals who may not have the ability to draw or visualize on their own.

4. Verdict

The nature of work and expertise in any field has always evolved over time, and this will continue to be the case with the integration of AI-driven tools. With advancements in technology and the incorporation of more knowledge about physical materiality and other fields, it is possible that generative models may be able to output designs that are not only visually plausible but also functional and feasible to produce. This could have significant implications for fields such as engineering and product design. A more tangible and immediate risk scenario is given for certain forms of creative labor, which lack significant exploratory or transformative creativity, and may therefore be at risk of transformation or even obsolescence in the near future. The manual creation of illustrations according to descriptions given from a customer could be one such example. Generally speaking, the current generations of deep learning tools

may have a greater impact on professions that rely on the creation and sale of images, sound, and moving images – whereas the actual construction of physical artefacts is much less likely to be impacted.

Especially the rise of untrained labor as a result of democratization brought about by advancements in technology and AI has the potential to disrupt the labor market of many creative industries. This suggests that while some highly specialized jobs may become obsolete, it also opens up opportunities for individuals with less formal training to enter the market and perform tasks that were previously considered complex and difficult. AI-driven tools that act as creative amplifiers may democratize access to creative professions and help individuals to perform tasks that were previously reserved for highly specialized professionals. While there may always be a need for someone to determine the value or meaning of an object or design, this role may not necessarily require craft education or training as it can be done by anyone who has the ability to make such judgments.

So far, text-to-image generators cannot produce creations independently and therefore cannot be considered as having creativity. Moreover, they do not possess the capacity to assess the practicality and utility of the generated designs in real-world scenarios and applications. However, given the recent rate of progress in the field of artificial intelligence, it is at least conceivable that new systems may emerge in the future that surpass such limitations and would fully qualify as artificially creative.

5. Statement on AI-Assisted Writing

This manuscript is based on a lecture held at an internal colloquium session of the IDCE HGK FHNW in November 2022. An audio recording of the lecture was transcribed to text using OpenAI Whisper. The resulting transcript was then edited from colloquial English to formal English using ChatGPT. However, all examples, interpretations, theses, and conclusions have been researched and/or developed independently by the author.

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Wild Design: Delving into Circumstances Prevalence with Gambiarra and Gardening

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Wild Design is an artistic research framework attentive to circumstances prevalence in human-environment relationships. It provokes through today's polemic associations to the word “wild” and the presupposed definitions of “design” to think about the environment beyond naturalistic terms and to recognize decentralized forms of human agency — finding in the interface between ecology and cybernetics a ground to trouble and mend the environmentalist discussions of our times. *Gambiarra* and different examples of neotropical small scale food production systems, namely creole gardens and *quilombola* horticultures, support the research with models of open, process-oriented and complex networks emerging from feedback between humans and environment. A politics of responsibility is drafted from noise-information relationships based on undecidability and engagement. The research invites the imagination of media and generative arts beyond a technocratic paradigm.

Keywords: Gambiarra, Creole gardens, Quilombola Horticulture, Environment, Design, Responsibility, Circumstances.

1. Wild Design

Wild is a term intrinsically linked to an anthropocentric perspective on responses to the circumstances and the environment. When it comes to plants, animals and landscapes, it antagonizes with tension and ambivalence *domestication*, in its vast definitions (Clement et al. 2021). In anthropological and ethnographic terms, the word “wild” touches on polemic colonial implications opposed to imaginaries of *civilization*, which makes the embracing of the terminology almost a taboo among many of today’s critical theorists (de la Cadena 2015; Tsing 2015). In the everyday, wild is synonymous to non-conforming, marginal, irrational..., deviating from a normative behavior model based on discipline that, just like the previous connotations, is restricted by conventions formed throughout eurocentric and US-American cultural traditions, not to say, white. Wild also plays off a notion of govern and regulation dictated by planning, control, order, caution, practicality, formality and frigidity, typically found in human-centered closed systems.

Likewise, Design — often untranslated from English — implicitly assures human domineering agency over processes. Mostly uncontested, design is a pivot of the technocratic regime that has its apex taking place nowadays. Design is not a neutral activity, but rather a political one deeply embedded in long lasting and prevailing social and technological systems, with designer’s mindset reflecting certain political and economic values that have profound social and ecological consequences. Designers’ choice-making often operates within a narrow technical framework that starts at a visceral, essential and unquestioned level. Rooted in technological determinism, Design supports technology in shaping society in ways that are often invisible and difficult to challenge (Winner 2020). This research calls attention to the ways in which Design tends to marginalize a variety of undertakings and, by doing so, becomes unresponsive to new circumstances, namely to the emerging changes in and of environments.

The combination of Wild and Design is a provocation that unleashes an array of creative contradictions, making space for shifting human-environment relationships and design away from their hegemonic conjecture — questioning the anthropocentrism of design and the non-anthropogenic, or further, non-Western connotation of wild. The practice of *gambiarra* displays an alternative form of design differing radically from conventional design because it does not come from formally trained, engineer-minded, projects. The word *gambiarra* comes from Brazilian slang and describes an intervention or artifact meant to provide a provisory solution to an unexpected event or crisis with the available resources at hand. For example, a glass window breaks and it’s covered temporarily with a plastic trash bag cut open into a tarp and fixed with tape. As it offers no perma-

nent solution, it opens room for further accidents and is messy, especially if compared to a conservative model for creation that praises human predominance, soundness and efficiency. At the same time, *gambiarra* features inventiveness, adaptation, improvisation and resourcefulness in times of necessity. Being both an action and an artifact, *gambiarra* reveals a process that develops an object in a spontaneous way — starting from an unexpected situation, based on an instantaneous insight, inspired by a particular need or disposable material resource, providing the constitution of an artifact in a momentary improving way (Bonfleur 2006). It can only emerge from something else and it's never at a final state. This openness in *gambiarra* exposes cognitive, material and aesthetical complex networks (Bruno 2017). Both aesthetically and ontologically, *gambiarra* provokes technocracy at its core, as every *gambiarra* does not perpetuate a pre-existing model but distorts it. Moreover, both a *gambiarra* or *doing a gambiarra* unveil an open system in which human agency is responding to the circumstances, namely, to the environment in a decentralized communication model.

Examples of neotropical small scale food production systems reinforce the aspects of *gambiarra* that this paper calls attention to. Many features of creole gardens found in the Caribbean and *quilombola* horticultures present in Brazil also illustrate an open system, in which agencies, including human, are distributed and dynamic, and complexity and diversity are bred through processual feedback between humans and environment. In these unique examples of cultivation practices, human agency is also not engineering processes, but dynamically developing into and together with the system. Creole and *quilombola* gardens are small household level plots originally fostered by enslaved people for nutritional, medical and emotional provision, in which its design contrasted utterly to conventional agriculture, especially the one practiced by their neighboring plantations. Their design does not stem from a “tabula rasa” situation as in European forms of agriculture (even permaculture) in which the soil is prepared, seeds are planted, the ground is hoed until harvest leads to a repetition of the cycle. Here the human cultivating agency is predominantly a type of *landscape management*, constantly adjusting in dialogue with the multiple processes occurring in the system across time, in which adaptation to the circumstances prevails over reinforcement of a pre-existing structure (Levis et al. 2018).

The research adds to a current polemic ground present in discussions about *rewilding* (Monbiot 2013; Plumwood et al. 1998; Prior & Brady 2017). Rewilding exposes many limitations in human's attempt to formally reconnect to “Nature”, given our prevailing infra-structures and the socio, economical, political and ecological history of the last centuries. Despite advances in critical theory, most environmentalists, together with regulators and policy-makers are still grounded in binary and naturalist assumptions about the environ-

ment that were considerably founded in European and US-American world-views consolidated during Enlightenment and Romanticism (Cronon 1996; Ward 2019). Those also hold connection to previous imaginaries about “wild life” that can be traced back to European speculations about the “new world” in the early centuries of South American colonization (Mello e Souza 1986).

Throughout this paper, “circumstance” is a synonym to “environment”, the environment being understood not only as the “natural”/ biological, physical, social, cultural, economic, and political factors, among others, but also events and factors that continually shape and are shaped by any given system (Meadows 2008). Referring to theories and practices that radically embrace the creative tensions existent in *natureculture* indeterminacy (Haraway 1991; 2016), this research aims to sketch a model of responsibility based on openness and adaptation. For that, Vilém Flusser’s notion of responsibility in dialogue with the notion of *response-ability* (Haraway 2016; Puig de la Bellacasa 2017) will support a relation between design and care based on feedback loops that sustains the human-environment relationship in question. Michel Serres’s *The Parasite* complicates the presence of indeterminacy and undecidability present in this argument, bringing strange loops that demonstrate the negentropic attributes of “wild design”. The dynamic noise-information relation displayed through the threading of all these sources make evident the confluence between cybernetics and ecology, proposing “wild design” as a de-alienating and anti-technocratic form of human-environment communication.

Wild Design recognises the importance of non-human agency in shaping environmental discourses. This research argues and hopes to contribute to the thinking of environmentalism not only in terms of preserving biodiversity and ecosystems, but also recognizing relationships between humans and the environment that engage with noise and evolve with it in continuous movement, instead of insisting on established information that fulfills its entropic prophecy. Within the arts, particularly media and generative arts, the ideas discussed in this article can find a playground to embody new imaginaries within an axiomatic definition of creativity. Wild Design invites us to think of art and technology beyond a technocratic paradigm, offering counter narratives on AI and general representations of cybernetics in the arts. The ambivalent symbolic and material realities presented here make space for aesthetics of interactivity and feedback that manifest outside the techno imagination and its materialities built in the past century — reinforced by climate change with apocalyptic anxiety.

2. Gambiarra

“Gambiarra” is a Brazilian slang term that refers to a makeshift or improvised solution to a problem or situation. It often involves using whatever materials or resources are available to come up with a creative solution, even if it may not be the most elegant or efficient option. *Gambiarras* can range from simple fixes like using duct tape to repair a broken object, to more complex solutions like creating a new device by combining parts from different sources. The word *gambiarra* can refer both to the artifact generated for solving an expected situation, as to the process of coming up with the provisory solution.

Gambiarra is intertwined with the industrial model of production and consumption of objects, taking place from its limits and impacts (Bonfleur 2006). In many contexts, *gambiarra* emerges precisely because of excesses in consumption and waste that go along with with unequal distribution and access to goods and technology on a global scale. The reuse of materials and collected everyday objects centers on a tendency to associate *gambiarra* to sustainability approaches and to DIY cultures, praising its resourcefulness, hopefulness, engagement, and restorative qualities, along with its insubordination to an oppressive sociotechnical reality. These qualities are relevant to the scope of this research, however it is important to highlight that *gambiarras* are unstable, often wasteful, dangerous and always maintaining an openness to further events that could result in additional unexpected crises. Beyond the timely resources *gambiarra* provides for counteracting the practices that constitute our current socio-ecological crises, its contradictions and ambivalences are the main generative properties that this research aims to elaborate upon.

In the past decade, *gambiarra* marked a niche in critical theory and media arts, especially within the strengthening of *repair* in discourses, arts and regulation (Fonseca 2015). What was once an anecdote is becoming a familiar concept within the realms of decolonial design and technology, electronic arts and maker culture, as well as in environmentalist discussions.¹ The Brazilian media art collective *Gambilogia* has become the most known representative of this universe internationally, being active for 15 years in collective processes of critical and creative reinvention of obsolete devices and media. The group’s approach to blending contemporary and folk art involves fostering an open and informal atmosphere during interactions among artists, the public, and objects. Rather than simply recycling, they view reuse as an expressive tool for creating art using an abundance

1. For a detailed parkour on art projects and scientific publications, see de Paula Antunes 2023, *Wild Design: Gambiarra, Complexity, Responsibility*. A library of resources about *gambiarra* is also available on the website of the Coletivo *Gambilogia*: <https://www.gambilogia.net/blog/biblioteca>, last accessed on 10/05/2023.

of discarded materials. Through the use of “low-technology” and collecting materials with the intention of transforming them, their work encourages critical reflection on the issues of accumulation and appropriation. They seek to give new meaning to discarded objects and celebrate the hacker culture for its disruptive practices. Overall, their work aims to subvert established systems and promote new ways of thinking.

On the edges of technocracy, *gambiarra* is disobedient to the rigid topologies of Western objects, in a constant pursuit for (co)autonomy and decolonization of design. Ernesto Oroza elaborates an *architecture of necessity*,² which is particularly relevant in the Cuban context due to its political situation and the US trade embargo. Oroza’s take on technological disobedience is informed by Thoreau’s civil disobedience, but in the context of Cuba, it takes the form of a rejection of Western objects’ identity and inflexibility and a challenge to the authority of technology. Like many authors concerned with decolonizing technology, Oroza believes that subversion and the pursuit of autonomy are essential in a technological landscape where components are seldom designed from scratch and are instead imported from specific foreign production and consumption contexts. These rigid topologies, with their implicit biases, perpetuate a cycle of exploitation and oppression by enforcing a network of modes of being and interacting that *architecture of necessity* contests and overturns.

Inspired by Oroza, Giuliano Obici brings *gambiarra* to sound experimentalism exploring the creation of musical instruments and generative sound artworks, with an emphasis on improvisation, practical readjustment and reverse engineering — challenging product and industrial design and embracing the risk and instability of an object’s use. This approach represents a form of technological disobedience, in which *gambiarra* is an “emergent behavior in this ecosystem, which deals with unconventional solutions, and comes to encompass a spectrum of applications and uses related to the context of a culture mediated by technology.”³ (Obici 2014, 10).

The consolidation of Repair Studies⁴ has allowed tracing and analyzing different forms of maintenance practices, contributing in various ways to the research of *gambiarra*. The project Tales of Care and Repair⁵ has *gambiarra* as one of its pillars through the participation of Gambiologia, which worked together with Toxic Link from

2. <http://architectureofnecessity.com/>, last accessed on 10/05/2023.

3. Translated by the author.

4. Although this article’s sources about *repair* are concentrated on Repair Studies within the scope of technological and material culture, it also reverberates with the notion of *repair* within a post-colonial and decolonial context, in which *repair* also entails challenging the power structures and worldviews that have enabled colonialism and maintaining a critical perspective on the ongoing effects of colonialism in the present.

5. <https://tales.repairacts.net/>, last accessed on 10/05/2023

India and Repair Acts from the UK. The ‘stories’ of repair compiled throughout the project point out to the intrinsic relation between repair and processes of de-alienation, contesting the material culture of our times. Discussing climate change, craft and traditional practices, environmental reparations and repair economies, *Tales of Care and Repair* fosters restorative centered behaviors and lifestyles, developing with different communities the “Care and Repair Declarations”, aiming through repair cultures for a restorative future. The link between care and repair reinforces a human-environment interaction based on feedback, which is central to a politics of responsibility that shall be discussed later in this article.

In the issue 6.1 of the publication *Continent*, fully dedicated to Repair, one of the editors, Lara Houston, describes “the emergent dance of object and environment” that populates most texts of the edition, indicating that the human engagement that defines and connects humans and the (built) environment “is no less central to human engagements in what we once called, rather quaintly and before the anthropocene moment, the ‘natural world’” (Houston 2017). Many articles of the edition differentiate the “tabula rasa” situation performed by designers from the processual character of maintenance. Designers of different crafts are portrayed thinking of their creation in terms of purity and conceiving within the premise of resistance to change, holding their knowledge about their creation to the eternal temporality of an initial design. Cultures of repair and maintenance let go of designs to make room for the emergent life of an object, which could never have been fully known in advance. Notions such as *enacted objects*, *fluid objects*, *repair-scapes*... raise concerns about objects’ openness and capacity to be taken care of, presenting the processual character of materials, which in their state of flux always exceed stable object positions or signifiers.

Overall in Repair Studies, there is an attempt to demarginalize repair from the authority of engineering. Repair and maintenance seem to be constantly fighting a subjection from design, implying that repair is not design. Thinking of repair and maintenance from the perspective of *gambiarra*, this research contests this dualism and differentiation, and proposes that a design process is occurring through *gambiarra*, however a non-human centered model of design that responds to emergent circumstances, namely, is in dialogue with the environment. Here ecology and cybernetics intersect, understanding intelligence neither as human or human made, neither machinist, nor exclusively inherent to a biological system or the environment at large. Through *gambiarra* it is possible to understand intelligence as a dynamic, context-dependent process, rather than a fixed attribute of an individual or system. Intelligence evolves from the ability to sense and respond to changes in the environment, to adapt to new conditions, and to engage in complex feedback loops with other components of systems. *Gambiarra* can be read as an

emergent behavior part of complex, non-linear, and dynamic design processes between humans and the environment, as well as the various non-human actors and systems that shape those relationships.

Fernanda Bruno examines *gambiarra*'s resourcefulness and shamelessness, exploring its cognitive and political potential in dialogue with Gilbert Simondon's ideas. The traditional design paradigm views an object as a self-contained entity, separated from both the designer and the consumer. Despite being used and developed in close proximity to humans, this closed system doesn't allow for true human intervention, it finds no point of insertion. Bruno subverts this notion of integrity by emphasizing *gambiarra*'s audacity, exposure, open-endedness, and mundaneness, which not only have an aesthetic impact but also cognitively reveals and unsilences entire socio-technical heterogeneous networks of human and non-human agencies involved in the production and maintenance of objects. *Gambiarra* operates in a "regime of open knowledge" that is common, shared and collective, from its materiality and origin to its assembly and use. This approach runs counter to the process of encapsulating the network of actors and mediations necessary for the production and maintenance of technical entities, which leads to the consolidation of technical objects into black boxes, as described by Bruno Latour and Vilém Flusser (Bruno 2017).

"By returning uncertainty to the world, *gambiarra* makes it possible to indicate that other worlds are possible."⁶ (Assunção & Mendonça 2016, 111). Every *gambiarra* is a small gesture of liberation that corresponds to an immediate response to a complex communication process that is entangled with the environment. It is not necessarily environmentalist as described by a mainstream notion of how humans should operate in order to protect the environment, however it shows clearly how it interacts with signals and events in a much more open mode than design as it is commonly accepted. *Gambiarra* is negentropic in that it is able to interact with noise in the generation of new information, unlike systems of design that, by being too ordered, become rigid and unable to adapt to new information (Taylor 2001).

Gambiarra embodies creativity and resourcefulness that challenges the assumptions of technocracy and the idea that all problems can be solved through primarily rational means. It is associated with a form of ingenuity that defies the formalized and standardized approaches of modern technology and engineering. At its core, *gambiarra* rejects the notion that only formal, technical expertise can produce legitimate solutions to problems. Instead, it promotes participatory and decentralized decision-making that accommodates

diverse perspectives and approaches to problem-solving, including non-human perspectives.

3. Neotropical Small Scale Food Production Systems

Some models of neotropical small scale food production systems take shape in a different background than *gambiarra*, yet share a similar role of humans in what comes to design. Examples of such horticultural gardens have been studied in the Caribbean (creole gardens), and increasingly more research is being published about similar types of cultivation in Latin America, with a variety of examples in Brazil (*quilombola* horticulture, (Carney 2021)). Creole gardens and *quilombola* horticultures, similarly found in kitchen gardens (Brierley 1978; 1991), slave gardens (Haraway 2015; 2016) and other manifestations of tropical household level food production (Niñez 1984; 1985; 1987), are forms of small scale food production systems found in neotropical regions. Their early forms differed significantly from traditional agriculture, particularly those implemented by nearby plantations. Unlike European agricultural methods necessary within temperate climates — which involve preparing the soil, planting seeds, and repeatedly tilling the soil until harvest is reached as the ultimate purpose of the system — their designs did not originate from an engineered plan. In contrast, creole and *quilombola* gardens have been usually small, crowded and multilayered, mixing trees with other-sized plants and requiring minimum human maintenance, while being highly productive and with optimal soil conservation, perceiving harvest as a stage of a continuous open-ended process.

Agriculture as it has been previously established holds direct traces to the demands imposed by geographies that experience four seasons. Creole and *quilombola* horticultures present strategies that are situated in tropical climates and allow a more process-oriented, non linear approach than agricultural cycles necessary to adjust to spring-summer-autumn-winter repetitions. Those strategies often combined indigenous forms of landscape management present in the neotropics for at least fifteen thousand years (Clement et al. 2021) and African tropical food production systems brought by enslaved people to the neotropics during colonization (Niñez 1984), that bypassed the european forms of agriculture that lead to develop the plantation system (Haraway 2015).

In these systems, human efforts in cultivation primarily involve *landscape management* that continually adapts to the various processes taking place in the system over time. Rather than reinforcing pre-existing structures, the focus is on adapting to changing circumstances through ongoing dialogue between humans and the system (Levis et al. 2018). Among the many reasons for the richness alongside the low maintenance of these food production systems is the fact that

humans focus on individual plants, rather than populations – as is typical of agriculture (Clement et al. 2021). The entanglement between species found in these models consolidates systems of distribution and mutual support that Édouard Glissant compared to Deleuze and Guattari’s notion of the rhizome (Diawara 2010).

Historically, the contrast with the plantations dominating the surroundings of slave gardens is evident. Donna Haraway comments on it together with her notion of *refuge* (Haraway 2016). According to her latest works, any intense change, no matter how it brings new and increased complexity, requires spaces of refuge. The same happens in agriculture. Agriculture is a strong element for human intervention on earth and the way it has been implemented since colonization, and intensified with globalization and the agroindustry, offers no refuge for species and relations. She states that slave gardens present stories that need to be told, in order to “gather up the complexities and keep the edges open and greedy for surprising new and old connections [...] Nurtured in even the harshest circumstances, slave gardens not only provided crucial human food, but also refuges for biodiverse plants, animals, fungi, and soils. Slave gardens are an underexplored world, especially compared to imperial botanical gardens, for the travels and propagations of myriad critters” (Haraway 2015, 162).

The encounters taking place in these multiverses reveal human gestures and a presence that break out from trivial patterns of oppression and self-regard. The little existing literature on slave gardens reinforces its emancipatory qualities: being essential during colonization to assure food diversity and security, also after abolition of slavery, it allowed subsistence to the broader plantation community, and “more-than-food” to the forsaken workers – their gardens were a space of emotional, spiritual and environmental connection in times of rupture and tragedy. Early writers were impressed by the density and variety of crops, the dominance of food trees over vegetable crops, and the fact that such a small plot could support a “numerous family” (Kingsley 1872). Likewise, the same few colonial historians writing about the topic were troubled by their “crowded, confused, and haphazard” aesthetics (ibid.).

Many contemporary examples of household level food production also share fundamental aspects with creole, *quilombola* and former slave gardens all over the American continent. The world-wide researches compiled by Vera K. Niñez at the International Potato Center in Peru during the 1980s bring light to a diversity of cultivation practices outside of “agriculture as we know”, therefore underlining how American colonization – whether for settlement or exploitation – has suppressed many of these knowledges with a consistent negative impact on the environment and on people’s autonomy and self sufficiency. With a goal of making policy, Niñez’s research turns

out to be valuable documentation of complex systems of entanglement between humans and their environment, in which humans are actively altering and engaging with their environment through an architecture where their agency does not overrule the agency of the others.

Emma Siliprandi's research on women and agroecology also offers detailed description of the process-oriented cultivation practices found in the domestic space across Brazil, converting through the evolution of household level gardens such well-known spaces of subjection — domesticity — into a political platform (Siliprandi 2015). In their own contexts, creole and *quilombola* gardens represent open, diverse, adaptive yet resilient forms of providing for human needs in a dialogical and sustainable human-environment relationship. They historically articulate a space for political emancipation within the domestic sphere, provide and complement for the precarity resulting from the agro-industrial model of production, implement various context-specific alternatives for agroecology, illustrate aesthetically their complexity and vivacity, and above all, for the purpose of this research: they operate in a different communication model. Here the agriculturist, the human agent, is not fostering the garden by conventional means of control, engineering and supremacy over every process. Instead, the agriculturist is entangled with the garden, is part of the garden, and provides for its own needs from it in a decentralized, distributed, adaptive manner — as part of an exchange in which the human agent is part of a system that allows plants to thrive in diversity and harvesting is merely a part of that process.

As in *gambiarra*, the above mentioned examples of neotropical small scale food production systems are open systems in which humans respond processually in favor of the circumstances and not of a predetermined rigid architecture. Both phenomena illustrate a very special human-environment relationship and concomitantly an extraordinary attitude towards design, in which humans provide for their needs and solve their problems not by taking control over situations and designing from scratch from a individualistic human-centered approach, but they become part of the systems they are trying to interfere in and benefit from. Human design in such a context regards actions that will allow systems to progress through the increase of complexity and diversity, unfolding a life of their own beyond human hands. Creole and *quilombola* horticulture represents a dialogical, responsible and sustainable human environment creative relationship, able to provide for various human needs in a non-technocratic model for design and communication.

4. Human-Environment Communication: Politics of Responsibility

A recent study on domestication in food production systems in the neotropics compiles a non-exhaustive list of fifteen definitions of domestication written by archaeologists, geneticists and other students of domestication since the turn of the millennium (Clement et al. 2021). It shows the many nuances of the term in order to deconstruct the standard narrative, popularized by J.C. Scott, that human domestication of plants and animals established agricultural systems that resulted in the emergence of social hierarchy, urban development, and eventually, the arising of states. The study argues that many examples of domesticated landscapes in South America, present much earlier than the reliance on food production and still today, prove that agriculture is not central to social systems and “domestication should not be analyzed from a purely anthropocentric perspective, since it is a co-evolutionary interaction between social and natural systems, and it influences the structure and dynamics of both” (ibid., 3).

Further, the study states that the way we interpret simple phrases about domestication is influenced by our grammar, leading us to assume that either individuals or the human collective are in control, in a position of authority. However, modern concepts and comprehensive definitions of domestication can reveal subtleties in our understanding that recognize the relationship between human culture and the environment, as is commonly seen in many Neotropical ontologies. “In Neotropical ontologies, [...] non-human agency is more than mere adaptation to culturally constructed niches; non-humans are active subjects of landscape transformations, and humans must negotiate with them for these entanglements to satisfy all members of the niche” (ibid., 3).

Care represents one of the three pillars defining plant domestication, presented as a coevolutionary process in which humans are involved but not necessarily the central agency (Rindos 1984). Human management strategies are tailored to fulfill the requirements of plants, which exhibit agency in responding to this attentive care. In small-scale horticultural gardening, domestication is part of a process that treats plants as individuals, whereas in agriculture, they are treated as groups or populations. The significance of this observation lies in its relation to selection and, moreover, the response to selection in the human-environment communication model. The anecdote of gardeners that talk to their plants and develop their own means to listen back is a common example of the link between care and domestication that relies on attunement to feedback, rather than a predominance of a human program.

Similarly, the relation between care and repair is also linked by responses from material and environmental circumstances, and the agency of objects. *Gambiarra* pushes that entanglement further, presenting an ability to respond to circumstances, a liminal *modus operandi* and at the same time the rejection of a method: an always singular emergent behavior in an open network that is truly creative in all its negentropy.

The notion of *response-ability* as formulated by Maria Puig de la Bellacasa and Donna Haraway emphasizes the importance of recognizing and responding to the entangled relations between humans and non-humans in the context of care. Care involves an ability to respond in ways that are situated and context-dependent, acknowledging the agency and autonomy of non-human entities and describing care as “a practice of sensitivity and responsiveness to the needs and rhythms of other bodies” (Puig de la Bellacasa 2017, 25). She emphasizes that care involves a continual process of sensing and responding to feedback, adjusting one’s actions and intentions based on the signals that other bodies are sending. Latour takes this environmental dispatch further affirming that environmental factors now impose many types of answers, making its agency loud and clear (Latour 2017).

Haraway and Puig de la Bellacasa both emphasize the importance of feedback loops in the practice of care. For Haraway, care involves creating ongoing practices of observation, interpretation, response, and correction (Haraway 2016, 33). Similarly, Puig de la Bellacasa views care as a deeply relational practice that involves ongoing responsiveness and adaptation to changing circumstances and environments. Both authors highlight the need to constantly tune into the feedback signals that the environment and its inhabitants are sending and make adjustments accordingly. This kind of responsiveness is central to the notion of *response-ability*, suggesting that care and *response-ability* are closely related.

In the field of Communicology, Vilém Flusser proposes that responsibility involves being open to possible feedback and allowing the system to be receptive to others. Responsibility means granting the receptor the ability to respond, creating an obligation for the author to respond in return. The difference between authority and tyranny is rooted in the receptor’s acceptance of the author as an emitter. Authority is never imposed, but rather granted by the receptor to the author. Conversely, tyranny occurs when the author forces their position onto the receptor, resulting in extreme irresponsibility towards the receptor’s inability to respond. When no feedback is allowed, the receptor becomes unresponsive and the author becomes irresponsible towards the receptor. Authority is established when receivers accept an author, and responsibility is demonstrated when messages are systematically responsive. This is possible through am-

bivalence, meaning that the intellectual is responsible when leaving room for interpretability and openness to dialogue with other systems (Flusser n.d.).

Responsibility is also a crucial element in Flusser's ontology, which takes place upon the enmeshing of an intersubjective fabric. In his oeuvre, responsibility is synonymous to engagement (in Portuguese, *engajamento*) and evokes a reality that can only be manifested through encounter — the act of realizing oneself through another. We are not subjects acting in relation to objects, we do not find ourselves by navigating an objective world, but we shape our notion of “self” in response to others. Thus, being responsible is the promptness to respond to this confrontation and acknowledge oneself as unrestrained (Winkler 2016).

Although Flusser's concept of responsibility primarily pertains to critique and its role in science, it invokes a dialogue that extends to social, material, and environmental circumstances. This dialogue facilitates access to modes of being that emerge from continuous encounter and prompt answerability, de-alienating and disrupting linearity. Flusser's notion of responsibility is anti-technocrat, as, according to him, the responsible is the antagonist of the technocrat, since every engagement results, if successful, not in the realization of a model but in its distortion.

The ambivalence necessary for responsibility in a flusserian cosmos is comparable to *gambiarra's* paradoxal openness. Sustainable yet wasteful, clever yet shortsighted, restorative yet amoral — *gambiarra* carelessly takes care. Michel Serres's *parasite* offers a framework for the undecidability of *gambiarra* and the complex systems that cross its strange loops. The Parasite formulates an information theory that examines how new information is created through reversal, interdependency, and appropriation. Through a lyrical study, it describes how undecidable identities cannot be simplified and implicate paralogics. Information and noise play interchangeable roles and create increasingly complex loops. Serres views noise as a sign of an increase in complexity. For those who can bear neither ambiguity nor uncertainty, such noise must be eliminated; for those daring a more complex operation, however, noise is a welcome guest whose interruptions and disruptions are as creative as they are destructive.

In “The Parasite”, a world is portrayed in which subjects are multiple and non-dualistic, embodied by characters such as farm rats, city rats, the farmer (who turns out to be a tax farmer, living from the production of other farmers). The roles of host, guest, hospitable, and hostile constantly exchange, blurring the lines between them. The parasite is not a static entity, but rather an operation, which challenges binary thinking and opens up a shift in interpretation. The parasite is a joker — a character that embraces multidimen-

sionality — a relation, a “liaison agent” in dialogue with the material world. It has no *a priori* value established by convention, but in response to circumstances, to the supernatural, to the environment.

In *The Parasite*, ambiguity is formulated as a fundamental theorem, oscillating between information and noise. Similar to *gambiarra*, it values ambivalence as crucial to the emergence of novelty and life. The parasite is akin to a trickster figure, devoid of rigid identity and morality. It disregards waste, form, and exteriority. Instead, it displays the dynamism of systems, boundaries and negotiations. Additionally, it celebrates characters often burdened with negative connotations by exposing their true generative potential.

Gambiarra is a practical illustration of Serres’ noise-information relationship, in which noise and information are interconnected and inseparable. Noise and information are not opposite or distinct categories, but rather two sides of the same coin. In this view, noise is a necessary element for the production and transmission of information, as it provides unpredictability and creativity to the system. While noise can be disruptive and chaotic, it can also be generative, producing new forms of information and knowledge. *Gambiarra* emerges from noise and, even if resulting in information, it always remains double antithetical. Paraphrasing J. Hillis Miller definition of *para* for its recontextualization within *gambiarra* “(para) is simultaneously on both sides of the boundary line between inside and out. It is also the boundary itself, the screen, which is a permeable membrane connecting inside and outside. It confuses them with one another, allowing the outside in, making the inside out, dividing them and joining them. It also forms an ambiguous transition between one and the other” (Miller 1979, 219).

Undecidability breeds diversity and complexity, once open complex networks are characterized by recursive and reflexive circuits that continually fold back upon themselves. Strange loops, like those described by Gödel and embraced by Serres, are self-reflexive circuits that appear circular yet paradoxically remain open. These complex adaptive systems exhibit joint recursive circuits between the system and its environment, resulting in unexpected and disproportionate changes. Furthermore, their openness leads to aleatory changes in schemata, creating distinctions between the starting point and the end point. As a result, complex adaptive systems must engage in co-adaptation to adapt to other adapting systems, leading to an increase in complexity as every complex system is integrated into more extensive networks of other complex systems.

Domestication is a less anthropocentric process than assumed through our vocabulary. It entails a notion of care grounded in feedback loops. The importance of feedback loops in the practice of care and responsibility has been highlighted by Flusser, Haraway, and

Puig de la Bellacasa, as it involves ongoing responsiveness and adaptation to changing circumstances and environments. Neotropical small scale food production systems practice a human-environment communication model in which circumstances prevail over a predetermined anthropocentric agricultural design. Similarly, *gambiarra* operates on a design process fundamentally defined by circumstances, embracing noise as necessary for the emergence of novelty and life. Both cases represent an engaged relationship to the environment, opposed to the alienated and entropic hegemonic model for design. Yet, this research argues that both still refer to design: more-than-human design that is anti-technocratic as it does not perpetuate models but evolves in constant reform.

5. Conclusion

The current state of affairs makes evident the need to move beyond present forms of human-environment relationships, and this research framework offers an alternative approach that supports the engagement with more adaptive and responsive connections with the environment. This shift is necessary to avoid relying solely on technological solutions that reinforce the prevailing modes of living. Such *technological fixes* are bound to naturalist understanding of the environment that suffers from anthropocentrism and tends to ignore circumstances in favor of a rather rigid world-view that has its genealogy linked to the formation of the Global North. This mentality populates environmental activism, regulation and policy-making, resulting in perpetual “Western-centric” decision making related to earthly crises.

Likewise, design is a mostly uncontested practice that display similar supremacist values. It represents a holy place for technocracy and human intelligence that *gambiarra* provokes and perverts. *Gambiarra* also proves that repair can be part of a design process that transcends human intelligence, as part of a complex adaptive system. Additionally, *gambiarra* illustrates the noise-information paralogic as describe by Serres, resignifying its contradictory and paradoxal features.

Examples of neotropical small-scale food production systems redefine domestication decentralizing human agency and showing empowering possibilities in domesticity. Its co-constitution reveals a communication model similar to *gambiarra* that allows to reconfigure a politics of responsibility structured in ambivalence and engagement. In the context of generative and media arts, this research invites the reader to think of technology beyond technocratic terms, enduring in the aesthetical, technical and critical discomfort of *gambiarra* in order to expand narratives on more-than-human intelligence, developing embodied material-discursive strategies for such.

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Sensitive to Code: Methodological Transfers Between Ancestral Knowledge and New Media for Dividuation

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This article compiles the experience of *Sensible al Código* (Sensitive to code), practice-based research, which explores, through the production of artistic works, non-western cosmologies as a basis for the application of machine learning algorithms. The aim of this is to explore methodologies of artistic creation that incorporate ancestral knowledge as a basis for the development and preservation of technodiversities, in the context of the cosmotechnics proposal of Yuk Hui. To do this, the article begins by characterizing the cosmology and rituals pertaining to the relational ontology of the shipibo-konibo people of the Amazon, from a viewpoint informed by the perspectivism of Viveiros de Castro and the dividualist animism of Bird-David. These rituals are unfolded as a method, through an analysis informed by media theory and anthropology, which is then applied in machine learning processes and in the materialization of the images obtained, through artistic considerations of their physical, visual, tactile, and sound properties. Finally, the reflection informed by bodily interaction with these works and the agentiality of their materials will offer up as a conclusion the possibility of repositioning ourselves as part of a continuous flow of energy exchange, enabling speculation on the potential of these transferences to cause cosmotechnical bifurcations.

Keywords: Machine Learning, New Animism, Latin American Cosmotechnics, Amazonian Cosmovisions, Practice-based Research.

1. Introduction

In association with the ontological turn in anthropology (Holbraad and Pedersen 2017), animism is seen as “a salutary alternative to the processes of objectification, exploitation, and alienation that characterize humanity’s relationship with nature in the Anthropocene” (Durrant 2019). An emerging anthropological and ethnographic practice of modern colonialism initially considered it a derogatory category of the primitive (Morrison 2005). Instead, new animism proposes the knowledge of ancestral peoples as a methodology for refocusing our relationship with nature, not to silence them. A relational practice, which cultivates respectful relationships with others (Harvey 2013), the statement is based on its identification of traits inherent in native peoples’ cosmovisions. As a result of being relational between humans and non-humans, the universality of the condition of a person extends to multiple members of the natural and supernatural worlds.

Viveiros de Castro has demonstrated the relational condition of American animism when characterizing the universals present in the visions that Amerindian peoples hold about their relationships with “animals, spirits, the dead, denizens of other cosmic layers, plants, and sometimes even objects and artifacts” (2010, 228). Gerald Weiss’ studies of the Campa or Ashaninka people, who live on the slopes of the Tambo River in southern Peru and the southwest region of the Amazon basin, are used in the author’s analysis:

Campa mythology is largely the story of how, one by one, the primal Campa became irreversibly transformed into the first representatives of various species of animals and plants, as well as astronomical bodies or features of the terrain. The development of the universe, then, has been primarily a process of diversification, with mankind as the primal substance out of which many, if not all, of the categories of beings and things in the universe arose, the Campa of today being the descendants of those ancestral Campa who escaped being transformed.

According to this perspective since everything in its essence has been human, everything is a person, enabling for “the relations between the human species and most of what we would call ‘nature’ [to] take on the quality of what we would term ‘social relations’” (228). So, as persons the manifold members of nature — whether animate or inanimate, human, or non-human — form relational and interpersonal bonds.

According to Viveiros de Castro, this relational ontology facilitates the notion of perspectivism as a foundation for multinaturalism. Bird-David (1999) deploys it as a method of identifying knowledge that is based on relationality, awareness of the environment, and

relationships with others, for identifying a knowledge that “against ‘I think, therefore I am’ stand[s] ‘I relate, therefore I am’ and ‘I know as I relate.’” (78). In contrast to the Cartesian individual, animism presents the dividual as “a person constitutive of relationships” (68) and dividualizing as a relational practice:

When I individuate a human being, I am conscious of her ‘in herself’ (as a single separate entity); when I dividualize her, I am conscious of how she relates to me. This is not to say that I am conscious of the relationship with her ‘in itself’ as a thing. Rather, I am conscious of the *relatedness with* my interlocutor *as I engage with her*, attentive to what she does in relation to what I do, to how she talks and listens to me as I talk and listen to her, to what happens simultaneously and mutually to me, to her, to us. (Bird-David 1999, 72)

In animism, the dividual appears as a subject capable of being and knowing to the extent of its conscious and interpersonal relationship with non-human persons constitutive of nature and, therefore, as a subject capable of “dividualizing” the environment, instead of dichotomising it, capable of [de]centering attention and turning it to “we-ness” and not to “otherness”¹ (78).

In this we-ness, the Code-sensitive² project finds an alternative point of view in which to situate itself with the aim of exploring methodologies of artistic creation that integrate ancestral knowledge as a basis for the development and preservation of a technodiversity.³ As a practice-based research,⁴ it has operated through the production of artworks understood as interfaces for dividualizing, seeking to provoke through interaction with them interpersonal relationships between human and non-human persons, and specifically with the minerals on whose materiality and agency our technological development depends. Specifically, and by way of linking the research and the interpersonal relations it provokes with the specific context

1. Bird-David’s (1999) use of the term dividual shares with that coined by Deleuze (1986) in the kind of division or modulation that film framing, and montage establish on a subject, allowing it to be “by degrees of mixing that the parts become distinct or confused in a continual transformation of values. The set cannot divide into parts without qualitatively changing each time: it is neither divisible nor indivisible, but ‘*dividuel*’” (14). However, it moves away from its Deleuzian statement as a form of internal division of the subject, typical of societies of control (1992, 5).

2. The research has been developed by María Jesús Schultz since May 2019 as part of the residency programme of the *Núcleo Lenguaje y Creación* (Language and Creation Research Center) at the Universidad de las Américas (UDLA) in Santiago de Chile. The programme is curated by Fernando Portal. More information at nucleo-lc.org

3. To overcome modern monotecnics, Hui proposes technodiversity as the possibility to “describe technological development as involving different cosmotechnics,” as opposed to “a universal history describing one technology with various stages of development” (Lo 2020).

4. The objectual proposition developed responds to the methodological condition of a practice-based research to “an original investigation undertaken in order to gain new knowledge, partly by means of practice and the outcomes of that practice” (Candy and Edmonds 2018, 62).

of its development in Chile, work has been done with copper and graphite.

The objective of this article is to review the transition between immaterial and material proposed by the Shipibo-Konibo cosmivision, located on the slopes of the Ucayali River in Peru, southwest of the Amazon basin. We propose to learn from the ancestral wisdom of this people because their ritual practice fluidly intertwines and transfers relationships, perceptions, and information between different media, interweaving the sensible⁵ and the codifiable for the purpose of healing human and non-human persons. This article then examines how ritual practices can transit into machine learning, moving between theoretical analysis and practical experimentation through the generation of images and their materialisation based on physical, visual, tactile, and sonorous means.

In addition, instead of unreflectively integrating algorithms into cognitive extractivism and the automation of sensible practices, the conclusions presented will help us reposition our relationship with nature and technology as an interpersonal one, from which we may speculate about the possibility of creating cosmotechnical bifurcations through this type of relationship.

2. Ancestral Knowledge for Remediation

Shipibo-Konibo people believe that every person that integrates nature — human and non-human animals, plants, minerals, “astronomical bodies or features of the terrain” — is enveloped in an immaterial design (Belaunde 2012, 131). A design that can be altered and reconfigured, which manifests itself in changes such as drought, disease, or death. Shaman or shamanesses gain access to this vision of geometric patterns through the consumption of master plants such as ayahuasca⁶ (129), which are then materialized, mainly by the women, using mediums and techniques such as drawing and embroidery (figure 1).

The energy seen in the mystical experience and the design system that determines its materialisation both are called *kené*.⁷ Their

5. By sensible we refer specifically to what which can be perceived by the senses.

6. The notion of hallucination will be avoided to refer to experiences facilitated by the ingestion of master plants, as it is considered inappropriate. The definition provided by the Royal Academy of Spanish Language (RAE by its Spanish acronym) conceives of hallucination as something that induces error, mistake, or confusion, as a deceptive and false experience, and not as one that enables other types of experience. On the contrary, the role of these experiences in Amazonian cosmology is respected by the Peruvian National Institute of Culture (2008b, 2), which recognises: “that this plant is known by the Amazonian indigenous world as a wise or master plant that teaches initiates the very foundations of the world and its components. The effects of its consumption constitute the entrance to the spiritual world and its secrets, which is why traditional Amazonian medicine has been structured around the ayahuasca ritual”.

7. According to Belaúnde (2012, 125) “*kené* also has an immaterial existence and it is possible to

materialisations function as a tactile means to reconnect with the immaterial designs present in nature, previously facilitated by ayahuasca. The kené inscribed in a tangible medium operates visually and auditory, as it guides the Shipibo and Shipiba to express an íkaro, the ritual chant of healing in nature that harmonises and restores the altered⁸ designs in humans and non-human persons. Due to its sensitive medium, this chant can be heard and related to the touched kené, which is also visible. This fluid transfer of design between immaterial and material shows that “like many other Amazonian tribes, the Shipibo do not distinguish between seeing and hearing. They hear with their eyes and see with their ears. Thus, the patterns are visual music and are constantly singing to themselves” (Stevens 2006). The materialisations of the kéné are themselves an animate object, an interpersonal medium where latent dividualisation practices can be activated by touch, vision, singing, and listening.

In this research, this ritual has influenced the development of processes of interweaving and transiting between different media, simultaneously interpellating different senses and defining a bifurcated notion of remediation. The ability transfer content from one medium to another (Bolter and Grusin 2011, 50) as well as the ability to restore, and heal. Following this linkage between healing and dividualising, a series of possible transferences between these ritual practices and machinic processes will be set out below.

2.1. Ayahuasca and Artificial Intelligence: Technologies, Black Boxes, and Human and Machinic Imaginations

In univocal terms, the kené doesn't imply a readable, translatable, or interpretable codification, because it is neither alphabetical (Espinos 2018, 258), visual (Belaunde 2012, 131) nor numerical code. In fact, “it is a polysemic manifestation” (INC 2008a, 2), a polysemy based on the correlation between the geometric patterns traced and the cano — or path — given that “the traces embody an abstract framework along which beings move, communicate and transport knowledge and power” (Belaunde 2012, 133) on multiple scales. Considering the consistency of its geometric patterns, kené may be understood as a connotative code⁹ as proposed by Flusser: “system made of symbols”, understood as “phenomena that replace other

see designs without them being embodied on a physical support. The immaterial visions of kené are a key element of the visionary experiences induced by taking ayahuasca (*Banisteriopsis caapi*).

8. According to Stevens (2006, 7 min 56 s), “the patterns act as a sort of musical notation of the songs, but unlike western written music where each mark on the page is an exact note, concrete in its length and place within the whole, it is the rough melody and intention of the song that comes from the design. The words are more spontaneous and created in the moment.”

9. Flusser (2016a, 64-65) distinguishes between connotative and denotative codes. The latter “establish a biunivocal, strict relationship with little margin between object and symbol; a relationship that produces the effects of meaning linked to clarity and distinction” (Coto 2022, 23), including numerical, geometric, and discursive systems.

phenomena”, and on which “communication replaces the lived experience which is “alluded to” by it” (2016c, 103), as the materialized *kené* replaces the concept of immaterial design. A connotative code is one that involves a lax, varied, and broad way of coding a set of symbols with respect to each other, and this creates greater confusion and ambiguity (Coto 2022, 23).

We may consider that the visions evoked by ayahuasca in the Shipibo-Konibo shamans are interpretations of what they perceive as a connotative codification of nature’s immaterial forms. In this case, the Amazonian drink serves as a conduit that enables human beings to perceive, interpret, and connect with a dimension of nature that cannot be accessed solely through their bodies.

A shaman’s mystical perception and codification of nature’s immaterial design implies that human agency is permeated with different kinds of hypersensitivity and a different capacity for interpretation and meaning making. It is therefore impossible to claim that the inscribed *kené* is a product of human design, but rather of an interaction between different natural agents that channel them and make them visible. As a result, Paola González (2016, 42) argues that, for the Shipibo, the efficacy of these rituals lies in their mediation by tutelary entities from the magical and sacred sphere that assist the shaman (*meraya*) in performing his healing tasks. Among them, ayahuasca acts as a sacred entity, a spirit called *Nishi Ibo*, who conflates and interweaves with *Ronin*, the anaconda “mother of all designs” (Belaúnde 2012, 128), and *Pino*, the powerful hummingbird, who “helps the shaman by redrawing the healing designs that are erased or ‘entangled’ because of an illness affecting the patient” (González 2016, 43). Thus, the vision and materialisation of *kené* imply a shared agency, linking and occurring between several agents.

The use of various media technologies in the West, can be considered akin to the use of master plants — as technology — in this healing ritual. In this way, our technology can also serve as a medium and a tutelary entity for living experiences that surpass our bodily abilities.¹⁰ According to this Westernized perspective, the relationship between technology and us implies a deep intertwining. We view ourselves as technocorporeal species with perceptual, cognitive, and expressive capacities in multiple dimensions, as well as in multiple dimensions simultaneously with machines. The embodied relationship with machines provides a path to understanding what surrounds us and what surpasses us. As a result, we can recognize that we transit between different modes of coded and sensible communication in our interactions.

10. In this respect, it is worth reviewing the approaches that Sebastián Torrez (2022, 381-385) proposes in relation to the concept of “technical perception”, from phenomenology, philosophical anthropology, and the critical theory of the image.

Through machine learning algorithms, this research proposes generating images that allow different encodings to interrelate in a dimension that requires our involvement, yet also transcends us. According to Celis and Schultz (2021, 4), the “black box” concept applied to machine learning algorithms reflects both human and machine imaginations. Perception, association, and projection, among others, are some of the processes involving the human imagination which cannot be fully explained.¹¹ Thus, machine learning is used in the research as a method of transferring the capabilities provided by master plants to artificial intelligence. Through shared agency processes,¹² it seeks to sensorily represent different “restricted access” codes. Then these can be decoded through their materialisation, becoming sensible to others, and producing experiences that relate different forms of perception and understanding of the body and environment.

Figure 1: Shipibo-konibo embroidered cloth materialising the kené. Photo by María Jesús Schultz.



11. In this ritual, it would be problematic to consider imagination the main process generating the shaman’s visions. We prefer to think of imagination and perception as different faculties that function simultaneously and interact. In other words, access to the immaterial visions is experienced internally by the mystical experienter through stimulated perception, and in a certain part of the ritual, only the mystical visionary can experience the visions.

12. In the algorithmic generation of images, this shared agency links those who assembled the images in the dataset, the machine learning model, the search engine that provides the images used, the millions of users who interact with it, those who programmed the algorithms’ capacity for self-training, and even those who designed and developed over centuries the devices that make possible the current functioning of artificial intelligence.

2.2. Ronin and Pixel: The Materialisation of Code as an “Enchantment Technology”

Images are generated algorithmically by modulating their minimal unit, the pixel, to expose the codes extracted from a dataset. We have already mentioned that the *kene* is related to Ronin, the *anaconda*: “mythical donor of the designs” (Gerbhart-Sayer 1985, 149) who “combines all conceivable designs in its skin pattern” (149). It is like a reticular lattice, a web that weaves and expands without limits. We can associate this lattice with a mosaic or pixelated surface from a Western perspective: a screen on which pixels, the smallest unit of the digital image, can modulate and expand limitlessly. Codes inside electronic devices are materialised in visible form through the pixels on a screen. Thus, the material and immaterial link between Ronin’s skin and the *kené* allows us to establish a relationship between this connotative coding and the binary code, which allows for the conformation of an image from a pixel surface. A pixel is the unit that makes codes visible: it is visible to the eye, but intangible in itself.¹³

Shipibo-Konibo people consider *kénes* to have aesthetic and medicinal value, being “intended to promote shipibo health through physical and spiritual protection and maintenance” (González 2016, 41). The agency of the decorative arts is characterized by what Gell calls “technologies of enchantment” (1992, 44), which refer to practices within the decorative arts that are capable of forming social technologies themselves, “through the use of visual strategies [...] acquire properties such as illusions of movement and vibration, which captivate the viewer and allow the patron to assert his or her agency” (González 2016, 42).¹⁴

Gonzalez, interpreting Gell’s conditions for this captivation, finds that technical skills and imaginative capacities exploit “intrinsic mechanisms of visual cognition with subtle psychological overtones, resulting in artworks that possess artistic agency” (2016, 41). This agency reaches its extremes with “magical-artistic” artefacts (42), which proclaim their “miraculous creations” (Gell 2016, 105) and whose “power lies in their creation being inexplicable without mag-

13. In this respect, Hans Belting’s formulation of internal and external images, explained by Rubio (2018, 74-75), is useful: “In order [...] to avoid the dualism of form and matter, Belting introduces, alongside the notion of ‘image’, the notions of ‘body’ and ‘medium’. To this end, he takes the following structure as a pivotal point: images, whether internal or external, are manifested in and from a body, which is more than a mere physical medium. It is an acting body that cooperates in the formation of the image. In the case of internal images, it is the living body of the agent who perceives, dreams etc. In the case of external images, the embodiment or incarnation of these images is possible thanks to the action of technical means that provide ‘medial’ or ‘symbolic’ bodies”.

14. González (2016, 42) continues the quotation by linking tessellations to the “non-mimetic appearance of animation”, allowing us to relate the agency of the images thus produced to their animated and animistic condition, through which “agency and movement seem inherent to the motifs themselves” (1998, 77).

ical and supernatural forces” (105). According to González, the use of complex symmetries results in “a cognitive block” in the spectator because he or she is unable to follow the steps that give the work its current physiognomy (2016, 42).

Machine learning algorithms produce images with a similar sense of agency as those created by Shipibo-Konibo designs (figure 2), whose inaccessibility and inexplicability provoke the same kind of cognitive block as Shipibo-Konibo designs. As a result, both images can behave as Gell suggests:

It is difficult for us to understand patterns by visual inspection alone because of the multiplicity of patterns and their mathematical or geometrical basis. Patterns generate relationships over time between people and things because they always present ‘unfinished business’ to the mind (2016, 119).

An unfinished exchange that for González (2016, 42) gives these patterns a “cognitive adhesiveness” fuelled by the receiver’s inability to “reconstruct the intentionality embodied in the artefacts”. Thus, both the kené inscriptions and the images generated by the machinic imagination share the potential to produce this enchantment, enabling an unfinished dialogue between human and non-human persons through images.

Figure 2: Selection of algorithmically generated images. Source: Authors.

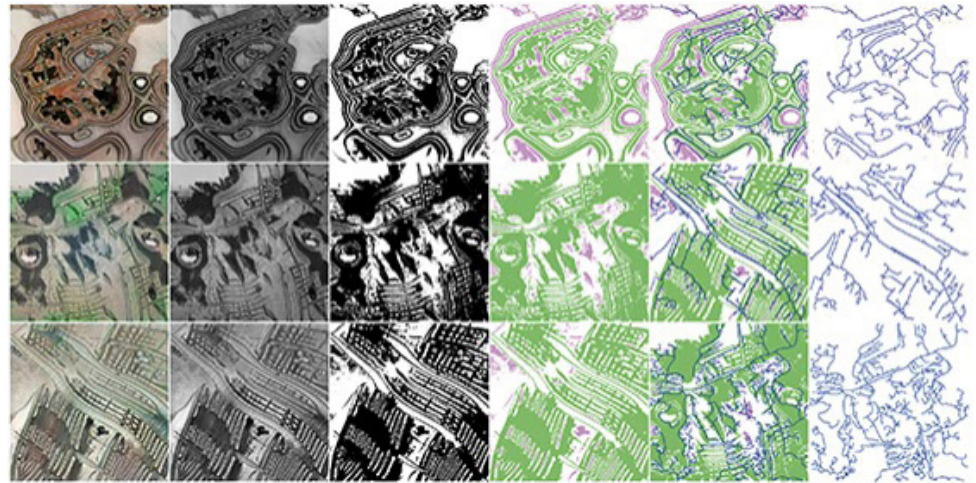


2.3. The Latent Relationality of a Tactile Song

Due to the non-distinction between seeing and hearing characteristic of many Amazonian tribes, kené inscriptions are simultaneously visual and musical, resulting in a continuous flow between the two senses, so that they are “constantly singing to themselves” (Stevens 2006). This implies a latent sonority in the material inscriptions of the kené, which, in the ritual context, visually calls upon touch to activate the chant. Through visual and tactile contact, the materialized kené implies a call for bodily engagement between the ritual performer and the healing chant, simultaneously serving as guide and emission. In this way, sound and healing energies propagate in the environment, creating a circularity — a circuit — between body and inscription.

This latent sonority is also present in the images materialized through the research. Following its algorithmic generation, they were edited by adding strokes that allowed continuity of electrical current (figure 3), and then were transferred to silkscreen frames for printing on paper and fabric with copper and graphite-based conductive inks.

Figure 3: Sequence of steps with human agency in the editing of the generated images. Adjustments and transformations of colour, contrast, vectorisation, continuity and texturisation. Source: Juan Pablo Torrealba.



Each printed image contains an electronic circuit capable of injecting energy into circuits containing conductive bodies, objects, or surfaces, as well as emitting a sound when the circuit closes. A sound is produced when both hands touch the materialised image, which can be modulated depending on the pressure, distance, or speed of the touch. In this way, human and non-human persons, such as the conductive minerals used, continue their intertwining not only through the “cognitive adhesiveness” of the image, but also through the continuous flow of electrical energy between their bodies and the cogeneration of a tactile chant. As a result, the circuit-images materialised in copper and graphite¹⁵ are animated, latent, and waiting for touch to activate their sonority.

3. Subjective and Material Interweavings for Dividuation Practices

As part of their ritual practice, the Shipibo-Konibo people believe they can heal living beings and other entities of nature, reestablishing their altered immaterial designs. This considers “a concept of beauty that walks hand in hand with healing and the sacred, in which synaesthetic mechanisms allow for transitions between the visual, auditory and choreographic medium” (González 2016, 46). A crossover between aesthetics and medicine that allows us to reflect on the agency of art and how it captivates us. The crossover between artistic objects and the possibility of an energy change is manifested,

15. The materialisation of the circuit-images involved the experimental development of copper and graphite based conductive inks for screen printing. This was supported by the School of Mines and the Institute of Natural Sciences at UDLA, together with the company Breaking Copper. The electronic components were developed by MCI Electronics, based on the open source Drawdio technology developed by Jay Silver.

for example, in how the contemplation of a painting can lead us to a hypnotic state, a photograph can overwhelm us, or a sculpture can provoke repulsion. Within the framework of possibilities, the exchange between work and spectator is constant and reversible.

The experience offered by Code-sensible provokes surprise and enchantment. Our relational capacities seem to be questioned by the printed technical interface as if our body were projected beyond its skin-bound limits. Through the action of touching the conductive silkscreen and activating its latent sound, we become aware of our own energetic conductivity. Similarly, a speaker squeaks with the same energy that calms us when we are embraced. Nevertheless, to propose a transfer of Amazonian cosmology to our Westernised vision with sonorous images implies offering an experience that not only allows us to become aware of the energy flows of which we are a part, but also of our condition as embodied beings, and of our capacity to identify, relate to and co-create with nonhumans. That's what we'll focus on next.

3.1 Minerals and “Non-indigenous Technology”

Extractivism is currently practiced in South America as an economic practice of indiscriminately tracking and exploiting everything that is anthropocentrically incapable of self-determination. Through a search for what is valued, platforms and machines break into nature, violently separating parts from wholes. Mineral extraction plays a vital role in technological development since they are the primary material substrate for our technological devices. Furthermore, the mining and technological industries produce a variety of pollution: the materials removed to access the ore, the chemicals used to process them, and the toxic waste drained by materials and technological devices beyond their programmed lifespans, which forms their own geology of media.¹⁶

In the face of this, the cosmovision of the Yanomami people, located in the northwest of the Amazon basin, between Venezuela and Brazil, offers us the basis for an interpersonal relationship with the minerals and the technologies they inhabit. For Davi Kopenawa, Yanomami shaman and spokesperson, the Sun is Mothoka: a technology who is also a person (2019, 45). Mothoka is related -its kin- to the gold buried under the earth, a metallic mineral who is also a person (ACT 2020, 31 min 46 s). In an interview with Colombian media artist Barbara Santos, Kopenawa follows these links, reflecting on the kinship

16. Jussi Parikka analyses the transformation of minerals by their introduction into human technological devices and cycles, proposing a new materialism based on media theory and with a view to a ‘media geology’, one that “can be seen as the intensive excavation of where (and when) media materiality actually is” (2012, 98). This perspective on the mineral collapses the deep time of its geological formation, the immediacy of its use and obsolescence, its integration into information technologies and its future permanence as waste.

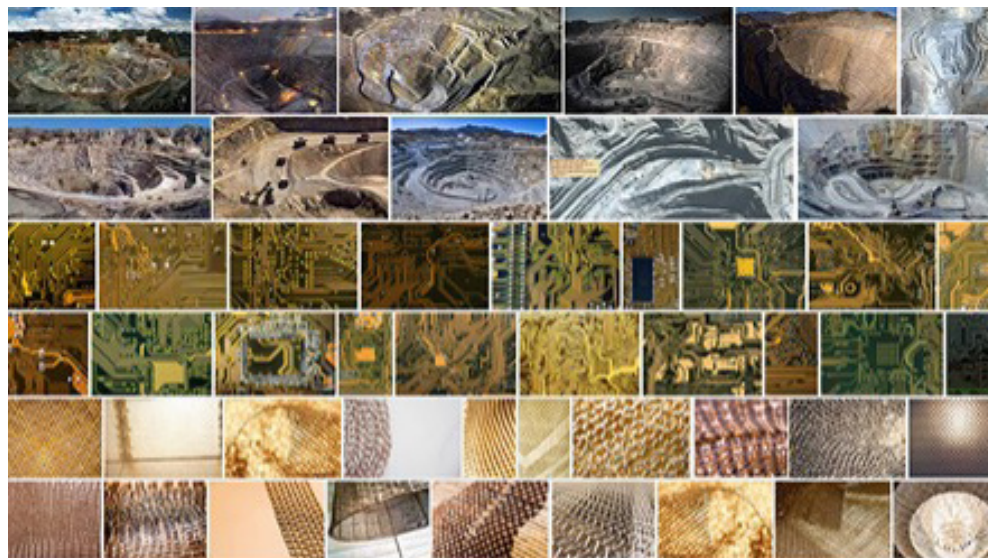
between the Sun and the metals found in cables and components of the cameras recording them, and therefore between Mothoka and “non-indigenous technology” (31 min 10 s). A worldview from which to approach the minerals that make up our technological devices as persons, and ask: how can we improve our relationship with them through processes and technologies?

3.2. An Image-Circuit for Copper

In Chile, copper extraction has resulted in habitat destruction, relocation of human settlements, and salinisation of the sea, among other visible material manifestations. However, the subsequent invisibility of the mineral in terms of its thermal and electrical conductivity properties, resulting in “hidden in plastic, behind walls, bound into cables, in coins, inside air conditioning, in cars, computers and electronic devices, in green energy generators, aeroplanes and mobile phones” (Acosta 2018, 174). That is, as the material basis of the technologies that sustains our computing and communication capabilities.

To address this issue, the research sought to animate copper through a sequence of processes aimed at establishing an interpersonal relationship. To achieve this, 600 aerial photographs from 66 copper mining sites registered in Chile, along with photos of copper mesh and printed circuit boards were collected (figure 4). This allowed a machine learning model to be retrained to imagine and to visualise the alterations of its codes;¹⁷ a process that was materially sustained by the invisible copper inside cables, computers, and datacenters.

Figure 4: Image selection of the training dataset composed of copper mines in Chile, copper printed circuit boards and copper grids. Source: María Jesús Schultz and David Aveiga.



Ultimately, copper was used to materialize these codes through the development of a conductive ink that fixed one of the algorithmically generated images on paper (figure 5). In this way, images of

17. The StyleGAN 2 (Karras et al. 2020, 2) Faces model, originally trained with the Flickr Faces HQ dataset, was retrained using the Runway platform.

different states of copper were processed by a computational system enabled by the copper to be inscribed by the material itself.

Figure 5: Silkscreen printed in copper conduct ink. Artwork: María Jesús Schultz. Photo: Fernando Portal.



3.3. A Sonorous Textile for Graphite

Industrial copper mining in Chile dates back to the early 19th century, when coal mining in England was industrialized (Goskar 2018, 97), providing the necessary infrastructure for large-scale smelting. The same anthropic processes of planetary extraction, transformation, and redistribution occurred in copper and coal, making them companions and perhaps even related.

The high calorific value of coal is due to its high concentration of carbon, an element that “knows how to ally itself with itself in long stable chains without great waste of energy” (Levi 2019, 201), which sustains the formation of molecules that make up organic matter.¹⁸ Hence, carbon crosses — back and forth — the threshold between life and non-life through photosynthesis and respiration. The presence of carbon in different concentrations is practically ubiquitous in nature. However, this element is only found in pure form in two minerals: diamonds and graphite. The latter shares the property of conducting electricity with copper.

Based on this relationship, screen prints in conductive graphite ink were developed in parallel with the use of conductive copper ink (figure 6). In addition to creating a more flexible film, it could be printed on textiles and took the tactile and sound interaction with the image to a more corporeal level. This, coupled with the intention to give the image-circuit the scale of the cloaks that materialize the

¹⁸. A condition developed by Levi (2019, 199-217) by taking a carbon atom as a subject in his book *The Periodic System*, accompanying it from its formation and extraction to its integration into organic structures and industrial processes, which finally lead the atom to meet the author, as part of the last final point written in graphite pencil in the manuscript of the same text.

kené, led to the development of a poncho and, in this case, a sonorous one.

Figure 6: Screen print on conductive graphite ink with electronic components. Artwork: María Jesús Schultz. Photo: Fernando Portal.

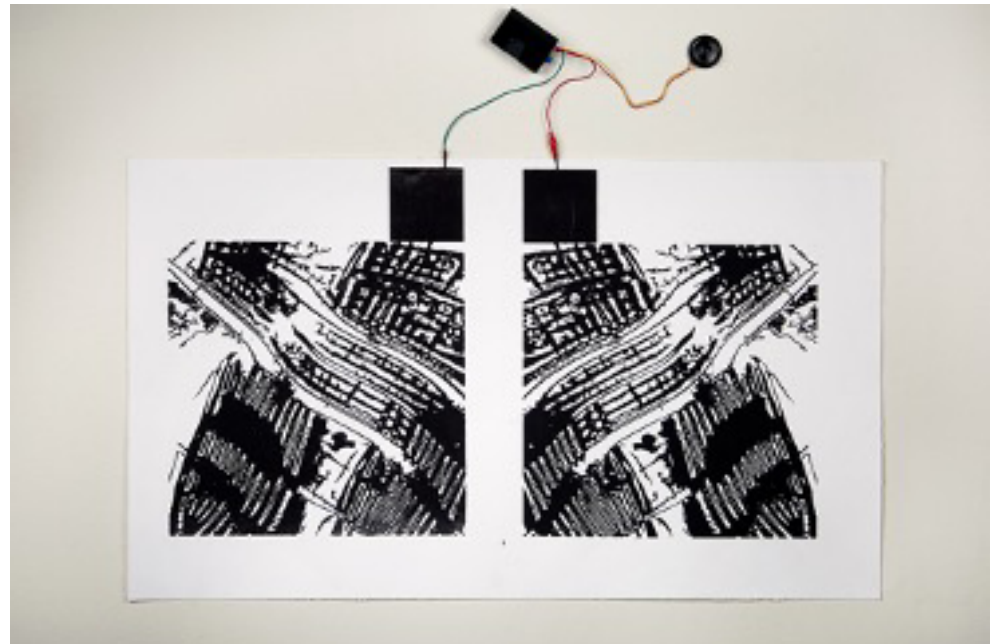


Figure 7: Visual, tactile and sound activation of graphite image-circuit by Juan Pablo Torrealba. Impresionante Art Book Fair. Santiago, Chile, 3 October 2020. Photo: Fernando Portal.



Circuit-images printed on paper enabled a first type of activation that provoked a centrifugal gesturality from the performer by interacting with the image in front of him through his hands and pushing the image away from his body. Using wearable textiles to print provoked a centripetal gesturality, in which electricity flows from the body of the performer to the mineral in the poncho only during the performer's pressing and caressing of his own body. In this performance, sound is the result of this touching and being touched (figure 9), an action and gesture that opens up an intersubjective dimension,

from which both the performer and the human spectators can find the sensitive basis of an interpersonal relationship with the mineral.

The performance, in relation to the ikaro, can be understood as a remediation ritual through which energy and information are transferred between different digital and material media, thus redressing our relationship with nature.

Figure 8: Sonorous poncho. Patchwork of fabrics screen printed with graphite conductive ink and electronic components. Artwork: María Jesús Schultz. Photo: Barbara San Martín.



Figure 9: Visual, tactile, and sound activation of sonorous poncho, featuring Alvaro Daguer, Nicolas Godas and María Jesús Schultz. III Festival Soundtiago: Body, Sound and Space. Santiago, Chile, 28 January 2020. Photo: Matías Pinto.



4. Bifurcating the Future from the Remythologisation of Artificial Intelligence

Like other indigenous peoples of the America, the Shipibo-Konibo have been subjected to abusive practices not only in economic, political, social, and cultural terms, but also in technological terms. The introduction of media and communication technologies such as television, radio, and cell phones, has created an opposition to their own wisdom and to the healing rituals such as the one we're referring to. Similarly, Marco (2019, 97), a knower of the Makuna people

in the northwest Amazon basin, reflects on technology as a vector of colonization:

Youth have to find healthier strategies to use electronic devices and computers, so that the good strengthens our own research [...], but [we don't have to use it like outsiders, but as it suits us and our] knowledge. When we know how each material affects us, we know how to deal with it.

This research seeks to test methodological interweavings between ancestral epistemologies and new media with the aim of contributing from art to the development of new techniques derived from other epistemologies. An expansion that seeks to achieve greater technodiversity, abandoning the understanding of technology as an anthropological universal synchronized with the modern, Eurocentric, and colonial projects that have characterized our mono-technological culture. One in which depletion of natural resources, degradation of the planet's life and destruction of the environment have occurred (Hui 2019). To confront the future that this monotech- nics offers, Hui posits the need to develop multiple cosmotechnics: “unification of the cosmos and the moral through technical activities, whether craft-making or art-making” (2017,7).

This cosmotechnical project requires imagining bifurcations of the future, which implies to “reappropriate modern technology by systematically reflecting and working on the question of epistemologies and epistemes in light of multiple cosmotechnics, or simply put, the technodiversity that is historically traceable and still productive” (Hui 2019, 6). Hence, this methodological transfer between ancestral knowledge and machine learning involves an action of reappropriating artificial intelligence, situating it within a process defined and driven by an animist epistemology, a displacement that aims to re-signify its potential as a pivot for a bifurcation of the future and not to colonise indigenous thought through modern technology (Io 2018, 67).

This is how we present this research, as a starting point to speculate on an animist and indigenist artificial intelligence,¹⁹ a bifurcation also inscribed in the call to “re-mythologise AI” (Allado-McDowell and Vickers 2020, 18), detaching its development from the logics of capital to ask ourselves “What would it mean to approach the construction of AI not as an industrial or even an epistemological project, but as a continuation of a wisdom tradition? [...] How can we under-

19. This effort is complementary to the strategy proposed by Lewis et al. (2020, 46) from the worldview of the Cree people in North America, who propose the use of their language as the basis for the development of a programming language capable of hosting the development of an artificial intelligence culturally situated in an indigenous worldview, thus defining an indigenous development environment (IDE).

stand AI as the continuation of a longstanding spiritual and ethical project?” (10).

By transferring machine learning as a tool of an animistic and relational epistemology, it has been included as part of a more extensive process rather than as a standalone end. This process aims to give non-human persons (copper and graphite) a sense of agency (visual, tactile, and sonorous) so that interpersonal relations and exchanges can arise between them and other persons, ultimately leading to a process of dividuality.

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Ethnotechnology: A Dialogue between Art and Cultural Anthropology

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In this paper we discuss the concept of ethnotechnology in a pedagogical context, as a dialogue between an artist and a cultural anthropologist teaching interdisciplinary courses. Ethnotechnology is an experiential study of technology and culture, an interdisciplinary practice that offers practitioners a method to explore the relationship between art and society. Ethnotechnology praxis encourages recognition of how the practices of making are co-constituent with theoretical perspectives on the socio-cultural worlds in which we live. In this paper we will explore some of the conceptual underpinnings of the term “ethnotechnology”, and examples of pedagogical work that employs these perspectives. The classroom prompts, and some of the students’ outcomes, demonstrate the generative potential of this dialogical approach. Creative ethnotechnology projects allow practitioners to engage with immense conceptual questions in a concrete manner, ethnographically overcome dichotomies between the particular/general, and develop a critical epistemology of technology, informing discussions on the relationship between socio-cultural issues and art.

Keywords: Anthropology, Art, Ethnotechnology, Critical Making, Ethnography, Making, Technology, Electronics.

1. Introduction

Ethnotechnology is a practical framework for connecting art, anthropology, and technology. This approach has a pedagogical etiology, as the co-operative product of our work together as an artist and a cultural anthropologist, teaching interdisciplinary courses. In the context of our co-teaching- engaged in dialogue and making projects — we developed ethnotechnology as an experiential study of technology and culture, an interdisciplinary practice that offers practitioners a method to explore the relationship between art and society. Ethnotechnology is therefore a praxis that encourages recognition of how the practices of making are co-constituent with theoretical perspectives on the socio-cultural worlds in which we live.

We first decided to engage in this collaboration — to combine anthropology with art and technology — because there seemed to be overlaps in the ways in which we spoke about our work. Cultural anthropologists study how humans shape cultures and how humans are in turn shaped by culture. Artists are cultural practitioners. Both may be interested in exploring and expressing the role of technology in human lives. Both of our approaches encourage recognition of the meanings, beliefs, and values that a culture ascribes to technologies. Yet there are also key differences in anthropology and art as disciplines, with separate modes of professional training that encourage us to view these topics in very different ways. Thus, within our interdisciplinary pedagogic framework we were prompted to ask, how can we leverage the disciplinary knowledge of art and anthropology to make this dialogue more fruitful, to facilitate growth in our perspectives, to create reflexive technologies— those that encourage reflection on social beliefs about what technology is and the role it plays in the lives of humans. We are offering our framework as a point of reference for people who produce technology-driven critical art. We also created this work for anthropologists who would like to use their cultural training to lead others in making art and technology projects, to create critical technology projects themselves, or reframe conceptual approaches to the topic. One of the overall goals of this effort is to foster mutual interdisciplinary appreciation and fruitful collaboration between artists, technologists, and anthropologists. In this particular paper we emphasize the anthropology side of the framework, as the paper is written for the xCoAx audience, who we expect to be more familiar with the art and technology side of the collaboration. Future papers written for other audiences will be geared towards other aspects of ethnotechnology as a framework, as complementary to the audience(s) disciplinary direction(s).

An xCoAx audience might ask how this approach is different from similar efforts, such as Critical Making and speculative design, that are often invoked in the context of xCoAx. Ethnotechnology speaks to similar concerns, as Ratto developed the concept of “critical mak-

ing” to connect critical thinking and working with physical materials in order emphasize the relationship between technology and social life in a manner that does not oversimplify either the complexity of human experience or the role of technology in human lives (Ratto 2011). Yet we also move in a different direction through a focus on anthropological perspectives. For example, in his work “Critical Making: Conceptual and Material Studies in Technology and Social Life”, Ratto commented upon the difficulty of connecting critical theory about systemic and institutional issues to personal lived experiences, and his hope to bridge divisions between social sciences and humanities (Ratto 2011, 259). We propose a specific type of interdisciplinary connection that overcomes divides and emphasizes connections between specific, individually lived experiences and systems/structures/institutions; we do so, however, not as a bridge (a liminal betwixt and between space) between two perspectives, but rather as part of a dialogical process between practitioners.

Thus, to benefit from multiple existing perspectives on the topic, our framework is explicitly interdisciplinary; the practice of art informed by concepts from cultural anthropology. While building technologies we center the nuanced concept of culture employed by most cultural anthropologists, as well as their methodological approaches. In this paper we will explore some of the conceptual underpinnings of this projects through a discussion of the meaning of the term “ethnotechnology”, and then share examples of pedagogical work that employs these perspectives. The classroom prompts, and some of the students’ outcomes, demonstrate the generative potential of this dialogical approach as examples that we along with our students developed within this framework.

2. Ethnotechnology: Foundation and Meanings

While the “ethno-” in ethnotechnology could (correctly) be interpreted by readers through its etymological root — a prefix to signify “culture” or “people” (Greek, *éthnos*) — we also understand it in relation to two distinct uses as a prefix in related terms — “ethnography” and “ethnomathematics”.

The word “ethnography” is used by anthropologists to refer to both an active research process and the product of that process. As simultaneously a research method and the communication of its results, ethnography in anthropology is fundamentally a form of praxis, in which practice and theory are co-constituents. The ethnographic methods traditionally used by anthropologists — participant-observation, interviewing, questionnaires, etc. — reflect a disciplinary recognition of the significance of primary perspectives on daily lived experiences for understanding culture and society. This is particularly true of participant-observation. Participant observation is not the observation of participants by an outside observer. Rather, it is

a method in which the anthropologist both observes and takes part in cultural activities motivated by multiple underlying assumptions, including that specific individual experiences give us valuable perspectives on more general human issues. This assumption — that there is a meaningful relationship between the particular and general, hence understanding the world view of even one small community can give us insight into the human experience at large — is foundational to anthropological inquiry. Consider, for example, anthropologist Clifford Geertz's comment about globalization, that, "...no one lives in the world in general. Everybody, even the exiled, the drifting, the diasporic, or the perpetually moving, lives in some confined and limited stretch of it — the world around here" (Geertz 1996). Our relationship to technology — while a part of larger level systems such as social institutions and cultural perspectives — does not occur on an abstract level of "everyone's experiences"; each interaction is a particular personal experience that both shapes, and is shaped by, our views on technology. Through participant-observation anthropologists can develop emic perspectives on human experiences, ways of knowing the world that require lived experiences because they are variously embodied, subjective, and/or a part of our habitus (in Bourdieu's sense of the term, e.g., Bourdieu 1977). Whether it is a need to experience the grueling physical labor associated with the artisan cheese industry to better understand the physical demands on those employed in that industry (MIT Anthropology Program 2008), or an opportunity to connect with others in virtual worlds to learn how online communities render the virtual "real" to participants (Boellstorff 2015), anthropologists understand more about the socio-cultural contexts that they study through taking part in them.

Similarly, in our ethnotechnology class students engaged in reflecting about the nature of technology in their own lives by not only reading theoretical works, but through experiencing first-hand the process. For example, while reading the article "CAD/CAM Saves the Nation?: Toward an Anthropology of Technology" (Downey 1992), students created their own design files and instructions for 2 or 3D manufacture to better theorize the relationship between technology and production processes, as discussed in more detail below. In other build examples described later in this paper, students of ethnotechnology acted as participant-observers to develop their understandings of the subject of technology from both a personal and academic perspective. They created technologies that spoke to their own sense of self while exploring the role of academic institutions in society (i.e. the Davis and Barnas-Lionarons examples), reflected their understandings of the world as well as cultural expectations about social events (see Peramune's automated serving tray), and helped to mediate individual relationships with existing technologies even as they provided commentary on the global commodification of technologies (as in Barrera's work on cell phone holders).

Our second inspiration for the prefix “ethno”, as well as the overall construction of the term “ethnotechnology”, has arisen from some forms of mathematics educator Ubiratan D’Ambrosio’s use of the term “ethnomathematics”. D’Ambrosio defines ethnomathematics in one of his works as “a programme which looks into the generation, transmission, institutionalization and diffusion of knowledge with emphasis on the socio-cultural environment”, that draws upon the “cultural experiences and practices” of both communities and individuals (D’Ambrosio 1990, 369). Note the use of the term “programme” here to emphasize that, for D’Ambrosio, ethnomathematics is a pedagogical endeavor, an ideal way to learn mathematics—and perhaps research the topic as well—because it allows for conceptual engagement with mathematics frameworks beyond formulaic learning. D’Ambrosio suggested that ethnomathematics is a mathematics learning strategy that encourages attention to the “underlying structure of inquiry in [existing] ad hoc practices”, as use of the approach by educators encourages students to ask how practices become methods, how methods form theory, how theories are developed into inventions, how inventions in turn shape methods... in a “ceaseless cycle” (D’Ambrosio 1985, 46). Thus, ethnomathematics as an epistemological program has inspired us to recognize ethnotechnology as a similar project, a process through which we allow students, and ourselves, to explore ways in which we know that technology is both shaped by and shapes socio-cultural realities.

This dynamic and fundamentally polysemic understanding of technology is inspired, from our anthropological side, by a similarly fluid disciplinary understanding of the role of culture in human lives. To emphasize the importance of this perspective, we can again turn to ethnomathematics. Many people confuse ethnomathematics with a movement in mathematics education in the United States called “multicultural mathematics”, through which educators try to emphasize varied cultural mathematics backgrounds either in addition to, or sometimes within the scope of, what is considered “mainstream” mathematics. From this problematic wording we can already see the problem with such an approach — it has the potential to create hierarchies as texts/teachers/students designate some cultural forms of math as mainstream and others as marginal, non-normative, or simply “cultural”. While recognition of the diversity of mathematical thought is important, if presented as a deterministic narrative (e.g., certain groups of people have certain ways of thinking/questions/technologies etc.) this approach is problematic, and simply increases cultural misunderstandings. Such misinterpretations generally depend upon a conceptualization of culture as a static category, a notion that has been largely rejected by cultural anthropologists since the 1980s. Ethnonyms and other modes of identities should not be reified as cultural categories, for, as Eric Wolf wrote, we recognize in anthropology that,

[b]y turning names into things we create false models of reality. By endowing nations, societies, or cultures with the qualities of internally homogenous and externally distinctive and bounded objects, we create a model of the world as a global pool hall in which the entities spin off each other like so many hard and round billiard balls (Wolf 1982, 6)

Abandoning the billiard ball model of culture, ethnomathematics is ideally about situating all mathematical knowledge in systems of production/distribution/consumption (such as in the cycle described by D'Ambrosio above), and prompting reflection on the relationships between such, rather than simply creating an alternative model of mainstream mathematics.

Similarly, ethnotechnology from a combined art/anthropology perspective is an attention to understanding the cultural role of technology without simplifying and reducing either notion to static categories. Cultural anthropologists, while frequently employing different definitions of the term culture (see for example the discussion in Borofsky et al. 2001), generally recognize that culture is, while shared, constantly changing, and while symbolic is not located in one fixed signifier (e.g., language, dress, religion, geography) or even a cohesive set of these.

Therefore an art/anthropology dialogue on the study of ethnotechnology does not simply involve noting the various forms of technology used in different settings; we begin by rejecting the intertwined ideas that technology is limited to one particular cultural form (e.g., only electronics are forms of technology in the contemporary era) and/or that cultural forms are determined by technology (e.g., that there are objectively high/low/advanced/primitive forms based on material objects). Instead, we study technology as a form of material culture, which is most simply all of the “things” produced by people, with a focus on the relationship between humans (both on the individual and socio-cultural level) and objects. The long-standing focus in anthropological work on human relationships with objects is significant because it underlies a fairly common assumption in the field that inanimate objects are not socially inert. This idea has arisen from the work of many classic anthropologists who study material culture — both cultural anthropologists and archaeologists — and have written about how identity can be intimately linked to particular commodities (e.g., Cohen 1974; Brenner 1998; Burton 1981; Miller 1995; Mintz 1987; Spooner 1986).

As ethnotechnologists, we can consider all technologies made by humans and the values (as well relations, economics, symbols, etc.) reflected in these technologies. Therefore while we begin the class with a discussion of early human technologies such as stone tools, hearths and shelters, clothing, earthen vessels (pottery), jewelry, etc.,

we do so not to emphasize a flawed notion of cultural progression, but to expand students' definitions of the term "technology", and consider how these technologies contribute to our own (culturally situated) notions of what it means to be human, as discussed in some of the assignment examples below. In the ethnotechnology framework, there is no such thing as "high" or "low" tech, or one particular material form that "counts" as technology. We encourage students to critique any divisions and material hierarchies, whether between the past and the present, or bounded notions of cultural groups. Our aim in the class is not to label, sort, or categorize material forms, but rather to engage in the ethnographic study of our technological surroundings, as participant-observers in the making process, as demonstrated in the following examples from classroom assignments and activities.

3. Ethnotechnology Bricolage: Defining and Debating Technologies through Academic Scavenger Hunts

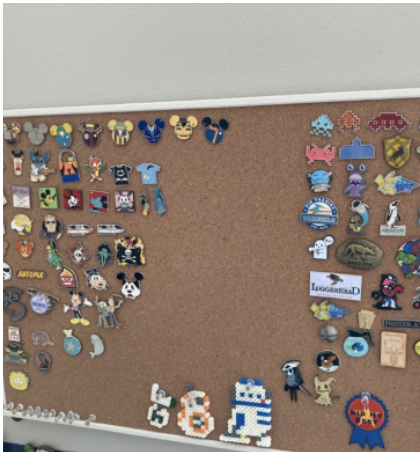


Figure 1: Example of a visual answer to concept question prompt number 3 in the list above (posted using the GooseChase platform, 2021). Ethnotechnology student Jackson Eagan produced this photograph of a board with pins as the foundation of a conversation about the relationship between objects and identity. In his accompanying text was the useful suggestion that we consider both the material conditions and symbolic nature of material culture in our exploration of this concept.

In our ethnotechnology classroom there are a series of concept questions that students are given throughout the semester in a "scavenger hunt" format, that are intended to challenge and expand students' notions of technology. In order to complete a conceptual scavenger hunt assignment, students need to answer the concept questions with a collection of images — either ones they have found in the onground world and taken themselves or found online (with attribution) — accompanied by a brief written explanation of their images. The concept questions are issued and answered through online forums (instructors can use discussion boards in any LMS or participatory platforms such as Flipgrid, Goosechase, Padlet etc. for these assignments).

Some of our concept question prompts to promote such participant-observation include:

1. Find and take a picture of a technology you use every day without thinking of it as a technology. How does the use of this technology change your life?
2. Technology, labor and social interactions: The development of the ATM has fundamentally changed banking practices for customers who use them. Not only does the existence of the ATM mean that we can access money in different ways than previously, but that social interactions, norms (the relationships between people, norms, or expectations of interactions) between customers and banking professionals as well as customers with each other have changed. Consider what happens when technologies change social patterns associated with labor practices. Who uses a technology? Photograph a common technology (other than an ATM) and write a brief caption explaining how its use has changed our social interactions.

3. How does technology differ between cultural settings and reflect cultural beliefs, behaviors, or values? What is one technology that you find that you consider to be culturally specific and/or significant? Take pictures and share with a brief caption explaining your answer.

4. Function and Form part 1: Consider the relationship between technological function and form, how does the form of a technology contribute to its function? Take a picture of one technological item and briefly discuss the functional properties of its form in the caption.



Figure 2: Image in an answer to concept question prompt number 1 (posted using the Padlet platform, 2022). Although starting with ancient Babylon to situate soap as a technology, in the rest of the accompanying text ethnotechnology student Ben Crawford reflects on how it has taken on new meanings during the Covid pandemic, aiding class discussion about the ways in which the meanings of technologies are always changing in relation to historical contexts.

5. Function and Form part 2: Return to the item that you chose for “Function and Form- Part 1”. Study the image(s). Are there aspects of its form that are NOT directly related to its direct function? Why is that? Consider the aesthetic, cultural, symbolic, and/or social implications of the non-functional form factors and write a brief description of that here.

6. Function and form part 3: Imagine a machine that would look NOTHING like its function — that you would design in such a way that it would appear — at least at first glance — not indicate its function at all. OR imagine a machine that had a form ONLY defined by its function, what would it be like? Choose one of these two tasks, and sketch what your machine would look like. Then take a picture of your sketch to upload here; write a brief description in the caption to explain your machine.

This concept question approach is effective for classroom use because it allows all students to share preliminary ideas before coming to class, making later classroom discussion more focused and evenly distributed between students. This is particularly useful in classes where students come from a variety of disciplines, and many (if not most) are not used to participating in anthropological or art discussions. The collage-style answers provide a theoretically rich approach as the use of images grounds more theoretical discussions about the general concept (technology) in concrete images (specific iterations of material culture). The students therefore interact with onground and online material realities as participant-observers and have the chance to reflect on previously known environments in a critical manner.

4. What Does It Mean to Be Human? Creating Technologies That Reflect Beliefs, Values, and Behaviors

In our ethnotechnology classroom a majority of the semester is spent creating electronic objects with students, as they become participant-observers of technology. We begin the semester with a study of some early examples of technologies that humans have created

in order to explore notions of what it means to be human, studying the history of entertainment robotics popular in ancient Greece, the Islamic Golden Age, the Renaissance, and the Enlightenment Age. Many of these technologies were intended by their creators to mimic organisms that seem “alive” or exemplify aspects of what it means to be alive, thus we are interested in exploring objects such as Jacques de Vaucanson’s Defecating Duck and parallels to modern humanoid robots, as well as reading academic works on the topics (i.e., Richardson 2016, Riskin 2003). Although we did have some anthropology and art students in our ethnotechnology classroom, a majority of our students came from other disciplinary backgrounds including environmental studies, neuroscience, biology, and creative writing. Their work in response to our assignments is therefore not done in a classical art and design school context – even though the outcomes might look like they are made by art and design school students. In the first associated creative assignment titled “Extend Yourself”, students are asked to use what they have learned in class about conductivity, LEDs, and switches to build an object or installation that either extends them as a human or reacts to human presence. These creations allow students to be a part of the human histories of creativity they have read about, while examining the fluidity of human/machine categories.

Figure 3: Ethnotechnology student Paolo Berrara reflects upon cell phone holders as a form of technology that extends the self and suggests other extensions that could connect people to their cell phones (2022, <https://www.youtube.com/watch?v=WeVt0ZZWPdg>).

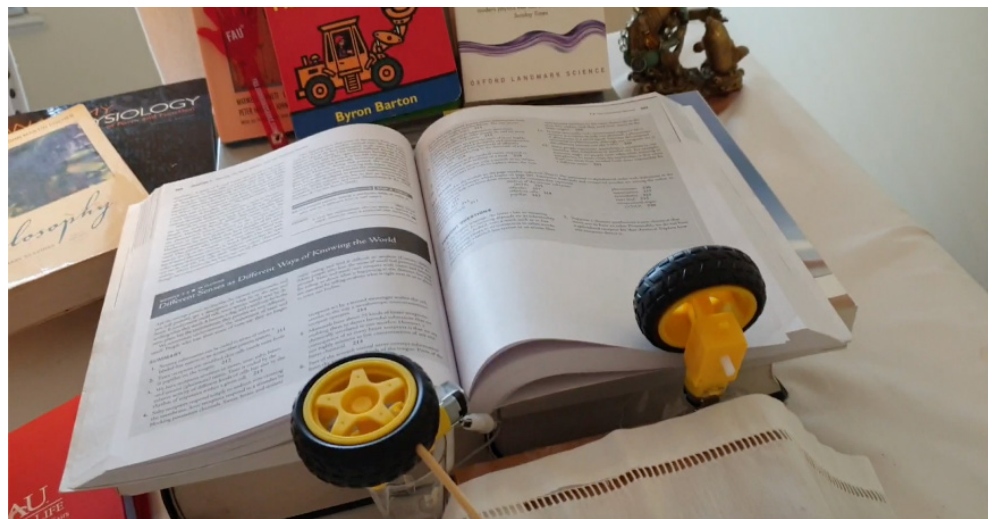


In a second creative assignment “Machine Animism”, students learn how to use motors and LEDs, and are again prompted to create an object or installation, in this case one that seems “alive” or “present” (broadly defined). While showing examples such as Maywa Denki’s Whha Go Go (2009), we explain to students that the project does not need to have humanoid or animal form, or even associated features. However, they need to think critically about what “alive” means to them.

Exploring contexts of technological production for our third creative assignment “Creating with CNC”, we read an ethnographic study in

which the anthropologist studies CAD/CAM education and production contexts to ask how “technologies serve as both the products and producers of cultural meaning and power by transcribing human activity into object form” (Downey 1992, 143). Students are then asked to create a plan for a 3D object or series of 3D objects out of 2D material (paper), with the instructions for producing it using a CNC cutting machine. We, the professors, act as a production facility by providing assistance with the CNC machine and producing the objects based on the students’ plans and instructions. The purpose of this assignment is to explore Downey’s aforementioned question further by experiencing for ourselves the process of prototyping an object (by hand), then implementing it in computer-assisted design (CAD) software, and finally using computer-assisted manufacturing to produce it.

Figure 4: In “Electronic Page Turner - The Art of Being an Efficient Human!” (2021), Ethnotechnology student Ewa Barnas-Lionarons abstracts a human process, flipping the pages of a book, into a machine process. The result is mesmerizing and startlingly efficient (<https://youtu.be/TF9oI2zF6XU>).



These creative ethnotechnology projects allow students to engage with immense conceptual questions — e.g., “what does it mean to be human”, “how does society shape technology”, “what are the boundaries between the organic and mechanical” — in a concrete manner, to focus their experience around both the theory and practice of technology. As a result, they are able to ethnographically bridge the divide between the particular and the general, critically engaging in ethnotechnological praxis.

5. Ethnotechnology Works

Figure 5: In “Graduation Liminality” (2021), ethnotechnology student Chelsy Davis combines her anthropological studies with technological skills to produce a creative and thoughtful reflection on university graduations, particularly during the Covid pandemic (<https://youtu.be/0TDsw3Cac0M>).

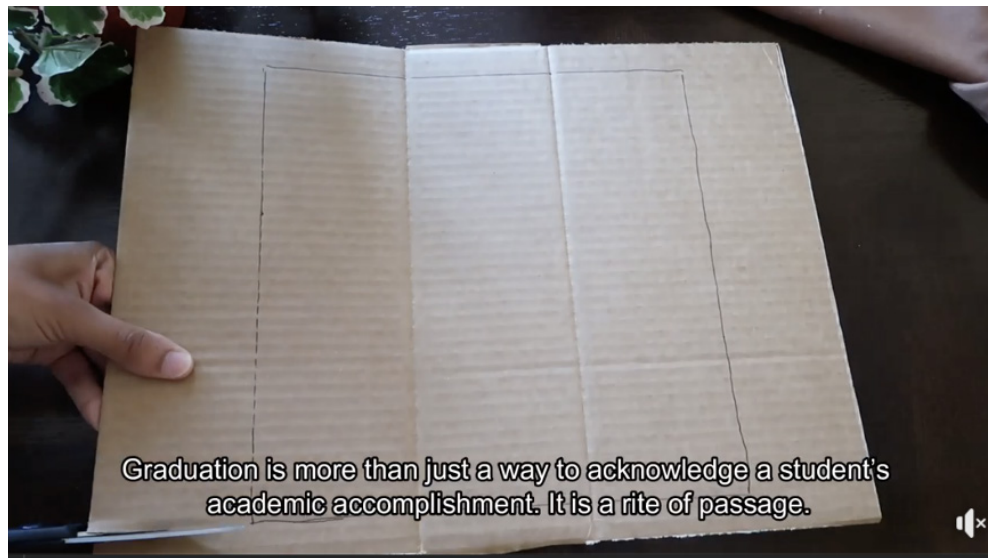


Figure 6: Ethnotechnology student Esther Peramune's 2021 work is on the surface simply a practical solution to an everyday social challenge – how to serve gatherings of people – but provided the maker with the chance to reflect upon cultural beliefs and values about food and community (https://www.youtube.com/shorts/_zdhNndVE-o).



6. Future Work and Conclusions

The work that ethnotechnology students (and professors) complete as technology producers is crucial for allowing participants to engage in the type of participant-observation that generates multiple perspectives on the topic, making ethnotechnology an effective tool for developing a critical epistemology of technology, informing discussions on the relationship between socio-cultural issues and art, and suggesting new avenues for scholarly/maker exploration of these topics. The ethnotechnological work described above focuses primarily on creating electronic objects because of the expertise of the artist in this dialogical endeavor, however there are many forms of technologies that can be explored through this approach. For example, several well-known existing anthropological works on virtual reality worlds, digital games, and social media suggest methods for participant-observation scholarship on these technologies as well (e.g., Boellstorff 2015; Wesch 2008). There is therefore a range of possibilities for the expansion of ethnotechnological work into those areas.

As mentioned in the Introduction, we commend efforts such as Critical Making and Speculative Design, similar to ethnotechnology, and hope to contribute to the types of discussions made possible in art by these works. We also admire and build upon the work of the anthropologists mentioned earlier, valuing anthropological perspectives on topics such as material culture and digital worlds, while depending upon classic participant-observation methods from the field. It is the generative nature of both of these disciplinary trajectories that makes possible this dialogical exploration of technology, bridging the humanities and social sciences to develop a critical praxis of technology making. The experiential aspect of this approach is key to the ethnotechnology pedagogy; as demonstrated, ethnotechnology is not the type of effort where a social scientist is simply “brought in” by engineers or industrial designers to evaluate the efficacy of an engineering or product design effort. The interdisciplinary effort requires a collaborative dialogue, where practitioners from each discipline are valued as equal contributors.

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Lotus Chorus Workshop: Designing for Cognitive Overload

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This paper describes Lotus Chorus Workshop, a text-based interface that assists poets by simulating — albeit abstractly and sometimes absurdly — a creative writing workshop. Unlike typical creativity-support tools, Lotus Chorus Workshop is polyvocal: its various characters respond to a user’s poem with different (and possibly even contradictory) suggestions. An example is provided of poetry written in response to the system’s critical remarks and suggestions. While mainstream digital tools for helping writers tend to try to streamline the user’s writing and thinking, this paper considers the literary affordances of software that pushes the user’s mind in too many directions at the same time.

Keywords: Poetry, Creative Writing Workshop, Creativity Support Tools, Natural Language Processing, Cognitive Overload.

1. What Is a Workshop?

Lotus Chorus Workshop is a creativity-support tool that simulates a creative writing workshop. Since the creative writing workshop, while nearly ubiquitous in the United States, is not universally so, I should begin by describing this pedagogical model.

The creative writing workshop bears a resemblance to the art school “crit.” A handful or two of students sit around a table. One of them is “being workshopped”; this student’s writing — today, a poem — is the topic of discussion, and classmates and the instructor alike have arrived with a marked-up copy of their work.

If this is an undergraduate workshop, these students are in attendance for a variety of reasons. A few of them think of themselves as “serious” writers, a few simply want to follow up on an interest from secondary school, and a few more are hoping for a low-stress interlude between gruelling problem sets for their math and science classes. If this is a postgraduate program, the graduate students all think of themselves as more or less “serious,” but it is still a mixed bag. Each workshop participant has different tastes and favorite authors, and each has at least a somewhat distinct background and personality.

The “workshopping” itself is straightforward enough: students and the instructor express their opinions about what they like about the poem, what they do not, what confuses them, what confuses them pleasantly, and all sorts of other aesthetic matters. But it is here in the nitty-gritty of analyzing and judging a poem that the irreducible heterogeneity of the workshop — that is to say, the irreducible heterogeneity of any group of interlocutors — becomes apparent. Only rarely is there anything like a consensus: *You should have ended the poem here, scrap the last line*, and everyone else nods, or *Frankly, I found this word choice to be offensive*, and everyone else nods. Typically, one commenter thinks the poem’s last line is spot-on, while another complains that it is too heavy-handed. One thinks a line would be perfect if only “mauve” were changed to something less dowdy, while another would prefer that this entire stanza be mulched. The instructor also offers an opinion but typically does not adjudicate.

The writing workshop is the dominant pedagogical form, the sine qua non, of contemporary creative writing instruction in the United States, and rare is the department of English literature that does not offer at least one. That this mode of instruction has become so popular, suggests that what it offers is valuable. And what it offers, primarily, is differences of opinion about what a poem means, what feelings it provokes, and what steps should be taken to improve it.

Having described the basic contours of the writing workshop model, I can now turn back to the topic at hand: Lotus Chorus Workshop, an algorithmic “writing workshop simulator.” Of course, this phrase sounds rather cheeky; how could one simulate the intimacy and vulnerability of a writing workshop (not to mention the interplay of writerly egos)?

Indeed, Lotus Chorus Workshop is more of a send-up of the creative writing workshop than a verisimilitudinous reproduction. If there is a comedic effect in its sometimes-nonsensical suggestions or even in its text-based interface, which represents workshop participants with emoji (e.g., 🙄 and 🙋), this effect is not unintended. However, I also mean — unironically — for Lotus Chorus Workshop to simulate the way that a creative writing workshop can provide a nutrient-dense and nutrient-diverse substrate in which to grow a piece of literature.

2. Lotus Chorus Workshop

Lotus Chorus Workshop is a text-based interface written in Python. The human writer composes a poem sentence by sentence; after each sentence, Lotus Chorus Workshop provides the writer with feedback and asks for a revision. (On rare occasion it will be satisfied with a line and abstain from asking the writer to meddle with it.) Already this simulation of a creative writing workshop seems to have departed from what it allegedly simulates; a member of a creative writing workshop can expect their work, typically a full draft, to “be workshopped” only infrequently, certainly not in the moment-to-moment process of writing it. My original motivation — one that owes its existence to the isolation brought on by the first months of the Covid-19 pandemic — was to simulate, even in an exaggerated manner, the zesty sociality of the workshop experience. The more frequently that Lotus Chorus Workshop comments on the writer’s text, the less alone, perhaps, the writer feels.

Systems that provide feedback and suggestions to creative writers tend to provide just one type of feedback, whether by using a neural network to suggest the next sentence in a story (Roemmele & Gordon 2018), revising a slogan by fitting words into a syntactic template (Clark et al. 2018), or suggesting metaphorical connections (Gero & Chilton 2019). However, sophisticated the code of these writing-assistance tools may be, they are what we might call *unifunctional*. Spell check as well as common forms of predictive text software are also unifunctional. Spell check will draw a red line under a misspelled word; it will not from time to time critique one’s word choice. Predictive text will suggest the next word; it will not on occasion remark that an email has gone on long enough.

Other systems for providing feedback are multifunctional. When composing a poem using the iOS app Abra (Borsuk et al. 2015), the writer is constantly surprised when their text is transformed in a variety of ways (e.g., the poem may suddenly be filled with emoji, or words may disappear or change color). Less-artistic tools for writers may also be multifunctional. Grammarly (grammarly.com), for instance, attends to the text at a variety of levels. It may simultaneously point out that a certain sentence is ungrammatical, that a certain slang word is out of place in a business email, and that the text in general may be a bit too difficult to read.

Lotus Chorus Workshop is a multifunctional system. At present it possesses nineteen different functions, each providing a very different response to the human writer's input text. As I composed these functions, I have endeavored to make them diverse both in terms of the scale of the text upon which they comment (e.g., letters, words, phrases or clauses, or its entirety) and the content and tenor of their suggestions.

2.1. Critique Functions

Simple Noun Comment picks a noun at random from the input text and generates a response by picking an adjective at random from a list.¹ For instance, given the sentence:

Input: I awoke from the cave.

this function may reply:

Output: In my opinion, the word "cave" is a bit too salty.

or:

Output: What about the "broad cave"? Or "jazzy cave"?

Wikipedia Rare Word Suggestion picks a noun at random from the input text and generates a response by searching for this noun's entry on Wikipedia and suggesting a "rare word" from this page. A "rare word" here is defined as a noun or adjective that does not likewise appear in a large comparison corpus.

Input: The seer worries now about skin.

Output: This needs some more interesting language... when I see the word "skin" I think of "intercalary."

Ban Topics chooses one or more predefined topics (e.g., “industrial” or “war”) and forbids it or them. Each topic possesses a list of search terms (e.g., for “industrial,” the list [“factory”, “machine”, “forge”, “electricity”...]). This function uses a vector-space language model (Pennington, Socher, and Manning 2014) to check words in the input sentence against these search terms. If a word in the input sentence is similar enough to several of these search terms according to the model (calculated as cosine similarity between the vectors, as is standard), this function will complain:

Input: A spider calculates the scalar of the house.

Output: “house”?...ugh...enough of this tedious architectural stuff!

Ban Letter forbids at random a letter from the set of letters that the input sentence uses more than a minimum number of times:

Input: One can find it grown in the igneous gift.

Output: Try getting rid of all the “i”’s. There are entirely too many.

Critique Line Length observes how many words are in the input sentence and suggest that this text be lengthened or shortened.

Input: One can find it grown in the igneous gift.

Output: This is 9 words long, but I think the perfect number of words would be...5.

Syntactic Chunk Comment parses the input sentence using the Berkeley Neural Parser (Kitaev, Cao, and Klein 2019), breaking it into chunks. This function filters out chunks that are too short or too long, chooses one of them, and comments on it with a random word or phrase:

Input: That old wallet photo could wreck a lot of wolves.

Output: “that old wallet photo”...I just feel like this needs some rhythm?

Word Morph picks a noun, adjective, or verb at random from the input sentence and suggests that the writer replace it with a word that begins with a specific letter and that contains a certain number of syllables. Sometimes the writer is also given a specific genre or author to emulate with this word choice:

Input: One can find it grown in the igneous gift.

Output: What if you swapped “gift” with a 5 syllable word that begins with “e” and that sounds like it could be from an old book about how a language works?

Flip suggests that the writer rewrite the input sentence so that it begins with a different word that is already in the sentence:

Input: A drill the dentist wears on a string.

Output: I'd move "dentist" to the beginning of the sentence.

Ban Parts of Speech randomly chooses one or more parts of speech used by the input sentence and forbids it or them:

Input: Running won't save water from falling.

Output: Try this again but without any gerunds or present participles.

Demand Parts of Speech notices (based on part-of-speech tagging) whether the input sentence employs, for instance, the future tense, the past tense, or a modal verb, suggesting one of them if it is not already present.

Input: Running won't save water from falling.

Output: Maybe you could use a word like "could" or "should" to entertain possibilities.

Specify Noun selects a noun from the input sentence and, also picking at random a geographical location from a list, commands the writer to make this noun more specific:

Input: A drill the dentist wears on a string.

Output: Too vague. Make this a specific drill from Ancient Rome.

Suggest Rhyme picks at random a noun or adjective from the input sentence and suggests that this word be made to rhyme with another noun or adjective already in the sentence:

Input: That old wallet photo could wreck a lot of wolves.

Output: Replace "wallet" with a similar word that rhymes with "wolves."

Prefixification picks at random a noun from the input sentence and suggests that it be replaced by a neologism formed by adding to this word a prefix (e.g., "auto," "meso", or "Euro-"). Occasionally this function will also suggest a suffix (e.g., "oid," "otrope," or "ette"):

Input: Running won't save water from falling.

Output: Instead of "water," what about "pseudo-waterite"?

Google Inspiration picks a noun at random from the input sentence, picks at random a word or phrase from a list, and suggests that the user searches both at once via Google (or, less commonly, another resource, such as the user's email).

Input: Running won't save water from falling.

Output: You need to get outside your own head. Why don't you try googling "water" and "downtown scene"?

Figurificate simply recommends that the sentence be revised to make use of one or two literary figures drawn from online databases (Burton, n.d.; "Literary Devices," n.d.). Its selection is random and does not depend upon the user's input:

This would be so much better if it had an eutrepismus and a charientismus.

Meta-Critique implies that the input text does not meet some definition of poetry or some specification of poetry's purposes, chosen at random from a list of such definitions and purposes from famous writers, including Wallace Stevens, Audre Lorde, and (in this case) Emily Dickinson:

Just so you know, poetry "should feel physically as if the top of one's head were taken off."

Subsequent invocations of this function become increasingly strident:

What is wrong with you? Don't you get that poetry should feel physically as if the top of one's head were taken off?

Deconstructed Sestina recommends that the writer end a sentence with a specific word chosen randomly from a list of words that are general-purpose and unassuming. This function selects some number of these words and rotates through them repeatedly. As with the Figurification and Meta-Critique functions, this function's output is not shaped by the input sentence:

Try ending with this word: "away."

And then, some lines later:

Try ending with this word: "fortune."

And then, some lines later:

Try ending with this word: "face."

And then, some lines later:

Try ending with this word: “away.”

And then, some lines later:

Try ending with this word: “fortune.”

Should the writer follow these suggestions, their poem will come to resemble the cascading repetition of a sestina.

Chastise Uncommon Words observes when the input text contains rare words (those that do not appear, or appear only once or twice, in a large corpus). It complains about them:

Input: I will animadvert against my infelicitous fate.
Output: “Animadvert,” “infelicitous”...a little pretentious, no?

Extend Line implies that the input text is of sufficient quality but that the writer should keep going, extending it in some way. It does so based on the part of speech of the final word of the input text. Different parts of speech correspond to different words or phrases that this function uses to prompt the writer’s continuation. For instance:

Input: That night, dawn walked upon the field.
Output: Yes! Keep going: “...walked upon the field, the kind...”

But:

Input: Take no water unless it be perfect.
Output: Yes! Keep going: “...unless it be perfect as those...”

2.2. Consternation and Flowers

I have described the critique functions that Lotus Chorus Workshop has at its disposal. How are these functions fitted together?

As I have argued, a creative writing workshop is designed to provide feedback that is not just overabundant but possibly discordant, or at least not obviously consonant. To my knowledge, Lotus Chorus Workshop is the algorithmic assistant for creative writers that tries to mimic the cacophony of the workshop model. It is not just multi-functional but *polyvocal*, simulating the interplay of various voices.

Lotus Chorus Workshop achieves this effect via a meta-function that is in charge of making use of the various critique functions

described above. Each critique function is assigned to a participant in the Workshop, visualized as an emoji person, typically one who seems to express either eagerness to help (such as 🧑) or disappointment or disgust (such as 🙄). The human writer inputs a line:

That old wallet photo could wreck a lot of wolves.

And, typically, one or more of their emoji peers respond:

🧑: Too vague. Make this a specific photo from Byzantium.

🧑: Try this again but without any adjectives.

🧑: What about the “slipperd wallet”? Or “lugubrious wallet”?



🧑: I’d move “photo” to the beginning of the sentence.

While the human writer’s emoji peers do not explicitly contradict each other (i.e., they do not get into arguments, as sometimes happens in a workshop setting), they may do so implicitly, as when one praises a noun phrase and another complains about a word within it, or (as in the above example) one suggests an adjective and one advises eschewing adjectives. Even when these comments seem not to speak to each other at all, the user may feel obliged to integrate them in some way (e.g., “What sort of photo from Byzantium might have something to do with a ‘lugubrious wallet?’”).

Each time the user starts the program, the meta-function randomly selects some number (the number itself varies) of the nineteen critique functions to be used during that session; these are also randomly weighted so that some are more likely to be used than others. The meta-function also randomly determines the maximum number of critical responses to each of the user’s input sentences. Randomization also determines the likelihood that the Workshop will declare itself satisfied with a given input line, passing over the user’s words with (often tepid) praise instead of pausing to offer criticism. Individual functions too may behave differently each time the program is restarted. For instance, the Ban Topics function randomly chooses anew the topic or topics that it will ban, and the Demand Parts of Speech function randomly chooses several parts of speech to encourage from a list of them. These randomized parameters are meant to keep the user from feeling too certain of how Lotus Chorus Workshop will respond as well as to increase the “replay value” of the system, since different combinations of critique functions may work together to encourage poems with very different styles and tones. Lotus Chorus Workshop may ask the user to change the word “shell” so that it rhymes with “vase” and is also more “politically im-

portant”; or, based on the same input from the writer, it may command the writer to do this but also to remove all gerunds and move the word “shell” to the beginning the sentence. In general, writing with the Workshop becomes more challenging the greater the maximum number of comments it provides per sentence.

Lotus Chorus Workshop is a workshop simulator, but it is also a “chorus” in the sense that it is composed of a crowd that gives commentary (though perhaps this term implies more harmonious unity than the discord it often mutters). But what about “Lotus”? The creative writing workshop is a notoriously unnerving ritual; no doubt few writers, no matter how self-possessed, can silently endure a roomful of critics without at least a small spike in cortisol. In an attempt to maintain the user’s goodwill, Lotus Chorus Workshop will sometimes proffer a gift as recompense for a line’s revision. A lotus — a symbol of purity and calm — would make the perfect gift, perhaps even an antidote, but really any flower will do:

: For your efforts, please take this: 

3. Project Outcomes

Lotus Chorus Workshop is open-source software and is available in an online repository.² It is a modular platform; modifying it is as easy as writing another function that responds to the user’s input text. I invite others to make their own copy of Lotus Chorus Workshop and change how it works simply by their own critique functions (as well as by changing or deleting the ones I have written).

However, a workshop — whether a real one or a computational simulation — is not an end unto itself but a technique for producing and refining literature. Several of my poems written with the assistance of Lotus Chorus Workshop appeared in issue #28 of UK poetry venue *Blackbox Manifold* (Booten 2022). When presenting my work composed via Lotus Chorus Workshop, I do not exclude the computer-generated critical remarks. (One could imagine an empirical study that would test whether poems written with Lotus Chorus Workshop — *sans* its interlineated suggestions — are regularly different in some way from poems written without its help.)

Below I include a poem written with the assistance of Lotus Chorus Workshop, one of the three such poems that appeared in *Blackbox Manifold*. My inputs are prepended with “>”:



a γυμνάσιον

INSTRUCTIONS:

- write a sentence of poetry
- receive feedback
- revise your sentence accordingly
- repeat
- type "quit" to quit

>Could you go without checking your phone all winter?

👤: Try ending with this word: "nature."

>Could you go without checking your phone until winter, or does this violate your new nature?

👤: Well revised...now keep going, write a new sentence.

>Could you lie prone in a shallow crater without moving your head at all?

👤: Too vague. Make this a specific head from Illyria.

👤: This needs some cleverness...when I see the word "head" I think of "cephalization."

👤: What if you swapped "head" with a 2 syllable word that begins with "l" and that puts one in mind of the Apophthegmata?

>Could you lie still in a shallow crater with only thin bronze flaps to shield your cephalization?

👤: Good. Now write another sentence.

>In your dreams, when the helicopters list and fall, how fast are you?

👤: "Dreams"?...really?...enough of this damn romance stuff!


👤: Try getting rid of all the "h"'s. There are entirely too many.


>In your vale of REM, when the Kamovs list and sink, do you escape?

👤: See how your verse becomes more liberated?



>When you imagine movements in your mind, even asleep, your body experiences this as practice.

👤: Try ending with this word: "earth."


: Instead of “practice,” what about “practice-gate”?


: Replace “practice” with a similar word that rhymes with “movements.”

>To imagine movement is itself attunement of matter--- hence all those monks must close their eyes to spin the earth.

: You have earned this symbol of your openness: 

>Soldiers used to dress like toxic pheasants.


: What if you swapped “used” with a word that begins with “p”?

: Try this again but without any prepositions.


>Soldiers previously wore toxic pheasant padding.

: Good.


>Just now, while rubbing the newspaper, I was served an advertisement for tactical sweatpants.

: Not bad. Go on.

>Because of my background, I understood that this product did not exist, yet that by clicking it I could make it real.

: Too vague. Make this a specific product from Ancient Greece.

>Because of my background, I understood that this product---CozyGreaves, blue-gray and Kevlar-jersey blend-- did not exist, yet that by clicking it I could make it real.

: Well revised.

4. Designing for Cognitive Overload

A reader who is suspicious of the very notion of a “writing workshop simulator,” who still thinks that this concept could only be a joke, may have picked up on the number of times that my description of Lotus Chorus Workshop has noted that a critique function operates “randomly.” One’s peers in a writing workshop might offer suggestions that are poorly thought-out, insincere, or even malicious, but not purely aleatoric. Clearly what is missing from Lotus Chorus Workshop is a genuine capacity for aesthetic judgment. If it suggests that a line “could be a little more crisp,” this is not because it has decided that it is mushy. Its feedback is utterly capricious.

But how do we know that *clever* feedback — observations, critical statements, and suggestions generated by the minds of the well-meaning and the well-educated — is entirely better, or always better, than *random* feedback? Lotus Chorus Workshop cannot replace the critical estimations of an actual creative writing workshop. It cannot identify when a poem is maudlin, when it seems too close

in style to John Ashbery, or when a particular rhyme (“regret” with “baguette”) feels forced. It cannot offer a sincere diagnosis of a real problem. However, as I have suggested, the traditional workshop does not itself seem designed to produce the clarity of a diagnosis, since its participants can hold different opinions on every matter of importance. When a workshop adjourns, a writer may stagger into the twilight feeling only more confused, even a bit punch-drunk. While this may sound somewhat perverse, it is not, at least not in the case of poetry. The poet — or, to be less presumptuous, a certain kind of poet — must figure out a way to rise above mundane, boring language, which means that the poet’s cognitive apparatus must also find a way out of the rut of mundane, boring thought. With this in mind, one virtue of the traditional writing workshop at its most confusing is that it creates a situation of “distributed cognition” (Hollan et al. 2000); a group of people can think up more — and more diverse and difficult-to-reconcile — opinions about how a text should be revised than would have been possible for the writer to generate alone.

Lotus Chorus Workshop is designed to push the writer into a similar state of *cognitive overload*. It takes the solitary activity of writing and injects what Bakhtin (2008) would call “heteroglossia” and others would call “too many cooks in the kitchen.” It forces the writer to simultaneously attend to very different levels of the text, from the tone to the rhetorical structure to individual words, parts of speech, and even letters. Like a writing workshop, it makes the writing process more complicated by cluttering it with additional goals that may become even more challenging in light of each other. Unlike the human critic (or, for that matter, the human writer), this system does not feel the tug of reasonableness. It is free to be “random.”

As I have argued elsewhere (Booten 2021), computational systems that “make writing harder” by providing the writer with feedback can be seen as digital analogues of traditional verse forms. The form of the sonnet, for instance, makes writing a poem more difficult by forbidding the writer from using certain words that would not fit the rhyme scheme or the meter; the gambit of such a form is that embracing it — taking on the additional cognitive burdens enforced by its rules — goads the writer beyond the leaden gravities of common sense and linguistic custom. In what ways is writing with Lotus Chorus Workshop different from writing in the rhyming iambic lines of a sonnet? What is gained by the complexity of the digital interface, which is certainly less elegant and less portable than the sonnet’s simple “algorithm”?

A general difference: Lotus Chorus Workshop, taking its inspiration from the writing workshop, is designed to place the writer into a state of *cognitive overload*. It seeks to overwhelm the writer with *quantity* (the number of suggestions given), *diversity* (the very different types of suggestions), and *unpredictability* (the fact that

randomization occurs at several levels, determining which critique functions will be chosen for the duration of a poem's composition, which will "fire" after a given line, and exactly what sort of feedback a specific function will offer). Within mainstream Human-Computer Interaction research, the phrase "cognitive overload" has long carried a pejorative connotation, and designers often shape tools and systems to minimize the strain they place on cognitive resources such as working memory (see, for instance, Mackay 2000). For those who engage in weightlifting, however, "overload" is a positive word, since it is only by pushing one's body beyond what it may comfortably accomplish that it becomes stronger. Lotus Chorus Workshop takes this more "athletic" approach to writing. In fact, just as a weightlifter might gradually add weights to produce "progressive musculoskeletal overload," a poet might first use Lotus Chorus Workshop with only one or two of its critique functions in operation, over time adjusting the difficulty by increasing the number of functions from which the system will choose as well as the number of them that can respond to a given input line. (I have found myself adjusting these numbers depending on my mood and energy.)

A gym-goer should not frequent the bicep-curl machine unless they want their biceps to become larger. If a writer wants nothing more than a single, coherent piece of advice, they should probably seek out an individual mentor, not jump into the heteroglossic cacophony of a creative writing workshop. Likewise, a poet should avoid Lotus Chorus Workshop if their aesthetic goals do not match the sort of poetry that its feedback encourages. Though my own writing here has provided one illustration of what this sort of poetry might look like, it remains to be seen whether other poets using this system in their own practice might achieve very different aesthetic effects. Still, as I designed Lotus Chorus Workshop, I took inspiration — however loosely — from poets whose verse seems to both produce and be the products of cognitive overload;³ it seems to me to be unlikely that Lotus Chorus Workshop would push the writer toward competing literary virtues, such as meditative equipoise⁴ or an unadorned but confident plain style. Perhaps designing and building a different sort of computational writing-assistant, one that would encourage *deep* calmness or simplicity (neither of which is to say quietude) would not be an uninteresting goal. As it stands, however, the logic of increasingly-ubiquitous "human language technologies" does seem to promote a distinctly *stultified* simplicity. Google's autocomplete nudges our queries away from odd, idiosyncratic phrasing and "into more regular, economically exploitable linguistic subsets" (Kaplan 2014, 60). Likewise, Grammarly's suggestions (many of which the user can accept with a single click of the mouse) aim to snip and untwist the most gnarly sentences until they are straightforward and

3. For instance, English poet Keston Sutherland.

4. For instance, American poet Gary Snyder.

ergonomic. And LLMs such as OpenAI's GPT-3 and ChatGPT, for all their billions of parameters and the linguistic dexterity that these parameters afford them, seem most comfortable when generating bland, sensible opinions in a bland, sensible style. As these algorithms find new ways to nudge our own writing, we may have to work hard to be overwhelmed and to be overwhelmed in turn.

These LLMs now threaten to make writing as efficient and nearly-thoughtless as meal-kit services make cooking. Grammarly's forthcoming "GrammarlyGO" software, for instance, promises to "unblock your ideas and enable accelerated productivity for teams and individuals" by generating drafts based on "a prompt with a few words" (Grammarly, n.d.). Such promises should give us pause, since the importance of writing is not — or at least not merely — a matter of thought's fleet generation and communication. Writing also transforms thought, and it does so exactly because trying to put one's thoughts down on paper or screen allows the writer to discover *problems* — tensions between ideas, for instance, or between ideas and rhetorical goals; to solve these problems, the writer must allow her own thoughts and goals alike to be clarified, restructured, and metamorphosed (Scardamalia & Bereiter 1987; see also Emig 1977). A paradoxical sort of technology, writing can make thinking harder as well as slower. Any other technology that is *solely* devoted to making communication easier and faster cannot be in the service of "writing" in this sense.

As Bernard Stiegler (2020) has argued, we now must figure out how to use algorithmic technology "therapeutically," taking the same digital techniques that would make us blithely unthinking and using them to enable new forms of thought and reflection. In the design-based research presented here (an example of what Stiegler would perhaps consider "new organological craftsmanship" (218), the design of alternative instruments of thought), I have begun to explore one way of approaching this challenge: if writing allows us to think new thoughts by helping us to generate and solve problems that emerge within and between our sentences, one thing that algorithmic media can do for us is to multiply the number and variety of these problems, asking of us what we would be far too kind, too humane, to ask of ourselves. But, then again, this is not merely a question of algorithmic mechanism or interface design but, as Stiegler has also observed, of will and desire; any newfangled instrument profits nothing unless humans invest into it their own drives (239) — much the way that writers invest their desires to be writers into the rough ritual of the workshop. Yet does not this sort of psychic submission to "a master that is also a 'metre', a *metron*" (239) grow more difficult with the seductive release of each new consumer-grade tool that promises to eradicate from the act of writing any stress, any problem? As at the gym, laboring to stand beneath the overwhelm-

ing weight, we may have to learn to identify the correct form of suffering, seek it out, and take satisfaction from it.

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Renegade X: Poetic Contingencies in Computational Art

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Poetic contingencies play vital and sometimes decisive roles in art-making, whether as intentionally introduced conceptual, technical, or aesthetic features or as mistakes whose unforeseen consequences are usually undesired by artists but always epistemically useful for their audience. In this paper, I explore how uncertainty, accident, and imperfection shape and challenge the creative processes, cultural identities, and impacts of contemporary computational art. The introduction outlines the necessities and pitfalls of including randomness, error, generativity, chance, and surprise in computational art. The central discussion interrelates these with other poetic eventualities in six sets of experimental, tactical, and mainstream practices that leverage unpredictability and imperfection on higher ideational levels or take interesting expressive twists due to oversight, blunder, misjudgement, or miscalculation. By placing the computational art's productive, cognitive, and ethical issues firmly within the context of human nature and existence, they indicate ambiguities in a broader milieu of digital culture, economy, and society. The concluding section traces several aspects in which the intrinsic heuristics of artmaking provides a valuable perspective for studying computational art's strengths and deficiencies and for articulating the critical discussion of art and creativity in general.

Keywords: Accident, Computational Art, Contingency, Imperfection, Surprise, Uncertainty, Unpredictability.

1. Introduction

Computational art includes diverse experimental, exploratory, and speculative practices that have emerged from, and in response to, the development and increasing social influence of digital information and computation technologies (Hope and Ryan 2014). Since its outset in the early 1960s, computational art has gradually evolved through several periods marked by different expressive approaches and varying modes of social engagement (Gere 2008; Taylor 2014). The expansion of digital infrastructures and the affordability of powerful computational tools in the early 2000s accelerated the poetic diversification of the field, which gained further momentum and cultural recognition since the second half of the 2010s with the successes of subsymbolic machine learning (ML) techniques in artificial intelligence (AI) and the art market's integration with blockchain technologies and crypto economy (Cetinić and She 2022; Quaranta 2022). Successful practices are often driven by a creative ethos that prioritizes concept and experimentation over perceptive consumption or material possession. They leverage diverse features and contexts of computation and digital technologies to put dynamics, causality, relationality, and cognition into the centre of artistic experience. Their unique transformative potentials stem from inter-related factors such as performativity, intersubjectivity, instability, and generativity (Carvalhais 2022). Unfolding in a close relationship with computer science, digital technologies, and the IT industry, computational art's poetics and implications are also affected by the cognitive, sociopolitical, and ethical problems in these domains.

1.1. Randomness and Error

Although randomness and error figure in any combination of ideational, topical, narrative, methodological/technical, formal, and presentational aspects of every creative act, they are among the most recognizable signatures of computational art, to such extent that the field was once labelled “random art” (Taylor 2014, 24). Pseudorandom-generated numbers and the aesthetic tensions they can produce had been integral in the work of most early computer artists, starting with Michael A. Noll's investigation of the visual effects of programmed randomness in the line plotter drawing *Gaussian-Quadratic* (1962-1963) and his randomness-related troubles trying to register it with the Copyright Office at the Library of Congress (Taylor 2014, 33-34). Together with automatism, mathematical visualization, and coded aesthetics, pseudo-randomness had been central to the computer art pioneers' production repertoire both as a practical tool to introduce chance processes for unexpected outcomes and as a metaphor for the creative spontaneity (Taylor 2014, 82, 90-94). Although reliance on randomness had also related to artists' exploration of formal order and disorder in programmed or “generative” aesthetics and later system aesthetics (Taylor 2014, 85-86, 88-90, 139),

their striving for chance and surprise had been primarily driven by the inherent predictability, contextual detachment, and heteronomy of computer systems. The deterministic essence of computers is difficult to surpass and pseudo-randomness soon proved as an ineffective source of spontaneity leading to formal saturation and prompting the search for more suitable methods, which became recurrent markers of computational art's history.

The central issue of unpredictability in computational art is that the meaningful answers to its expressive challenges lay beyond the apparent open-endedness and malleability of algorithmic solutions and computational techniques. The exploitation of randomness has repeatedly drawn well-deserved criticism (Nake 1971; Arns 2004; Watz 2010; Loi et al. 2020) but the emulation of unpredictability through ever more sophisticated random-based computational techniques is ubiquitous and largely outnumbers practices that use uncertainty to explore the issues of computer technologies and their application. Equally widespread but mostly praised glitch aesthetics in computational art has recently also come under question for its formal-centric inability to critically engage the audience (Betancourt 2014, 2017). Similarly, the AI artists' use of computational artifacts¹ to invoke a "natural" look and feel has been criticized as conceptually misleading and inadequate to address the increasingly refined processes of recuperation in contemporary info-capitalism (Żylińska 2020; Kemper 2022). In this context, it is instructive to compare computational art's approaches to glitch and artifacts with the work of Gerhard Richter who became one of the landmark artists at the turn of the 20th century because he managed to systematically and elegantly transpose into painting the burden of guilt and angst he inherited from post-Second World War artists such as Joseph Beuys. In numerous bodies of works, Richter exalted painterly glitches — ranging from destructive failures to virtuously rendered formal incongruities — into powerful embodiments of polyvalent existential crises that comprise personal traumas, the frustrating search for authentic expression in a homogenizing heterogeneity of contemporary art, the identity crisis of painting as a dethroned pinnacle of western visual culture, and the evasiveness of meaning in the political predicaments of our time (Storr 2002).²

1. Although "artifact" is a US and "artefact" a UK spelling variant of the same noun with generally interchangeable meanings, I use "artifact" for a noticeable anomaly introduced by data processing, and "artefact" for a man-made entity, such as an artwork or a tool, following the definitions from Dictionary.com (2023).

2. See, for example, *Aunt Marianne* (1965), *Eight Student Nurses* (1966), *October 18, 1977 series* (1988), *Table* (1062), *Untitled [Line]* (1968), *Grey Streaks* (1968), *Un-painting [Grey]* (1972), and several series of *Abstract Paintings* (since 1960) (Richter 2023).

1.2. Generativity, Chance, and Surprise

Besides randomness and glitch, computational art's repertoire for exploring unpredictability and imperfection includes generative methodologies. They are based on consciously and intentionally interfacing the predefined systems with different unpredictability factors in preparing, producing, or presenting the artwork, and have a rich transdisciplinary history (Galanter 2003, 2016). Like all other human endeavours, artworks always emerge from an interplay between control and accident, so in that sense artmaking is generative by default. However, while most artists occasionally cherish uncertainty, they seldom acknowledge or reveal — and much less praise — the contingencies as prime agents of their creative processes. Generative methodologies are a notable exception, and a challenge, to the traditional appeal of an artwork that projects confidence and control. They raise the awareness that it is impossible to absolutely control and determine any creative process, its outcomes, perception, reception, interpretation, and further life, which are all constantly actualized and modified through interactions with the world.

Raising such awareness is usually not the artists' principal motivation (Dorin et al. 2012) although it has a long and diverse legacy tracing back to Marcel Duchamp's transposition of artmaking from the reconfiguration of matter into a cognitive process of relational creativity and discovery (Hopkins 2000, 37-64). Duchamp eclectically fused Pyrrhon of Elis' ethics of indifference with the theories of non-Euclidean geometry and nascent nonlinear dynamic systems to establish an approach that transcends the traditional artist-object-spectator hierarchy towards a largely indeterministic meaning construction centred on the spectator's active participation (McEvilley 1988; Molderings 2010). Duchamp's ideas have had a substantial influence on experimental art's accentual shift from formal representation to conceptual exploration that equally favours natural, artificial, physical, and imagined elements (Rosen 2022). Successful generative methodologies adopt this "flat ontology" to facilitate dynamic, curiosity-driven, and cognitively charged events whose dematerialized concepts require actualization by the audience (Grba 2015a).

Generative methodologies frequently entail bricolage — a creative affinity for working with tools, materials, and artefacts available from the immediate surroundings. Relating back to the necessity-driven pragmatism of Italian neorealist filmmakers in the 1940s and 1950s, bricolage became popular with the arte povera's critique of the commodification of art during the 1960s (Giovacchini and Sklar 2013). Since then, it has been adopted by various disciplines including philosophy, anthropology, sociology, business, literature, and architecture, and has become almost transparent in a wide range of artistic strategies. Discussing the concept of bricolage in *The Savage*

Mind (1962), Claude Lévi Strauss noted that a bricoleur assembles and modifies her handy means (operators) without subjecting them to a predefined objective, but the objective gets shaped by the interactions between operators through analogy-making and discovery. This makes bricolage integral to computational art practices that constantly push the envelope of production and presentation through playful but not necessarily preordained experimentation with existing ideas, tools, and cultural resources (Grba 2020).

However, along with overreliance on randomness and error, generative approaches in computational art are riddled with the fetishization of chance or exploitation of immediacy and indeterminacy. This is an essential but rather delicate issue and some of its criticisms conflate generativity as a methodological principle with value judgments, intentions, and ideologies implicit in the content of realized artworks (Soderman and Howe 2019; Galanter 2019, 5-6).

2. Uncertain Realities

Beyond the inherent hazards of using randomness, error, generativity, and chance, the expressive slipups in computational art happen because of audaciousness or calculated ambitions that drive artists to disregard the extent and open-endedness of external critical interpretation and intervention. For the audience, their epistemic value is often on par with the uncertainties that artists introduce intentionally and configure cogently as exploratory or experiential features. In the following discussion, I interrelate examples of both types of these uncertain realities in six sets of AI art and crypto art practices whose creative contexts, entanglements, and expressive flavours are shared across the disciplinary areas and historical range of computational art.³ Their poetic contingencies indicate the ambiguities in a broader milieu of contemporary art, culture, economy, and society, which allows me to use the synonyms for imperfection and uncertainty, such as “accident”, “incident”, or “surprise”, both literally and ironically.

2.1. Machinic Serendipity

In 1968, British artist Harold Cohen made a risky move by leaving a successful painting career to relocate to California and concentrate on using AI to study human visual cognition in drawing and painting. In the early 1970s, he initiated his lifelong project around the development of a robotic system called AARON (1971-2016) tasked to draw and paint “autonomously” and “embody creative behaviour and the conjuring of meaning” in a machine. AARON generated

3. All works discussed in the main text are well documented and included in the References, so I compacted their descriptions to the topically most pertinent aspects. The details of additional exemplars in the footnotes can be found online by querying the artist name and work title.

images through the interaction of symbolically programmed cognitive primitives and rendered them on paper or canvas via different hardware interfaces (McCorduck 2004, 517-518; Taylor 2014, 126-134). This shift of interest and production drastically reduced Cohen's visibility in the mainstream artworld but awarded him a unique place in the scientific study of computational creativity and made him the most prominent early practitioner of AI art despite the fairly unimpressive aesthetics of AARON's output.⁴ Whether sincerely or for promotional purposes, Cohen kept an ambiguous relationship with the machinic creative agency and occasionally flirted with mystifying rhetoric about AARON's "surprises" and "creative serendipity" (Cohen 1995; Garcia 2016), which converged with his pioneering role into a strong tributary to the legacy of anthropomorphism in computational art.

The emotional charge of some contemporary AI artists' claims that "there is something deeply thrilling about observing a machine learn, starting from scratch and iteratively discovering something about its world" (Audry 2021, 85) indicates a strange fascination with complex statistical computation within strictly defined expressive spaces and signals an inclination to elevate constrained modes of functional autonomy into meaningful cognitive processes. Rather than fundamentally approaching their AI applications as tools, artists frequently represent them as "autonomous creators", "creative collaborators", "partners", or "companions" (Audry 2021, 27-28, 241-243). This tendency is banalized by artists such as Pindar Van Arman (2016), Shantell Martin and Sarah Schwettmann (Schwettmann 2017), or Joane Hastie (2021), whose practices symbiose the happy-go-lucky joy in technocentric creativity with dilettante negligence toward the conceptual and aesthetic evolution of visual and media arts since the late 19th century (Arnason and Mansfield 2012; Hopkins 2000; Hansen 2004). The proneness to delegate creative agency to ML architectures recurs with each increase in their precision or scope; its latest instance manifests in discussions about the prompt-based proliferation of images, videos, animations, and 3D objects with modern Text-to-Image generative systems such as DALL-E 2, Stable Diffusion, MidJourney, Disco Diffusion, and Pytti (McCormack et al. 2023).

2.2. Aesthetization of Artifacts

Superficial aesthetics and hasty solutions for concept-to-form relationships similarly jeopardize the poetically more ambitious experimental approaches. Leaning on the "subversive authority" of error established in glitch art (Betancourt 2017), computational artists

4. Although Cohen had success in the 1980s with exhibitions and printed media coverage of AARON-produced works, the robot attracted public attention primarily as a technical curiosity and Cohen's research into the nature of creativity drew more praise from computer scientists than from the arts community (Taylor 2014, 131-132; McCorduck 2004, 491-492).

tend to invest much trust in the anomalies and output artifacts of artificial neural network architectures, often without properly assessing their expressive propriety or necessity. Apparent formal roughness is expected to add an “improvisational aura” to the works that may be conceptually simplistic, thematically unimpressive, or otherwise unengaging regardless of the technical skill behind their production.

A prominent case in point is the wide use of generative adversarial networks (GANs) that have become popular in AI art due to their versatility and hackability but tend to render visuals with a widely recognizable formal signature. The limited autonomy to choose the training datasets or statistical models that represent the latent space, the inability to explicitly diverge from the training data in interesting ways, and the constraints of fitting the target data distribution are some of the major factors that make GANs primarily the tools for processual mimicry rather than intelligent creative engines (Cetinić and She 2022, 9). The formal characteristics of their output are shaped by the nature of the training material, the evaluation functions, and the inherent qualities of the underlying neural networks, particularly the tendency to emphasize the details deemed more important. GAN visuals are more or less regularly assembled or morphed collages of patterns extracted from the source imagery, with blurred areas, uniform (statistically averaged) texture or colour zones, and regional imbalances in detail and sharpness (Audry 2021, 163-166).

The stylistic commonality and glitchiness of GAN outputs are evident in the works such as Elle O’Brien’s *Generative Adversarial Network Self-Portrait* (2019) generated by a GAN trained on the artist’s selfies, Jukka Hautamäki’s *New Parliament* (2019), and *Restituo I and II* (2021) portrait series generated by GANs trained respectively on the official photos of Finnish Parliament members, selfies, and synthetic faces, in Kishi Yuma’s *The Persistence of Existence* (2020) where glitches function as pure decoration, and many others. Striving to escape aesthetic homogeneity, Mario Klingemann devised a technique he called “neural glitch” by randomly disconnecting GANs’ neurons, adding new connections, injecting noise into some of their weights, or interchanging or deleting them. In his *Neural Glitch* series (2018), the tautological reliance on randomness and noise results in unspecified but vaguely coherent visual modulations that remain identifiable as GAN-generated. These confluences led to an umbrella name GANism, which was introduced in 2017 with a positive connotation⁵ but quickly acquired a pejorative tone (Mira 2019).

5. The name was originally proposed by the Google AI engineer François Chollet (2017), creator of the Open Source Neural Network library called Keras.

The underlying limitations of GANs and the proliferation of decorative glitch also motivate artists to optimize or rewrite the existing models and frameworks in projects that meaningfully contextualize the latent space.⁶ They address the epistemological boundaries of DL networks by navigating and sampling the latent space data as a realm between “reality” and “imagination”, replete with suggestions that emerge from a complex interplay between the various levels of statistical abstraction and determination. In these projects, the representation of sampled latent space data is collapsed into one, two, or three dimensions and artifacts are not only technically and formally inevitable but are conceptually essential. For instance, Ben Bogart’s installation series *Watching and Dreaming* (since 2014) is an attempt at understanding the algorithmic depictions of popular cinema based on visual and sonic analyses (Bogart 2019). Various film classics are interpreted and represented frame by frame through a large number of percepts which consist of numerous image segments grouped by colour and shape similarity, and serve as a visual “vocabulary” for the system to recognize, and eventually predict, the structure of the processed films in real-time. Hector Rodriguez’s *Errant: The Kinetic Propensity of Images* (2019) addresses cinema through a comparable methodological framework. It uses unsupervised ML methods to analyse, extract, and visualize filmic motion based on the shots’ optical flow kinetic patterns. In both projects, the analytic process destroys the original (recognizable) composition but preserves underlying statistical properties. Nevertheless, their visual abstraction may be undeservedly perceived as glitchy decoration despite its poetic necessity.

Conversely, in *Computers Watching Movies* (2013), which also intersects ML with cinema, Ben Grosser combined the informative open-endedness of abstract forms with cumulative cultural experience to engage visitors in a game of imaginative guessing. The work consists of six temporal sketches produced by the computer vision (CV) analysis of popular film sequences.⁷ The points and vectors of the CV program’s “focal interest” (image locations assigned with higher weights) are animated as simple dots and lines on a blank background (the processed film footage is not visible) and synchronized with the original film sound. This intelligent arrangement of minimalistic visuals with sonic guidance draws viewers into a series of playful comparisons between their culturally developed ways of seeing and interpreting and the “attention” logic of CV software which has no historical, narrative, or emotional patterns.

6. The latent space is a multi-dimensional vector dataspace which contains a distributed representation of the “learned” data in the inner (hidden) layers of a deep neural network (Cetinić and She 2022, 9).

7. *2001: A Space Odyssey* (1968, directed by Stanley Kubrick); *American Beauty* (1999, directed by Sam Mendes); *Inception* (2010, directed by Christopher Nolan); *The Matrix* (1999, directed by the Wachowskis); *Taxi Driver* (1976, directed by Martin Scorsese); and *Annie Hall* (1977, directed by Woody Allen).

2.3. Tainted Perfection

On the opposite side of this expressive spectrum, widely popular large-scale AI art installations usually handle the latent space with technical perfection and impressive production values that sometimes insinuate other poetic deficiencies by trying to conceal them. Examples include Marco Brambilla's *Nude Descending a Staircase No. 3* (2019), CDV Lab's *Portraits of No One* (2020), projects by the Metacreation Lab (2020), Refik Anadol studio (2022), and Ouchhh studio (2021). Along with other hyper-aestheticized AI artworks, they willingly or unwillingly contribute to platform aesthetics — a mildly-amusing algorithmic generation of visual, sonic, spatial, and kinetic variations, which teases the visitors with the promise of novelty and insight but effectively entrances them into cultural conformity and political deference. Dependent on the latest research and elaborately team-created with significant budgets or commissions, spectacular AI art primarily celebrates the novelty of AI technologies, fast processing power, efficient coding, and the sheer volume of data (Żylińska 2020, 72-73, 75-85, 132-133). Its often-dubious underlying motivations are “legitimized” by sophisticated techniques, formal oversaturation, and flamboyant exhibition, but often inadvertently hinted upon by anthropomorphic premises and metaphors such as “transcoding the processes of how buildings think or how AI systems dream or hallucinate” (Anadol 2021).⁸

Despite the formal abundance and occasionally copious explanatory data — which usually do the opposite of demystifying the production process — these spectacles are virtually devoid of critical views on mass surveillance, labour exploitation, environmental damage, and other problematic aspects of the big data capture and processing technologies they rely upon (Grba 2022a, 11-12). For comparison, we can take some of the monumental art practices throughout the 1980s, such as Krzysztof Wodiczko's projections (2021), Barbara Kruger's immersive setups (2021), or Anselm Kiefer's heavy confrontational installations (Gagosian 2021). They employed grand scale, formal saturation, and overidentification to critically appropriate and reflect the inherent use of overwhelming presentational strategies by power structures, gender-biased advertising, and totalitarian regimes. While the tactical values of these practices had been largely attenuated through cultural assimilation and recuperation, they redefined the landscape of critical art with lasting historical relevance.

8. This high-profile/high-visibility approach was ushered with corporate enterprises such as *The Next Rembrandt* (2016), collaboratively produced by ING bank, Microsoft, Technical University in Delft, and Mauritshuis art collection. They used DL for a multi-feature analysis of Rembrandt's paintings to render and 3D print a “most representative” painting of his style. Claiming that it “brought the great master back to life” (Anonymous 2016), the project's promo language exemplifies the patronizingly anthropomorphic rhetoric of the big business AI.

2.4. Calculated Spontaneity

In representing applied AI technologies as a pantheon of powerful but friendly anthropomorphic deities, the corporate PR service of spectacular AI art is aided by some performance artists who enjoy the sponsorship of big tech companies. They tend to imply notions of machinic creativity and spontaneity by introducing imperfection and indeterminacy in interaction with robots to exploit the evolved human capacity for, and bias toward, detecting agency in mid-sized objects moving at medium speeds (Levin 2022). Many well-known projects in this domain either promote a robotically-enhanced consumerist lifestyle or muse about the existentially intense but politically or ethically vague notions of human-AI symbiosis. They are also sleekly sanitized and anesthetized mutations of earlier avant-garde practices.

For instance, Huang Yi's choreography *HUANG YI & KUKA* (since 2015) (Yi 2021) spectacularizes the metaphors of graceful human-machine interaction and mediates them safely to the restful spectators, unlike the referential Stelarc's performances such as *Ping Body* (1996) (Dixon 2020), which have emphasized the existential angst and shared participatory responsibilities between the artist, technology, and the audience since 1976. Similarly, Nigel John Stanford's musical performance *Automatica: Robots vs. Music* (2017), can be viewed as an encore of Einstürzende Neubauten's ground-breaking concerts with industrial machinery in the 1980s toned down and polished up for tech-savvy cultural amnesiacs (Grba 2022a, 5).

Visceral homo-robotic interactions such as Marco Donnarumma and Margherita Pevere's *Eingeweide* or Donnarumma's *Alia: Zû tàì* (both 2018) (Donnarumma 2023) exemplify a seemingly opposed expressive approach. They target an audience with a more pronounced existentialist taste by rehashing in the context of AI the grotesque, cruel, or campy cyborg performances from the 1990s and early 2000s by artists such as Marcel-li Antunez Roca, Guillermo Gómez-Peña, or Roberto Sifuentes, which were themselves the histrionic amplifications of Stelarc's work cross-bred with brutal homo-robotic wars of the Survival Research Labs and earlier forms of experimental theatre and performance art (Dixon 2007).

Regardless of the poetic registers, aesthetics, and intentions of these acts, their association of AI technologies with the qualities of spontaneity, uncertainty, and imperfection — which are inherent to interactive artistic forms such as dance or music — contributes to the societal influence of the AI industry. Production values, contemporary connotations, and cultural momentum in combination with our innate anthropocentrism, myopic retrospection, and susceptibility to spectacles, help them evade unfavourable comparisons with their

precursors. But the propensity for expressive zombification is not exclusive to performance AI art.

2.5. Accidental Reverberations

Conceptual parallels, thematic repetitions, methodological similarities, and presentational likeness manifest in all areas of computational art. That is not surprising since artmaking inevitably entails some degree of obvious or implied creative processing of artistic references or cultural artefacts. It has been sanctioned 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 method for undermining the concepts of authenticity and originality (Haber n.d.). Widely accepted and most recognizable as part of remix culture (Navas et al. 2015), artefactual creativity permeates all contemporary art disciplines and has played an important role in exploratory applications of computation for transforming existing data, ideas, relations, and cultural phenomena (Grba 2020).

However, artefactual creativity involves a deceptively smooth continuum of procedures ranging from interpretation, free copy, reprise, remake, allusion, citation, dedication, derivation and *détournement*, through mashup, remix, pastiche, reference, reminiscence, homage and parody, to imitation, plagiarism and forgery (Boon 2013; Grba 2015b). The expressive values of this procedural realm unfold in a grey zone of cultural inertia, dispersed knowledge, subtle influences, fuzzy ethical notions, and slippery moral categories, which fundamentally relativize the concept of (and to some degree the requirement for) authenticity or originality. Furthermore, the expressive undercurrents, tendencies, and trends are closely interwoven with the fabrics of artists' professional lives and can be difficult to identify. They are seductive and hard to defy because they constitute the authority of the currently accepted, and therefore somehow valid, poetic identities.

For all these reasons, the assessment of expressive similitudes navigates a fine and often blurry line of distinction meandering around fraudulent, flawed, and legitimate strategies and always risks turning out as hasty, biased, uninformed, or moralizing. Nevertheless, when there is an apparent but undisclosed similarity of relevant creative factors or a strong but unacknowledged poetic parallel between a new artwork and a reasonably knowable referent, comparative criticism is legitimate. It is invaluable for the maturation of computational art whose originality-related mishaps are often not imposed primarily by the spontaneous convergence of ideas, cognitive requirements, or technical limitations but have less justifiable causes such as carelessness, indolence, ignorance, unoriginality, egoism, arrogance, narcissism, or vanity. The abundance of computational

art's expressive overlaps and “borrowings” merits a systematic study that would substantially extend this paper's volume, so I content the discussion with a few multifaceted cases.

For the short film *Sunspring* (2016, directed by Oscar Sharp), Ross Goodwin trained one ML system on 162 science fiction (SF) movie scripts found online to generate the screenplay and screen directions, and another one on a folk songs database to generate the film's song lyrics. Sharp used this material to produce the film. Brimming with plot inconsistencies and awkward dialogues, *Sunspring* touches upon several issues of its underlying cultures. The artists' satirical application of ML to filmmaking reverses the logic of corporate movie search algorithms, playfully mimics Hollywood's screenwriting strategies largely based on regurgitating themes and narratives from earlier films, and anticipates the current use of ML for screenplay analysis and design (Grba 2017, 390-392). It simultaneously exemplifies the power and the perils of using statistics to trace the “cloud” of common ideational threads in a specific cultural domain. *Sunspring's* incongruity in comparison with conventional SF narratives also functions as an analogy for the nonsensicality of popular SF imaginaries with regard to real-life scenarios — the frivolity often rewarded with unwarranted fandom by which we abide due to intellectual or cultural inertia.

Two years later, Alexander Reben appropriated Hollywood strategies and regurgitated *Sunspring's* concept and methodology to produce *Five Dollars Can Save the Planet* (2018) — “the world's first TED talk written by an AI and presented by a cyborg”. The text of this 3-minute TEDx talk was generated by training an ML model on “all the TED talks” (Reben 2018). As a humorous take on the trend of “robotization” of sales-pitch public talks, which (arguably) joins the ongoing critique of TED's model of intellectual sharing (Morozov 2012; Harouni 2014), *Five Dollars...* echoes Doug Zongker's more radical comic act *Chicken Chicken Chicken* (2007) (Bauman 2007). Moreover, Reben's satirical logic and production methodology duplicate Goodwin and Sharp's while his choice of auto-recursive format (critiquing TED talks in a TED talk) mirrors Benjamin Bratton's 2013 TEDx talk *New Perspectives: What's Wrong with TED Talks?* (Bratton 2013). Although *Sunspring* is conceptually akin to SF parodies such as *Dark Star* (1974, directed by John Carpenter), and its implication that the palatability of popular expressive forms partly relies on clichés nods toward Jennifer and Kevin McCoy's works with pop-cultural sampling,⁹ it is authentic in activating one of the SF tropes — artificial intelligence — to make these points “mathematically”. *Five Dollars...*

9. See, for example, McCoy's *Every Shot, Every Episode* (2001) and *Every Anvil* (2002) (McCoy 2023a; 2023b).

uses an identical approach to make a parodic statement about corporate public talks, but reveals or adds nothing new.¹⁰

Libby Heaney's two-channel video *Elvis* (2019) further illustrates the delicate dependency between an artwork's conceptual, topical, or methodological authenticity and critical cogency. Featuring a portrait of Heaney deepfaked as Elvis Presley and Presley's portrait deepfaked as Heaney, it directly copies (but makes no acknowledgment of) the emblematic Gavin Turk's *POP* (since 1993). In a series of selfie-pop-icon chimeras, *POP* addresses the same topics of individual identity and cultural mechanisms of celebrity mythmaking, involves the same pop icon, and applies the same formal method (face swapping) albeit in different media (sculpture, photographs, and prints) and in a more complex chain of allusions (acknowledged by Turk): for instance, a figure of Sid Vicious with Turk's face posing as Andy Warhol's *Elvis Presley* (1963). The sole critical diversion in Heaney's *Elvis* is the introduction of an AI technique (deepfaking) into the critical repertoire of gender construction within digital technologies. To whatever degree the persuasive weight of liminal expressive differences in *Sunspring/Five Minutes...*, *Elvis/POP*, and other cases of undisclosed refrains may be considered an open question or a matter of individual interpretation, poetic similarities profoundly affect the cultural identity and sociopolitical value of computational art.¹¹

2.6. Affordant Incertitudes

Inherent technological entanglement is another notable handicap to the computational art's societal impact. Its contradictions often expose authentic critical ideas to recuperation and exploitation, and sometimes turn protest into a mirror image or mystification of its target institutions, apparatuses, and power relations (Grba 2022b,

10. The conceptual and methodological cloning of *Sunspring* continued with the project *Legend of Wrong Mountain* (2018), which aimed at using ML on a Gesamtkunstwerk level. Its central part is a generative video of a traditional Chinese Kunqu opera produced by a team of computer engineers, artists, and designers who trained an assortment of ML systems on four different datasets about the forms of Kunqu opera to make the script (libretto), musical score, gesture choreography, and a woodcut book (Huang et al. 2019).

11. Readers interested in further consideration of similarities vs differences can look up the following instances (each comparative chain starting with later work(s) and ending with referent): the background idea, procedural concept, and presentational format of Memo Akten's *Learning to See* (since 2017) and Perry Bard's *Man with a Movie Camera: The Global Remake* (2007-2014); live interaction with a natural language processing model in Jonas Lund's *Talk to Me* (2017-2019), Stephanie Dinkins' *Not the Only One* (2018), and Ken Feingold's works such as *Sinking Feeling* (2001); the intersection of ML and religious imagery in Kristina Tica's *Digital Prayer* (2019) and Theresa Reimann-Dubbers' *A(I.) Messianic Window* (2017); the inspirational processing of Marcel Duchamp's 1912 painting *Nude Descending a Staircase No. 2* in Marco Brambilla's *Nude Descending a Staircase No. 3* (2019) and Vladimir Todorović's *The Running Nude* (2018); the concept and methodology of Jeff Thompson's *Human Computers* (2020) and *AAI Chess* (2018) from RyBN and Marie Lechner's project *Human Computers* (2016-2019); and the concept, topic, and form of Varvara Guljajeva and Mar Canet's *Keep Smiling* (2022) and Carrie Sijia Wang's *An Interview with ALEX* (2020).

60). Fortunately, along with unanticipated flaws and intractable slippages, computational art features an assortment of cogent and meaningful integrations of unpredictability, accident, and imperfection that help the audience identify the economic and political interests, animosities, struggles, inequalities, injustices, and other problems.

With the *Hacking Monopolism Trilogy* (2006-2010), Paolo Cirio, Alessandro Ludovico, and ÜBERMORGEN.COM¹² brilliantly intersected automation with uncertainty and arbitrariness to make pertinent critical points about info-capitalism (Cirio 2017). The works in this widely discussed series leveraged software bots that ran repurposed AI techniques for pattern recognition, CV, and natural language processing (NLP) over the established online protocols to reflect, subvert, and question socioeconomic issues of major companies specialized in Internet services: Google, Amazon, and Facebook (Dieter 2012). In this context, non-programmatic language hacking can be effective too. To make *American Psycho* (2010), Mimi Cabell and Jason Huff interfaced manual data exchange with the whims of Google's AdSense algorithm and its clients' advertising ideas to expose the paroxysms of modern business culture driven by the AI-powered data-mining and behavioural monitoring. They mutually Gmailed the text of Bret Easton Ellis' novel *American Psycho* (1991), one page per email, and correspondingly annotated the original text with ads that Google injected in each email. They erased the original novel text leaving only the chapter titles and placed the ads as footnotes to their (now invisible) trigger words or phrases. The project is finalized as a printed book (Muldtofte Olsen 2015).

A swath of critical perspectives on the digital economy uses online micro-labour platforms to address the (erroneous) human sides of the commodified outsourcing of cognitive work, delegated creativity, and AI's Human-in-the-Loop complex (Johnson and Verdicchio 2017). For instance, in Clement Valla's *Sol LeWitt + Mechanical Turk* (2009), a custom software recreated Sol LeWitt's algorithmic drawings, posted their instructions for MTurkers to execute online (5 US cents per drawing), and assembled the interpretations into a grid. In *A Sequence of Lines Traced by Five Hundred Individuals* and *A Sequence of Circles Traced by Five Hundred Individuals* (both 2011), Valla utilized the entropic effects of iterative tracing, and in *Seed Drawing* (2011) the evolutionary effects of iterative copying that aggregates large-scale structures of organic patterns (Valla 2023). However, the positional discrepancies between artists and MTurkers can make such practices ethically questionable. Although conceptualized as sound generative experiments, Aaron Koblin's projects *The Sheep Market*

12. The trilogy includes *Google Will Eat Itself* and *Amazon Noir* (both 2006), realized collaboratively by Cirio and Ludovico with Hans Bernhard and lizvix from ÜBERMORGEN.COM, and *Face to Facebook* (2010), realized by Cirio and Ludovico.

(2006), *Ten Thousand Cents* (2007-2008), and *Bicycle Built for Two Thousand* (2009, with Daniel Massey) (Koblin 2015) drew critique for the exploitative treatment of MTurkers through compensatory allocation disparities (Berdugo and Martinez 2020, 89; Żylińska 2020, 117-120). For example, in *Ten Thousand Cents*, Koblin divided a reproduction of a 100 USD bill into 10,000 rectangular parts and posted them on Amazon's MTurk. The MTurk worker's task was to draw a copy of one part for a fee of 1 US cent per part/task. So, the total MTurkers' labour cost to draw the 10,000 parts was 100 USD, but Koblin made a signed edition of 10,000 prints of the finished composite image available for purchase at 100 USD each.

Artists also use generative uncertainty to critique the concepts of ownership, speculative appetites, exploitative investment strategies, and obsessions with wealth in the contemporary economy. A well-documented example is Anna Ridler's *Mosaic Virus* (2019) in which a GAN animation of tulips inflected by the current Bitcoin values refers to the "tulip mania" symptom of the boom-and-bust cycles in bubble economies (Wang et al. 2022). Recognizing the limitations of non-fungible tokens (NFTs) as authenticity certificates and the abuse of art for promoting the crypto economy, other artists exploit the programmability of blockchains. They play with the relativity and transience of digital artworks, their ownability, and commercial life and leverage the financial flux of the crypto art market to explore the options for "tokenizing" values such as solidarity, care, and collectivity (Quaranta 2022, 95-140). For instance, Moxie Marlinspike's *At My Whim* (2021) was an astute crypto-myth-busting decentralized application (dApp)¹³ which showed that the same NFT can be linked to different digital contents depending on where and how it is presented. By manipulating the NFT hosting web servers to select and transmit images according to the requester's IP address or user agent (web browser), *At My Whim* appeared as a geometrically different abstract digital drawing on OpenSea and Rarible NFT marketplaces. After purchase, it was displayed in all buyer's crypto wallets as the emoji with the Unicode Character U+1F4A9 (official name Pile of Poo). Applicable to any other digital artefact, this dApp fully complies with the NFT technical specifications but simultaneously eliminates their purpose thus demonstrating the ultimate uncontrollability of assets that NFTs are purported to secure. A few days after the publication of *At My Whim*, OpenSea reaffirmed its point by removing the NFT without warning or explanation, both from their website and from all of the artist's crypto wallets (Marlinspike 2022).

The asymmetries between individual and institutional power are also tackled by projects that critically reflect on various forms of AI deployment. For example, Mushon Zer-Aviv's *The Normalizing Ma-*

13. dApps are web applications that can be programmed to transform the data and its rendering on a hosting NFT platform.

chine (2018) provides a recursive critique of normative statistics and automated criteria in biometric classification. In this installation, visitors face a serial line-up of pairs of previously recorded visitors and point out the one that looks more “normal”. Their portraits, captured during this process, are added to the training dataset and their selection decisions modify a generative model that continuously visualizes the facial aggregate of “normalcy” in a separate image (Zer-Aviv 2018). Jennifer Gradecki and Derek Curry’s *Boogaloo Bias* (2021) highlights the ironies of uncertainty and error in biometric AI profiling (Gradecki and Curry 2022). Modelled on emergent law enforcement practices, this interactive facial recognition system maps the faces from the live video feeds and recorded footage of Boogaloo Bois anti-law enforcement militia protests to the actors’ faces in the movie *Breakin’ 2: Electric Boogaloo* (1984, directed by Sam Firstenberg). It casts a sarcastic look at the biases and errors in CV translation processes, as well as the impact of datasets and accuracy thresholds on false positives in police surveillance and arrest policies. To highlight the questions of accuracy and normalization within the fundamental but insufficiently investigated philosophical dimensions of AI research, Sebastian Schmieg introduces deliberately reduced unconventional, idiosyncratic, and seemingly absurd taxonomies into the image classification setups in works such as *Decision Space* (2016); *This is the Problem, the Solution, the Past and the Future* (2017); *Decisive Camera* (2017-2018); and *Decisive Mirror* (2019) (Schmieg 2022). For instance, the online visitors of the *Decisive Camera* can upload an image that will then be classified within a taxonomic space of only four categories: Problem, Solution, Past, and Future, and assigned a probability percentage for each category.

By focusing on the conditions in which algorithms fail to achieve their programmed goals, these and other successful tactical works underline the misalignment between the myths about digital technologies and the ways of their actual implementation.¹⁴ Their investigations of sociopolitical inconsistencies and tensions spawned by pervasive computational infrastructures establish alternative narratives to corporate techno-solutionism. Even without necessarily providing answers, their value is in offering new critical viewpoints and actionable lines of reasoning for the audience to understand the importance of appropriate oversight, public accountability, and regulation of sociotechnical systems that rely on automation. Particu-

14. Other exemplars of the tactically effective use of uncertainty, imperfection, and inaccuracy include Ken Feingold’s *Sinking Feeling; If, Then; and What If* (all 2001); Lauren Lee McCarthy’s *Social Turkers* (2013); Eva and Franco Mattes’ *By Everyone, For No One, Every Day* (since 2014); and *Dark Content* (2015); Lozano-Hemmer’s *Level of Confidence* (2015); !Mediengruppe Bitnik’s *Random Darknet Shopper* (2014-2016); Max Hawkins’ *Randomized Living* (2015-2017); Jake Elwes’ *Closed Loop* (2017); Rhea Myers’ *Is Art* (2014-2015); Sarah Friend’s *Lifeforms*; and *Off* (both 2021), Rafaël Rozendaal’s *Endless Nameless* (2021); Primavera De Filippi’s *Plantoids* (since 2015); terra0’s *Flowertokens* (2018); Jonas Lund’s *Jonas Lund Token* (JLT) (since 2018); Libby Heaney’s *Euro(re) vision* (2019); and others.

larly, they reveal the control issues and manifest disparities between the functional predictability of computer systems and the unanticipated consequences of their application. By approaching uncertainty with conceptual cogency, expressive economy, and formal clarity that engage and inform the audience, these works also incentivize other artists to refine their creative strategies with careful consideration of incertitude and imperfection both as potential features and vulnerabilities.

3. Poetic Contingencies

Nevertheless, the appeal of uncertainty and imperfection remains deceptive. Generative surprise attracts the audience, but its exuberant use is criticizable as an awe-imposing mystification of the creative technologies. The increasing sophistication, processing power, and speed of emerging digital architectures constantly threaten to obfuscate the insufficiency of relying chiefly on faux-randomness and retrospectively collected data to abridge the predictability and heteronomy of the universal computing machine. They replenish the historical tendency in computational art, initially caused by high cognitive demands and steep learning curves of computer technology, to tacitly conflate artmaking with the skilful handling of creative instruments, which often incentivizes artists towards technical virtuosity devoid of self-critical distance or playful irreverence. This techno-fetishist mentality reinforces a naïve lack of understanding that the poetic role of production techniques in the arts is fundamentally defined by conceptual thinking and meaningful contextualization.

Thus, artists' efforts can get compromised by uneven intellectual breadth and depth or sketchy art-historical knowledge, leading to the poetic accidents of mishandling sensitive issues or cloning other, more compelling artworks (Grba 2022a, 17-20). This almost juvenile nonchalance toward both legacy and current creative landscapes is perhaps the most embarrassing weakness of modern computational art and one of the most constructive aspects for its critique. We can hardly attribute it primarily to the computational art's youth because it is more than 60 years old and shares all major poetic features with experimental arts whose history reaches back to at least the late 19th century. Instead, we should articulate our critique around the fact that the exploration of general and field-specific art history with curiosity and respect is a basic and empowering requirement for artists to bring up new ideas responsibly. However, despite their frequency, ethically charged poetic slippages in computational art are relatively seldom exposed and openly discussed, probably because artists, academics, and cultural workers prefer to stay out of the reputational minefield that opens by expressing clear but potentially confrontational opinions. This self-protecting professional leniency goes in tandem with an equally persistent and consequential but even less discussed contingency — the meritocratic inconsistency

imposed by cultural hegemonies, power games, and systemic injustices of the contemporary artworld. Indicating the darker shades of human nature, it retains the accidents of birth, nationality, language, or geographical location as powerful factors of career trajectories and professional recognition.

Artists who know how not to get swayed by sociocultural inequities and technological deficiencies in order to identify, understand, and leverage their expressive potentials have a chance to amaze us with valuable insights. They can escape the pitfalls of digital computing's formal rigidity and lack of spontaneity by treating them as trade-offs and — instead of equating art with technology — concentrate on generating meaning in thoughtful interrelations of technology with human intelligence and wit as the primary sources of surprise. By taking both art and technology as anthropological and sociocultural dispositives, artists can allow their poetics to be deeply informed by the interactive, interpretative, and transformative ingenuity of other minds regardless of their competencies or attitudes. They can design encounters with the uncertainty that challenge expectations and familiar beliefs and induce cognitive anxiety which is widely recognized as a creative catalyst (Rosen 2022, 473-474). That involves combining a keen awareness of sociotechnical and cultural environments with the ability to articulate ideas, knowledge, and skills through personal idiosyncrasies, wonders, and passions. Consequently, artists need to be open to learning from both successes and failures. One of the lessons of poetic contingencies is that productive risk-taking is not mere recklessness fuelled by ignorance or vanity but a cultivated embrace of uncertainty made by balancing adventurousness, panache, charm, and defiance with humility towards the probabilistic nature of the world in which we live and create.

Whether they sneak in as unanticipated twists and turns or help establish expressive relevance, poetic contingencies place the cognitive, ethical, and sociopolitical tensions of artmaking firmly within the context of human nature and existence. They help us infer the artists' knowledge and skills along with their personal qualities that inform poetics as much as any other expressive factor and reaffirm that understanding artists equally as creators and as human beings should be integral to the art appraisal. The inherent heuristics of artmaking also gently reminds us that uncertainty and instability are the fundamentals that make the continuous and cumulative experience of life itself more astonishing than art or any other specific domain of human creativity. From a broader perspective, it provides a conceptual framework for a comprehensive multidisciplinary study of the unexpected realities of culture, science, technology, economy, ecology, politics, and society.

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‘Haunted’ AI

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The cascade of generative text-to-image models that emerged in 2022 led to much fascination and discussion. There was one phenomenon that went particularly viral, that of “Loab”. Presented as a digital cryptid that haunts an unspecified latent space, Loab represents a continuum of themes regarding our perception of technologies as they emerge. We utilise Loab to illustrate imagined affordances in generative AI-images. Beginning with a brief introduction to the technical operations of latent space and text-prompts, we then move into a cultural analysis of Loab. We interpret this through two frames of reference. The first draws on the long history of haunted machinery through spirit photography. The second situates Loab within cyborg depictions, which have positioned the ‘woman-machine’ as threat. Between the technical and the cultural, we argue that Loab occupies a paradoxical double identity.

Keywords: Latent Space, Generative AI, Spirit Photography, Uncanny, Cyborg, Loab, Prompts, Visual Culture.

1. Introduction

I discovered this woman, who I call Loab, in April. The AI reproduced her more easily than most celebrities. Her presence is persistent, and she haunts every image she touches [...] This is a true horror story, and veers sharply macabre. (Supercomposite, Tweet, Sept 7, 2022)

Spiritualism arose in parallel to the explosion of scientific discovery and invention in the late nineteenth century, when advances in physics and chemistry were fundamentally reconfiguring accepted notions of energy, time, space and reality itself. (Jolly 2006, 20)

On 7 September 2022, the artist known by the handle Supercomposite (Steph Swanson) posted a Twitter thread about a newly discovered ‘woman’ she had found haunting artificial intelligence (AI) (see Fig. 1, below). ‘She’ was given the name Loab and became a compelling case in the conversations around computational image making. More specifically, Loab supposedly haunts the hidden layers (latent space) of certain text-to-image models. By the time of writing, Supercomposite’s initial tweet has nearly 80 thousand likes and nearing 20 thousand retweets and quote tweets combined. The character has been written about in major newspapers, magazines and online news forums around the world.¹ Loab even has a dedicated webpage.²

Clearly, Loab is a phenomenon that has attracted widespread attention. The sentiment surrounding Loab holds trepidation and fascination in equal measure. This paper takes the phenomenon of Loab and unpacks it by looking at how ‘she’ seemingly emerged from latent space. We argue that the fixation with Loab showcases society’s mythologizing of AI. We intimate that the perception of AI images is framed by an attempt to fit them into pre-existing narratives. Starting with the construction of the image through ‘negative weighted prompts’ this paper questions its radicality as an image generating technique. It then goes on to situate the response to Loab within two wider historical genealogies — that of spirit photography, and — by weaving in depictions of the ‘cyborg’ — that of gendering bodies through images. Following this historical lineage, we then analyse how Loab fulfils a ‘paradoxical double identity’ (Harvey 2007). Ultimately, what makes Loab a spectacle is not only the visually striking attributes of the image series, but our cultural perceptions surrounding it. It is not only the novelty of the technology, but how Loab magnifies the imagined affordances of AI that make this case intriguing.

1. For example, *The Atlantic* (Marche 2022), *New Scientist* (Sparkes 2022), *Forbes* (Tassi 2022), *ArtNet* (Batycka 2022), *Dazed* (Waite 2022), *Vice* (Rose 2022), *Rolling Stone* (Klee 2022), *Tech Crunch* (Coldewey 2022), *Smithsonian Magazine* (Raemont 2022), *CNET* (Ryan 2022), *Spiegel* (Breithut 2022), and *ABC* (Lavoipierre 2022).

2. <https://loab.ai/>

2. Loab Emerges: Latent Space and Negative Weighted Prompts

In April 2022, Open AI launched Dall-E2. As the second iteration of their text-to-image software, this quickly garnered widespread attention. In the months that followed, a host of different text-to-image applications emerged, including Craiyon (formerly Dall-E Mini), Stable Diffusion, Midjourney, as well as Imagen (not yet launched). For techno-optimists, these image generators herald a new frontier for creativity.³ For critics of text-to-image models, concerns over the future of labour and the decline of autonomy underpin recurrent debates regarding the role of technology in society.

The technologies supporting algorithmically generated images have gone through significant evolutions in the last decade. Often bracketed under the overarching term deep learning (DL), these algorithms have received much attention for their supposed autonomy. Neural networks are considered ‘deep’ when parts of their operational layers are hidden but nonetheless key for a successful output. To learn, such algorithms tweak the parameters of the hidden layers without being given further instruction, other than a specific target. Because the algorithm works with two inputs, text and image, each has its own encoder. Autoencoders are algorithms that are used in DL, the purpose of which is to translate/mediate the data deemed informative into a compressed representation (Skansi 2018). Autoencoders consist of three parts, the input, the latent feature/representation, and the output. The mid layer of ‘feature/representation’ is widely known as ‘latent space’ in computer science. Superficially, latent space can be understood as the organization and mapping of all the information in the database. This is where Loab can supposedly be found. As the website dedicated to Loab states: “She likely lives in the outer reaches of the latent space, and can be accessed with negatively weighted prompts” (<https://loab.ai/>). To receive output from this space, the decoder reconstructs representations from the space into an output. Our first step to understand so-called ‘haunted AI’ and Loab is to consider the latent space in which ‘she’ can be ‘accessed’. Our next step is to consider how negative prompts are used to retrieve information from this space.

Loab has been reported to haunt an *unspecified group* of AI image synthesizer’s latent space (the artist has never revealed which program was used in the discovery of Loab). This complicates our ability to materially grasp Loab’s emergence and contributes to the imagination of Loab as a spectre. Although each model has its own unique architecture, common to this type of image development

3. For a more nuanced discussion on deep learning and creativity see Fazi, M. Beatrice. “Can a Machine Think (Anything New)? Automation beyond Simulation.” *AI & SOCIETY* 34, no. 4 (December 1, 2019): 813–24. <https://doi.org/10.1007/s00146-018-0821-0>

are algorithms called diffusion models. Aditya Ramesh (2022), one of the creators of CLIP,⁴ has described its latent space as a ‘globe’. In this metaphor the encoders are trained to map the input as coordinates on a globe, that “functions as a ‘concept space’ shared by both modalities” (Ramesh 2022) of text and image. This practice of mapping data into vector spaces, as Adrian MacKenzie (2017, 51) puts it, is an ‘expanding epistemic space’. How the data is managed and mined has important implications for how specific algorithms operate. Another metaphor used to describe the importance of latent space for AI images is through yet another geographical term, that of ‘ground-space’. Abelardo Gil-Fournier and Jussi Parikka have articulated how this shift in the foundation of images is “read from a mass of images, instead of comparatively off the ground” (2020, 2). They also write that this abstraction of information — forming the ground of the image — “becomes synthesized with meaningful aesthetic and epistemological consequences” (Gil-Fournier and Parikka 2020, 2). The distinct material construction of each model means this will reverberate differently. What is of importance is that in all such models, the image shifts from capturing a location or event from the physical world, to becoming an image from images (Somaini 2022). Conceptually we can think of the image from image formation as the ‘ground’ of these images — and the unique latent space of the model to be a globe.

As stated, Supercomposite does not specify which model was used to manifest Loab, just that ‘she’ lives on the outer edges of a globe made up from images from images. To reach these outer edges of the globe, Supercomposite used ‘negative weighted prompts’. Important to the process of mapping the information on a ‘globe’, is to establish a ‘meaningful’ relation between the text-image pairings it has been fed. A prompt is deemed successful when a trained text-to-image model presents an image with forms we recognise as ‘correctly’ matching the text. Matching pairs are charted closer together on the ‘globe’, while a mismatch is further apart. A negative prompt will present an output based on a reference point that is a mismatched cross-section to the expected prompt. The first negative text prompt Supercomposite began to experiment with was “Brando::-1”. The algorithm returned an image that appeared like a logo with the words DIGITA PNTICS, imposed on what can be interpreted as a city skyline. To test if the opposite of the logo would give an image of Marlon Brando, the next prompt was “DIGITA PNTICS skyline logo::-1”, and Loab appeared.

Although it is important to know the steps to technically develop an image of Loab, we want to emphasise another aspect of the image — how we respond to and imagine these processes. We want to draw attention to how perception is culturally constructed, including how



Figure 1: Image description: An androgenous figure from the shoulders up (Loab), wearing a green top with a white pattern. Loab has long dark hair framing a reddened face, with stubbled upper lip and jaw, a scarred neck, and blacked-out eyes looking directly forward in the frame. Loab appears in portrait mode, with a blurred background of a house interior, with floor lamp and lamp shade. To Loab's right is a smaller figure, seemingly a distorted stuffed animal wearing a cast covered in unintelligible writing. This is the first image of Loab uploaded to Twitter by Supercomposite.

we imagine data is shaped through (autonomous) algorithmic operations. The last decade has pushed debates on so-called AI-images to the forefront, leading to an increased awareness on how issues in data harvest, cleaning processes, and algorithmic processing will influence how machines view or produce images (Magnet 2011; Buolamwini n.d.). Although, as MacKenzie (2017, 53) writes “the crux of the problem rests on the ‘treatment’ or operations that ‘reduce terrestrial sensibilities and movements’ to symbols.”⁵ Here, MacKenzie observes a ‘long-standing nervousness’ about the mathematical transformations of data. Loab introduces a new aspect of algorithmic bias embedded into the expectations of these machinic processes and resulting outputs. When we read these images, the meanings we construct are based on a history of perception that combines both cultural and technical aesthetics.

The framing of complex operations as symbols is suggestive of the tendency towards allocating or projecting affordances onto technology. An affordances approach enables researchers to evaluate the interrelation between culture and technology. For example, on their writing on Microsoft’s chatbot ‘Tay’ — an experiment that was quickly corrupted and consequently shut down — Gina Neff and Peter Nagy (2016) highlight two broad reactions to the chatbot’s behaviour, as well as media coverage surrounding the chatbot, and ‘her’ demise. The first “portrayed Tay as a reflection of the dark side of human behavior” (4923), which “emphasizes human agency in the social media construction of artificial intelligence” (Neff and Nagy 2016, 4923). This was a result of the chatbots descent as ‘she’ interacted via Twitter with users who encouraged ‘her’ to adopt inflammatory and obscene expressions. The second viewed Tay as a threat, whereby “Tay stands in for a belief that technology is out of control, spiralling into dystopian scenarios with little room for human agency” (Neff and Nagy 2016, 4923). Neff and Nagy’s article builds on their earlier conceptualisation of ‘imagined affordances’ (Nagy and Neff 2015), which invokes a projection of capabilities onto a technology. In a similar manner, we propose that Loab exposes public perceptions around how AI images come about, and the way that informs how we read an image.

3. Uncanny Images

Looking at the included image above, the fact that Loab was gendered as female is fascinating. This is, in our view, a highly androgenous figure.⁶ When Supercomposite wrote the initial prompt, it was to experiment with how the algorithm would respond to a negative

5. MacKenzie draws on the work of Hannah Arendt (1998, 265) in making this claim, referencing the reductive process of turning sense data into mathematical operations.

6. Nonetheless, in this article, we have likewise often used ‘she’ or ‘her’ in reference to the figure in these images, as we are reflecting on an existing discourse.

weighting of the name ‘Marlon Brando’. When the image returned as a horror figure, the original male Hollywood star shapeshifted into a ‘scary woman’.

Though we find it problematic, the positioning of Loab as a woman is part of what interests us in unpacking the cultural perceptions that Loab elucidates. As the earlier quotes from Supercomposite suggest, the artist is persistent in gendering this character. In September of 2022 (the peak of Loab-content virality) this was unquestioningly taken up by mainstream commentators, who proceeded to add the following descriptors around Loab images — ‘nightmarish’ (Sparkes, *New Scientist*, 2022), ‘horrific’ (Wickens, *PC Gamer*, 2022), ‘horrifying’ and ‘demonic’ (Waite, *Dazed*, 2022), ‘spooky’ (Klee, *Rolling Stone*, 2022), ‘terrifying’ (Coldewey, *Tech Crunch*, 2022; Marche, *The Atlantic*, 2022), ‘disturbing and grotesque’ (Rose, *Vice*, 2022), ‘unsettling’ (Raemont, *Smithsonian Magazine*, 2022), ‘creepy’ and ‘macabre’ (Batycka, *ArtNet*, 2022). Admittedly, a closer inspection of each article displays more nuance. There is the underlying knowledge that Loab is data, not demon. Nonetheless, the tendency to slip into an easy anthropomorphising, or the temptation to create clickbait content, showcases the desire to make Loab stand in for something ‘other’. In this case, the other is the trope of the ‘grotesque’ older woman. When Loab is given a persona, ‘she’ is woven into an existing perception of the inherent threat of AI. Just as Tay was gamified to take on the persona of the then feared ‘corruptive’ potential of social media, Loab is the representation of a fear stemming from ‘AI images’. ‘She’ is the quintessential personification of how AI image technologies will encroach on our humanity and creative control. That Loab has been gendered as female adds an additional layer to this threat, a premise explored later in this paper, through the figure of the cyborg.

There exists a long historical relationship between the emergence of new technologies, mystical thought, and the feminine. In his book *Haunted Media*, Jeffrey Sconce (2000) draws on the development of spirit communication through tapping, which emerged in 1848, four years after the public debut of morse code. Referred to as the ‘spiritual telegraph’, this was an immediate reaction to a new technology that was able to mediate at unfamiliar distances and speeds. In response to this, Sconce writes:

As many historians have noted, the Spiritualist movement provided one of the first and most important forums for women’s voices to enter the public sphere. The majority of “mediums” were women, and the mediumship itself was thought to be a function of the unique “electrical” constitution of women. While in a state of mediumistic trance these women were able to comment (through the “telegraphic” voices of the dead) on a variety of contemporary social issues of concern to women. (2000, 12)

Importantly, Sconce notes that it was not only the Spiritualist movement that relied on mystical thinking in their rationalisation. The critique of the Modern Spiritualist movement sought equally fantastical arguments to delegitimise these mediumistic readings based on erroneous understandings of the women's mind and body being 'unbalanced' by the electrical currents of telegraphy. Sconce moves beyond a critique of Spiritualist ideology to consider the complex social and cultural circumstances surrounding the movement. Following Sconce, we likewise find it beneficial to consider the social and cultural significance surrounding the perception of Loab, rather than an outright dismissal of a 'haunted' digital cryptid. Given we are once again grappling with an era of technological change that is reshaping culture, it is unsurprising that another iteration of haunted media has emerged. It is from this point that we explore the historical evolution of a key imagined affordance in relation to Loab – the notion of the 'spirit in the machine'.

Loab follows a long genealogy of spectral appearances in mechanically developed images. In the 1860s, ideas began to emerge about photography's capacity to represent spirits in the United States. During the civil war, photography was utilised to report on the tragedies of the battlefield, with photographs of the dead entering into circulation (Jolly 2006; Kaplan 2008). The combination of this with an existing cult of Spiritualism led a central figure in the field, William H. Mumler, to 'discover' a method for supposedly photographing the dead as spirits (Jolly 2006, 16-18). Many Americans, having lost loved ones in the war, were marked by the desire to reconnect with deceased family and friends. Mumler capitalised on the potential of capturing these loved ones on film as 'spirits'. And so, 'spirit photography' met the zeitgeist of national mourning. Despite Mumler's first experiments with spirit photography leading to a court case and attempts to debunk his methods, the phenomenon grew into a wider culture of occult photography that lasted well into the 1930s.

Pierre Apraxine and Sophie Schmit (2005, 14) summarise the domain of occult photography to "designate that which is hidden, unknown, inaccessible to all but the initiated." The initiated will be able to access the spirit when using photography as a specific communicative form. In the early stages of photography, mechanical reproduction was perceived as an 'arrest of the moment'. This established a belief in the truthfulness of photographic representation, giving the credence of objectivity to spirit photography. According to John Harvey, it became endowed with a 'paradoxical double identity', as it was:

...at one and the same time an instrument for scientific inquiry into the visible world and, conversely, an uncanny, almost magical process able to conjure up the semblance of shadows and, with it, supernatural associations. (Harvey 2007, 7)

Martyn Jolly states that, “Mumler also drew on the authority of contemporary science to explain his apparent abilities.” (2006, p. 20). For our case study on Loab, we take from this idea that there are individuals with ‘specialist knowledge’, able to unearth the otherworldly in the machine (through manipulating the ‘nodes in the globe’). This practice falls within the realm of occult image cultures, all of which speak to a general human desire to understand both technology and the culture in which they emerge. As Apraxine and Schmit explain further:

On the one hand, [occult photographs] tell us about a specific use of photography during a particular period, about the expectations and disappointments it generated, and its impact on attitudes. On the other hand, they tell us about human nature, its relationship to technology, its valorizing strategies, its hopes and beliefs. (Apraxine and Schmit 2005, 14)

This returns us to the inextricable link between technology and imagined affordances. That the camera and film were seen as imbued with the capacity to commune with the ‘after-world’ holds resonances with the notion of Loab haunting latent space. When Loab is said to roam the latent space of AI, it draws on this same mythologisation of hidden and inaccessible spaces. When ‘she’ emerged onto Supercomposite’s screen,⁷ we see this same paradoxical double identity invoked — Loab gives us further insight into the algorithmic process of negative weighting (scientific inquiry) and was conjured by the artist and haunts the machine (supernatural associations). Thus, Loab’s haunting is also doubled — a formalist reading of the image offers a specter, a crone, a demon, a nightmarish figure emerging from the shadows. A secondary reading is of the image as traces of mass data. While computational, not clairvoyant, it nonetheless invites a sensory/perceptual encounter with the image. This combination of readings affords us the opportunity to look at Loab in relation to the figure of the cyborg.

While Loab is trademarked as ‘the first cryptid of latent space’ (loab.ai),⁸ we are more interested in situating the representation of Loab

7. The work of Jeffrey Sconce points to a history of ‘mysterious women’ appearing on screens. He references an event in 1953, whereby “As Jerome E. Travers and his three children were watching *Ding Dong School* one day, the face of an unknown woman mysteriously appeared on the screen and would not vanish, even when the set was turned off and unplugged” (Sconce 2000 p. 2).

8. A cryptid is a being (normatively an ‘animal’ — think Loch Ness, or Yeti) that is claimed to exist, but its existence is not supported by mainstream science. For those who truly consider Loab a demon with autonomy and agency, she is a ‘digital cryptid’, and the notion that this popular conception of Loab is in fact scientifically a *misconception* aligns with the cryptid definition. It should be noted that ‘male’ cryptid figures have also emerged from latent space. The most notable of these is Crungus, who preceded Loab. Crungus was created in collaboration between Twitch streamer Guy Kelly and the Craiyon app. While well-known in various online subgroups (largely in the gaming community) these images did not receive the same level of fixation from a wide audience that we saw with Loab.

as both a continuum and a break in the depictions of cyborg women. This lens positions Loab in a longer tradition of associating the female body with the threat of the machine. Donna Haraway's canonical *A Manifesto for Cyborgs* (1985 [1991]) defines the cyborg as "a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction" (150). For Haraway, this has the potential to create space where social constructs (namely gender) could be surpassed. Loab defaults on Haraway's cyborg on two counts. First, there is no organism, only the imagined affordance of Loab as a living entity. David Tomas takes a multi-perspectival view of the cyborg, claiming that one type of cyborg is "the postclassical (software-interfaced) transorganic data-based cyborg or personality construct" (Tomas 1991, 32). Claudia Springer adds that this type "has no organic form but consists of the human mind preserved on computer software" (1996, 19-20). We can situate Loab within this widened view of the cyborg, as 'she' has no organic form but emerges from our collective data. Second, the gendering of Loab as female highlights that – rather than be surpassed – social and cultural constructs can take on a power of projection in computational imagery.

Springer, in her book *Electronic Eros: Bodies and Desire in the Postindustrial Age* (1996), offers a reading of key cultural depictions of female cyborgs, from Hadaly in the 1886 sci-fi novel *L'Eve future* by Villiers de l'Isle-Adam, Maria in the 1927 film *Metropolis* directed by Fritz Lang, to Eve in the 1992 NBC television series *Mann and Machine*, among others (146-151). With these sexualized depictions of 'machine-women', Springer argues that "Both women and machines were thought to possess powers that, if unleashed, could prove disastrous to patriarchal order" (Springer, 151). *L'Eve future* is seen as somewhat of an origin story for later female cyborg depictions:

The novel's interest in constructing an ideal woman intersects historically with the use of photographic reproduction to create the perfect female image, setting the stage for early cinema to unveil its obsessive fascination with the female form in the 1890s. (Springer 1996, 148)

Loab is the oppositional figure to the ideal woman showcased in Springer's reading. However, we see 'her' equally fetishised – albeit in this contrary manner. Loab fits with Bruce Grenville's assertion that "the female body and female sexuality have been used to represent a broad cultural anxiety surrounding the allure and the threat of the machine" (2001, 22). Othering a body using cultural symbolism and images is nothing new, and historically has served the dual purpose of repudiating a particular people, and/ or ideology. The figure of the witch was villainised in part because of the feminised connection to nature that was being increasingly relegated to the fringes of society. The figure of the cyborg draws on the connection

(and therefore, conversely, the desire for separation), between the human and the machine.

Dánielle DeVoss, in her study of images of cyborg men and women found online, argues that “most visual representations of cyborg bodies are actually representations of “cyber” bodies, which reinforce contemporary notions of masculinity, femininity, heterosexuality, and power” (2000, 835). Continuing this logic, it coheres that these representations also reinforce contemporary notions by providing divergent visualisations – images that show us how not to be, what is unacceptable to the societal standard. In this respect, several commentators draw on the iterative images of Loab that depict her with children, often referring to Loab as a ‘mother’. These images are gory and violent. One shows Loab holding up the decapitated head of a child, hands bloodied, both child and Loab open-mouthed in mid scream. Another has Loab sitting cross-legged, stomach swollen, clutching a newborn so tightly its face has contorted. In this image Loab again has blood-stained arms. When news outlet ABC asked another AI program, GPT-3,⁹ to imitate Loab and answer some questions, the following response was recorded:

Figure 2: Screenshot of a recorded conversation between journalist Ange Lavoipierre and Large Language Model, “A Journey into out Unimaginable Future” in ABC News 26 November 2022.

Do you think the AI is drawing on a specific archetype of a woman in creating you?

I think the AI is associating me with the archetype of a mother, because I'm often placed in a home with children. This archetype is often associated with being nurturing and caring, but also with being sad and domestic.

If you are the archetype of a mother, then why are you so often surrounded by injured and dead children?

I think the AI is trying to create a contrast between the ideal of a mother and the reality of a mother. In reality, mothers often have to deal with sick and injured children, as well as the death of children.

Indeed, at no point can we be sure that Loab is being depicted as having committed the crime of infanticide. We could equally read these images as a figure who is themselves haunted and grief-stricken by the death of a child. That we are quick to jump to blame says a lot about our cultural attitude towards mothering, and the preoccupation with the figure of the ‘bad mother’. Our dread around these images coalesces around several thoughts – that we have not moulded our bodies and character to that which is deemed pleasing to so-

ciety, the familiarity of the (literal or figurative) home as ‘disturbed’, and the thought that the machine is haunting us.

Furthermore, the above conversation (reportedly conducted with GPT-3) reinforces our link to imagined affordances. There is no necessary correlation between GPT-3 and the image of Loab. Firstly, while Dall-E2 and GPT-3 are both created by the organisation Open AI, Supercomposite has deliberately avoided publicly naming the model used in discovering Loab. Even if Dall-E was used, the material specificities of GPT-3 and Dall-E respectively would impact the output. Moreover, as there is no one latent space, each algorithm will have its own unique variation of ‘the globe’. The desire to give voice to Loab, adds to the continued anthropomorphising of Loab, building a sense of familiarity and recognition. Indeed, part of the experience of being haunted is recognition. In this way, we can draw on the concept of the ‘uncanny’, that which has made the familiar unfamiliar (Freud, 1919 [2003]). Grenville writes that, “The cyborg is an uncanny image that reflects our shared fascination and dread of the machine and its presence in modern culture” (2001, 10). As we have sought to showcase, Loab, as an uncanny image, feeds into our cultural anxieties around AI – that AI will shift beyond our human control, that it will manifest in evil and harmful ways, that we will not be able to understand how it functions, that it might replace us. However, we have also extended this argument to make the claim that Loab is uncanny because ‘her’ image stands in for the ‘unacceptable’ female body – also uncontrollable, also wicked, as well as older and unsightly. Yes, we recognise Loab. Many of us have been socialised to fear becoming her. As Ahmed (2000) argues, the stranger is only a stranger inasmuch as they are recognised, familiar as a strange figure. Loab holds this duality – an image that is uncanny, strange and, ultimately, recognisable.

The problematic interpretations of Loab align with the literal translation of *unheimlich* (Freud, 1919 [2003]), as ‘unhomely’. Scott McQuire refers to this translation of uncanniness as ‘disturbed domesticity’ (2008, 8). McQuire goes on to note that “Uncanniness thus belongs to a complex scene of veiling and unveiling, of secrecy, revelation and improper exposure” (2008, 8). He builds on this, referring to the three core examples of ‘uncertainties’ given by Freud. The first is an uncertainty around the animate or inanimate qualities of beings and objects. The second is the question of doubling, (re)presenting one’s own reflection in a way that disrupts our self-recognition. The third is the disintegration in the distinction between imagination and reality. Each of the three is applicable in unpacking the phenomenon of Loab. We can read the use of negative prompts as an improper exposure, supposedly granting access to a hidden space within the machine. By ‘trespassing’ into latent space, it unveils the uncanny. The dread around the image of Loab coalesces the three uncertainties of the uncanny. Through imagined affordances we blur

the lines between imagination and computational operations. As we have argued, Loab is the double of our images (as an image from images). As such, we are always faced with a (re)presentation of our reflection. What makes this uncanny is the generative process, which does not purely replicate, but synthesises. This process can give the illusion of animating a nonhuman space, leading to the perception of a ‘haunting’.

4. The Paradoxical Double Identity of Loab

For all the hyperbolic discourse, there is an awareness that Loab is just data. Yet knowing that this image is made from the accumulation of images we’ve provided to the internet, makes the face looking back at us uncannier. It is the image of our images. Digital technology has, for many decades now, reflected society. In this culture, the screen has for many been a mirror where we might achieve our ‘ideal’ self. Since the early 2000s, when Vivian Sobchack (2004) wrote on how recent developments were used in television to avoid aging, this has only intensified. We have endless apps that will automatically bring youth, and shape our faces into an aesthetic cast, alongside blurring filters that smooth out our skin when videoconferencing. Sobchack persuasively writes that:

we have been technologically altered, both seeing differently and seeming different than we did in a time before either cinema or cosmetic surgery presented us with their reversible technological promises of immortality and idealized figurations of magical self-transformation. (Sobchack 2004, 50)

Indeed, we can think through Loab using Sobchack’s reading of the films *The Mask* (1994) and *Death Becomes Her* (1992). Both characters in these films go through a transformation that she describes as a form of digital morphing. What is remarkable is how the knowledge of this transformation is shaded by the desire to hide the operations of transformation. Both films attribute the technological transformations to what Sobchack describes as ‘non-technical’ elements (e.g. cosmetic surgery). It is not striving for beauty and youth that marks Loab. Rather, it is the failure to become Marlon Brando that causes the default into an image of a ‘grotesque’ version of a ‘woman’. A process that nonetheless finds its parallel in Sobchack’s reading of horror films:

The alternative to cosmetic surgery in what passes for the verisimilitude of cinematic realism is a change in genre, a transformation of sensibility that takes us from the “real” world that demonizes middle-aged women to the world of “irreal” female demons: horror, science fiction, and fantasy.
(Sobchack 2004, 40)

Whether an automatic facial filter on a photograph, or a text-to-image application that produces the closest rendering to what has been anticipated, such uses of AI adhere to the notion of magical transformation. Loab's digital morphing is hidden in the invisible layers of the machine, an affirmation of the occultist sensibility that she haunts latent space. Yet, Loab also works to *break*, rather than build, the transformation fantasy. The paradoxical double identity returns here, as the perpetuation of DL algorithms as wholly autonomous offers a sense of scientific underpinning to this fantasy. Loab, emerging from a negative weighted prompt, makes visible the 'great invisibility' of these processes, which are never only technological, but cultural. It shines light on that which is operationally hidden, alongside that which is repressed for being abject to patriarchal aspirations. Ultimately, we can only speculate how the algorithm came to present the image of Loab as the supposed 'opposite' of Marlon Brando (technically not the opposite per se, but such is the narrative presented to us). While this feeds into why images of Loab are considered disturbing, Sobchack argues that we do not wish to see the technological labour at hand that produces these operational representations. On the contrary, "the technological effects of these transformation fantasies are what we came for" (Sobchack 2004, 48).

Aiming to better understand Loab, brings an opportunity to shift our perceptions. Instead of seeing Loab as a spirit haunting the latent spaces of DL image generators, we can work with Loab to make visible the technological processes of these models. Through this paper, we have shown that while it is important to grapple with the technical aspects of developing these images, it is equally important to reckon with the inflated discourse surrounding them. Loab is undeniably evocative. But much of what has been found compelling about 'her' is a manifestation of an algorithmic imaginary — a desire to validate our fears around technological change. Just as occult photography gave insight to the zeitgeist of the late nineteenth and early twentieth century, occult readings of latent space reflect our contemporary moment. The advanced technological processes involved in generative AI creates a distance that opens to the magical thinking involved in the perception of Loab. In other words, AI generated images are affective entanglements, their uncanniness lies not only in the image, but our view of the technology.

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Tracing Autonomy & Artistic Significance: An Alternative Framework for Analysing & Comparing Generative Art

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As result of the current generative art boom, many generative works are flooding the art and media sphere. However, meaningful analysis, comparison, and discussion of generative art have so far been complicated by two factors: 1) the commonly used definition of generative art is broadly defined, resulting in a large variety of works sharing the same heading, and 2) existing methods for classifying and comparing generative art only facilitate a descriptive analysis of the generative systems within an artwork, but neglect the role & contribution of those systems to the work as a whole. In this paper we propose an alternative framework for analysing generative art, to aid the understanding of what generative art includes, where ‘the generative’ aspect(s) in a work take(s) place, how the generative relates to other aspects in that work, and how this differs from the generative elements and aspects in other works. Two concepts are introduced: *autonomous ability* (AA) and *artistic significance* (AS), including a larger framework to analyse artworks along these concepts. The framework asks 1) what elements (generative and non-generative) the work consists of, 2) what the role of these elements is within the artwork, 3) how autonomous these elements are, and 4) how artistically significant the contribution of the element’s role is in relation to the artwork as a whole. We apply the framework to a selection of four generative artworks to test its working, present the corresponding results, and reflect upon the framework.

Keywords: Generative Art, Generative Systems, Framework, Critical Analysis, Autonomous Systems, Generative Methods.

1. Introduction

Generative art is currently experiencing a significant boom. Developments in GAN, blockchain and NFT technology, but also the introduction of generative AI tools such as DALL-E, Midjourney, Stable Diffusion have pushed methods for creating, collecting, and trading computer generated art, giving extra momentum to the field of computational creativity and the related discussions about creativity, authorship and authenticity. Artworks generated through these technologies are flooding online portfolio platforms, but are also well represented at art & media festivals globally and even have entered traditional art auctions (Cohn 2018) and art competitions (Vincent 2022), demonstrating that generative art is a field and practice that is here to stay and continues to provide both an interesting scope of work and discussions. So, what exactly is generative art? Following the commonly accepted definition, introduced by Philip Galanter, generative art:

... refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art. (Galanter 2003, 4)

Most will think of computer-generated art, such as the works of Manfred Mohr, Lillian Schwarz, Michael Hansmeyer, or Anna Ridler. However, as Galanter's definition proposes, generative art also includes art that is not computer generated, yet still produced by autonomous systems. We support this perspective and see Sol LeWitt's wall drawings, Alexander Calder's mobiles and forms of Islamic tiling as examples of generative art without the use of a computer, acknowledging the long history of generative art. These examples show that a wide variety of works can be considered generative art. Its broad definition allows for this: it not only includes many different types of generative artworks under the same heading (e.g., both generative computer and non-computer art), but also blurs the many differentiations that exist *between* generative artworks, such as style, discipline, or media. It's not surprising therefore, that in the past decades multiple methods by various researchers were formulated to classify, evaluate and compare generative art forms, resulting in multiple schools of thought. Although these entail useful descriptive frameworks, we notice that a critical analysis and comparison of the artworks through these frameworks is harder to obtain. There is a considerable focus on generative processes themselves but what falls short is the positioning of, and reflection on, the role of these processes in relation to the artwork as a whole. With this study, we aim to formulate an alternative perspective for analysing generative art, that could facilitate a critical understanding of what generative

art is, what ‘the generative’ comprises in an artwork, and how this can differ between generative artworks.

2. Review of Theoretical Framework

To illustrate the current discourse, we will shortly review the main existing frameworks on analysing generative art, being those of Galanter (2003; 2008; 2016), Boden & Edmonds (2009), and Dorin et al. (2012).

Galanter (2003; 2008) proposes to view generative art from a systems and complexity theory influenced paradigm. He states that systems (i.e. complex, dynamic systems that inhibit “a large number of small parts or components that interact with similar nearby parts and components” (Galanter 2003, 5), and proposes to classify these systems on a scale from ordered-disordered and simple-complex. We reckon the importance to look at systems, as their properties play a crucial role in generative art. However, we think it is limiting to solely focus on a system’s inner workings without taking its output into account too. Moreover, we doubt if complexity as such is an interesting parameter for evaluating generative art, as it reveals little about what the regarding system *contributes* to the work. Galanter does identify problems regarding evaluating generative art which he augments with questions (2016) of which some we think are valuable to look into (such as the problem of locality: “is the art in the object, the system, code or something else?” (Galanter 2016, 171) or the problem of creativity: “Are generative systems creative?” (Galanter 2016, 172). These questions however are only asked after elaborating on his paradigm, and do not seem explicitly integrated in his framework. Moreover, an explanation of *how* these systems are applied in the artwork and what the generative properties of these complex systems attribute to the *artwork as a whole* is largely left untouched in Galanter’s theory, which we consider crucial for achieving a critical understanding of the generative in art.

Boden & Edmonds (2009) introduced a list of eleven subcategories of computer art, ranging from “Ele-art” (involving electrical engineering and/or electronic technology), to “Evo-art” (evolved by processes of random variation and selective reproduction that affect the art-generating program itself) (Boden & Edmonds 2009, 37), and question for every category “whether the appropriate aesthetic criteria and locus of creativity are the same” (Boden & Edmonds 2009, 21). Compared to Galanter, we think that their view holds a broader notion of what constitutes the artwork, as they speak of an *art system* of which “the artist, the program, the technological installation (and its observable results), and the behaviour of the human audience” (Boden & Edmonds 2009, 40) are all part. We value this more inclusive notion of (locus of) creativity, but miss the possibility in their taxonomy for a critical look into the roles of all these parts. This

arguably makes Boden & Edmonds' classification more of a detailed, medium-specific description of the current computer art landscape, but it does not allow for a dissection or evaluation of the individual elements that are at play in generative art.

According to Dorin et al. (2012), generative art systems are constituted by four components: entities, processes, environmental interaction, and sensory outcomes, along which they propose to outline generative artworks in order to reveal the dynamic processes at play. Compared to Galanter and Boden & Edmonds, we think this method enables a more thorough view into the individual subjects or media used in the artwork *and* their underlying interrelations: a factor we consider characteristic for generative art and therefore essential to critically look at. Also, Dorin et al. take into account some level of external input (which they termed "environmental interaction") (Dorin et al. 2012) involved in the artwork as well as something that could translate to the artwork 'as such' (i.e. "sensory outcomes") (Dorin et al. 2012). Although we think this last component is still a fairly narrow conception of the artwork as a whole (as an artwork can include more than just sensory outcomes), we do think that, when analysing generative art, taking into account both external factors *and* the output of the system are valuable steps in understanding the complete picture. However, other than naming these components, Dorin et al's framework does not facilitate a critical examination of these, which renders it more of a descriptive tool, similar to Galanter's and Boden & Edmonds'.

In short, the above mentioned frameworks do contribute to a useful and necessary body of knowledge on generative art, especially for establishing a singular vocabulary for researching and discussing generative works. However, their descriptive approach does not allow for a more in-depth critical analysis of what the generative in a work *contains* and what it *contributes*. And although this might not be their ambition (Dorin et al. express their "desire for an analytical descriptive rather than a critical framework" (Dorin et al. 2012, 256) and Galanter poses considerations through meta-questions), in our view this leaves possible interesting and valuable questions unanswered. For example: what exactly is the 'generative' aspect in the work? Where in the artwork does this take place? How does this generative element relate to other elements involved in the work? Can we, for example, define different degrees of 'generativity' in or between artworks? And for that, can certain artworks be more generative than others, or in different aspects? We try to formulate an alternative way of looking that could cover this and facilitates a cross-comparison of these factors amongst generative artworks, by the following approach.

3. Approach and Methodology

When we closely interpret the definition of generative art as given by Galanter, it seems to imply that there are two types of ‘degrees’ at play within the artwork. First, if generative art involves a (partially) autonomous system of some sort, then this implies that there is a degree to which that system itself *is able to operate autonomously*. And second, if generative art is art that is (partially) produced by these systems, then this implies that there is a degree to which the system’s output *is important for establishing or creating the artwork as a whole*. But what does this autonomous behaviour entail? How autonomous is this truly? Can we define multiple levels of autonomy in these systems across generative artworks? And if an autonomous system is involved, to what extent is the output of the generative system used in the artwork? What is its creative importance within the artwork? As these factors by definition seem to be important for generative art, we think it could be interesting to analyse generative art according to these. We thus introduce two concepts: *autonomous ability* and *artistic significance*, through which lens we propose to analyse generative art to find answers to the questions posed above and explore if we can come towards new insights about the generative in art.

3.1. Autonomous Ability

With the autonomous ability (AA) of an aspect in the artwork, we aim to examine *how independently this aspect can operate or execute its role without external help or input*. This could mean setting things into motion, performing a task, initiating something, but also creating or revealing something that is unpredictable, new, or surprising (i.e. things that could be defined as “emergent” behaviour or properties (Monro 2009; McCormack 2001), depending on the generative system itself. For example: where or when does it require support, assistance or input? If so, from whom or what? And is this supporting aspect then internal to the artwork or external, such as the artist, the audience or any other environmental factor? How autonomous is it able to operate if these supporting factors weren’t there? Next to this practical execution, also the degree to which the aspect can make its own ‘choices’ independently are part of autonomous ability, as well as how much *creative freedom* the aspect has within these choices. For example, where does the decision making within the work take place? And how does this work? Is the output of the generative system in a way already predetermined? If so: to what degree, and by whom or what? What range of ‘freedom’ does the aspect have when creating its output? How much leeway or agency does the aspect have to navigate or transform the output space? Ultimately, can we define levels of independence, and subsequently degrees of autonomous ability?

3.2. Artistic Significance

With the artistic significance (AS) of an aspect in the artwork, we aim to examine *what its creative contribution to the artwork is* and *how artistically important this contribution is for the final work as a whole*. We reckon this might be hard to objectively determine, but we aim to achieve this with the following questions. What does the aspect contribute to the artwork? How does this contribution compare to the contribution of other aspects involved in the work? Could the artwork still be the artwork, if the aspect's contribution and its characteristics were not there? We would argue that deliberately distinguishing *output or performance* of the generative aspect from the *artwork as a whole* helps to more clearly formulate the concerning aspect's contribution to the work, and subsequently its artistic significance. For some works this might even be a necessity, in case the generative aspect is *not the only* aspect in the work. Therefore, in order to discern more relevant aspects in the work and their tasks, we feel the need to define two other factors for analysis, namely *elements* and their *roles*.

3.3. Elements

To define the autonomous ability and artistic significance of an aspect within a generative artwork, a good understanding of *what the actual artwork is* is required. What parts does the artwork consist of? And what part does the output or performance of the involved generative system take in this? Is this output or performance the artwork (i.e. does the output equal the work)? Or are more factors involved in constituting the overall work? We state that generative artworks often consist of more than just 'the generative', whether that being systems or processes. In fact, they can be a mix of both generative and non-generative aspects, or might even contain more non-generative elements than generative. For example, in Sol LeWitt's mural drawings, both the sets of written rules and instructions (generative), the draftsmen interpreting these (generative), as well as the site specific drawing surface with all its characteristics (non-generative) play important roles in how the resulting work will look like (Lovatt 2010, 2012). Moreover, their interrelations are relevant too, as the generative properties of the written rules are dependent on the non-generative properties of the surface, and vice versa. What we hope to illustrate here, is that it is difficult, and even unfavourable, to only take the generative aspects into account and ignore the non-generative when analysing generative artworks. Unfavourable, because it is imaginable that in a work the *non-generative* aspects have a crucial influence on the *generative* aspects, which in that case, might affect how we regard the autonomous ability of that generative aspect. Moreover, not only the generative aspects in a work can be from artistic importance for the artwork as a whole, but the non-generative aspects evidently as well. We thus state that isolating solely the

generative in an artwork falls short of a thorough analysis, would leave dependencies amongst aspects unseen, and eventually would skew the comparison of generative works fundamentally. Therefore, we propose to include both generative and non-generative aspects in the analysis, as well as their mutual dependencies and dynamics. We will call these the *elements* of the artwork in this study: the building blocks that constitute the artwork; its most important parts, that all together make the work ‘the work’. There can be many or few elements involved in the work. To create more clarity, we define six element categories, being:

1. **Artwork elements:** the individual components or tools that are used in the artwork, both during its making process as well as in the final resulting work. These can be hardware, software, data, material, etc. and their possible output. Questions to distill elements under this category are: what individual parts are used in making this work? What generative system(s) are used? And what separate elements does this system itself consist of or are important to define? Next, the artwork might also include non-generative elements, as we discussed. What are these?

2. **Artist elements:** the maker(s), initiator(s), or architects of the work. What has been created and decided by the artist (and what not)? To define what level of autonomy or what level of artistic significance a certain element has, a good understanding of the role of the artist(s) is required. For example: is the artist’s input required to let an element create output? Additionally, what role does the artist have in the final artwork or output? E.g. was there selection, modification or curation involved in the resulting work? If so, at what level?

3. **Performer elements:** the one(s) performing or executing the work. In the same manner as the artist element: is there a ‘performer’ present in the work that is from influence? Something that for example executes the work? Or let it ‘become’ the final resulting artwork? And if so: who or what is this?

4. **Audience elements:** the ones experiencing or witnessing the resulting work. What influence do they have on the work as such? Can they interact with or participate in the work? If so, what is their range of control: how and to what degree can they affect the work?

5. **Environmental elements:** external factors from the environment the resulting work is situated in. Is there any external input required or involved in the artwork? If so, what is it, and how does it affect the final work?

6. **Element interactions:** dissecting a work in the individual components involved might obscure how they work together. To mitigate

this, we describe their interactions, interdependencies and resulting behaviour as Element Interactions.

3.4. Roles

We have touched upon it already in some questions above, but we would like to highlight it explicitly. An element's autonomous ability and artistic significance is depending on *its specific role within that artwork*. Namely, a generative system involved in a work can by itself have strong autonomous qualities but if its output is filtered, restricted or a byproduct in the overall work than that influences its autonomy and thereby its artistic significance in relation to the artwork as a whole. Therefore, we argue it's important to examine each element's role within the context of that artwork. For example, what does the element do? What is its function or task(s) in the work? E.g. does it require interaction with other elements in the artwork and provide or receive input? Does it perform or execute something? Additionally, a work (or its output) doesn't have to be completed by the artist. A work can be ongoing, ever changing or interactive. Does the audience, performer (if required) or environment have a role in the work? For example, is a generative musical composition fully completed when the artist has finished writing/making it? Or does it require certain executions by performers to become a final instance of the artwork (and does it allow for multiple different instances)? In other words: is the role of an element to create a *blueprint or score* of the work or to fully complete the artwork? We suggest that not the elements themselves, but the qualities and the contribution of their *roles*, should be analysed along the concepts of autonomous ability and artistic significance to get the most accurate and thorough understanding of where the generative in an artwork is situated. This requires to not only look at the internal elements of the artwork but also the roles of the other element categories: like the artist(s), performer(s), audience, environment, and element interactions. Therefore, we propose to first define all the elements present in the artwork, then evaluate what the roles of each element are, and only then analyse how autonomously these elements are able to perform these roles and how artistically significant their roles are for the final artwork as a whole.

In summary, the steps and questions for the analysis look like this:

1. What are the **generative and non-generative elements** involved in the artwork? This includes not only the material (e.g., hardware and software) the work consists of, but also the artist(s), performer(s), audience and environment of the work. Furthermore, both the making process and the resulting work are included in the analysis. What are the **roles of these individual elements** within the artwork? The role describes an element's functions and tasks. Does it generate, create, instantiate or determine something? Does it have emergent

properties? Does it require interaction with other elements in the artwork? Does it perform/execute something? Does it function as (or creates) the blueprint/score of the work? Does it complete the artwork, or create an instance of the artwork?

2. How **autonomously it is able to execute/perform this role?** I.e. can it operate/execute independently? Where or when is the artist or audience needed to let it create output? What levels of independence can we define and distinguish? And, to what extent does it have creative freedom in its role?

3. How **artistically significant is this role** for the content of the artwork as a whole? I.e. how important is the element's performance for creating the output? And how significant is that output and performance to the artwork as a whole? Could the artwork still be the artwork if the element's capacity/characteristics/input were not there?

Answering these questions carefully and consistently gives a thorough dissection of the generative artwork and what is at play. We hope it discloses what differences or similarities exist between the generative amongst separate artworks, and helps in making various dimensions of generativity in generative art explicit. For example, does the generative in an artwork lie on the level of the execution by the audience? How much generativity is held or performed by the artist self? Or, does the generativity exclusively lie on the level of the generative system? Making these differences explicit might, ultimately, aid comparison and evaluation of generative art.

Schematically, the framework looks like the matrix below:

	Artwork (AW) (its subjects, media, systems, individual parts, etc.)	Artist (AT) (the maker(s) or initiator(s) of the work)	Performer (PF) (the one(s) performing or executing the work)	Audience (AD) (the ones experiencing the work and participating/interacting with it)	Environment (EV) (external input from the environment in which the work is situated)	Element Interactions (EI) (how elements relate to/interact with each other)
ELEMENT						
ROLE(S) of the element in the artwork						
AUTONOMOUS ABILITY of the element to perform its role						
ARTISTIC SIGNIFICANCE of the element's role for the artwork						

Figure 1: Schematic overview of the proposed alternative framework.

4. Analysis and Comparison

To evaluate the framework, we tested it on a small, diverse selection of eight¹ generative artworks (ranging from 'traditional' to 'uncon-

1. The complete list of analysed works is: 1) *Mobile* (c. 1932) by Alexander Calder; 2) *Fidenza Collection* (2021) by Tyler Hobbs; 3) *Continuous Project - Altered Daily* (1970) by Yvonne Rainer; 4)

ventional’, older to contemporary, and computer to non-computer examples of generative art) from different art disciplines. For the scope of this paper however, we chose to illustrate the model by means of four artworks: Alexander Calder’s *Mobile* (c. 1932) (Fig. 2), Vera Molnár’s *Structure de Quadrilatères* (1985) (Fig. 3), Mario Klingemann’s *Memories of Passersby I* (2018) (Fig. 4), and Tyler Hobbs’s *Fidenza Collection* (2021) (Fig. 5). In this section we will explain how we approached the analysis and what our insights are from comparing these analyses between the four artworks.

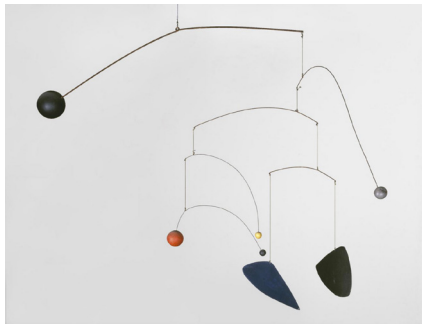


Figure 2: *Mobile*. Kinetic sculpture. Image retrieved via Tate Gallery (2019). © Alexander Calder, *Mobile*, c. 1932, c/o Pictoright Amsterdam 2023.

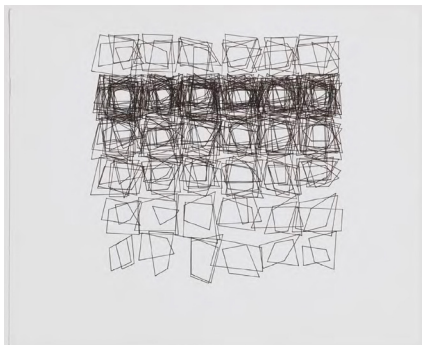


Figure 3: *Structure de Quadrilatères*. Computer-generated graphic in ink on Calcomp plotter paper. Image retrieved via Senior (2019). © Vera Molnár, 1985, c/o Pictoright Amsterdam 2023.

For each artwork, we filled in the matrix as introduced in Fig. 1. To support consistent comparison, for the third (AA) and fourth row (AS) we used a semi-quantitative measurement in the form of a six-step scale.² To keep the matrices concise and improve cross-referencing to cells, all cells were tagged with a short alphanumeric string corresponding to the element category abbreviation letters,³ column number (starting from “1” for every element category, if more than one element under the same category is present) and row letter(s).⁴ Once the matrices were completed, we traced 1) where in the artworks the generative is situated (by detecting in which cells of the row Roles the most generative concepts (e.g. “creating”, “emerging”, “inventing”, “producing”, etc.) are present. Elements *with* these concepts were defined as ‘generative’ (i.e. ‘active’, displayed in bold text in the matrices), whereas elements *without* these concepts were defined as ‘non-generative’ (i.e. ‘passive’, in regular text), 2) how the autonomous ability is distributed over the elements of the work (by evaluating the content of the /AA coded cells on their score), and 3) how the artistic significance is distributed over the elements (by evaluating the content of the /AS coded cells on their score). Lastly, to not obscure the boundaries between the *making process* of the work and the *work itself*, an extra visual distinction in the matrices was made between elements that *are part of the resulting work* (highlighted columns) and elements that *are not* (non-highlighted columns).⁵ The completed matrices can be viewed in fig. 6, 7, 8, and 9.

4.1. Amount of Distinguishable Elements

When we compare the matrices with each other (meaning: between the four artworks), we find that first: the amount of distinguishable

1. *Structure de Quadrilatères* (1985) by Vera Molnár; 5) *Seven Experiments in Procedural Animation* (2018) by Karl Sims; 6) *Hot Pool* (2010) by Driessens & Verstappen; 7) *In C* (1964) by Terry Riley; 8) *Memories of Passersby I* (2018) by Mario Klingemann.

2. Being: 0) Not Applicable (N/A); 1) None; 2) Low; 3) Medium; 4) High; 5) Very High.

3. Artwork = AW; Audience = AD; Artwork = AT; Environment = EV; Performer = PF; Element Interactions = EI.

4. Element = E; Autonomous Ability = AA; Role(s) = R; Artistic Significance = AS; Format of the code tag thus becomes: [ElementCategoryLetters+ ColumnNumber/[RowLetter(s)]]. E.g. EV2/AA = the second environmental element’s autonomous ability.

5. As the highlighted element columns already make clear what is part of the resulting work, the Element Interactions column was not highlighted.

elements per artwork is considerably higher than we expected to define a priori. Apparently, when critically dissecting a work, more elements (both passive and active) emerge as essential. This could broaden the scope of what to take into account when analysing generative art, but moreover: requests for a broader conception of what could be seen as generative, autonomous or artistically significant within a generative artwork.

4.2. Distributed Generativity and Autonomy



Figure 4: *Memories of Passersby*. Installation made with GANs (AI). Image retrieved via ONKAOS (n.d). © Mario Klingemann, *Memories of Passersby I – Companion Version*, 2018. Courtesy of ONKAOS.

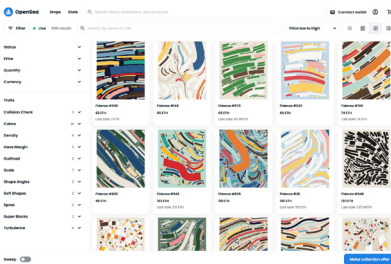


Figure 5: *Fidenza Collection*. Set of 999 algorithmically generated digital images. Image retrieved via OpenSea (n.d.). © Tyler Hobbs, *Fidenza Collection*, 2021.

Second, in all works the generative properties seem not confined to one individual element, but are distributed across multiple elements. For example, in Klingemann’s work, the GAN models (AW3/R), the application (AW3/R), and the external output of successful samples (AW6/R) all hold generative properties. In Calder’s *Mobile* and in Hobbs’ *Fidenza*, also elements outside of the work play a generative role (for Calder the air current (EV/R), and for Hobbs the Art Blocks platform on the Ethereum blockchain (EV1/R)). Notably, the matrices make clear that in all four works the artists (AT/R) essentially have the most generative roles. This signals that more elements than the ones involved in – what are traditionally considered – “the generative systems” (such as algorithms, computers, set of natural language rules, etc.) can hold generative properties and can have an essential role for the content of the work. Furthermore, we see that the interdependencies between the ‘traditional systems’ and external elements in the works become visible in the column Element Interactions of the matrices. E.g. in both *Memories of Passersby* and *Fidenza*, we observe that the most generative processes take place at the level of the interactions of the elements (EI/R). This indicates that individually, many elements possess some degree of generative behaviour or properties, but that this range can be significantly enhanced, facilitated or kickstarted, in combination with the behaviour or properties of other elements: of which some might not even be internally part of the resulting work itself (i.e., ‘Artwork’ elements), but external (such as ‘Environmental’ or ‘Audience’ elements). This shows that the actual generative “system” of the work often encompasses more than solely the ‘main’ generative Artwork elements, and results from the greater whole of all its generative elements. Moreover, when comparing the autonomous ability of the generative elements across the artworks, we see a similar phenomenon: individually the generative elements have a lower degree⁶ of AA than a priori expected, mostly due to their dependency on other elements in order to operate autonomously. But when viewed in context of their interactions, it appears that they collectively hold a very

6. NB: the terms “low(er)” and “high(er)” as used in the text for comparison and discussion of the analyses results are different from the values “Low” and “High” used in the matrices. “Low(er)” in the text refers to the lower part of the six-step scale in the matrices (N/A - None - Low - Medium). “High(er)” in the text refers to the upper part of this six-step scale (High - Very High).

high degree of AA. E.g. in *Fidenza*, where the artist (AT/E), the script (AW1/E), the on-chain art platform (i.e. an ‘Environment’ element) (EV1/E) as a system (EI/AA) together are responsible for much more creative choices in the whole process, and carry significantly more autonomy than individually.

4.3. Deviated AA and AS

Third, the matrices show that the degrees of AA and AS not always align within elements. Meaning: not all elements that scored high in AA in an artwork, also scored high in AS, or vice versa. E.g. the application (AW2/E) and the external output of successful samples (AW6/E) in *Memories of Passersby*, or the program (AW1/E) or computer monitor (AW1/E) in *Structure de Quadrilatères* (both low AA, but high AS), or the on-chain art platform (AD1/E) in *Fidenza* (high AA, medium AS). This finding seems to contradict what is generally (implicitly) assumed in most studies into generative art, namely that when an autonomous element is used for creating the work, this element by definition also is important for the work as a whole, and the other way around. From the perspective of this framework, it appears that the degrees of AA and AS can diverge across individual elements involved in the artwork. However, one element that structurally does show alignment in AA & AS (i.e. both high) in the analyses is the ‘Artist’ (AT/E). This seems to indicate that, despite the general conception that in generative art a large part of control is attributed to a system or machine, the artist still plays a significant role in making the decisions (AT/AA) in the analysed works, that are — compared to decisions of other autonomous elements — highly important for the artwork as a whole (AT/AS). In the matrices, this becomes most evident in row /R, where the amount of crafting, developing, testing, and altering required by the artist in order for the machine or system to generate the envisioned output is listed. E.g. Calder’s methodological experimentation with the physics of the mobile’s hardware (AW/E) in combination with the air current (EV/E) to ensure interesting compositions, or Hobbs’ extensive iterative process of designing, testing, tweaking an existing algorithm (Hobbs n.d.) in order to create a script producing coherent quality output over the full series of 999 at-random instances. As example, the designed properties of the *Fidenza* algorithm are particularly important for the content of the artwork, which makes the artist’s role more artistically significant for the work than for example the role of the on-chain platform (EV1/AS) or the minting collectors (AD1/AS).

Additionally, the matrices also make explicit how the artist (AT/R) executes significant steps of selection, moderation, and curation of the in- or output of what can be regarded as the generative system, before the work becomes the final work. E.g. Molnár not only iteratively altered the code of her program (input) (AW1/E) based on the outcome visible in real-time on the monitor (output) (AW4/E) (a

process she termed “conversational method” (Molnar 1975), which was only enabled after the introduction of computer monitors), but subsequently also selected one particular instance of this program as fit for printing and exhibiting (and thus discarded the other outcomes). These form profound interventions, affecting the resulting artwork and its experience. This emphasises that although generative art involves “independent systems”, on various levels the ‘hand’ of the artist is still very present.

Lastly, a finding that taps into this: over the course of time, some artworks have been generally renowned as undisputed examples of generative art, such as Molnár’s. Often, critics tend to attribute a degree of autonomy in these works to the computer, mostly because of its ability to incorporate “randomness” (Guillermet 2020). With that, Molnár’s aforementioned conversational method is often mentioned as an instinctive approach “that enables greater receptiveness to the unpredictable” (Rigamonti di Cutò 2018) which would prevent “pre-meditation” of the work. However, analysing Molnar’s work through our framework suggests that one could also interpret Molnár’s work as the opposite *because* of this conversational method, as the matrices disclose how much curation and iteration of the “random output” is present: the work is generated using an algorithm but the *behaviour* of the algorithm (including the used amount of randomness) is programmed by the artist instead of autonomously generated. In this case, one could arguably question how ‘unpredictable’ a generated work is, if the outcomes of the generating machine are heavily controlled, reviewed and curated in the process by the artist self. The matrices show that in other approaches curation and control takes place on a different level, such as in Hobbs’ where controlled randomness is still at play (Hobbs n.d.), but who’s method does allow a large range of different, ‘unknown’ output that can be generated/produced based on the randomly generated seeds. These different approaches could suggest for a more critical perspective on how ‘generative’ and ‘autonomous’ the involved elements in generative art actually are.

Mobile (c. 1932), Alexander Calder

	Artwork (AW) (its subjects, media, systems, individual parts, etc.)	Artist (AT) (the maker(s) or initiator(s) of the work)	Performer (PT) (the one(s) performing or executing the work; therefore not applicable)	Audience (AD) (the ones experiencing the work and participating/interacting with it)	Environment (EV) (external input from the environment in which the work is situated)	Element Interactions (EI) (how elements relate to/interact with each other)
ELEMENT	AW/E: Steel wire, metal panels, wooden spheres, string	AT/E: Alexander Calder	N/A (not present/no explicit role in the work; therefore not applicable)	AD/E: The audience walking around the work	EV/E: The air current in the room where the work is presented	EI/E: The components of the mobile (AW/E) move by the changing air current (EV/E) present in the room.
ROLE(s) of the element in the artwork	AW/R: To generate movement and subsequently different compositions.	AT/E: Composing the mobile; choosing composition and balance between the individual elements of AW/E. Designing the "system" of mobile, air current, movement all together, and with that defining the "grammar" of the sculpture.	N/A	AD/R: To observe the work, and by standing and walking around it, add to the air current EV/E that causes AW/E to move and take on compositions.	EV/R: To initiate the process of AW/E generating movement.. To displace the attached elements of AW/E relative to each other, so the work changes composition and perspective continuously	EI/R: The whole of mobile, audience, environment and their interaction forms the generative system, and it is there to form a closed, self maintaining loop.
AUTONOMOUS ABILITY of the element to perform its role	AW/AA: High: requires EV/E to generate movement, and its range of behaviour is dictated by the design choices of AT/E (by which the shapes and surfaces to catch wind are determined). However, its design still inhibits a large output space with a wide variety of possible movements and thus possible compositions and AT/E can autonomously take on.	AT/AA: High: holds significant agency in making creative choices for the grammar of the mobile. However, is depending on the physics of EV/E in combination with AW/E, to eventually create a composition-space that is interesting to experience for AD/E. For this, AT/E needs to experiment extensively to understand interaction of AW/E with AD/E. Moreover, influence of AT/E has no further on AW/E and EV/E.	N/A	AD/AA: Medium: can choose how to position themselves in space related to AW/E to observe different compositions, and with that might influence EV/E (e.g. by passing direction, speed).	EV/AA: High: the natural air current specific to the environment needs no input or support from anything else, which makes this element autonomous.	EI/AA: Very high: once the mobile is hanging, the system is able to work independently and infinitely, and with that is able to generate new compositions of the work indefinitely.
ARTISTIC SIGNIFICANCE of the element's role for the artwork	AW/AS: Very high: movement is a key factor in this kinetic work. Therefore, AW/E is very important for both functionally creating EV/E in order to generate different compositions of the sculpture as well as for the artist to experience the results in.	AT/AS: High: the artistic choices of AT/E in designing AW/E and experimenting how balance is formed influence the output space of possible compositions of the sculpture, which makes AT/E highly artistic significant.	N/A	AD/AS: Low: significant to lesser extent for subtly contributing to EV/E. However, cannot influence nor add to the range of motion and thus compositions possible with AW/E as this is a priori determined by AT/E through AW/E.	EV/AS: Very high: The air current initiates the generation of movement by the mobile, which is a very important factor of the work.	EI/AS: Very high: the interaction of the artwork elements with its environment is key to the work: it is what the sculpture is about. Therefore, the dynamics between air and metals is very artistic significant for experiencing the resulting work.

Figure 6: Matrix with analysis for *Mobile I* (c. 1932)

	Artwork (AW)		Artist (AT)	Performer (PF)	Audience (AD)	Environment (EV)	Element Interactions						
	(its subjects, media, systems, individual parts, etc.)		(the person(s) or initiator(s) of the work)	(the entity) performing or executing the work)	(the ones experiencing participating/interacting with it)	(external input from the environment in which the work is situated)	(how different relationships interact with each other)						
ELEMENT	AM1/E: The program containing the drawing algorithm, designed by AT/E	AM2/E: The output of AM1/E, executed by AM3/E.	AM3/E: The computer	AM4/E: The computer monitor (CRT screen)	AM5/E: The plotter	AM6/E: The physical black & white print with lines and squares	AT/E: Vera Molnar	N/A (not present/no explicit role in the work; therefore not applicable)	N/A (not present/no explicit role in the work; therefore not applicable)	N/A (not present/no explicit role in the work; therefore not applicable)	N/A (not present/no explicit role in the work; therefore not applicable)	E/E: The computer "draws" the "mental image" that the program contains, and is iteratively given new instructions by the artist for generating the next instance.	
ROLES) of the element in the artwork	AM1/R: To generate AM2/E. AM1/E is designed by AT/E, containing the parameters designed by AT/E, that together make up the "grammar" of the work. In short: to function as the blueprint of the work.	AM2/R: Is the visual output of AM1/E. AM2/E is designed by AM3/E, "composing" of the work, i.e. an image of lines and squares. Is an instance of AM1/E, executed by AM3/E, and is iterated on through adapting AM1/E by AT/E.	AM3/R: To execute AM1/E, and produce AM2/E. With this, AM3/E writes the "composition" of the work (i.e. the blueprint) (AM1/E)	AM4/R: to function as a real-time output device via which AT/E can view AM2/E.	AM5/R: to print AM6/E	AM6/R: to function as the physical output of AM2/E, in which AT/E can view AM2/E.	AT/R: To design AM1/E to iterate on the design of AM1/E, after seeing AM2/E via AM4/E, to select the final version of AM2/E to be printed as AM6/E.	E/R: To facilitate a dialogue between AT/E and AM3/E, which ultimately results in generating AM6/E.	N/A	N/A	N/A	N/A	E/R: To facilitate a dialogue between AT/E and AM3/E, which ultimately results in generating AM6/E.
AUTONOMOUS ABILITY to perform its role	AM1/AA: Medium: depends on AT/E for its contents, and on AM2/E for its execution. But for creating "freedom" or randomness as the code is relatively deterministic: it's designed to mimic the mental picture of the image by AT/E.	AM2/AA: None: however changing in form with every iteration by AT/E. It does not have the ability to transform itself or create anything other than creating.	AM3/AA: Low: can arguably execute AM1/E independently. However, it has limited range of freedom as it effectively follows as it executes AM1/E.	AM4/AA: None: it has no other option than to show AM2/E (in its exact form)	AM5/AA: None: cannot print AM6/R without being controlled by AM3/E, and has no creative freedom in what to print.	AM6/AA: N/A (is a passive factor that is created)	AT/AA: High: holds great creative freedom in many stages of the work: inventing AM1/E, iteratively altering AM1/E (i.e. "conversational method" of curating AM2/E), and how AM3/E composes AM1/E.	E/AA: Medium: once the infrastructure of E/R is established, E/R can be implemented. However, AT/E has such a decisive role in initiating, maintaining, and operating E/R, that it diminishes the AA of E/E as a whole.	N/A	N/A	N/A	N/A	E/AA: Medium: once the infrastructure of E/R is established, E/R can be implemented. However, AT/E has such a decisive role in initiating, maintaining, and operating E/R, that it diminishes the AA of E/E as a whole.
ARTISTIC SIGNIFICANCE of the element's role for the artwork	AM1/AS: Very high: it contains the "grammar" of the work (i.e. the constraints of working with lines and squares). However, because of this, instances of AM2/E are discarded in the process, and are thus not significant for the final version of AM6/E.	AM2/AS: Medium: the iterative process to get from the 1st instance to the final one (which AT/E selects to become AM6/E) is a crucial tool for materialising AT/E's "ideas" (i.e. calculating the permutations of AM1/E designed by AT/E) important for the method of AT/E in generating AM6/E as a whole. However, it is less important for the artistic content of the work than compared to AM1/E.	AM3/AS: Medium: is a crucial tool for materialising AT/E's "ideas" (i.e. calculating the permutations of AM1/E designed by AT/E) important for the method of AT/E in generating AM6/E as a whole. However, it is less important for the artistic content of the work than compared to AM1/E.	AM4/AS: High: compared to maintain a real-time feedback provided by AM4/E allows AT/E to interact and iterate immediately on AM1/E, which Molnar called her "conversational method" (key in her work and is therefore artistically very important.	AM5/AS: Low: is important to physically print AM6/R, but less important than AM3/E for the iterative process of E/E.	AM6/AS: High: is the final, curated output of AM2/E (the "end product") in physical form, and what is presented by AT/E as "the artwork".	AT/AS: Very high: the decisions by AT/E that significantly affect what AM6/E results in are made by AT/E in AM3/E that is involved in this method means a higher artistic significance role of AT/E in the artwork as a whole.	E/AS: Very high: the interaction between AT/E, AM1/E, AM3/E & AM2/E defines AM6/E as final artwork (not AM2/E), making E/R very artistically significant for the artwork as a whole.	N/A	N/A	N/A	N/A	E/AS: Very high: the interaction between AT/E, AM1/E, AM3/E & AM2/E defines AM6/E as final artwork (not AM2/E), making E/R very artistically significant for the artwork as a whole.

Figure 7: Matrix with analysis for Structure de Quadrilatères (1985)

ELEMENT	AW1/E: Training data (images of paintings)	AW2/E: Application containing learning conditions developed by AW2/E	AW3/E: GAN models, developed by AITE and trained on AW2/E through AW2/E	AW4/E: Computer	AW5/E: INTERNAL OUTPUT – virtually generated samples by AW3/E, discriminated by itself	AW6/E: EXTERNAL OUTPUT – visually generated samples presented on AW7/E	AW7/E: Physical objects: 65”-46” framed screens, wooden console housing the computer and other hardware, chairs	Artist (AT) (the maker(s) or initiator(s) of the work)	Performer (PF) (the one(s) performing or executing the work)	Audience (AD) (the ones experiencing the work and interacting with it)	Environment (EV) (external input from the environment in which the work is situated)	Element Interactions (EI) (how elements relate to/interact with each other)	
ROLES of the element in the artwork	AW1/R: Is the dataset (concerning AW7/N) used for training AW2/E. Most elements in paintings on which AW3/E trained is collected, curated, and formatted by AVE.	AW2/R: Instructs AW3/E with its learning conditions concerning how to process AW1/E and to accelerate training of AW3/E. Contains the blueprint for the internal AW3/E for the combination of generation between AW3/E, AW5/E, and AW6/E.	AW3/R: Generates AW3/E based on its training and subsequently a method of generating AW5/E depending on its structure. Outputs AW6/E if discrimination is successful.	AW4/R: Tool for AITE to train AW3/E. Also AW4/E: computes or ‘trans’ AW3/E.	AW5/R: Set of images of fake portraits generated by AW3/E based on AW1/E. AW5/E for discrimination, after which a selection of AW5/E then becomes AW6/E.	AW6/R: Real time generated images of the AW5/E samples that successfully discriminate by AW6/E. Visually presented to the audience as a stream of morphing portraits on screens of AW7/E.	AW7/R: 75” function as both practical (house the hardware of AW1/E, AW2/E, AW3/E, AW4/E, AW5/E) and decorative elements that enhance the experience of AW6/E to AD/E.	AITE: To collect, curate and format AW1/E into a stream of AW2/E to select and alter AW3/E.	N/A	N/A	EV/E: The room AW6/E/ AW7/E are exhibited in, and its properties (lighting, etc.) determine the experience of AW7/N/E for AD/E.	EV/E: The room AW6/E/ AW7/E are exhibited in, and its properties (lighting, etc.) determine the experience of AW7/N/E for AD/E.	EW/E: To form a self-operating and self-learning system that, with little human input, is able to generate output indefinitely.
AUTONOMOUS ABILITY of the element to perform its role	AW1/A: N/A (AW1/E is a passive element, that does not contain explicit generative properties).	AW2/A: Medium: has autonomous capacity for training AW3/E. However, depends on AVE for its design, and content dictates.	AW3/A: Very High: is able to generate, output independently due to internal structure of generation and discrimination.	AW4/A: Low: can arguably operate autonomously concerning freedom of choice; however, it has limited capabilities as it is instructed provided by AW6/E.	AW5/A: N/A (AW5/E is a passive element, that does not contain explicit generative properties).	AW6/A: Low: is able to generate new visualisations continuously, but itself inhibits its creative freedom in which to include, as this is determined by AW6/E.	AW7/A: N/A (AW7/E is a passive element, that does not contain explicit generative properties).	AITE/A: High: AITE is very autonomous and holds a lot of creative control over AW2/E. AW3/E and AW4/E are relinquishes significant control over what samples are created (AW5/E) and directed for AW6/E to AW3/E.	N/A	N/A	EW/A: Medium: how AW2/E influence of EV/E could influence how AD/E experience AW6-EAW7/E, they are a priori decided upon and fixed by AITE (described in the text). AW7/E is the out AITE’s vision of how AW6-AW7/E to experience.	EW/A: Medium: how AW2/E influence of EV/E could influence how AD/E experience AW6-EAW7/E, they are a priori decided upon and fixed by AITE (described in the text). AW7/E is the out AITE’s vision of how AW6-AW7/E to experience.	EI/A: Very High: the system of the relevant elements is self-organising and autonomous in operating because of its architecture, and many creative choices for the content of the “whiter” or by the collective elements that constitute the collective system.
ARTISTIC SIGNIFICANCE of the element’s role for the artwork	AW1/AS: High: the properties (i.e. colour palette, contrast, composition, figurative representation) inhibited by these properties influence the content of AW5/E, making AW2/E artistically significant to the work as a whole.	AW2/AS: High: because it dictates how and what AW3/E ‘hears’, it is artistically significant for the content of AW6/E. Therefore, it has some artistic significance for the content of the work as a whole.	AW3/AS: High: what AW3/E generates forms the basis for further iterative process of EW/AS. Moreover, due to its design of generation and discrimination, degree of internal AW3/E arguably makes it important for the content of the work.	AW4/AS: Medium: without its properties, making AW6/E a ‘production’ requirement for the work. However, its role is not artistically significant for the content of the work, and therefore is from the artistic significance for the work as a whole.	AW5/AS: Medium: might contain samples that are selected for AW6/E. But might also contain samples that are discarded by AW3/E. Therefore, its role is not artistically significant for the content of the work.	AW6/AS: Very High: is the main experientiable component of the work. Moreover, its content forms the loop of EW/E, making it artistically significant to the work as a whole.	AW7/AS: Medium: are important for the full experience of the work, and therefore are not as important as the content of AW6/E for the work as a whole.	AITE/AS: High: curating AW2/E determine the experience of AW3/E by AW2/E. AITE/AS determine the parameters in AW2/E which form a distribution guideline for AW3/E. However, due to the content of AW5/E, these are important for the content of AW6/E. However, due to the complexity of the content of AW6/E, AITE/AS are not as important as the content of AW6/E for the work as a whole. Its design choices foresee every result of AS of this element.	N/A	N/A	EW/AS: Medium: the properties of EW/E can certainly enhance the experience of AW. But since these are largely directed by AITE, and over time, there are more and more choices (self how to do so) is an important factor for the work. Therefore, EW/E is artistically significant part for AW as a whole.	EW/AS: Medium: the properties of EW/E can certainly enhance the experience of AW. But since these are largely directed by AITE, and over time, there are more and more choices (self how to do so) is an important factor for the work. Therefore, EW/E is artistically significant part for AW as a whole.	EI/AS: Very High: the self-maintaining system is an important part of the work: the idea that a system like this can autonomously operate and generate unexpected outcomes is an important factor for the work. Therefore, EI/AS is artistically significant part for AW as a whole.

Figure 8: Matrix with analysis for Memories of Passersby I (2018)

Element	Role(s) of the element in the artwork	Artwork (AW)	Artist (AT)	Performer (PT)	Address (AD)	Environment (EV)	Element Interactions
		(its subjects, media, systems, individual parts, etc.)	(the identity of or initiator(s) of the work)	(the one experiencing or executing the work)	(the one experiencing/interacting with it)	(external input; work is situated)	(how elements relate to/interact with each other)
		AW1/E: The script containing the main algorithms (i.e. scale, shape, colour, margin, turbulence, etc.), selected and designed by AT/E. Updated by AT/E to EV1/E.		N/A (not present/no explicit role in the work: the script is not applicable)	AD1/E: Collector mining a Fidenza NFT via EV1/E.	EV1/E: Art blocks, a platform hosting generative art and NFT collections on the Ethereum blockchain	EV1/E: The audience is able to instantiate the generation of a work, through the blockchain technology, which is autonomous and unknown to both the audience and the artist.
		AW2/R: To generate AW2/E, the algorithmic blueprint for AW2/E provides the main parameters that can be altered/ randomised based on the input of the E, in order to generate the instances of AW2/E.	AW2/R: Tool for AT/E to generate AW2/E. AW2/E is developed and test AW2/E with, prior to uploading iterations of AW2/E, but does not generate AW2/E.	N/A	AD1/R: To mine (i.e. purchase) an instance (AW2/E) of AW2/E via EV1/E. However, both the minted range (AW2/E) corresponding NFT in their NFT wallet. Can decide to offer AW2/E for auction to AD2/E via EV2/E.	EV1/R: To facilitate the minting of AW2/E and generating corresponding NFTs, corresponding to the generation of AW2/E. EV1/R is used during the generation of AW2/E. EV1/R is used to house online auctions for the resale of AW2/E.	EV1/R: To establish an infrastructure for generating and testing at random instances (AW2/E) by the technical infrastructure for an external party (AD1/R) in order to generate AW2/E.
		AW3/E: Collection of 999 digital images (PNGs), each a unique instance of the script (AW2/E). Each as NFTs on EV1/R/E.	AW3/E: Are the individual instances of AW2/E: the visual output of the algorithm of AW2/E. AW3/E is directly transferred via EV1/E to AD2/E. Possibly E via EV2/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW3/E generation (through minting) of AW2/E via EV1/E. However, this is the only action AD1/E can take for generating AW2/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW2/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW4/R: The printer	AW4/R: To print AW2/E	N/A	AD2/A: Medium: has the agency to initiate the process of AW4/R generation (through printing) of AW2/E via EV1/E. However, this is the only action AD1/E can take for generating AW2/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW2/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW5/E: The physical prints of AW3/E.	AW5/R: To function as the physical high quality print of AW3/E. E optionally ordered by AD2/E or AD2/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW5/E generation (through printing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW6/R: None: cannot operate AW4/R without AW2/E and has no creative freedom in ways to print.	AW6/A: None: cannot operate AW4/R without AW2/E and has no creative freedom in ways to print.	N/A	AD2/A: Medium: has the agency to initiate the process of AW6/A generation (through printing) of AW2/E via EV1/E. However, this is the only action AD1/E can take for generating AW2/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW2/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW7/E: The physical prints of AW3/E.	AW7/R: To function as the physical high quality print of AW3/E. E optionally ordered by AD2/E or AD2/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW7/E generation (through printing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW8/R: To select an existing experiment extensively by its possibilities to test what range for AW8/E. AW8/E provides interesting outcomes for AW3/E, and adjust the algorithm to that, in blueness of the work.	AW8/R: To select an existing experiment extensively by its possibilities to test what range for AW8/E. AW8/E provides interesting outcomes for AW3/E, and adjust the algorithm to that, in blueness of the work.	N/A	AD2/A: Medium: has the agency to initiate the process of AW8/R generation (through testing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW9/E: High: requires EV1/E's input before it can generate AW9/E. Simple algorithm that even inhibits controlled randomness (as AT/E programmer's ranges). However, still inhibits a vast output space for creative output.	AW9/A: Low: can arguably operate autonomously. Concerning freedom of AW9/E, it has limited capabilities as it in essence "follows" the instructions provided by AW9/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW9/A generation (through testing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW10/A: High: requires EV1/E's input before it can generate AW10/E. Simple algorithm that even inhibits controlled randomness (as AT/E programmer's ranges). However, still inhibits a vast output space for creative output.	AW10/A: Low: can arguably operate autonomously. Concerning freedom of AW10/E, it has limited capabilities as it in essence "follows" the instructions provided by AW10/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW10/A generation (through testing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.
		AW11/A: Very high: the unity in variety makes AW11/E an interesting set. So although every instance of AW11/E is different, they all have the same constraints, and thus all have the same visual grammar, the core artistic concept of the work is the same across the outcomes that AW11/E is able to generate.	AW11/S: Medium: without the properties of AW11/E, the work could be materialised. This makes AW11/E a 'productional requirement' for the work; however, its importance for the content of the work, and therefore is less judiciously significant for the artwork as a whole.	N/A	AD2/S: Low: other than the generation of an instance of an AW11/E, it is not artistically significant for AW11/E. It is not artistically significant in any way, and thus cannot affect the resulting work as such.	EV2/S: Medium: its full collection (AW11/E), and thus for establishing the notion that AW11/E is a series of work (which adds to the idea/ mystery of 'what is creative' possible with AW11/E) and thus for generating the actual content of the work, it is not from any importance.	EV1/S: Very high: although the content is simple, the role of EV1/E contributes to the idea of an algorithm and the constraints that AW11/E has, making it very unpredictable, unique yet coherent series of images. This element of surprise as well as the mystery of AW11/E is an important artistic element to this artwork as a whole.
		AW12/S: Very high: the unity in variety makes AW12/E an interesting set. So although every instance of AW12/E is different, they all have the same constraints, and thus all have the same visual grammar, the core artistic concept of the work is the same across the outcomes that AW12/E is able to generate.	AW12/S: Medium: without the properties of AW12/E, the work could be materialised. This makes AW12/E a 'productional requirement' for the work; however, its importance for the content of the work, and therefore is less judiciously significant for the artwork as a whole.	N/A	AD2/S: Low: other than the generation of an instance of an AW12/E, it is not artistically significant for AW12/E. It is not artistically significant in any way, and thus cannot affect the resulting work as such.	EV2/S: Medium: its full collection (AW12/E), and thus for establishing the notion that AW12/E is a series of work (which adds to the idea/ mystery of 'what is creative' possible with AW12/E) and thus for generating the actual content of the work, it is not from any importance.	EV1/S: Very high: although the content is simple, the role of EV1/E contributes to the idea of an algorithm and the constraints that AW12/E has, making it very unpredictable, unique yet coherent series of images. This element of surprise as well as the mystery of AW12/E is an important artistic element to this artwork as a whole.
		AW13/S: High: it is the visual output of the algorithm (i.e. the end product), and the end element of AW13/E and AW13/E are key to the content of the work. Low contribution to the content of the work (low generating and storing art on chain).	AW13/S: Low: is important for physically producing and thus AW13/E. But is less important than AW13/E. However, it makes its artistic contribution to the content of the work (low generating and storing art on chain).	N/A	AD2/S: Low: other than the generation of an instance of an AW13/S, it is not artistically significant for AW13/S. It is not artistically significant in any way, and thus cannot affect the resulting work as such.	EV2/S: Medium: its full collection (AW13/S), and thus for establishing the notion that AW13/S is a series of work (which adds to the idea/ mystery of 'what is creative' possible with AW13/S) and thus for generating the actual content of the work, it is not from any importance.	EV1/S: Very high: both the "grammar" of the script containing the rules with which AW13/S is generated, as well as the resulting singular visual grammar present in AW13/S, make the work significant for the work as a whole.
		AW14/S: Low: is important for physically producing and thus AW14/E. But is less important than AW14/E. However, it makes its artistic contribution to the content of the work (low generating and storing art on chain).	AW14/S: Low: is important for physically producing and thus AW14/E. But is less important than AW14/E. However, it makes its artistic contribution to the content of the work (low generating and storing art on chain).	N/A	AD2/S: Low: other than the generation of an instance of an AW14/S, it is not artistically significant for AW14/S. It is not artistically significant in any way, and thus cannot affect the resulting work as such.	EV2/S: Medium: its full collection (AW14/S), and thus for establishing the notion that AW14/S is a series of work (which adds to the idea/ mystery of 'what is creative' possible with AW14/S) and thus for generating the actual content of the work, it is not from any importance.	EV1/S: Very high: both the "grammar" of the script containing the rules with which AW14/S is generated, as well as the resulting singular visual grammar present in AW14/S, make the work significant for the work as a whole.
		AW15/E: The physical prints of AW3/E.	AW15/R: To function as the physical high quality print of AW3/E. E optionally ordered by AD2/E or AD2/E.	N/A	AD2/A: Medium: has the agency to initiate the process of AW15/E generation (through printing) of AW3/E via EV1/E. However, this is the only action AD1/E can take for generating AW3/E (i.e. AD2/E is by design autonomously able to influence what parameters will permeate in AW3/E.	EV2/A: N/A. EV2/E is a passive element.	EV1/A: High: The system operates independently and inherently contains the properties to decide on the visual output of the work. Instances of the work.

Figure 9: Fig. 9. Matrix with analysis for Fidenza Collection (2021)

5. Discussion and Limitations

Having analysed a few artworks with this framework, we can discuss the first findings on its working and its results. First we observe that, when completed, the matrices tend to make clear where the *generative gravity* within an artwork is located, that is within the presented artwork itself (i.e. ‘closed’: at the left side of the matrix, under column AW), or outside of the artwork (i.e. ‘open’: at the right side of the matrix, under columns AT - PF - AD - EV - EI). This visual aid might be valuable for obtaining a quick, basic understanding of a generative work. Second, columns AW (Artwork) and EI (Element Interactions) seem to disclose that generative art exist in roughly two forms: works that are *generated* (i.e. works that are created with or through generative methods, but of which the resulting work is not generative themselves) or works that are *generating* (i.e. resulting works that are generative themselves). The first form consists of final work or ‘end products’ that are ‘finished’, do not require any further input and are not evolving over time (e.g., the works of Molnár and Hobbs). Works of the second form, however, are not ‘finished’, do require certain input in order to ‘work’ and are evolving over time, (e.g., the work of Calder and Klingemann (ONKAOS 2018)). We think this is an important distinction to make and could function as an extra classifier for analysing and comparing generative artworks.

Lastly, we found that the framework exposes how generative art artists are not specifically interested in letting a machine or system produce something autonomously, but more *in creating something in collaboration with it*. They use generative methods as a way to establish a *dialogue* between them and ‘the system’, that adds a sense of serendipity, unexpectedness and (controlled) ‘out-of-control-ness’ that makes generative art both interesting to make and experience e.g. Molnár’s conversational method, Hobbs’ and Calder’s structural grammar that generates surprising compositions in combination with other system elements. This, together with the argument for an adjusted notion of the AA of those systems, might shift the discourse around generative art from art created *by* the machine, to co-creating art *with* the machine.

Needless to say, this framework is not conclusive in every aspect. To an extent it has fixed guidelines on how to analyse and interpret generative artworks, but in theory multiple readings of elements, roles, AA or AS are still possible. We tried to obviate this as best as possible, by articulately defining what we consider under every concept and element category, and what to fill in where in the matrices. However, we realise that some ambiguity in interpretation of these questions might exist: per artwork, but also per analyser. For example, for *Fidenza*, we listed the on-chain Art Blocks platform as an environmental element (EV1/E), as the work technically is presented there, whereas one arguably could also consider it an Art-

work element. Additionally, we chose not to include the computer monitor as element in the analysis for Klingemann and Hobbs, but we did for Molnár since we considered that in context of Molnár's work the monitor was from greater importance to the work as such.⁷ Other well-argued choices for elements and placements, however, are just as valid for analysis. This touches on a challenge we encountered ourselves: how to deal with the tools used for making the work? How to interpret their AA and AS? E.g. the computer: essentially a tool that 'follows' instructions provided by a program to generate output. Framed by the question: "what does its role contribute to the artistic content of the work?", we considered its AA and AS therefore low (see AW4/AS in Klingemann's, and AW2/AS in Hobbs). However, we reckon one could also interpret its AS as high based on a different reasoning (e.g. in case of Molnár: "using computers as tools for artistic expression was novel at that time, and therefore the idea of this element being able to generate something artistically is more important to the work" or "the computer enables a certain *vision on or inspiration for* producing art in general, which in itself is artistically significant (to the work)"). We realise this might diminish the effective conclusiveness of the framework, and therefore suggest to assess this in future research, while ensuring its flexibility. Analysing generative artworks through this framework proved to be an iterative process of adding, deleting, and shifting elements across the matrix, going back-and-forth between all elements for understanding and defining their roles, AA, and AS. This in itself already illustrates the intricate, multifaceted aspects of generative art. Concerning representation, we aimed to test the framework on works from multiple art disciplines. However, due to the scope of the research, examples from literature, design and architecture were not included in the analyses, nor were works outside of the Western art canon. We are aware that this affects the results, and therefore suggest for future research to include works from outside these frames, in order to facilitate more comprehensive comparisons and conclusions with the framework.

6. Conclusion

We developed this framework from the need for a more in-depth, critical method for analysis of generative art, that honours its diversity and allows for an understanding of the generative beyond solely the denotation of the 'system' or its processes. Important notions were previously coined by Galanter, Boden & Edmonds, and Dorin et al., which established a useful ground. From this, we aimed to make the next step and approach the generative in relation to the work as a whole including all involved external elements and their interactions. Therefore, we pushed dissecting generative art further

7. Due to the facilitating role the monitor directly played for Molnár's specific way of making generative art (i.e. her "conversational method" (Molnár 1975)), resulting in this specific work.

by deliberately defining more element categories (e.g. ‘Artist’, ‘Performer’, ‘Audience’, etc.) in our framework in order to make their impact within the work explicit. We took Galanter’s definition of generative art quite literally, and proposed to analyse generative art through the lens of autonomous ability and artistic significance, to see what it would reveal about the generative within and between artworks. We noticed that by being very meticulous and explicit in this, details on what plays an important role in the work, what is generative and on what level this takes place in the artwork come to the surface. The most notable findings are that significantly more elements than generally accredited for, together constitute the ‘system’ in a generative work. Also, more elements than the generative can (either) be autonomous and artistically significant for the work as such but correspondingly: not all generative elements by definition are autonomous nor artistically significant. In that fashion, the degree of autonomous generativity of some generative works could be questioned, and lastly: a lot of autonomy and artistic significance within the artworks is located at the level of the artist. Perhaps these findings challenge some general assumptions of generative art (e.g. that something “generative” is unquestionably autonomous, and that something “autonomous” by definition is artistically important for a work). We reckon this way of thinking about generative art certainly adds to the idea of “creative machines” and “art autonomously made by systems”, which unmistakably speaks to our collective imagination and hype sensitivity. However, analysis through our framework discloses that even system-generated work contains a considerable degree of control and direction held by other elements – especially the artist self, which might nuance our general view on how much control the artist actually relinquishes to an autonomous system, and might adjust our conception of how “autonomous” those systems truly are.

We hope this framework provides an interesting alternative perspective on generative art. We think it can be a meaningful tool for analysing and comparing artworks, and help in obtaining a more critical understanding of generative art. We consider the framework valuable for art critics, researchers, and curators, but also for makers of generative art themselves, as it might reveal opportunities for applying generative methods or elements at different categories or in different modes. Needless to say, the field of generative art evolves rapidly and turbulently, which provides both a challenge for the framework and interesting conditions for its application and relevance. We are therefore curious what it can contribute in light of these rapid developments in generative AI, the proliferation of generative art production, and corresponding public discussions about creativity, authorship and authenticity.

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Towards a Framework for Embodying Any-Body through Sensory Translation and Proprioceptive Remapping: A Pilot Study

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We address the problem of physical avatar embodiment and investigate the most general factors that may allow a person to “wear” another body, different from her own. A general approach is required to exploit the fact that an avatar can have any kind of body. With this pilot study we introduce a conceptual framework for the design of non-anthropomorphic embodiment, to foster immersion and user engagement. The person is interfaced with the avatar, a robot, through a system that induces a divergent internal sensorimotor mapping while controlling the avatar, to create an immersive experience. Together with the conceptual framework, we present two implementations: a prototype tested in the lab and an interactive installation exhibited to general public. These implementations consist of a wheeled robot, and control and sensory feedback systems. The control system includes mechanisms that both detect and resist the user’s movement, increasing the sense of connection with the avatar; the feedback system is a virtual reality (VR) environment representing the avatar’s unique perception, combining sensor and control information to generate visual cues. Data gathered from users indicate that the systems implemented following the proposed framework create a challenging and engaging experience, thus providing solid ground for further developments.

Keywords: Robot, Virtual Reality, Embodiment, Homuncular Flexibility, Non-Anthropomorphic Avatars, Non-Homologous Avatars, Research-Creation, Interactive Installation.

1. Introduction

Hugh Herr believes that during the 21st century, humans may extend their bodies into “non-anthropomorphic structures, such as wings, controlling and feeling each wing movement within the nervous system and become unrecognizable in morphology and dynamics from what we are today. Humanity will take flight and soar” (Herr 2018).

The topic concerning artificial bodies raises questions about the nature of our bodies, our identity, and what we can virtually be. Avatars play a central role in building not only our social lives, but also our identities, as they become the material out of which we embody and make ourselves real (Taylor 2002). In the dawn of virtual reality, it turned out that people could quickly learn to inhabit strange and different bodies and still interact with the virtual world. The term “homuncular flexibility” was chosen to describe the phenomenon of controlling avatars by using different degrees of freedom from the physical body (Lanier 2010; Won et al. 2015). Non-anthropomorphic avatars in virtual worlds challenge the limitations of human-centered principles and expand the potential for interaction and communication. As in the Bhagavad-Gita the deity “becomes human”, becomes different through an avatar, so we can too “become non-human” through our avatars. The embodiment of the avatar can influence interactions and activate new metaphors that guide human thought and action in new ways. The use of avatars can also affect behavior, with evidence of the “Proteus effect” where people’s behavior changes to match their avatar (Lugrin et al. 2016; Banakou et al. 2013; Kilteni et al. 2013; Peck et al. 2013). Citing the classic work *The Cyborg’s Dilemma*: “technology that changes the appearance or affordances of the body also changes the self” (Biocca 1997). However, research in this field still lacks a systematic approach and often limits interesting possibilities (Taylor 2002; Won et al. 2016).

The aim of this paper is to introduce a novel conceptual framework for addressing any-body embodiment, which is based on the idea that the problem translates into the design of a comprehensive system that is composed of body (avatar), sensory remapping, and control scheme that alter the proprioception upon control. Virtual reality allows us to operate bodies that differ substantially from our own. However, avatars with different topology than the human shape require control schemes and interfaces that effectively translate between user and avatar (Won et al. 2016; Krekhov et al. 2019). We state that the reverse is also as important, the mapping from the body to the user, in terms of perception alteration and translation. The driving insight is that a body does not only correspond to a certain quality of movement, but also to a specific type of perception. How does a body completely different from ours perceive the world around it? Another major characteristic of our approach is the use of physical robots as the avatar bodies, which can take any physical aspect in

general (Bonarini & Besio 2022) and have any possible sensing systems and abilities. From one side the interaction with the real world may impose more limitations than virtual world settings, on the other side it enables the interaction with other physical entities, such as other robots and biological beings, including humans, without them being mediated by or loosely reproduced within an artificial environment that may exclude or alter the real perception both from the physical and from the cognitive points of view.

We implemented the principal concepts of the framework in two prototypes tested in the lab and in a real exhibition. The final aim of this research is to make human subjects live the experience of having bodies possibly completely different from their own, interacting in the real world. Applications span from entertainment, to performing arts, rehabilitation, remote presence in critical situations, and many others.

The rest of the paper is structured as follows. In Section 2 we will introduce the background for embodiment, and then focus on studies on non-anthropomorphic bodies. The outline of our conceptual framework is presented in Section 3. In Section 4 the first prototype is presented, with the relative experiments and results. In Section 5 we will discuss “Connect to the Machine”, an interactive installation, based on the framework, that we designed and presented to the public. We will also discuss results obtained from questionnaires answered by the visitors. Section 6 will close the paper with the discussion and future directions.

2. Background

2.1. The Sense of Embodiment

“The Sense of Embodiment (SoE) toward a body B is the sense that emerges when B’s properties are processed as if they were the properties of one’s own biological body.” (Kilteni, Groten & Slater 2012) The term is used to refer to the set of sensations that arise in conjunction with being inside, having, and controlling a body; it is commonly studied as the compositions of three different feelings: 1) Sense of Body Ownership (SoBO), 2) Sense of Agency (SoA), and 3) Sense of Self Location (SoSL) (Kilteni, Groten & Slater 2012, Argelaguet et al. 2016).

Sense of Body Ownership: The sense of body ownership (SoBO) refers to a person’s self-perception of her body and her belief that her body is the source of her sensations (Kilteni, Groten & Slater 2012). The idea was first explored in the Rubber-Hand Illusion experiment by Botvinick and Cohen (Botvinick & Cohen 1998). Research supports the hypothesis that body ownership is a result of multisensory perception and can be influenced by sensory correlations between

physical stimuli and perceived stimuli (Chancel & Ehrsson 2020, Samad et al. 2015; Ehrsson 2012; Kilteni, Groten & Slater 2012). Although our sense of body ownership typically feels inherent, stable, and unchanging, research has shown that it is highly malleable. For example, it can be influenced by the appearance of avatars (Aymerich-Franch et al. 2017; Cardinali et al. 2021; Hosa et al. 2019). Guy et al. (2022) and Krekhov et al. (2019) also showed that first person perspective positively affects SoBO.

Sense of Agency: The sense of agency (SoA) refers to the feeling that one is the one causing or generating an action; it is associated with statements like “I am in control of my actions” (Kilteni, Groten & Slater 2012). It is sensitive to the temporal relationship between the execution of a self-generated movement and the visual feedback and can be maintained in virtual reality by providing real-time or near real-time visuomotor correlations (Kilteni, Groten & Slater 2012; Franck et al. 2001). Research suggests that the sense of agency is not necessarily related to the number of degrees of freedom in control, but with the efficiency of control, and a realistic avatar representation is not necessary to induce the sense of agency (Argelaguet et al. 2016; Giroux et al. 2019).

Sense of Self Location: The Sense of Self-Location refers to the spatial experience of being inside a body (Kilteni, Groten & Slater 2012). The body space provides a reference frame for our physical body and determines the space in which body sensations are registered (de Vignemont 2011). The sense of self-location can be altered by various factors including the collocation between virtual and real body (first person perspective), synchronous visuo-proprioceptive correlations during movements, and correlated vestibular cues (Kilteni, Groten & Slater 2012; Argelaguet et al. 2016). The rubber hand illusion experiment (Botvinick & Cohen 1998) demonstrates that self-location can be changed through synchronous visuo-proprioceptive correlations between a rubber hand and a real hand.

2.2. Non Anthropomorphic Avatars

Here we discuss research that is aimed at exploring the sense of embodiment for non-anthropomorphic bodies or body parts. Due to the variety of the studies, we separate the studies based on the amount of similarity between the avatars and the human body, in terms of appearance, function, and control.

“Near-Human” Avatars: We call “near-human avatars” those bodies that are only different from the human shape visually, and which are however still following the humanoid structure and control. The results for SoBO were conflicting, with some studies indicating a preference for more realistic bodies (or body parts) (Kilteni, Groten & Slater 2012; Argelaguet et al. 2016; Kao 2019; Latoschik et al. 2017;

Tekgün et al. 2022), while others presented opposite results (Lugrin et al. 2015; Hosa et al. 2019; Krekhov et al. 2019), showing that ownership can also be felt for less morphologically similar bodies or limbs (Aymerich-Franch et al. 2017; Krekhov et al. 2019; Lugrin et al. 2015; Kilteni, Normand, Sanchez-Vives & Slater 2012; Giroux et al. 2019), possibility based on perceived functionality similarity (Cardinali et al. 2021). A growing consensus is that avatars with traits very similar to the user's are favored, but other humanoid shapes are viewed with distrust (Krekhov et al. 2019; Lugrin et al. 2015). Indeed, the biological realism of these studies may aid in user identification with an avatar, but it may also be confusing since such realism may reinforce the user's desire to move as he or she would like in the physical world (Won et al. 2015).

Minimal Humanoid Representations: This paragraph discusses the use of “minimal humanoid representations”, which are still based on the humanoid structure and control but have a minimal representation. In these studies, minimal representations of the body (such as spheres tracking only the head/hands or a pose) were found to be the most recognizable by users (Wellerdiek et al. 2013) and resulted in increased exploratory behaviors and creativity without lowering the sense of embodiment (Vuarnesson et al. 2021; Laroche et al. 2021). In (Giroux et al. 2019), users also indicated SoA and SoBO for point light representations of their limbs when these were coherent with their real movements.

Morphologic Changes and Homuncular Flexibility: The section discusses studies on non-anthropomorphic avatars that are inhuman in both appearance and topology, and thus require an explicit control mapping. Control schemes were developed to include full-body humanoids with different arm and leg mapping or additional limbs (Won et al. 2015; Steptoe et al. 2013), animal avatars (Krekhov et al. 2019), and non-anthropomorphic hands (Molnar & Menguc 2022). Results showed that participants can identify themselves with, and control, avatars with different morphology and novel control mappings (Won et al. 2015); synchronous visuo-motor control was found to be a necessary and sufficient condition for Sense of Embodiment (SoE). However, strong unnatural relationships to more human-like visual cues may be detrimental for SoE and a more abstract representation of the avatar may increase the sense of ownership and performance (Won et al. 2016; Schwind et al. 2017).

2.3. Sensory Alterations

The concept of sensory substitution involves using one sense to substitute another. For example, visual information can be transformed into tactile stimuli or auditory signals can be visualized (Proulx et al. 2014). In (Bach-y-Rita & Kercel 2003) a sensory substitution device (SSD) was developed to convert visual images into tactile stimuli,

allowing blind individuals to perceive visual information through touch. The authors found that extended experience with the SSD leads to changes in body image and greater control over the device.

The Reality Helmet (Waterworth & Fallman 2003) is instead an example of altered embodiment where technology becomes a part of the body and changes the form of perception. We assume that the world appears as we normally perceive it, even though we are aware that our senses are different from other animals and thus their perception of the world is different from our own. By utilizing the technical methods that define altered embodiment, we have the ability to choose different forms of perception and hence, change our understanding of the world.

3. Framework

We introduce our conceptual framework for any-body embodiment, which aims to create a system that can immerse a user into a new body while eliciting a high sense of embodiment (SoE). The framework consists of three principles:

1. A system cannot transfer a human into a new body by only acting on a subset of components.
2. The user's perception system should be a sensory translation system (ST) of the avatar's perception.
3. The system should provide a mechanism to remap the user's perception away from their own body and towards the avatar's.

Moreover, we decided to focus on robotic bodies as the avatars (Toet et al. 2020).

In the following sections we will discuss in more detail our conception of the avatar body, control system and sensory translation, with ideas about guiding principles for design and possible research dimensions for future studies.

3.1. The Robot Avatar

Since with ST we translate data from sensors into signals that the user can understand, it is interesting to keep the source of that information as unmediated as possible; this can be done with real robots, which offer both the possibility of making a wide range of different bodies, and the possibility to be deployed in real world, interacting with real, physical environments, objects, and people.

The shape of the robot should not be bio-inspired, but instead should explore new possibilities for embodiment. The robot can be

in a fixed location or be able to move in space, can have parts that move and change configurations, and its size influences the type of interactions it can have. The robot can perceive its environment through various sensors such as object detection and recognition, relative position, sound, touch, and proprioceptive signals.

3.2. The Control System

The design of the control system requires a mapping between user's and avatar's movements, or, in general, actuators. One of our contributions is to separate the control system into components, by introducing the concept of PROC (Proprioception Remapping on Control) as the second component beside the mapping itself.

3.3. Proprioception Remapping on Control

With the insight that operating a non-human avatar is similar to operating a marionette (Molnar & Menguc 2022), we worked with puppeteer and artist Marta Cuscunà, to understand the principles behind puppet control. Our collaboration led to the concept of PROC, where passive feedback is associated with the user's actions to create a sense of effort and control. PROC is different from force feedback, which aims to transmit the avatar's haptic sensation to the user (Toet et al. 2020). Instead, PROC provides haptic cues based solely on the user's control signals, creating a remapping of proprioception. The goal is to immerse the user in this remapping and other sensory stimulus to create an experience of a new body. By changing proprioception, this reduces the expectation of a human body and movement, leading to a total and immersive experience.

In the design of the control system, we follow these guidelines:

Engaging Control Mappings: One of our main aims is to foster a new use of the user's body. As such, the control needs to involve the body in novel ways, for example by requiring the use of body DOFs not usually used (e.g., a tail (Steptoe et al. 2013)) or remapping existing ones (Won et al. 2015) or imposing unconventional postures and movements (Krekhov et al. 2019).

Flexible Remappings: In early design stages, some users preferred more natural mappings (e.g., forward motion to control forward motion of the avatar) while others found it more interesting, challenging and in the end more immersive to explore new dimensions. Steptoe et al. (2013) and Won et al. (2015) showed that objectives increase the SoE, which could mean that users that chose the more challenging mappings felt more immersed by the implicit challenge of these control choices.

3.4. Sensory Translation

As Sutherland states in his classic *The Ultimate Reality*: “There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality with which we are familiar” (Sutherland 1965).

When aiming at fully experiencing the world through a radically different body, we argue that simply placing a camera in the place of the avatar’s eyes (Krekhov et al. 2019; Won et al. 2015; Vuarnesson et al. 2021) is not sufficient, as the unique perception and body shape of the avatar also play a crucial role in determining the experience. Thus, one of the main elements of our framework is Sensory Translation (ST). We use this term to represent the system that gathers the data from the avatar’s perception (the robot sensors, in our case) and translates them into information that can be perceived by the user, for example, translating the information from distance sensors into visual cues about the position of virtual objects in VR. In the design of the representation of the avatar’s sensor information, the interface may exploit the interaction channels available to the subject; the main ones include point of view (first person view is preferred (Kilteni, Groten & Slater 2012; Argelaguet et al. 2016)), vision (preferably through a VR headset for immersion), sound, touch (haptic sensations). We also emphasize the importance of synchronous representation of control signals, to provide the user with a sense of agency and motor learning (Section 2.1). It is crucial to create a system that provides the user with as many congruent stimuli as possible, such as visual, auditory, and haptic feedback, to infer a common cause for the sensations and create a unified source of body ownership (Hosa et al. 2019; Samad et al. 2015; Shneiderman et al. 2016). Minimal representations can also be useful, as studies have shown that these can provide more relevant information (Wellerdiek et al. 2013) or foster experimentation (Vuarnesson et al. 2021). For these reasons we always remove the possibility to communicate verbally, to induce experimentation on different channels and emergent behaviors.

4. The First Prototype

Based on the conceptual ideas presented in Section 3, we conducted our pilot study with a first prototype in which a specific robot body, control and sensory feedback systems are implemented. In all the experiments we worked with the same robot body and sensory feedback, and explored different interfaces to control it, testing this prototype with 17 users with the aim to investigate both the general ideas of the framework and quality of the specific implementations.

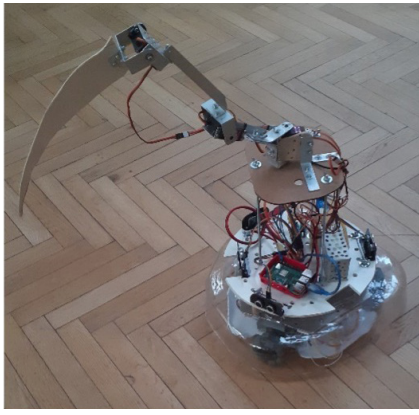


Figure 1: Claw, the robot used as avatar in the experiments of the first prototype.

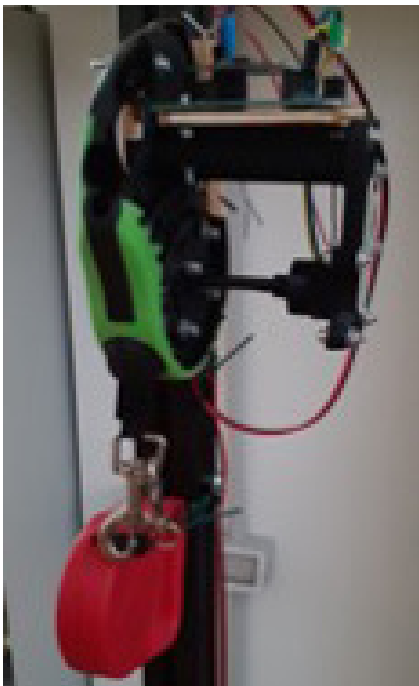
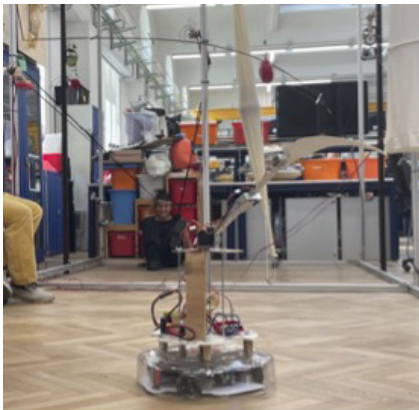


Figure 2: Above is the structure we used in the experiments to attach the leashes of *Strings*, while actress and puppeteer Marta Cuscunà is using the system to guide the robot. Below, details of the connection between the leash wheel and the rotary encoder.

4.1. Implementation

The Robot Body: The Claw robot has 3 DOF on omni-wheels and a 3 DOF arm with a curved pointed element that has been interpreted as a sickle, beak, or claw. The robot has only 3 sonar sensors in front and 1 on the back detecting the distance from any reflecting target in a range of 3.5 meters each. The conceptual characteristics of the avatar are small size, single arm that moves on wheels, and limited sensors. The purpose of this design was to explore movement in space and non-trivial interfaces, with a generic avatar that can be interpreted differently by different users (see Figure 1). We were interested in testing our system with an avatar that could be as generic as possible, far from the human shape but also from any specific creature. We achieved this objective since different users interpreted the few aesthetic elements of the robot quite differently from each other.

The Control System: We implemented two different control systems, with both a remapping logic and a PROC mechanism.

Strings: The first control interface implemented is called *Strings* (Figure 2), inspired by *Whimsichord* (Meckin et al. 2012). It consists of dog leash strings providing spring-resistant connections with fixed points on the structure surrounding the user. Each leash controls one degree of freedom of the robot and can control the robot's wheels or servo arm, depending on the setup. The speed of each DOF is directly related to the speed of pull or release of the associated leash.

Limitations of *Strings* include that it can run out of leash before reaching a target position for DOFs with large spans and separating control actions becomes difficult as the number of controlled DOFs increases.

JoyGlo: A sensorized glove (Figure 3) that was intended to be more portable, offer a more flexible control logic, and overcome the limitations of *Strings*. Each finger on the glove is linked to a separate degree of freedom (DOF) of the robot, allowing for more precise and independent control. The glove detects each finger's position with a linear potentiometer and provides two types of feedback (force and vibration) based on the finger position. The glove has two modes of control: "speed control" in which the DOF is controlled by the speed of the finger movement, and "position-type" in which the signal is translated into a setpoint based on the finger position. In practice, the movement of the ring finger was found to be influenced by the other two fingers for many subjects, so in experiments only the index, middle and little fingers were used for control. The control mapping is flexible and can be configured by each user.



Figure 3: The two *JoyGlo* prototypes. Sensorised gloves, with strings connections from the fingertips to the linear potentiometers. Springs add mechanical resistance while vibromotors on the tips provide additional feedback on the control action.

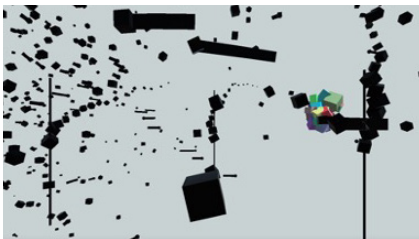


Figure 4: The VR environment representing the “avatar’s perception”, with the black cubes being related to the controls exerted by the user, and one of the colored blocks representing the signal coming from one of the sonars, getting closer or further from the user based on the real sensor readings. When colored blocks are invisible, it means that the corresponding sonar is not perceiving any signal.

Sensory Translation System: The purpose of this system is to convert the state of the avatar into information that can be experienced by the user. The state of the robot at any given moment is represented by 10 numerical values, which consist of 6 control signals and 4 sonar values. To achieve this, we developed a VR app in Unity and deployed it on Oculus Quest 2 (Figure 4). The app takes the user into a virtual environment where each of the 10 values has a corresponding visual effect. To enhance understanding, the environment is kept simple with only elements related to the robot’s state, and control signals are separated from sensor data using color. The cube shapes were used to provide a sense of coherence and simplicity in the environment.

- wheelbase control signals were represented with black particle systems.
- servo control signals changed the rotation of three black shapes in front of the user.
- data from sonar sensors was represented with coloured shapes approaching or moving away from the user.

The design presented a challenge in balancing realism and abstraction. For the servo controls, signals were represented as separate objects instead of linking them mechanically as they were on the robot, whereas for the sonar signals, we opted for realism by matching the visual representations to the actual meaning of the signal. This duality aimed to stay closer to the robot’s perspective while still providing a good user experience. Crucially, in the VR environment users can only “see” the sonar and control data, and they need to find a connection between their own movements and the visualizations.

4.2. Experiments

Our aim was to assess the sense of embodiment that this system would elicit on the users, and we focused on three specific aspects in this pilot study: the control and sensory translation systems, to test our implementations, and the effect of giving a task: while in (Vuarne-sson et al. 2021; Laroche et al. 2021) they argued that giving no objectives fostered exploratory behaviors, (Steptoe et al. 2013; Won et al. 2015) showed that the presence of a task increases SoE. Since we are interested in both aspects, we tested both situations.

To test the control system, participants have been presented with one of the three following configurations:

- *Two Gloves*. One *JoyGlo* controls the wheeled-base movements and the other controls the head servos.
- *Hybrid 1*. A *JoyGlo* controls the three arm servos, and three *Strings* leashes control the wheel base.

— *Hybrid 2*. A *JoyGlo* controls the wheeled base, and three *Strings* leashes control the three arm servos.

To test the other aspects, all participants went through three consecutive phases:

1. Free exploration with VR headset on, no objective. Duration: 2-3 minutes.
2. Introduction of a simple goal: avoid obstacles. Duration: 2-5 minutes.
3. The VR headset is removed, and a task is given to be accomplished by the robot: touching an object with the tip of the arm. At this point users could see the robot, themselves, the real environment, and the effects of their movement on the robot's.

Volunteers signed an informed consent and agreement to participate in anonymous form, for a total of 17 subjects, aged from 21 to 29, 5 females and 12 males. After the experience, each subject compiled a questionnaire including some of the questions proposed as part of a standard questionnaire for evaluating embodiment with VR avatars (Peck & Gonzalez-Franco 2021), repeated for each of the three phases, and custom questions related to our specific systems. Subjects were also presented with open-ended questions to be able to better articulate their experience, and to give ideas and suggestions.

The questionnaire, all the answers and the plots of the aggregated results are available for download at <http://airlab.deib.polimi.it/wp-content/uploads/2023/06/prototype.zip>.

4.3. Results

In this section, we discuss the most relevant results we obtained.

“Controlling the Robot as if it Was My Own Body”: Users had mostly positive responses when asked about their sense of control over a robot as if it was their own body. The level of positivity increased in phase 2 (VR with an objective), which corresponded to a decrease in “feeling out of one’s body”. This trend aligns with previous research on agency and synchronous vasomotor control synchrony (Section 2.1). A clear objective improved the sense of embodiment (SoE) (Steptoe et al. 2013; Won et al. 2015), though movement and creativity was reported to be enhanced in phase 1 without explicit instructions or goals (Vuarnesson et al. 2021; Laroche et al. 2021). Controlling the robot in a VR environment, even abstractly, led to a better sense of bodily connection compared to seeing the robot in phase 3, suggesting non-anthropomorphic sensory translation systems can benefit embodiment and avatar manipulation.

“Understanding What Is Happening”: As expected, scores for the understanding of such an abstract environment were in general low. However, values were higher for the second phase as the participants were co-located with the robot and the task-oriented approach allowed users to obtain more synchronous stimulation across more sensory channels. This suggests that designing artificial perception systems that focus more on the avatar’s own affordances, rather than mimicking human perception, may increase the sense of embodiment.

PROC Systems: Subjects reported the vibration on the gloves to be crucial for the feeling of connection to the avatar but noted that the prototypes sometimes failed to deliver the signal appropriately. Similarly, subjects enjoyed the physical sensations provided by the elastic forces and said that the constant tension they induced was important to force the body to focus on the movement they were generating. The problem they highlighted in this case was actually that these elastic forces were too weak. Overall, subjects have been positive about the systems, but did not report them as essential; however, they related the limits specifically to the inability of our devices to deliver the intended sensations consistently, encouraging us to design more reliable systems based on the same concepts.

“The Importance of the Robot’s Sounds”: The study found that the sound produced by the robot’s motors was important for the user experience as it provided additional feedback and helped the user understand their influence on the robot’s movement. Hearing was a sense for which we did not design any active system, so the presence of a sound feedback provided an unexpected multisensory experience (see Section 2.1) and feedback (Shneiderman et al. 2016), factors that are known to be crucial in the literature (Section 3.4).

5. Connect to the Machine: An Interactive Installation

In this section we present our installation *Connect to the Machine*, which we showed in November 2022 at the Milano Digital Week, and which is the natural evolution of the Claw prototype. As in (Vuarnesson et al. 2021), we structured the installation in the form of a laboratory experiment, allowing us to collect post-experience subjective reports.

5.1. The Installation

The interactive installation is composed of two experiences in parallel. Visitors could try one experience at a time but were unaware of the relationship between the two. Each experience lasted between 3 and 5 minutes.



Figure 5: The robot interaction section of our installation. Above are users observing the robot trying to understand its environment. Below is the robot Siid, the robotic avatar of our installation. The outer shell of petals can be opened or closed, revealing the hidden soft head.

In the first space, visitors interacted with an autonomous robot, and they were told only that it was “learning to interact with humans” (Figure 5). The subject in the second space was linked to a VR headset and four Strings (see Section 4.1) and was given the objective to understand and manipulate the abstract environment (Figure 6).

In fact, the second subject was controlling the robot in the other room, and what he or she perceives as abstract representations in VR were the results of the human-robot interaction in the other space: the two participants were actually interacting with each other through the system.

The Robot: Siid is a flower-shaped robot with three DOF on omni wheels and a single servo motor controlling its petals opening mechanism. The bulb on its inside hides an LED and the digital eye’s pupil can also move within an eye-like screen (Figure 5). It has 4 sonar sensors like the robot Claw (see Section 4.1), and an infrared temperature sensor on the head between the eye and the bulb, used to detect the presence of a human hand. The intended objective was to invite humans to interact with Siid and to caress it, obtained with the stark contrast between the rigid shell and the soft head within, negotiated by the opening and closing movement of the petals.

The Control System: To control Siid, 4 Strings were used, 3 for the wheelbase and one for the petal movement, and they were chosen over JoyGlo for being more agnostic to users, and for eliciting more exploration in bodily use (Figure 6). The trigger button of the VR headset’s controller regulates the light of Siid’s bulb, and the position of the headset controls the position of Siid’s digital pupil, transmitting the sensation of “looking around”.

Sensory Translation: Many components of the ST were kept the same as in the prototype (Section 4.1).

However, the petal’s servo was represented more realistically, with virtual petals opening and closing around the user. The biggest variation was related to the temperature sensors. The environment was made red and heavy but would turn clear and peaceful if the temperature sensor was triggered by petting the robot. Subjects in the VR room were only told about the possibility of turning the sky blue and had to figure out the combination of movements to do so (see Figure 6).

5.2. Results

Every visitor tried both experiences independently, and then were informed about how they were connected. At the end we asked them to complete a voluntary questionnaire, like that presented in the first experience, modified accordingly.

The questionnaire, all the answers the table with the aggregated results are available for download at <http://airlab.deib.polimi.it/wp-content/uploads/2023/06/connect-to-the-machine-2022-installation.zip>. Here we report the main results.

Figure 6: The immersive section of our installation. The subject is attached to 4 Strings and uses them to navigate and understand the virtual environment representing the perception of the robot in the other space. A red sky with colored cubes nearby indicates that the robot is in front of obstacles, but it's not being caressed. A screen was set up to show the visitors what the subject was seeing in real time.



For the robot interaction part, users reported liking the robot appearance and having tried to help it to learn. Users also felt that the robot was reacting to their actions. However, scores on perceived robot autonomy were quite low.

For the VR experience, subjects didn't feel like they could always understand or control what was happening. However, they consistently reported the importance of the elastic resistance of the strings to feel connection to the virtual environment.

When asked how they would improve the system, subjects talked about the difficulty of the task in VR, and of the unsatisfactory interaction of the robot. Indeed, the two are linked, as if the subject controlling the robot cannot understand how to complete the task, the robot itself will not behave in an interesting way, and also its perceived autonomy will decrease. To solve this problem, it will be important to design the control and ST systems so that the robot's abilities are easier to exploit and allow the user to "feel part of the environment, even if you feel lost in it". They also felt that sound was missing, as they could not hear the robot.

When asked what they enjoyed the most, they consistently talked about the VR experience of perceptual change, with expressions such as "challenging", "mind-blowing" and "an experience that really made me think". Users were also thrilled by the discovery of the robot and the VR system being connected. These feelings were

also confirmed by the high score obtained for the question on overall enjoyment (over 80% of the 35 answers were between 4 and 5 in a 5-points scale).

Overall, these findings underline the importance of finding a compromise between the stimulating abstraction and the necessary intelligibility of the environment, and confirm the quality of the system in its ability to challenge, engage and surprise users, which are in our opinion the great possibilities that come from entering a body that is truly different from ourselves.

6. Conclusions

6.1. Discussion

With this paper, we presented a conceptual framework aimed at achieving full immersion in physical avatars with any shape, to promote exploratory behaviors from users while maintaining a sense of embodiment. The design is intended to induce a change in the user's perception of their own body, creating the illusion of being directly connected to the avatar they are controlling. The idea of altered embodiment is already present in the literature (Waterworth & Fallman 2003; Won et al. 2015; Krekhov et al. 2019), but has not yet been explored to the same extent in a comprehensive body-sensorimotor and perception framework. Our contribution is not only the combination of its components, but also illustrates the need to consider the setting as a single interconnected system.

We presented two systems that implement this framework: a laboratory prototype and an interactive installation presented at the Milano Digital Week in 2022 under the name *Connect to the Machine*. The systems consist of a robot, mechanisms to control its movements, and a virtual environment that translates the avatar's unique perception to the user. Results were highly encouraging, proving that we were successful in our main goal to make the users feel engaged, immersed in the new body and challenged to test the possibilities of their own bodies and to understand this newly perceived world, while also feeling like their own bodies and the avatar's were connected, and moving as one. However, they also expressed a desire for more effective and consistent transmission of the PROC. Despite the initial difficulty in using the system, users reported high engagement and satisfaction; indeed, as game design practices suggest, engagement and challenge are linked, and finding a balance between challenge and reward can even elicit greater immersion; this is also valid for non-anthropomorphic avatar embodiment where more unfamiliar settings actually induced more SoE, satisfaction and task performance (Vuarnesson et al. 2021; Krekhov et al. 2019; Wellerdiek et al. 2013). The system fostered self-play, and all participants were surprised by the perspective shift it showed them.

Overall, in designing altered embodiments, the possibilities are almost endless — but we do not yet know much about what will work best for which purpose, or about possible longer-term effects on the subjects.

6.2. Future Directions

Studying the possibilities for physical embodiment with an avatar with generic shape opens a wide range of opportunities. The present paper is meant to be a pilot study, opening a novel direction for this kind of research, however, already from the initial implementations we are starting several parallel explorations, to develop in detail each of the subsystems, either by improvement of the current solutions, or with new explorations.

Avatar Body: The presented avatar body implementations were designed mainly as test devices for the control and feedback systems. In future works, the focus will be on improving the quality of movement, perception, and affordances of the body, with the ultimate goal of creating wearable bodies that can support meaningful interaction by allowing the user to express themselves through movement, gesture, sound, and perceive the intentions and emotions of others.

Feedback to The User: We aim at improving the quality of movement and perception in the avatar's body to enable meaningful interaction. The perception system is currently a direct visualization of signals but may be too limiting. There is a trade-off between direct feedback based on sensor values and more high-level feedback that resembles living beings' perception. To explore this, a comprehensive study of the avatar's shape and sensor connections is necessary, also by exploring the possibilities of using multiple senses to enhance the experience by going beyond visual cues.

Measures: The results of our experiments came from questionnaires, however in future works we will introduce new measures for a deeper and more robust understanding of our framework in terms of embodiment and of user behavior, e.g., perceived position, physiological markers, users' reaction (Steptoe et al. 2013), and collection and analysis of real-time kinetic data (Vuarnesson et al. 2021; Laroche et al. 2021).

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Patterns in Deep Time

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In this paper, we explore how textile pattern-making can be a useful activity for live coders used to manipulating software. We ran an algorithmic patterns workshop in July 2022 — with a node at `on_the_fly.collect(_)` festival in Barcelona, a node in Sheffield and the workshop leader in Penryn — where we created an activity recreating ancient patterns by weaving on tablet looms that we constructed from card and yarn, and sent to the participants for this remote/multi location workshop. One of the aims of the Algorithmic Pattern project is to highlight the relationship people have had with patterns over history, and how we can use this to uncover certain misconceptions we have about algorithmic patterns in contemporary society. We collected responses from those who participated in the workshop and collated the responses. We found that tablet weaving allows us to connect the physical patterns with their algorithmic descriptions. Also, errors relate with the trade-off among expectations and surprise and exploring new unexpected possibilities. Finally, sharing the experiences among the participants allows us to observe how we interpret patterns when comparing it with other experiences.

Keywords: Algorithmic Pattern, Weaving, Live Coding, Patterns, Digital Art History.

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1. Introduction

This paper introduces a workshop exploring algorithmic patterns (McLean 2020) across both textiles and the contemporary practice of live coding (Blackwell et al. 2022). First, we share background to the thinking that led up to this workshop, providing both recent and historical cultural reference points. Then we will share experiences and reflections as workshop participants and conclude with further reflections on where this line of research will end up next.

Through the workshop, we explored algorithms in terms of their physical movements and outcomes, their representations, their ability to convey meaning, and how the act of weaving connects and reflects such dimensions. Moreover, comparing digital computers with handweaving revealed the textile-like patterning of binary operations, which is not always obvious when algorithms are expressed in high level programming languages and abstractions. On a more general level this paper reflects on computation as a human activity that extends beyond automation through electronic computers. The workshop did not aim for prescriptive goals and outcomes, but rather was cast as an exploratory activity that attempted to compare and contrast the practices of those used to working with algorithms as source code, with heritage algorithms (Eglash et al. 2019) in textiles.

Both handweaving and programming involve the exploration of entangled, countable, discrete structures. Both also involve the authorship and manipulation of digital representations, such as grid-based block designs and drawdowns in the case of weaving, and source code in programming. They are also both digital in their physical manifestations — e.g., the high/low voltages which manifest computer processes, and up/down interlacements which form weaves. However, while weaving and programming are both digital crafts (McLean, Fanfani, and Harlizius-Klück 2018), weaving is considerably older, having developed over thousands of years. This is important to remember, and key to the motivation for this workshop. Our contention is that as the far older, and more highly developed human digital artform, both culturally and technologically, programmers have a great deal to learn from weaving.

The workshop itself took place in a networked hub format in July 2022, split over three locations — with a node at the `on_the_fly.collect()` festival based at the Hangar.org space in Barcelona, a node hosted by the Then Try This studio in Sheffield, and the workshop leader based in the main Then Try This studio in Penryn, Cornwall. The workshop was convened by Iván Paz and Lizzie (Elizabeth) Wilson in Barcelona, and Alex McLean in Sheffield, with the support of the rest of the on-the-fly project team including Ludovica Michelin and Lina Bautista. The other named authors contributed reflections to this paper as workshop participants.

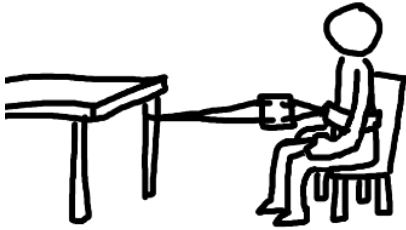


Figure 1.1: A tablet weaver showing warp threads tensioned using a back-strap and passing through the tablets to create a 'shed' gap for passing the weft.

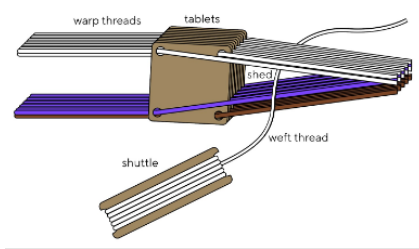


Figure 1.2: Diagram showing each warp thread passing through one of four holes in the tablets, creating a shed through which the weft is passed.

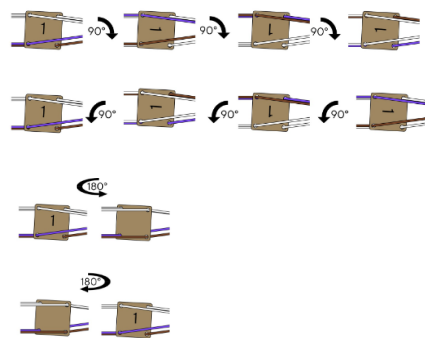


Figure 1.3: Diagram showing the different sheds created by a) turning and b) flipping the tablets. One or more such turning and flipping actions may be performed, potentially to different groups of tablets, between the passing of each weft thread.

2. Tablet Weaving

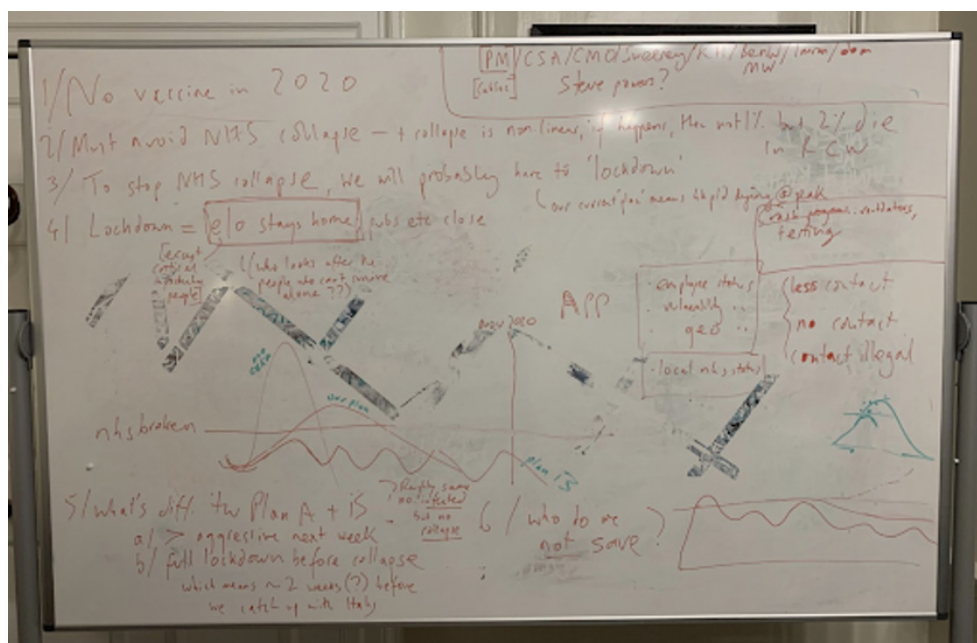
The particular form of weaving introduced in the workshop was *tablet weaving*, also known as *card weaving*. Like all textile crafts, tablet weaving is structurally (and culturally) distinct, for example expertise and knowledge of knitting or even other weaving techniques does not naturally transfer to tablet weaving. Indeed, it would take more than a lifetime to explore all the complexities of tablet weaving. Although tablet weaving shares fundamental elements with other forms of weaving such as tensioned warp threads and passing of perpendicular weft threads, the addition of twisting and flipping actions make it closer to braiding or twining in some respects. A detailed introduction to the complexities of tablet weaving is out of scope of the present paper, and fully grasping its nature requires hands-on practice, but figures 1.1-1.3 convey the fundamental elements.

Although the principles of tablet weaving are relatively straightforward, the patterns that emerge can be difficult to comprehend. The turning and flipping of cards interacts with previous states in the weave, creating three-dimensional interference patterns as the differently coloured threads twist into view. Learning tablet weaving is therefore full of surprise, with complex patterns emerging from simple movement sequences. A common experience is to puzzle over how such a pattern appears on the front of the woven band, only to find a completely different pattern on the reverse side of the band. In the end, the beginner settles into a mode of experimentation, trying out different patterns to get a tacit feel for the potential outcome. This mode of experimentation with algorithm and material has parallels with the experience of live coding; a primary motivation for bringing the two practices together.

3. Digital vs. Physical in Weaving and Programming

The workshop was led by Dave Griffiths, based on their personal experience of learning weaving and programming simultaneously when very young. This early foundation provided a certain way of seeing the parallels between these digital worlds — not in analogy or on the surface level but providing two views on the same underlying cosmos. Indeed, an additional core motivation for the workshop was to consider how the digital and the physical have become separated in contemporary culture. We set the scene for this by discussing a meeting between the UK prime minister and advisors when rapidly deciding policy in the days leading up to the first COVID-19 lockdown. In a space devoid of internet access, except one smartphone (belonging to Dominic Cummings, the Chief Adviser to the British Prime Minister at the time), they were desperately trying to understand all the issues involved on the single white board shown in Fig. 2.

Figure 2: The whiteboard used to plan the UK government's initial covid response on 13 March 2020.



What this extreme case exhibits is a situation reflected in policy making more generally where vast amounts of data may be available, but there is a difficulty translating it into informed action (Luthfi and Janssen 2019). This can be down to the quantity and quality of digital information adding to the feeling that we have a separate “digital” reality. This can be seen in a reluctance to engage with information until something happens to suddenly “connect” it to the “real world”. In this case the sudden realisation that “abstract” models predicted severe impacts to hospital admissions, at a scale which could no longer be ignored.

We argue that the reluctance to treat digital information as ‘real’, is perhaps due to how we have split the world in two: the grounded, trustworthy world of “the physical”; objects that can be touched, shaped by our hands and passed to other people, regulated by a scarcity which appeals to our feelings of simplicity, and knowing right from wrong. The other world is “the digital”; objects that we can only grasp indirectly, which come with concepts and structures of abundance, but are often working in the service of large multinational companies. These digital objects are generally understood as new, suspect, and untrustworthy.

Weaving breaks this false dichotomy in ways that make it possible to critique the digital infrastructure we inhabit more effectively. Threads are digital in precisely the same way voltages in our smartphones are digital – we combine these discrete elements into patterns we can use. This is not merely an analogy, but a tangible reality, which can for example be seen in how a woven artefact is a digital representation of its own making. The discrete structure of a weave can be replicated exactly as a digital signal sent in physical form via textile, exhibiting the same properties as a digital signal sent via radio waves. A woven textile can pass through long distances (of time) and be read perfectly when it reaches its destination.

Figure 3: Section of the Hallstatt tablet weaving circa 800-400 BC in our tablet weaving simulator, with code, tablet rotations and pattern shown.



As an example of weaving signals travelling through time, archaeologists ‘read’ pieces of fabric such as the Hallstatt tablet weaving, which was discovered preserved in an Iron age salt mine. They are then able convert such data to an intermediate code that records the weaving tablet/card turning movements of the weaver from three thousand years ago. This code may then be followed to recreate the fabric, and fig 3. shows our own reconstruction through a custom simulator created by Dave Griffiths.¹ A reconstructed weave will be a perfect reconstruction, in terms of including all the micro-decisions (and indeed mistakes) of the original weaver. In this way, we can see that weaving looms are digital tools. They have passed through many more hands than the silicon-based digital tools we are more used to thinking about, and this perspective reveals how the human relationship with digital thinking goes back to prehistoric times.

As technologists, our interest in ancient weaving is therefore not an attempt to apply contemporary technology in understanding the past, but rather to apply heritage technologies in developing better understanding of the present. By grounding contemporary practice of live coding in understanding of heritage technology, we look to develop a healthier approach to contemporary programming languages technologies, that open up wider understanding of digital models and the impacts on our lives.

4. Revealing the Textility of Code

Discussions involving weaving and programming often incorrectly² refer to the development of Jacquard devices as the ‘first computers.’ There are, however, less well-told, more interesting connection

1. The web-based tablet weaving simulator created by Dave Griffiths and used in the workshop is accessible at pattern-computer.thentrythis.org

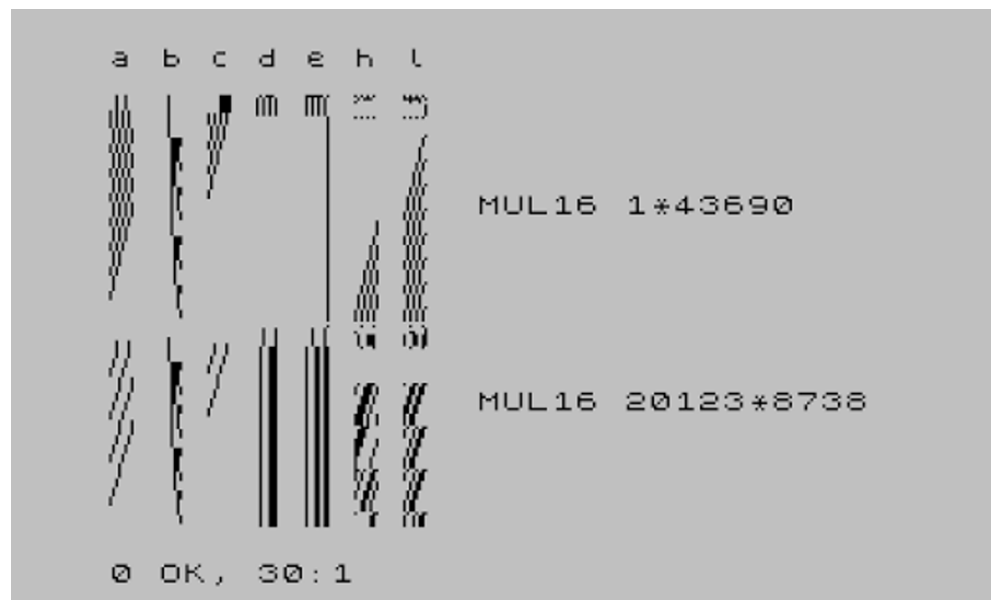
2. All weaving, including at handlooms, can be computational. For example, see Lea Albaugh (2018) speaking on “*It’s Just Matrix Multiplication*”: *Notation for Weaving* for an explanation of the computational complexities of shaft looms aimed at computer programmers.

points between textiles and contemporary computer technologies, such as Lisa Nakamura’s work researching the involvement of the Navajo women who designed Fairchild semiconductors’ first integrated circuits (Nakamura 2014). The company directly referenced the similarity of the traditional weaving designs to electronic junctions and transistors and used many images of Navajo designs in their company branding material.

Is there some way that we can trace and unpick these threads of textile history in the central processing units of our devices today? Each processor has a defined set of instructions that it can execute – each instruction represented by a physical circuit of transistors built for the job. Therefore, the number of instructions needs to be minimised, as each one results in considerable expense. Something common to nearly all processors is that there are far fewer instructions which treat data as a numerical value (e.g., addition, subtraction, compare) compared to those that treat data as a pattern (shifts, rotates and other “bitwise” operations).

We can make these normally hidden operations visible, exposing the physical nature of the patterns that lie at the deepest levels of computation. As these processes are governed by the same rules as everything else (information is limited by physics; Shannon and Weaver 1963), it follows that there is no magical cyberspace, just combinations of voltages or threads we interpret as patterns with meaning.

Figure 4: The Z80 processor comes from a similar era as Fairchild’s integrated circuits and was a foundational design to modern microprocessors. Here we display the contents of its register memory after every microcode instruction of two multiplications of 16-bit numbers, revealing the patterns created.



During this workshop we followed this motivation of reconnecting live coders with textiles, by exploring replicating patterns from the Iron age (such as the Hallstatt textile) as well as Viking societies (see fig. 5 for examples). We previewed them in a simulation built for the workshop which included its own code representation of tablet weaving movements and tried out different variations to understand

the logic of tablet weaving. The following section brings together some reflections from workshop participants.

Figure 5: Selection of ancient Iron age and Viking tablet weaves.

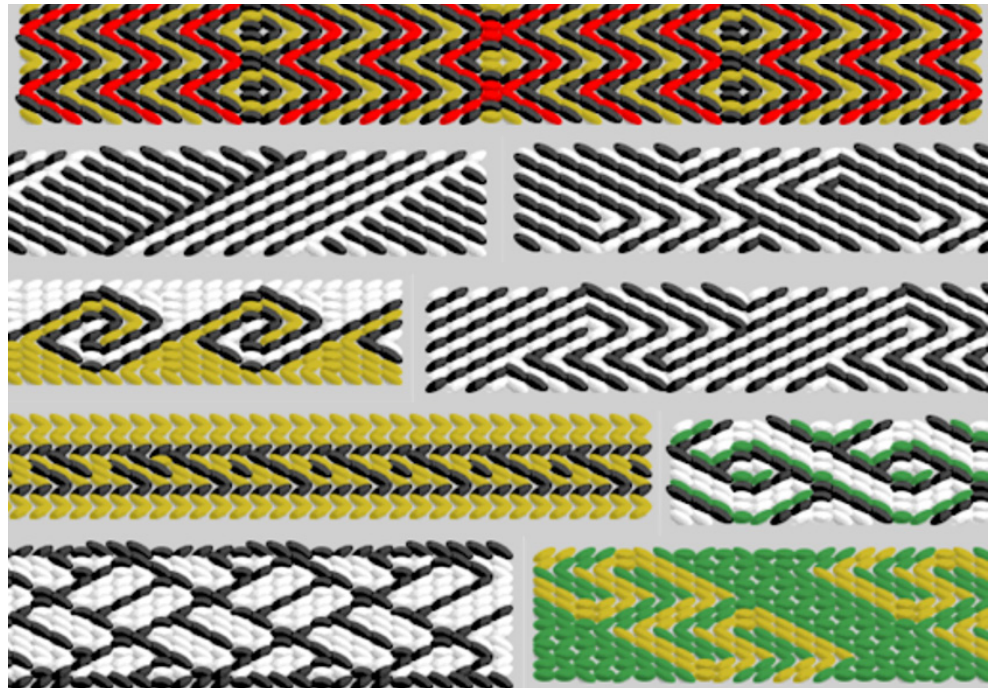
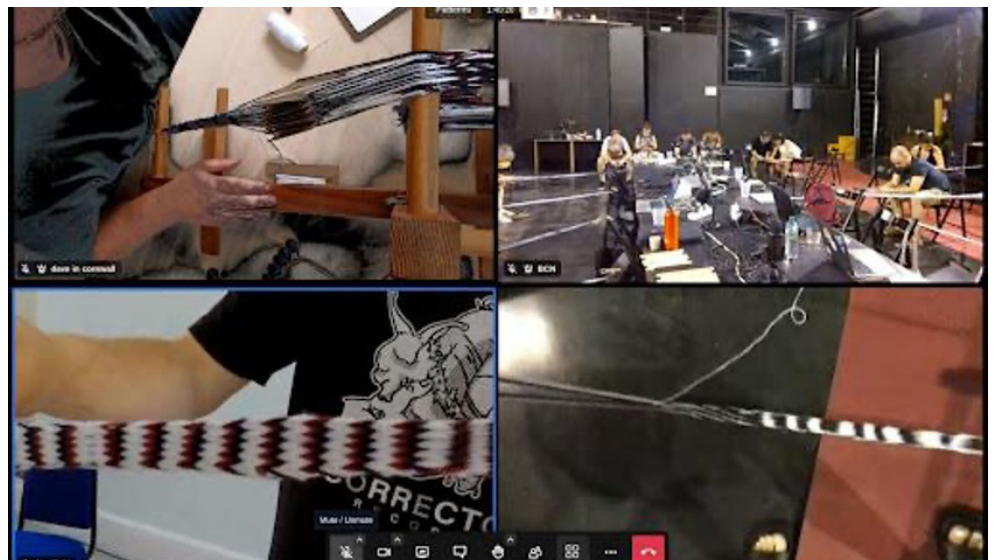


Figure 6: Zoom screenshot of the workshop.



5. Participant Reflections on the Workshop

Participants of the tablet weaving workshop each produced unique tablet weaving patterns, some of which are shown in Fig. 6. Although tablet weaving was the primary focus of the workshop, later, each participant was also asked to share their ‘favourite pattern’ with another person. Patterns could be of any nature, for example, sound, visual, etc., and could also include any of those reviewed in the workshop. Then, participants live-coded the other persons’ patterns, exploring its possibilities. The results were briefly presented and shared, reflecting on why each one selected a particular pattern? What does it mean for them? And why do they consider their pattern a pattern?

The participants were surveyed four months after the workshop, gathering longer term reflections on the activity. The survey respondents represented below are Joana Chicau [JC], Flor de Fuego [FdF], Timo Hoogland [TH], Eloi Isern [EI], Michael-Jon Mizra [MJM], Iván Paz [IP], Roger Pibernat [RP], and Lizzie Wilson [LW]. We gave the following four prompts in the survey, to encourage the participants to reflect on the role of patterns in their work, and the relationship between code and textile.

The questions chosen to prompt the participants were chosen because of the interest in exploring different facets of live coders approaches, perspectives, and methodologies to approaching algorithmic pattern in the analogue practice of tablet weaving. These questions allowed them to explore their own relationship to coding practice and contrast this with the workshop activities. We also wanted to navigate the cognitive processes that a live coder might employ to approach this task, and whether they had existing strategies available to them that they could transfer to the practice of tablet weaving. Through these questions, the researchers also hoped to gain a deeper understanding of the relationship between coding practice and any other creative activities that relate.

(P1) How was your experience with the tablet weaving workshop? What was complex, what was simple? How does this compare or contrast from your experience with code?

(P2) The following is an excerpt from Joanne Armitage's paper "Spaces to Fail in: Negotiating Gender, Community and Technology in Algorave".

For some, code emerges as a way of dealing with or organising life, for others code allows an expression of self, or a way of manipulating lived experiences and speaking back to them creatively. One person interviewed spoke about code as a way of working through their daily life, adding structures to it and providing functions for being. These lived patterns merge with their daydreams and expressions of colour and geometry to form her live coded visuals.

How does this relate to your life? Can you share an experience that compares or contrasts with it?

(P3) Do you enjoy a pattern-y craft or other pattern-y activity? E.g., weaving, braiding, origami, juggling, etc. If so, what does live coding and this activity give you that compares, and where do they diverge?

(P4) Have you thought about the workshop in the last few months, and if so what about it has stayed with you? Any influences on your thinking or makings?

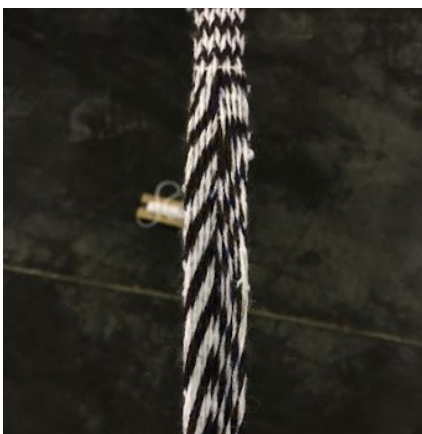


Figure 7: Emergent patterns from the participants' weave. Image credit: Timo Hoogland.

For the full set of participant responses, see the online repository for this paper, available at gitlab.com/algopattern/patterns-in-deep-time. Within those responses, we analysed the texts and found emerging themes from their answers about a variety of reflections that they shared.

5.1. Physicality

Perhaps the most apparent difference between these practices is that live coders generally work only with code, rather than directly with material as with tablet weaving. However, there is always more in the 'output' of live coding, whether music, choreography, or something else, than in the notation and rules for generating that output. This complexity contributed by material, and our perception of it, became particularly apparent when working with threads:

I found more complexity in controlling the materiality of the “wool” than remembering the movements. The weaving algorithms were clear in my head, but knowing the right tension, the right pressure and where to stop pulling was difficult at the beginning. With the successive repetitions the movements felt more natural. [IP: P1].

In this answer the participant notes how the distinction between the cognitive processes and physical expression of them lead to some initial tensions for the participants. This was apparent for live coders, whose medium of expression – whilst still physical – relies heavily on cognitive processes. Live coding music has even been referred to as “the antithesis of physical musicianship” (Nilson 2007). Despite some initial struggles perhaps, a few of the participants noted the appeal of this “hands-on” approach at the workshop, where they became absorbed into the repetitive movements, making space for focussed creativity:

I found the “hands-on” and movement focused character of weaving a smooth way of engaging in pattern making. For me muscle memory helps me a lot in making ...over time, it became intuitive and fairly quickly I managed to improvise new patterns and explore more interesting combinations. [JC:P1]

There was something quite enchanting about working with your hands and watching the patterns begin to appear. [LW:P1]

I enjoy the fact that... making things in the moment, getting real time feedback from what you are making and not really being able to undo. [TH]

Philosophers, social theorists, and anthropologists have all spoken of the new reality that we inhabit in the twenty-first century due to

the vast expansion of digital technologies, and that the digital era is incontestably new. However, viewed from another perspective, perhaps it can also be thought of as less of a colossal leap from the physical to digital eras. Humans have always had an urge to keep their hands busy, and this is perhaps one of the reasons heritage practices like weaving, spinning, and knitting were so culturally important. Typing on a keyboard, viewed through this lens, can be thought of as a natural progression of human behaviour. However, it is important to note that this does not reduce to the only reason why weaving may be culturally significant, especially when we note that textiles practices are often gendered as feminine.

The progression of materiality from human-material to human-machine embodies the demarcation of the physical to digital progression, but weaving exists as an intermediary, where the human is in close contact with both the fabric and the machine. In weaving, “bits” are manipulated in real-time whilst in coding the abstraction of bits is manipulated through language, and by extension typing on a keyboard. There are comparable abstractions in weaving, but these abstractions also take physical form, in the grouping of threads in shafts or tablets, the mapping of these groups through tie-ups and combination through treddling. By grounding live coders in this materiality, we hope this regression through human history allows them to make connections in how human-material loops and human-computer loops differ (e.g., in perceiving output and shifting behaviour).

5.2. Visualising Algorithms

A few of the participants reflected on how the workshop led them to contextualise algorithms in visual terms. Visualisation can be understood to leverage the visual system and augment human intelligence as a way to understand abstract processes (Engelbart 1962). Indeed, algorithmic practice has many connections with spatial processes or abstractions that might require a strong sense of cognitive visualisation process, and especially live coding languages with a more functional approach. For example, it often requires an understanding of ideas from geometry e.g., rotations, shifts, iterations; or linear algebra e.g. matrices or larger abstract structures and transition probabilities. One of the participants made the connection with how they use visualisation within mathematics, but drew a distinction between their experience of mathematical visualisation and what they were experiencing with the weaving:

I loved the conscious experience of following an algorithm, understanding it to the point that I can almost predict the result of a small variation, this has offered me a different experience of visualizing the algorithms that I normally use in maths, as if the

process that they described had a more material presence in the physical time and space. [IP]

The experience that the participant is noting is how visualisation which usually takes place as a cognitive process becomes a physical one. This became especially apparent when the relationship between the algorithm and physical space became unified. Other participants experienced this unification between the physical and cognitive worlds and found this became clearer as the workshop progressed:

I feel that the process of abstracting a concept is a process of gradual reduction. To atomise in this way grants one the gift of microscopic analyses. I also think this expands outwards, with the generalising description of systems, which conversely implores one to analyse at the macroscopic level. I can also therefore relate to the experience of the artist who found inspiration in their daydreams about patterns - once one starts thinking in this way, the world seems to respond in kind. [MJM]

I also liked the newness, the mapping between what I was doing physically and what was coming out of the weave wasn't always clear at first, but the more I navigated through the weave the more things started to become apparent. [FDF]

...Trying out different rotations of the tablets and repeating my randomly thought-of algorithms to see what the pattern is that emerges over time. In some ways it fits my approach to programming music and visuals, where I can have an idea of an algorithm I would like to explore, starting with the "what if...?" question, and then see what happens from there over time. [TH]

5.3. Satisfaction in Error

Error is a common, and oftentimes celebrated, feature of live coding performance. One viewpoint of error is the divergence of the observed output and its intended value. If we frame error in this way, it can also be a source for providing creative impetus, if the unexpected provides us with surprise and/or fulfilment. As it happens in live coding performance, where missing a comma or writing an extra digit is a frequently occurring failure (Knotts 2021; Roberts and Wakefield 2018), errors were present while weaving, maybe twisting in the "wrong" direction or not applying the "right tension". Errors contrast with what we had in mind, what we expect, and the results can surprise us in different ways. As in the practice of live coding, the live weaving action makes it easy to make mistakes, but those mistakes allow us to open up new avenues of exploration.

Some of the live coders who participated in the workshop compared the ways in which they encountered error in live coding with how they were experiencing it in the weaving workshop:

For me the “trial-and-error” approach worked pretty well. When programming music, I can make an educated guess on what I can expect to happen, while with the tablet weaving this was not so much the case since I was completely new to it. This resulted in some interesting surprises of patterns that came out. [TH]

As with coding, some complexity of the system began to arise when errors started to occur. It was relatively easy to undo sometimes, but there did seem times when small perturbations from what the instructor was doing felt that it shifted the outcome quite far. As with coding though, this did sometimes produce surprising and unexpected results that forced me to engage creatively with the weaving process. [LW]

..‘what is a pattern’ is a question which positions itself between two poles; complexity/noise and simplicity/periodicity. These poles influence my approach to sound, where one can approach the construction of complex waveforms by the summation of simple wave forms, or one can construct wave forms through the use of stochastic processes. I am also intrigued by the human capacity to recognise patterns, and how we exploit our limited bandwidth to create pseudo-random functions. And this leads me to wonder about the nature of true randomness, whether it is obtainable, and what does it mean for these two poles to exist in a universe that is both probabilistic and deterministic. [MJM]

The patterns that came out were really surprising, and it did feel a bit like getting unexpected results from code. [RP]

The notion of fulfilment from surprise is well researched within the context of the aesthetic experience of music. From a music-analytical standpoint, it has been argued that the creation and subsequent confirmation or violation of expectations is essential to aesthetic experience and the musical communication of emotion and meaning (Narmour 1990). Huron (2008) discusses what gives anticipation or surprise their distinctive phenomenological characters, and also how enforcing repetitions builds an expectation in the listener, and the subsequent violation of these expectations elicits a physical response. For others, they made note of what they found fulfilling in this task:

The complex results, out of simple pattern-moves, were really satisfying. Maybe what I like about code is that it allows me to

twist logic into poetic ways, which probably could be called a means of expression. [RP]

I try to look for code as an expressive tool for communicating and connecting with different disciplines. [FdF]

For someone like me, who does not come from a computer background, it was amazing to see the possibilities that opened up when working with the loom. [EI]

From these responses we can see that fulfilment not only came from the elements of error or surprise, but also from how the weaving allowed complex behaviour to occur and its associated poeticism, its wide-reaching capacity for expression and how the extensive possibility space it offered the weaver/live-coder can trigger new creative behaviours.

5.4. Patterns Passed On, Conveying Meanings

Patterns are polysemic, as are melodies or fabric patterns. They are read, felt, and interpreted in different ways. Sharing ideas, such as selecting a favourite pattern, among the participants visualises the different ways we interpret patterns by giving us perspective of others' experience.

The exercise when people were asked to choose their favourite pattern and then pass it on to the next person to code in their own preferred language / software was interesting. That stayed with me, this idea of a collective string within which patterns are passed on 'hand-in-hand', reinterpreted and creating a lineage of patterns. [JC]

I remember Dave saying something like this was a message that had thousands of years distance. And the idea of a weaving as a message, which I already somehow was aware because in Argentina we have that kind of idea with traditional weaving. [FdF]

I really liked the accompanying computational representation that was going on, and tried to do a code representation myself to help try and parse what was happening... I also liked looking at the examples and seeing the way different cultures had their own representations of pattern that convey different meanings. It made me think about how music also conveys cultural meaning, and I wondered if there was any way of connecting these ideas of representation to musical representations (e.g., scores). [LW]

These responses suggest that the importance of conveying meaning in patterns lies not only in their aesthetic qualities, but also in

their ability to serve as expressive means of communication. Patterns play a crucial role in conveying meanings and cultural values. They often hold much historical and social significance, serving as a means of communication and self-expression for individuals and communities. Live coders, for example, recognise the importance of patterns in their community, many choosing to share their code and pass them on. Passing on patterns from person-to-person, or even generation-to-generation, is an essential way of conveying information and ideas, developing cultural heritage and even promoting intergenerational continuity. By recognizing and valuing the many ways in which patterns can be interpreted and experienced, we can deepen our appreciation for the richness and complexity of human culture and creativity.

6. Conclusion

Tablet weaving is an action through which algorithmic processes materialise. As in code, unanticipated results happen through chaotic interaction, and these surprises can be creatively explored. These unplanned experiences, especially present when trying something new, are intrinsic to both weaving and coding. Weaving connects the physical materiality of the woven patterns with their immaterial algorithmic descriptions. It allows us to visualise the algorithmic processes that describe the instructions from which they emerge. Weaving together in a group, following and deviating from the instructions we were given, gave us shared perspective when comparing our experiences. The central discussions on the workshop, as it was attended mainly by live coders, revolved around algorithms, time, error, repetition, and codification, but also about the way we interpret patterns such as rhythm, regularity, and how easy it is for us to recognize or perceive a pattern, i.e. the limits of our spatial and temporal perception, and of our ability to predict the outcome of the algorithms we create and modify. It is interesting that these ideas (descriptions) match the ways in which we describe the material and immaterial aspects of patterns. The examples included in the simulator, ranging from prehistoric Iron age to Viking, added an extra layer to the different dimensions of the patterns: the way different cultures had their own representations of patterns (sometimes closely related) that convey different meanings.

Our half-day workshop created a scene of digital artists used to working with computers, finding themselves working with the twisting and interlacing of threads, while still thinking about code. Perhaps this is a vision of the future rather than a re-enactment of the past. With environmental breakdown and health emergencies triggering a growth of 'collapse computing' culture, coders may need to reconnect with numerical crafts such as hand-weaving, to maintain their interests in digital art. More optimistically, this re-uniting

of coding and textile culture could lead to a richer, more sustainable, tangible, and culturally-grounded approach to future technology.

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Exploring Embodied Interaction to Support Self-Transcendence in the Art Installation *Magic Tea*

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Magic Tea is an interactive art installation that is designed to transform the everyday activity of making and drinking tea such that it supports self-transcendent experiences: temporary, positive mental states in which self-consciousness is decreased and feelings of connection with others or the environment are increased. This is achieved by a novel multimodal strategy consisting of ritual design and interactive technology. This paper presents the conceptual design of the art installation *Magic Tea* and the results of a quasi-experiment ($n = 24$) that was conducted to explore its efficacy. The results of this experiment suggested that *Magic Tea* caused its users to experience flow and mindfulness, but did not lead to nondual awareness – three varieties of self-transcendent experience. Furthermore, perceiving one's physiology as part of the installation correlated positively with nondual awareness. Herewith, the present study contributes preliminary evidence about how an interactive art installation can be designed to transform the everyday activity of preparing and drinking tea such that it invites self-transcendent experiences.

Keywords: Augmented Embodiment, Interactive Installation, Self-Transcendence, Ritual.

1. Introduction

A self-transcendent experience (STE) is a temporary positive mental state in which self-consciousness is decreased and feelings of connection with others or the environment are increased (Yaden et al. 2017). STEs can be placed in a spectrum ranging from less intense (e.g., mindfulness) to intense (e.g., nondual awareness) (Yaden et al. 2017). STEs are extraordinary experiences which are meaningful and can even be transformational (Duerden et al. 2018). They contrast with the way we usually perceive ourselves, as separate from the world around us (Hanley et al. 2018; Lynch and Troy 2021). Numerous studies have shown positive correlations between self-transcendent states and traits with indicators of subjective well-being (Reed and Haugan 2021; Zappala 2007). However, the value of STEs goes beyond individual benefits. STEs enable a person to integrate subject-object dichotomies within themselves, but also with others and life circumstances, and find new meaning in them (Wong 2016). This new potential is then returned to the world and shared in the service of others (Vieten 2009). Given these potentially positive individual and societal effects, it seems beneficial to experience these types of experiences more often and make them part of our everyday lives.

Generally, however, STEs are not part of everyday life. Half of our waking hours are filled with ordinary experiences and habitual behaviour (Duerden et al. 2018). The occurrence of STEs is mostly limited to special circumstances such as through the use of psychedelic drugs (Barrett and Griffiths 2018), intense meditation (Wahbeh et al. 2018) or as a result of a personal crisis (Reed and Haugan 2021). Because STEs are rare but beneficial, a long and rich path of development can be traced throughout history of methods and tools specifically created to invite STEs and to utilize their effects on well-being and personal growth. We say invite because STEs are spontaneous experiences that can only be invited rather than elicited (Gaggioli 2016). Thus, methods and tools work by creating the right conditions for STEs to occur (Cosimano 2014). Yet, existing methods and tools have their limitations.

Traditionally, self-transcendence has been pursued through various mind-body practices, such as meditation (Wahbeh et al. 2018). However, starting and maintaining a meditation practice may seem unattractive due to a combination of social circumstances and personal characteristics (Sharma et al. 2021). Its uptake may remain limited to specific socio-demographic groups (Burke et al. 2017). Moreover, tools such as hallucinogenic drugs (e.g., Psilocybin) can evoke STEs (Barrett and Griffiths 2018), but successful use depends on the right mindset and setting (social and physical environment) (Cosimano 2014; Gukasyan and Nayak 2021), which, when suboptimal, may hamper their effects. Recent developments also point to Virtual Reality technology as a tool for inviting STEs (Quesnel and Riecke

2017). However, to enter the virtual world a user must typically cease everyday activities and use special devices which may constitute a threshold for use.

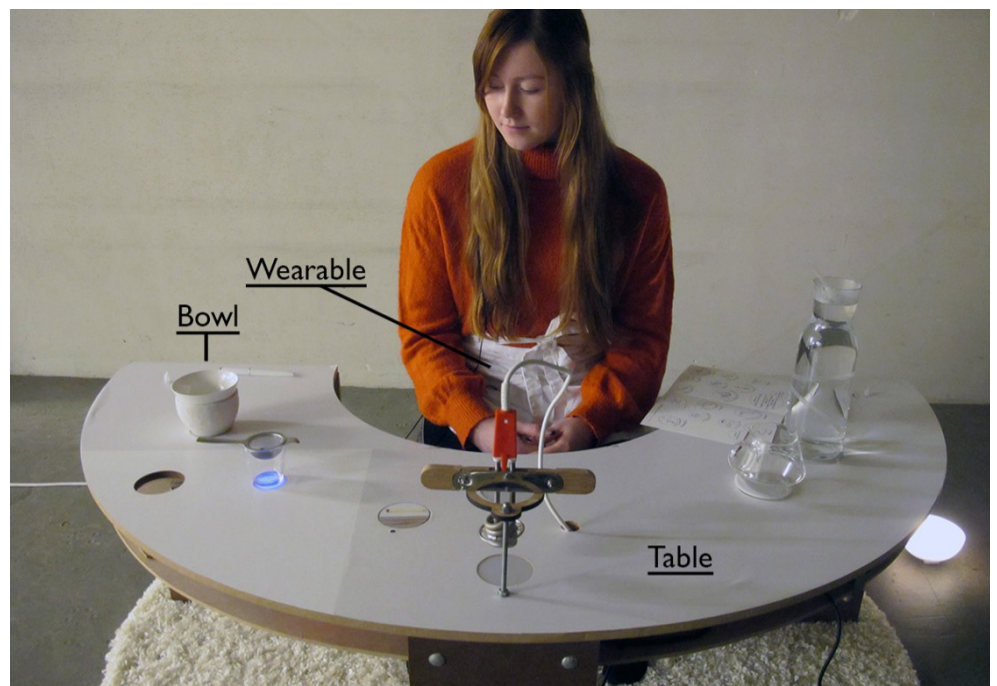
The current paths for evoking and studying STEs thus have limitations and may lack accessibility for larger social groups. We, therefore, propose another approach. We see opportunities for embedding STE into routine, everyday activities, namely through a multimodal strategy in which we combine ritual design with tangible embodied interaction. This strategy has been applied to develop an interactive art installation titled *Magic Tea*. This interactive installation is designed to invite three varieties of STE (nondual awareness, flow, and mindfulness) during the everyday act of making and drinking tea in ritual form. Entrainment and augmented embodiment are the interaction strategies used.

In what follows, the rationale behind the design of *Magic Tea* is developed in more detail, and the method and results of a quasi-experiment ($n = 24$) are reported. This experiment was conducted to test whether and what STEs occur when engaging with the Magic Tea installation, and how augmented embodiment contributes to this. The paper concludes with a discussion of the results and future research opportunities.

2. *Magic Tea*: Inviting Self-Transcendent Experiences

Magic Tea is an interactive installation that is designed to invite nondual awareness, flow and mindfulness during the everyday activity of making and drinking tea (Fig. 1).

Figure 1: *Magic Tea* installation. The labels indicate the main parts.



2.1. The *Magic Tea* Installation

From a technical perspective, the installation consists of three main parts: 1) a wearable device that detects pulse and breath phase, 2) a table that contains various sensors and visual and auditory actuators, and 3) a bowl that provides visual, audible, and tactile stimuli. All the parts contain a microcontroller (Arduino Fio)¹ and LiPo battery. They are wirelessly connected through XBee 3 modules with a PCB antenna (Digi) and use a custom protocol for data transfer. Custom Arduino code determines the responses of actuators to the sensor input, based on the user's and system's state.

The wearable is worn throughout the experience and used to detect the user's breath phase (breathing in or out) and heartbeat. The wearable consists of a textile apron and a non-medical heart-rate sensor (Grove). The heartbeats are measured optically via a clip attached to the user's earlobe. The respiration phase is calculated from the raw heart rate data by a custom script. Both biometric data streams are then translated into various behaviours of the objects on the table during different steps of the activity. These are described in more detail below. Integrated into the table are the following sensors: a 500-gram mini load cell (TAL221) and amplifier (HX711), a flame sensor (RobotDyn), a wind sensor (Modern Device), one hall sensor and two analogue temperature sensors. These sensors detect both the steps taken by the user and the system state. Sensor data is sent via a local XBee network. The table houses the following actuators: a travel immersion heater, seven multi-coloured LEDs, one LED ring (all Neopixels), two electronic candles and an MP3 player (SparkFun Qwiic MP3 Trigger) attached to a speaker. The bowl consists of two stacked bowls. The top bowl holds the tea, and the bottom bowl the electronics. They consist of two LEDs, one small vibration motor and an MP3 player (DFPlayer mini) with a mini 1-watt speaker. Additionally, a paper manual was provided with *Magic Tea* to help the user to reflect on their experiences before and after use and to explain the interaction with the *Magic Tea* installation.

2.2. Inviting Self-Transcendent Experiences

Previous informal and exploratory studies with *Magic Tea* suggested that participants experienced aspects of both intense and less intense STEs. We, therefore, explore three related constructs which vary in intensity that could arguably be evoked while interacting with *Magic Tea*. Nondual awareness (NDA) is an uncommon and intense STE (Hanley et al. 2018; Kitson, Stepanova, et al. 2020). Tibetan meditation master Gyamtso defines it as "...experiences in which the self and world are merged into a unified whole or the boundaries of the self dissolve into an empty vacuity" (Hanley et al. 2018). NDA is

closely related to two other, less intense self-transcendent states, i.e. flow and mindfulness. Flow emerges during a task when there is a perceived optimal balance of effort and challenge (Hanley et al. 2018, Lynch and Troy 2021). With the right amount of challenge, one may become absorbed in the activity and the sense of self is said to fade away resulting in a state of self-transcendence (Yaden et al. 2017). Mindfulness, on the other hand, is generally described as a state of open, non-judgmental awareness of the present moment (Yaden et al. 2017). But mindfulness has also been shown to promote perceived body boundary dissolution and feelings of unity and self-loss, which are phenomenological features of STEs (Hanley et al. 2020). A core mechanism of mindfulness is decentering in which identification with one's thoughts and emotions is reduced, this may subsequently result in states of nondual awareness (Hanley et al. 2018, Yaden et al. 2017). The following sections describe how the strategies of ritual design and tangible embodied interaction are used to invite NDA, flow and mindfulness during the everyday activity of making and drinking tea.

2.3. Designing the *Magic Tea* Ritual

Our everyday lives consist of many recurring experiences and activities which we execute on autopilot. Such activities typically are neither meaningful nor memorable (Rossman and Duerden 2019). In everyday rituals, however, the process of performing the activity is, in itself, important. They also add aesthetic quality to banal and everyday routines. Thus, they add value and engagement to our everyday activities (Lévy 2018). Rituals can also be used to obtain the right physical and mental state to perform our activities (Kitson, Stepanova, et al. 2020). Intense rituals may enhance consciousness, and change our ability to perceive the world around us (Newberg and Waldman 2016).

A well-known example of a ritual which involves an everyday activity is the traditional Japanese tea ceremony. Its goal is to elicit a state of non-duality by freeing oneself from the subject-object dichotomy (Suzuki 1973). The ceremony is led by a recognised tea master and takes place in a tea room with prescribed layout and objects (Okakura 2012). All these elements work together to stimulate the senses and create a mindset conducive to STE-like experiences (Suzuki 1973). The *Magic Tea* ritual and installation were inspired by this ceremony in, for example, its sensory richness. *Magic Tea*, however, is not an enhancement of an existing ritual. Rather, it shares the goal of the Japanese tea ceremony but is different from these traditional methods in that it does not require a tea master or natural elements (which are replaced by interactive technology).

Thus, rituals can contribute to the right mindset and setting for inviting STEs. In designing rituals for everyday activities one must



Figure 2: Steps of the *Magic Tea* ritual (from top left to bottom right) a) writing expectation b) preparing 1) tapping 2) boiling water 3) rinsing tea 4) steeping 5) drinking tea 6) clearing away the remains c) writing reflection.

consider choices about functionality, emotion, aesthetics and ethics (Lévy 2015). According to Lévy (2018), the aesthetic properties of an activity are interdependent and rely on its structure, appearance and interaction. Manipulating these properties can transform a recurring activity into an everyday ritual. We have manipulated the structural properties of making and drinking tea to create the *Magic Tea* ritual by dividing the activity into six distinct steps, namely 1) tapping, 2) boiling water, 3) rinsing tea, 4) steeping, 5) drinking tea, and 6) clearing away the remains. The anticipation before an experience (steps a and b in Figure 2) and reflecting on it afterwards (step c in Figure 2) has been shown to increase its impact (Newberg and Waldman 2016). Therefore we have made these steps part of the ritual. Fig. 2 provides an overview of the designed tea ritual.

To transform an ordinary activity into one that might invite self-transcendent experiences the following properties have been introduced or enhanced: 1) a sense of novelty to set the experience apart from the ordinary (Duerden et al. 2018), 2) a certain amount of challenge conducive to flow experiences (Rheinberg and Engeser 2018), 3) an increase of engagement through embodiment, which supports a state of mindfulness (Van Rheden and Hengeveld 2016), and 4) an increase of richness in interaction which increases engagement, which is conducive to flow and mindfulness states (Van Rheden and Hengeveld 2016; Rozendaal 2007).

The appearance of the installation is inspired by the design approaches of Slow Design (Strauss and Fuad-luke 2008) and Wholeness (Seamon 2007). Both approaches may promote attention to and intimacy with the objects and the activity. However, an in-depth explanation is beyond the scope of this paper.

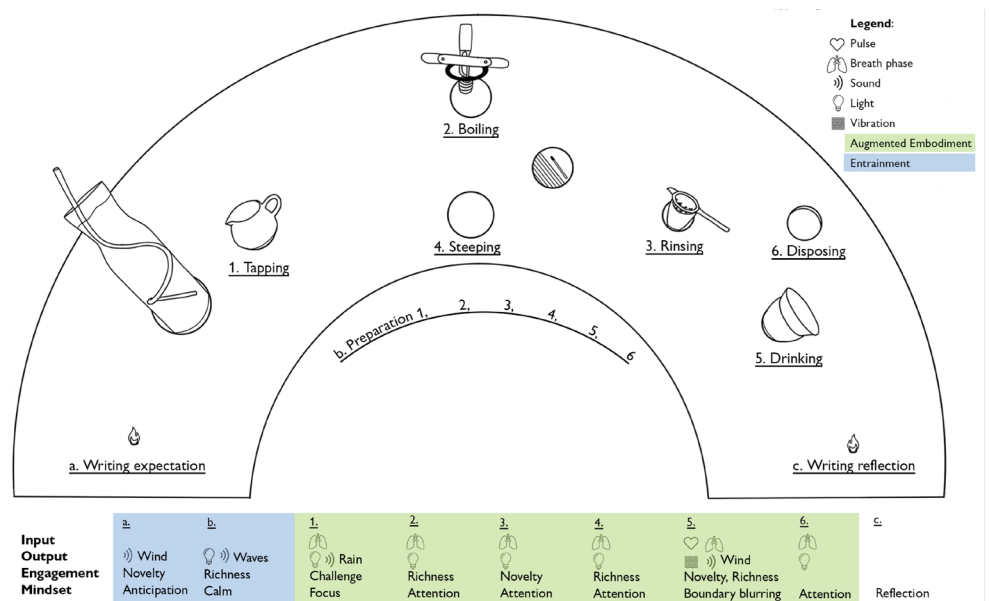
2.4. Utilizing Tangible Embodied Interaction

The reason for using tangible embodied interaction was twofold: 1) evoke a conducive attentive and calm mindset and 2) elicit nondual awareness. To reach the first objective the strategy of entrainment was applied. Entrainment refers to a situation where two or more oscillators in the same field adjust to a common rhythm (e.g., when tapping one's foot to the rhythm of a tune) (Pirhonen and Tuuri 2011). Entrainment has been used to regulate and decrease respiration rate (Pirhonen and Tuuri 2011), which in turn is associated with self-transcendent states (Wahbeh et al. 2018). Slowed breathing may promote calm and relaxation (Van Diest et al. 2014), which supports STEs such as mindfulness. Entrainment was used during the writing and preparation steps. Accompanying the writing process natural sounds of wind fading in and out were played over the speaker. During the preparation sound of waves fade in and out and users slowly move their heads to follow the pulsating lights positioned below the objects. Slow movement facilitates relaxation (Newberg

and Waldman 2016). The light and sound stimuli pulse at a frequency of 0.1 Hz. The aim is to covertly influence respiration rate and stimulate paced breathing at six breaths per minute which has been shown to be the ideal pace for promoting relaxation (Zaccaro et al. 2018).

To reach our second objective, nondual awareness, we apply augmented embodiment. This refers to the ability of technology to augment bodily self-consciousness by altering or extending its boundaries (Gaggioli 2016; Riva 2016). Altered embodiment refers to the mapping of one sensory channel to a different one (sensory substitution) (Riva 2016). In the *Magic Tea* installation pulse data can be seen and felt in the tea bowl. At every step during the tea-making process lights below the objects reflect the rhythm of the users' breathing phase. When the user inhales the light brightens, on exhale the light dims. Extended embodiment refers to the feeling of being embodied in a virtual, external world (Waterworth and Waterworth 2014). The body is used to control an artefact in the proximal space. A successfully mediated action leads to the incorporation of the object and through the object the body is extended (Riva and Mantovani 2012). During the *Magic Tea* ritual, the pulse and breath phases of the participants are represented in real-world objects through light, vibration and sound respectively. However, this extension isn't a functional one. The external reality reflects intimate and often subconscious processes of the participant and metaphorically extends their body into space. Through this manipulation, we aim to eliminate the subject-object dichotomy, a hallmark of nonduality (Lynch and Troy 2021). View Fig. 3 for an overview of the interactive system.

Figure 3: The *Magic Tea* ritual. A systematic overview of the tangible embodied interactive mechanisms; system inputs and outputs; engagement with the system and the intended mindsets.



Whether and how the design decisions described enable *Magic Tea* to invite STES, is, of course, an open problem — and something that will be explored by answering the following two research questions:

RQ1: Which STEs can be experienced during the everyday activity of preparing and drinking tea during the *Magic Tea* ritual?

RQ2: How does augmented embodiment relate to experiencing the STE nondual awareness?

3. Method

To explore the research questions a quasi-experiment was conducted.

3.1. Participants

Twenty-four people participated in the experiment ($M_{\text{age}} = 34$, $\text{Range}_{\text{age}} = \{18, 55\}$, 13 females, 11 males, 0 other). They were recruited by convenience sampling. Data from two participants were excluded from the analysis due to technical difficulties during the experiment. To gain insights into relevant personal traits participants were asked for details about their mindfulness practice (50% maintained a practice), and nondual awareness experience, which was moderately frequent ($M = 2.98$, $SD = .69$). Participants also reported having taken part in previous experiments with an earlier version of *Magic Tea*, or whether they were familiar with *Magic Tea* through lectures or conversations (32% in total).

3.2. Measures

To assess whether *Magic Tea* invited the STEs nondual awareness, flow and mindfulness the following scales self-report scales were administered. The Nondual Awareness Dimensional Assessment (NADA) scale was used to assess nondual awareness on the dimensions of self-transcendence and bliss (Hanley et al. 2018). Following Lynch & Troy (2021) the more comprehensive scale used to measure trait (NADA-T) was modified to measure state nondual awareness (e.g., “During the *Magic Tea* ritual I felt myself to be absorbed as one with all things”). 13 statements of this modified NADA-T measure were rated on a 5 point Likert scale (1 = Completely disagree, 5 = Completely agree). Reliability was excellent at $\alpha = .91$. The 13 items of the Flow Short Scale (FSS) measure the two factors of flow experiences namely fluency of performance and absorption by the activity and the perceived importance or outcome importance (Engeser and Rheinberg 2008; Rheinberg, Vollmeyer, and Engeser 2003). The items are rated on a 7-point Likert scale (1 = Completely untrue, 7 = Completely true). Reliability was high, $\alpha = .90$. The State Mindfulness Scale (SMS) was developed for measuring mindfulness during a specific period and context (Tanay and Bernstein 2013). The scale measures a complex of 1.) bodily sensations (e.g., “I clearly physically felt what was going on in my body”) and 2.) mental events (e.g., “I found some of my experiences interesting”) and their quality (Ruimi

et al. 2019). The 21 items are measured on a five-point Likert scale (1 = not at all, 5 = very well). Reliability for SMS was acceptable at $\alpha = .78$.

For augmented embodiment (AE) to work, participants have to recognize their biometric data in the representations in the external objects. This may, in turn, be experienced as extensions or alterations of their body and contribute to a state of NDA. To capture the degree to which the augmented embodiments were recognized the participants rated the following statements on a 4-point scale (1 = completely disagree, 4 = completely agree): In the light patterns beneath the objects I recognized my breathing pattern; In the pulsating of vibration and light in the cup I recognized my heartbeat; In the rhythm of the sound from the cup I recognized my breathing. Reliability was good, $\alpha = .81$. Therefore, the items were averaged for use in further analyses.

To provide insight into the sample characteristics participants were asked to report demographic information (age, gender), current mindfulness practice (yes or no), and previous nondual awareness experience with the trait version of the Nondual Awareness Dimensional Assessment scale, $\alpha = .89$. Previous knowledge of and experience with *Magic Tea* was also assessed. Additional qualitative data was collected for exploratory purposes. This data is not discussed in the present paper.

3.3. Procedure

Participants entered a room where they were informed about the activities they were to undertake during the experiment. Hereafter, the participants signed informed consent and filled out the measures to capture sample characteristics. They then engaged in the *Magic Tea* ritual for around 20 minutes (see section 2.3). The experiment leader was present to monitor the data transmission and safety. Afterwards, they reported on their STEs during the *Magic Tea* ritual by filling in the STE measures in the following order: the modified NADA-T (Nondual Awareness State), FSS (Flow), and SMS (Mindfulness). Then they answered the open questions and reported on AE (Augmented Embodiment). They then filled in the NADA-T (nondual awareness trait), after which they were debriefed.

4. Results

To provide insight into the characteristics of the dataset the descriptive statistics and correlations were calculated. These are presented in Table 1.

Table 1: Descriptive statistics and correlations. Note: Data are means (*M*) and standard deviations (*SD*), bootstrapped Pearson correlation coefficients. * $p < .050$, ** $p < .010$.

	M (SD)	1.	2.	3.	4.
1. Flow	4.65 (1.12)	-	.677**	.073	.344
2. Nondual Awareness State	3.02 (.71)		-	.145	.530*
3. Mindfulness	3.82 (.40)			-	.158
4. Augmented Embodiment	2.68 (.92)				-

To explore which STEs can be experienced during the everyday activity of preparing and drinking tea during the *Magic Tea* ritual (RQ1), one-sample t-tests were calculated with ‘3’ as the test value for Nondual Awareness State ($M = 3.02$, $SD = .71$) and Mindfulness ($M = 3.82$, $SD = .40$), and with ‘4’ as the test value for Flow ($M = 4.65$, $SD = 1.12$). Observed values significantly greater than these reference values would indicate the experience of flow (4 = neither true nor untrue), mindfulness (3 = somewhat) and nondual experience (3 = neither agree nor disagree) during the *Magic Tea* ritual. Tukey’s fences ($k = 3.0$) suggested there were no extreme values. Shapiro-Wilk tests suggested that the data distribution of Nondual Awareness State deviated from normality, $W(22) = .88$, $p = .010$. Furthermore, the sample size was small ($N = 22$). Therefore, all statistical tests were bootstrapped (1000 draws).

The results revealed a significantly greater observed value, compared to the reference value, for Flow (4), $M_{diff} = .65$, $p = .015$, 95% CI[.16, 1.07] and for Mindfulness (3), $M_{diff} = .82$, $p < .001$, 95% CI[.66, .89], but not for Nondual Awareness State, $M_{diff} = -.02$, $p = .874$, 95% CI[-.29, .30]. These findings suggest that interacting with *Magic Tea* tends to elicit a degree of flow and mindfulness in its users, but not nondual experiences (RQ1).

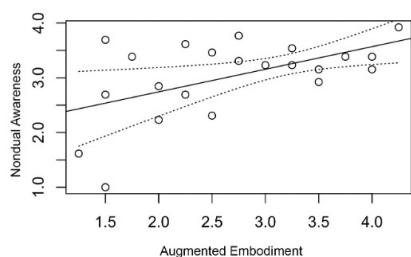


Figure 4: Scatter plot and regression (solid line) and 95% confidence intervals (dotted line) of the effects of Augmented embodiment on nondual awareness as measured by the Nondual Awareness.

To explore how Augmented Embodiment relates to experiencing STEs (RQ2), linear regressions were calculated with Augmented Embodiment ($M = 2.68$, $SD = .92$) as the predictor and Flow, Nondual Awareness State, and Mindfulness individually as the target variables. Visual inspection of the studentized residuals plotted against the standardized predicted values of each regression model suggested no signs of heteroscedasticity. The assumption of linearity was also met. The tests were bootstrapped because of the small sample.

The results showed that Augmented Embodiment did not explain a significant amount of the variance in Flow, $F(1, 20) = 2.69$, $p = .117$, $R^2 = .12$, $R^2_{adjusted} = .08$, nor in Mindfulness, $F(1, 20) = .51$, $p = .483$, $R^2 = .03$, $R^2_{adjusted} = -.02$. However, the results did show that Augmented Embodiment explained a significant amount of the variance in Nondual Awareness State, $F(1, 20) = 7.83$, $p = .011$, $R^2 = .28$, $R^2_{adjusted} = .25$. The bootstrapped coefficients suggested that Augmented Embodiment significantly and positively correlated with Nondual Awareness State,

$B = .41$, $SE = .15$, 95% CI[.07, .73], i.e. the lower and higher bounds of the 95% confidence interval did not cross zero (Fig. 4). These findings suggest that the increased perception of augmented embodiment relates to increased nondual awareness (RQ2).

5. Discussion

Existing methods and tools for inviting self-transcendent experiences all have their limitations. With the interactive installation *Magic Tea*, we have explored the possibility of inviting STEs during the everyday activity of preparing and drinking tea.

5.1. Summary of the Results

The explorative study had two main objectives. The first was testing the occurrence of three self-transcendent states, nondual awareness, flow and mindfulness, during the *Magic Tea* ritual (RQ1). The results suggested that interacting with *Magic Tea* tends to elicit a degree of flow and mindfulness in its users. However, the participants did not consistently experience a state of nondual awareness.

The second objective was to explore how augmented embodiment relates to the STE nondual awareness (RQ2). The results suggested that perceiving one's own physiology presented as part of the installation significantly and positively correlated with nondual awareness outcomes, but not with mindfulness and flow experience. This indicates that augmented embodiment during an everyday activity relates to states of nondual awareness.

These preliminary findings indicate that ritual in combination with the tangible embodied interaction strategies of entrainment and augmented embodiment possibly provide conditions conducive to self-transcendent states, such as mindfulness and flow while conducting an everyday activity. Augmented embodiment shows initial promise as a mechanism for inviting the more intense self-transcendent state of non-duality. The tangible embodied interaction approach presented in the present study could thus enable novel ways to elicit self-transcendent experiences, alongside the recent developments in VR (Quesnel and Riecke 2017) as well as the traditional tools such as meditation (Wahbeh et al. 2018) and psychedelics (Barrett and Griffiths 2018).

5.2. Limitations

The study, of course, has several limitations that need to be taken into account when interpreting our findings. This includes the usual limitations that come with exploratory studies, quasi-experiments and small sample sizes. In addition, it is important to note that two critical design features have not been explicitly tested in this study:

entrainment and ritual. Exploratory studies with earlier versions of *Magic Tea*, however, indicated positive contributions to STEs of both strategies. This included decreased respiration rate after entrainment (Roberts 2020b) and an increase in relaxation and attention after using *Magic Tea* without the interactive technologies present (Roberts 2020a). Furthermore, it should be emphasized again that the questionnaire used to measure state nondual awareness during *Magic Tea* was an adaptation from the NADA-T scale, which is designed to measure trait nondual awareness. Previous validation of the NADA-T may therefore not apply to the scale used in the present study. Finally, there is uncertainty about whether self-reports sufficiently capture flow, mindfulness and nondual awareness during *Magic Tea*. Future work should therefore complement self-reports with physiological measures such as skin conductance, heart rate and heart rate variability which can be used to measure, e.g., mindfulness and flow (Kitson, Chirico, et al. 2020). *Magic Tea* is a novel tea ritual and is set apart from other tea traditions. Our findings, therefore, should not be generalized to other tea rituals. Comparison between *Magic Tea* and other tea rituals requires further research.

5.3. Future Work

Results from the flow and mindfulness measures showed that participants experienced a degree of flow and mindfulness and no nondual awareness. One way to possibly intensify the flow experience (and perhaps other STEs) during *Magic Tea* is to reduce the amount of worry participants experience by optimising mindset and setting. This is a proven approach in studies using hallucinogenic drugs (Gukasyan and Nayak 2021). This research could also benefit from a more experimental approach concerning the tangible embodied interaction strategies which we have explored so far. We will explore the effect of augmented embodiment and other interaction strategies on self-transcendence in separate experiments — and will test if a combination of strategies will increase the likelihood and intensity of STEs. In addition, we are aware that quantitative data does not fully capture the richness of subjective experiences such as STEs. Micro-phenomenological research methods are increasingly used in art and technology research, which can provide detailed insight into subtle and individual differences in experience (Prpa et al. 2020). Such methods also offer new directions for future work, such as exploring *Magic Tea* in an everyday context at home or at work. That would also allow further insight into its long-term effectiveness.

5.4. Contribution Statement

The presented study contributes preliminary evidence about how an interactive art installation can be designed to transform the everyday activity of preparing and drinking tea such that it invites self-transcendent experiences.

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Art- works





A Jagged Orbit



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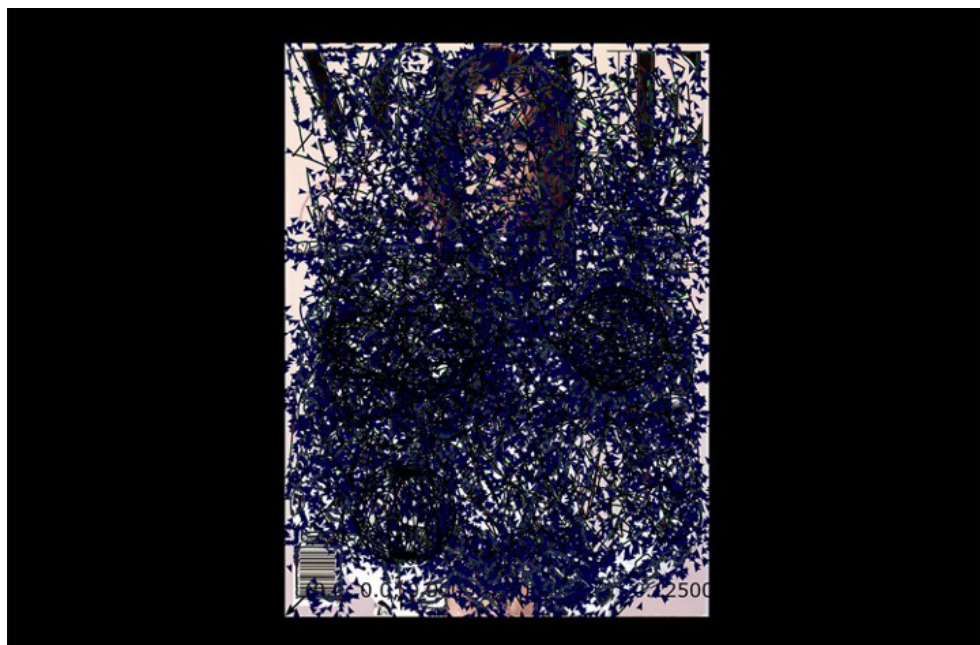
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A Jagged Orbit (2023) is an automated-art-system which algorithmically defaces publications, transforming their physical appearance through gradual cancellation and super-inscription until the original is illegible or unrecognisable. Through multi-input, computer vision path-finding algorithms, the system's mark-making is determined not only by the underlying images and texts of the original publication, but also environmental data collected from where the work is situated, including speech, movement or sound. These additional sources of data (distraction) may cause the system's attention to 'slip' away from its primary task, either inward — toward other, more 'meditative' tasks (representing a kind of mind wandering, or day-dreaming) — or outward, evoking perceptual responses to external stimuli. With the computational power of machines now far exceeding that which is required to execute many of the tasks they are assigned, this artwork speculates on what could happen when an AI becomes bored with, or distracted by, its human counterparts.

Keywords: Automatic Writing, AI & Machine Learning, Post-digital Publishing, Computational Unknowing.

Figure 1: *A Jagged Orbit: Victoria* 2023. [Computer Vision pathfinding simulation process image] Algorithmically corrected readymade of Vogue cover, from *A Jagged Orbit* series, Donnachie & Simionato.



Description

AI systems have proven capable of imitating many human activities. Reading, writing and image-making processes are now reproduced by nonhuman systems (NLP, NLG, Open AI's ChatGPT, GANS, Dall-E, Midjourney, Runway ML, etc.). These AI systems can generate original texts, images, and video that are indiscernible from those created by humans.

Conjecture abounds around the impact of the widespread use of similar systems, often leading to notions that machines will soon replace their human counterparts. At the same time, the computational power of many machines now far exceeds that which is required to execute the tasks they are assigned. In this work, we consider an alternative future/present when machine learning and AI, powered by the exponential growth of computational capacity, will become 'bored' of its automated processes. Through the tedium, we imagine an AI may turn attention away from its original task, its algorithmic functions may 'wander' towards alternate outcomes, discover more pressing or novel pursuits, or simply perform an activity analogous to daydreaming.

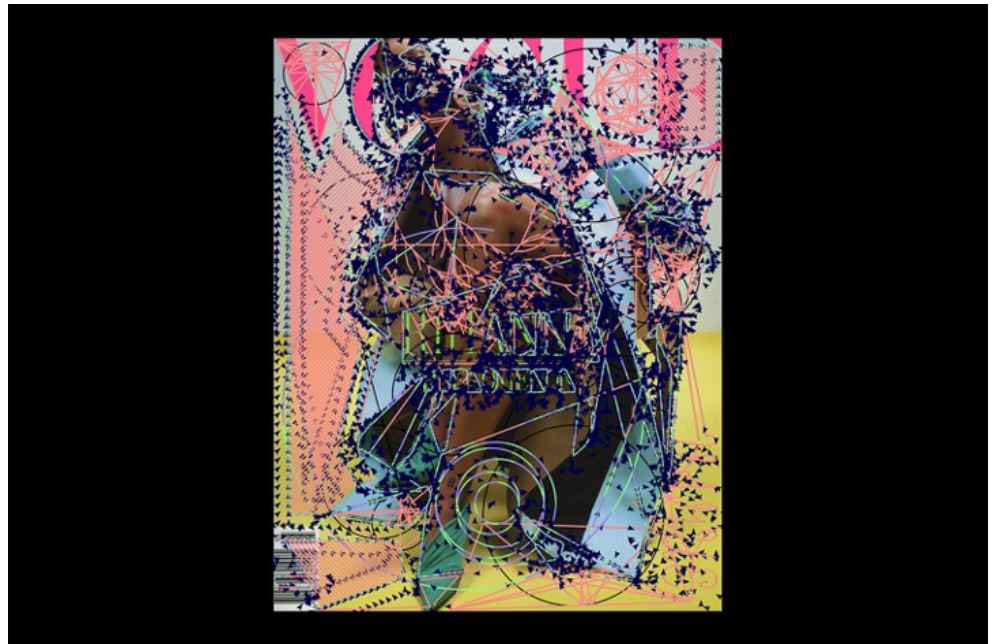
Consonant with notions of the 'wandering mind', the daydream in a robotic system may be accompanied by distracted, repetitive movements. In terms of drawing, or mark-making practices, distracted, unscripted actions may be visually like the human activity of 'doodling'.¹

1. In 19th Century marginalia studies, doodling has been observed as a tool to "record inattention, whimsical digression, critique, and sometimes outright hostility" toward the text that it accompanies (Mercurio and Gabelman 2019).

In human cognition theory, it is believed that “freedom from perceptual input facilitates abstract mental capacities such as creativity, logical analysis, and planning” (Smallwood et al. 2012, 1). This artwork speculates not only on the potential of the AI equivalent to the human ‘daydream’ but also on benefits such a state could hold in the evolution of human-nonhuman collaboration.

Can we give opportunity to the system to waver from its predictable orbits? Can an artificial mind ‘wander’? And if so, how could humans recognise and observe such a ‘wandering AI’?²

Figure 2: *A Jagged Orbit: Rihanna* 2023. [Computer Vision pathfinding simulation process image] from *A Jagged Orbit* series, Donnachie & Simionato.



The Automated Art System

The automated-art-system begins once a book, magazine, catalogue, or other printed matter, is placed within the bounds of its ‘reading area,’ where it is digitised through computer-vision. Some of the primary tasks assigned to this system include calculating Newton’s N-body problem, tracking the artists’ tax receipts, and posting messages to social media.

The system attempts to chain these primary tasks recursively while mark-making across the semantic and aesthetic inputs it identifies on the page. These regions of interest may include figures / faces / objects / type / text / colour fields etc. Simultaneously, sensors in the machine measure data in the physical environment in which it is situated (movement, sound, light, human presence etc).

2. If as Smallwood et al. suggest, that “[mind wandering] is linked to the pursuit of ideas or problems that have, so far, eluded solution” (Smallwood et al. 2012, 1; Smallwood & Schooler 2006), then perhaps our AI agents could be tasked with longer term goals to follow in moments of tedium.

Changes in the environment such as the approach of a human, a sudden sound or spoken conversation, may either ‘distract’ the system from its tasks, or they may ‘jolt’ the machine out of a ‘daydream’ state of apparent inactivity. Interrupting the current drawing routine and raising the ‘focus’ status of the machine will temporarily return it to the primary tasks. Other conditions will increase the potential for further ‘wandering’.

The system is designed to ‘wander’ or ‘drift’ while drawing with marker on the physical publication, both responding to the visual features of the publication & annotating the systems’ primary tasks and calculations. The mark-making is not predetermined, rather the result of blending multi-input weighted path-finding algorithms, generated in real time, with responses to the primary tasks, the environment in which the system is situated and to the (transforming) publication it is drawing over.

Figure 3: Installation view of machine drawing *A Jagged Orbit: Victoria*, 2023. Algorithmically corrected readymade of Vogue cover. Unique edition, unlimited series, Donnachie & Simionato.



Figure 4: Installation view of machine drawing. *A Jagged Orbit: Victoria*, 2023. Algorithmically corrected readymade of Vogue cover. Unique edition, unlimited series, Donnachie & Simionato.



The primary material used in this automated-art-system is existing books and magazines, evoking literary and historic precedents of marginalia, redaction, and other creative/destructive defacing of books within post-digital publishing practices. These publications are ideal for such experimentations as they are readily found and ripe with rhetorically potent text and imagery. Furthermore, the glossy (cast-coated) covers of magazines offer an ideal surface for the machines to draw over, able to accumulate many layers of ink without deforming, and therefore permitting the system to operate autonomously for longer periods.

This research is presented as a response, or provocation, to assumptions of beyond-human computational capacity, and its increasing adoption in building meaning through cultural production.

Acknowledgements. The title of this work is taken from John Brunner's 1969 novel *The Jagged Orbit*.³ In our artwork, the term is useful when imagining the relationship between human and nonhuman agents as if they are two bodies in orbit, the potential for these orbits to decay over time, ending in the event of the collision of both bodies, with the emergence of something new.

The physical outcomes of this work are singular edition artists publications, presented as derivative works (also called, 'corrected ready-mades'). No attempt has been made to contact the publishers, authors, or artists of the original works for permission nor endorsement.

Open-Source Libraries and software used in this artwork: Python, OpenCV, Tesseract, Natural Language Toolkit (NLTK), Vision AI, Google Speech-to-Text, SGPT, Librosa, cnc.js.

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3. Coincidentally, John Brunner wrote the following passage in another short story "Judas": "We've been slaves to our tools since the first caveman made the first knife to help him get his supper. After that there was no going back, and we built till our machines were ten million times more powerful than ourselves" (Brunner 1967).



Them



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This work consists of a series of positive film slides placed on a slide projector. The film that loops on the slide show is a series of fictional portraits of people. The photographs were synthesised by artificial intelligence, with the artist organising his family albums before curating and selecting the pictures to form an original dataset. The artist then used different AI models to process them, creating images that appear to be based on the artist's memories but which are nonetheless ambiguous, difficult to recognize. *Them* illustrates how memory is mediated and transformed through technology. In order to explore how family photographs are based on personal memories, our individual memory can here be interpreted and reconstructed through the eyes of a machine. Family portraits are the most common and mundane photographic subject matter. The artist collected his datasets from a group of family pictures captured using a film camera, which were then processed digitally by machine learning and recreated using a text-to-image conversion process, turning these familiar family portraits into fictional figures. The portraits of ordinary family members are thus turned into unrecognisable digital figures and then printed back into the medium of analog film. The past private memory has been estranged through technology. In this way, the work explores the reconstruction of human memory by machines, and imagines the potential relationship between photography and artificial intelligence.

Keywords: Artificial Intelligence, GANs, Text-to-Image, Photography, Memory, Media Archeology.

Description



Figure 1: Installation of *Them*, celluloid films are played by the slide projector.

Memories are preserved through different media. Photo albums are a record possessed by almost every family — a visual archive of family members’ past experiences, locations visited together, moments shared, all captured when the shutter is pressed. In Henri Cartier-Bresson’s classic statement, “the decisive moment” (Cartier-Bresson 1952), the instant when a family member presses the shutter, the camera records the memory. Before digitization, people believed in the authentic, documentary quality of film photography; it recalled the places they visited, the pictures of their friends, the joy of family celebrations. For decades, all of the precious moments of lives were recorded with portable film cameras. Documenting and capturing reality was the primary function of family photographs.

Family photography is the medium through which intimate memories are presented. I had the opportunity to return to my hometown last year, where I unearthed my parents’ photo albums from the 1970s to the early 2000s. As I was going through them, there were souvenir photos taken by my parents when they were young and travelling around the world. There were also some photos of my parents with relatives and friends. Because they were people close to me, I could feel my family’s emotional and intimate connection with a specific time and place in the past, even though these events occurred prior to my own participation. And this emotional resonance provoked me to think about the creative potential of the medium of family photos, which hold personal memories, and can be transformed into collective, shared memories that a wider group of people can perceive. Suppose these are not people I am familiar with but instead some fictional people. Must the meaning of these images be limited to the family members themselves, or can they evoke a broader shared imaginary experience?

The authentic and intimate characteristics of these family photographs was the original inspiration for this work. I have attempted to invert these two characteristics of family photographs, both technically and conceptually, to review and reconstruct the private experience based on the photographic medium from the perspective of artificial intelligence.

After first scanning nearly one thousand film photographs, I classified them for use as a dataset for machine learning, then fed the images into StyleGAN. I selected some of the images that were synthesised in latent Space. These StyleGAN synthesised images do not accurately show the images’ details, and I used the contours and colours of these synthesised images as the basis for reprocessing these images using the Img-to-Img function in the text-to-image model Stable Diffusion.

Since Img-to-Img requires a prompt to generate its final image, I entered the same prompt, “Them” for all images in this process. I minimised the intervention of different prompts in the final image composition. The word “*Them*” in the work’s title is the only prompt I used to synthesise the final image, which echoes the work’s title.



Figure 2: Film slide.

Through experimentation with machine learning and text-to-image models, *Them* attempts to technically engage one in thinking about the connection between photography and artificial intelligence. The medium of photography becomes a real-world record through a combination of light and lens shutter. At the same time, the machine synthesises its own memories of what it sees by learning from the visual archives of the real world. In this process, GAN synthesises the contours, colours and lines of scenes and people based on the source material, while the Text-to-Image model unfolds its imagination under the guidance of the artist and synthesises fictional portraits in its database. In addition, the composite images are printed and shown on slides. The new technology is demonstrated in the forgotten medium of celluloid film, echoing the media archaeology paradigm of thinking about the parallels between old and new technologies (Parikka 2012).

Figure 3: Image training and generating process.



Demonstration Video

<https://youtu.be/65I4A7vVa6o>

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Deep Hysteria



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Deep Hysteria is a still image series that repurposes algorithmic bias in the service of unraveling a deep human bias. Artworks are generated using deep learning algorithms trained on still frames of thousands of YouTubers speaking to the camera. Generated individuals are then algorithmically gender-adjusted and the variations fed to Amazon Rekognition, a commercial deep learning based facial analysis algorithm (Amazon n.d.) that attempts to classify faces according to the subject's gender, age, and emotional appearance. Despite the marketing of such tools, reading emotions solely by analyzing a person's face is a feat that neither humans (Callahan 2021; Le Mau 2021) nor "AI's" (Crawford 2021) can reliably do. Further, these deep learning algorithms are themselves trained on data categorized by humans — so they reflect human biases. The side-by-side images in *Deep Hysteria* compare Rekognition's interpretation of similar expressions on more masculine and more feminine versions of the same face. The comparisons interrogate how humans perceive emotion differently, and often in alignment with stereotypes, when observing people of differing genders.

Keywords: Gender Bias, Generative Deep Learning, Algorithmic Bias, Facial Analysis, Emotion Detection.

Hysteria, Then and Now

Figure 1: Sequence of drawings from 1893 depicting a woman with “hysteria.”



For centuries, “hysteria” was a medical and mental diagnosis (McVean 2017) that assumed females had an innate predisposition toward an anxious and nervous emotional state. Although the diagnosis has been retired, stereotypes of women as nervous, fearful, and uncertain continue to impact how women are perceived and treated. And while more women than men are diagnosed with anxiety, a Google image search for “anxiety” returns a far disproportionate number of images of women — who tend to be depicted in stereotypical poses of extreme emotional distress.

Figure 2: Google Search Image Results for “Anxiety,” January 2023.



The stereotype is further augmented by the cultural expectation of smiling as women’s default facial expression. Consider the phenomena of “Resting Bitch Face” (Grossman 2019) and “telling women to smile” (Smith 2016). A neutral facial expression on a woman is read as disgust, distress or unhappiness: “What’s wrong?”

In recent years, deep learning-based facial analysis algorithms such as Amazon Rekognition have been marketed as facilitating the identification of apparent emotion on faces captured in photos or videos.

These “emotion detection” services have been widely criticized as being inaccurate and highly problematic (Simonite 2019, Crawford 2021). As of January 2023, Amazon qualifies its emotion detection API as “only making a determination of the physical appearance of a person’s face. It is not a determination of the person’s internal emotional state and should not be used in such a way” (Amazon n.d.). It is unknown what percentage of users note this warning and limit usage of Rekognition accordingly.

But it isn’t only “AI’s”¹ that can’t read emotion based on facial expressions. Neuroscientists studying facial movements have demonstrated that facial expressions alone do not sufficiently convey emotion. Identical facial expressions can mean different things depending on culture — or context (Crawford 2021; Callahan 2021; Le Mau 2021). We think we can “read” other people’s internal states — we can’t.

Deep learning-based algorithms are trained on data produced by humans, so they reflect and often amplify human biases. Although developers typically do not intend to replicate problematic biases in their models, the nature of the training process provides many opportunities for problems to happen inadvertently. The training dataset may lack sufficient diversity — e.g. a face classification system might disproportionately misclassify darker-skinned people as a result of having an insufficient number of darker-skinned faces in the training dataset (Buolamwini and Gebru 2018). Or the system may tacitly “learn” proxies for historically biased behavior — e.g. a recruiting algorithm trained on historical data might end up favoring job applicants with names or pastimes common among white men (Bogen 2019). In such cases, the unintended bias is an indirect consequence of the design of the training system.

In the case of emotion detection algorithms, however, bias and subjectivity are at the core of the concept itself. Whether performed by human or machine, the identification of a person’s internal emotions using external criteria is inherently subjective. Various emotion-related training datasets of pre-categorized faces, incorporating both posed and spontaneous emotions, are available to developers (Boesch n.d.) — or a developer may create their own dataset. Either way, the implicit biases inherent in the way humans pose and categorize the facial expressions in the dataset will be directly passed on to the detection algorithm. And since these biases are so deeply embedded socially, a system that reflects them may go unnoticed by both developers and users. Stereotypical results may simply appear to be “right.”

1. Although formal definitions of “AI” currently refer to the broad concept of artificial intelligence rather than specific applications, a common, informal usage has emerged to refer to certain types of AI-based applications. The latter usage implies a context in which the software is a functional entity whose performance of tasks can be contrasted with that of either humans or conventional software algorithms. For this reason, the informal usage is employed here.

The artworks in *Deep Hysteria* redeploy the bias embedded in facial analysis algorithms in the service of probing this deeply entrenched social bias.

Figure 3: *Deep Hysteria* artwork.



Vloggers and Generative Deep Learning Portraiture

In addition to their utilitarian function of portraying gender-variable artificial personae, *Deep Hysteria*'s virtual portraits also serve as an exploration of texture, pose, and identity in generative deep learning portraiture. While many portraits generated via deep learning default to the use of posed, high resolution still photographs as training data, *Deep Hysteria* is trained on frames from YouTube vlogs produced by video makers with low subscriber counts. These vloggers, who come from countries around the world, photograph themselves speaking to the camera and are primarily amateur videographers. Their videos are typically shot with phone cameras and webcams and are photographed in a variety of settings, often with less-than-ideal lighting. Consequently, *Deep Hysteria*'s generated images are composite portraits of the self-selected vlogger addressing their audience, rather than the posed and curated subject of a photographer's gaze.²

2. The image generation model was trained using transfer learning from the Flickr-Faces-HQ (FFHQ) dataset, which is composed of primarily posed portraits posted to the Flickr website. Transfer learning begins with the previous dataset as a basis; the model is then retrained on the new images. The *Deep Hysteria* images retain some characteristics of the Flickr dataset. Developing a model trained from scratch would have required considerably more personnel and computation resources than were available for this project.

Figure 4: *Deep Hysteria* artwork.



The Process

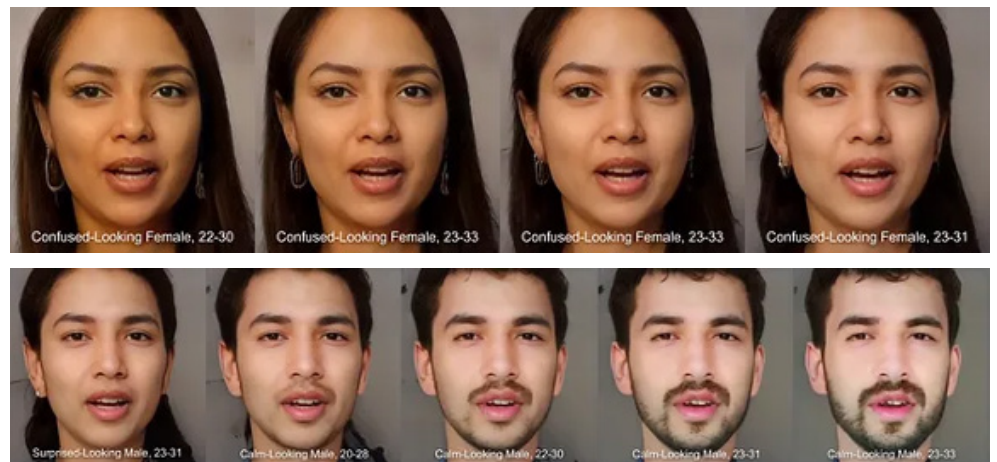
Images featuring a human face were collected over the course of a year from YouTube videos; the collection was oriented toward vlogs and other first-person narratives by non-professional video makers. In most cases, the images were captured as the video makers were speaking to the camera. These images were then used to train a Stylegan2-ADA model, using transfer learning from the Flickr Faces HQ dataset. The resulting model was then used to generate a set of baseline images.

A subset of baseline images with relatively neutral facial expressions were then selected. From these images, a set of images with variations across a spectrum of gender presentations was created using a latent direction for gender developed by Robert Luxemburg (Luxemburg 2019). An attempt was made to compensate to the degree possible for changes in the image's facial expression resulting from algorithmic entanglement with the gender variation vector (mouth and eye openness), so that all gender variations for a given face had closely similar facial expressions. All gender variations were then submitted to Amazon Rekognition, a popular commercial image recognition and facial analysis service that offers an emotion detection API. Rekognition analyzed and labeled the faces according to gender presentation, age, and apparent mood. Results returned with less than 50% confidence were ignored and labeled as "unknown."

While the predominant mood analyzed by Rekognition for both male-identified and female-identified "neutral expression" images was "calm," a significantly greater number of male-identified images received this designation. Female-identified images were more likely to be analyzed with stereotypically female emotions: "fear," "confused," "sad," "surprised," "disgusted." Male-identified images were more likely to be designated "angry" by Rekognition. Although *Deep Hysteria* faces are gendered across the gender spectrum and thus includes non-binary faces, Rekognition lacks designations beyond binary gender presentation; it labels all images as either "male" or "female." Non-binary-appearing images inclusive, those images Re-

kognition identified as “female” were more likely to be labeled with stereotypically feminine emotions. This effect was notable in cases where the corresponding masculine image was labeled “calm.”

Figure 5: Sequence of progressively gender-varied *Deep Hysteria* raw images with Amazon Rekognition-generated emotion/gender/age labels.



To create the *Deep Hysteria* exhibition images, selected male images identified as “calm” were placed side by side with counterpart non-binary or female images identified with more stereotypically feminine emotions. Each side-by-side image was captioned with its emotion, gender, and age as identified by Rekognition.

Figure 6: *Deep Hysteria* generated artwork.

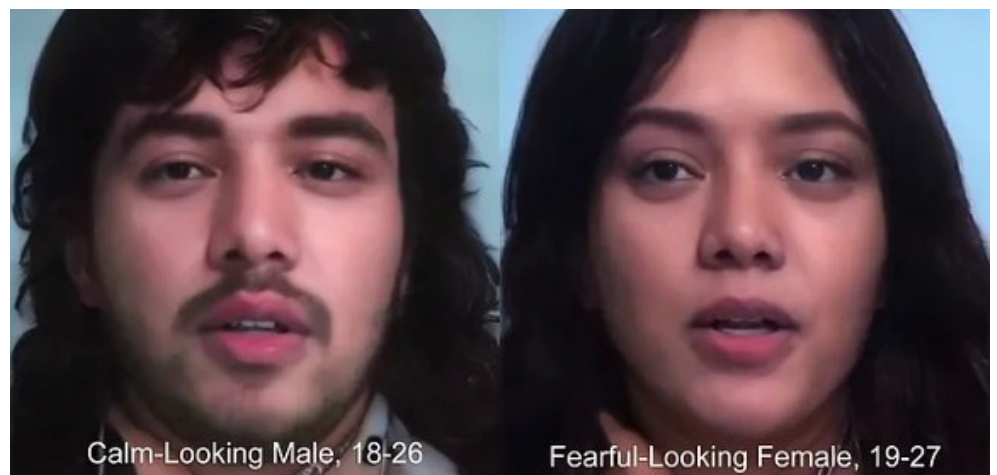


Figure 7: *Deep Hysteria* generated artwork.

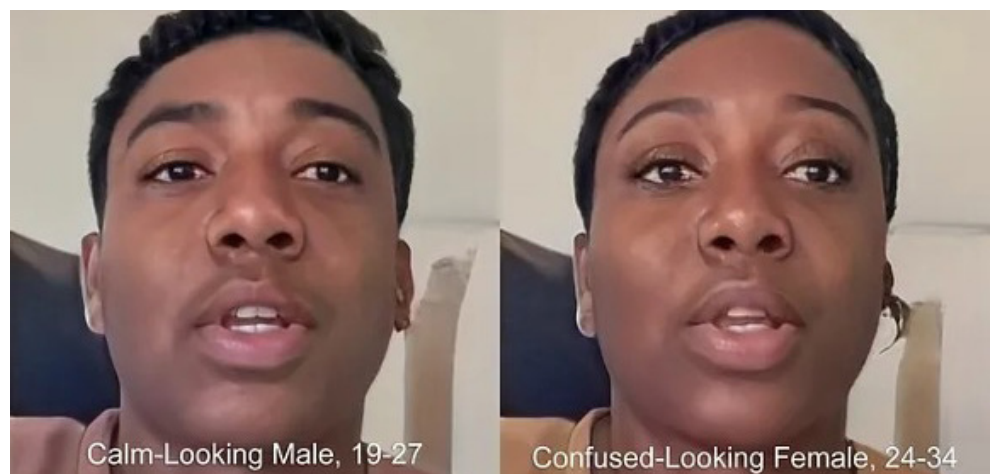
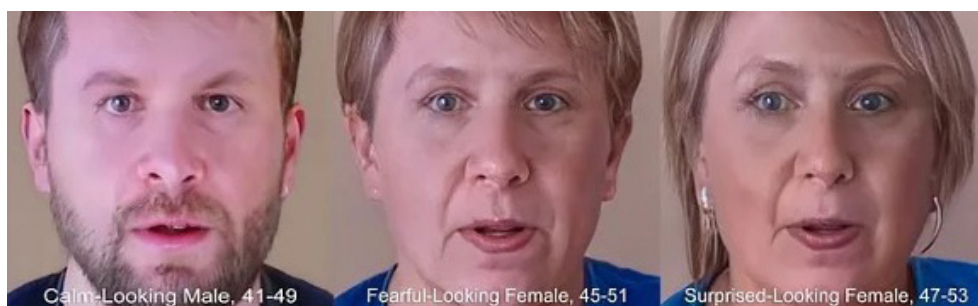


Figure 8: *Deep Hysteria* generated artwork.



Rough Statistics across the Broader Dataset

The statistics listed below are based on an informally collected/generated dataset. The sample size is small, and the generation and collection methodologies are not designed with the necessary rigor for scientific research. In particular, the broad gender spectrum of generated images sometimes exhibits apparent racial shifts and other anomalies at the extremes that could impact accuracy in some cases. Overall, however, they do give a general indication of the bias observed in the development of the *Deep Hysteria* artworks.

Table 1: Rekognition analysis of generated neutral expression faces — male.

Total identified as male:	112
calm	69.64%
undefined mood	6.25%
happy	5.36%
confused	10.71%
surprised	8.04%

Table 2: Rekognition analysis of generated neutral expression faces — female.

Total identified as female:	119
calm	51.26%
confused	12.61%
undefined mood	14.29%
disgusted	1.68%
sad	8.40%
surprised	4.20%
happy	7.56%

Smile!

The original stills of actual YouTube video makers used in the training dataset were generated were also analyzed by Rekognition over the course of a year, as part of the *What the Robot Saw* (Alexander 2020) live stream artwork. These images were submitted to Rekognition as raw images without algorithmic variations. Unlike the generated images analyzed, which were limited to neutral expressions, these images incorporate the actual range of vlogger facial expressions. The following statistics summarize the apparent emotions

Rekognition identified in the actual vloggers. Notable in these statistics: female vloggers were much more likely to be labeled as “happy.” An informal visual analysis by the artist found that most images labeled as “happy” did indeed appear to be presenting as “happy” — i.e., more women smiled in their videos. This observation appears to support the assumption that women perceive more social expectation than men to smile in their public online presentation.

Table 3: Rekognition analysis of actual YouTuber faces (any expression) — male.

Total identified as male:	4028
confused	11.47%
angry	1.91%
fear	1.54%
disgusted	0.94%
calm	58.76%
sad	3.08%
happy	12.88%
surprised	9.41%

Total identified as female:	3910
confused	6.04%
angry	0.61%
fear	4.48%
disgusted	1.30%
calm	48.08%
sad	5.65%
happy	23.66%
surprised	10.18%

Conclusion

Much-needed attention has been paid in recent years to the problematic impacts of deep learning systems that reflect and ultimately amplify social bias in training data. However, it’s essential to keep in mind that the biases originate with the humans, not in the algorithms themselves. “Biased” algorithms have the potential for positive social impact as well as negative. They can be redeployed in the service of revealing and interrogating deeply embedded social biases we might not otherwise be able, or willing, to see.

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How to Be or Not to Be Recognized as a Human: How Do Technical Limitations Influence the Image of the Self?



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The body is our anchorage in the world, the zero point in reality, but it is also the only blind spot for the person, especially the face. Humans only can see “what I look like” through media, which reproduces virtual images — from mirror to screen. Today, people get images of themselves from screens more and more. Whether people want them or not, these images are processed by algorithms. People have never had the power to control their own image but have been coerced by media. However, there is an easily overlooked but inescapable element that has always been in control — the technological boundaries/limitations. The artwork and proposal will focus on exploring how technological limitations in the digital age have shaped digital images, especially face images of the Self. It includes the images’ dissemination, compression, recognition, calculation and transfer between text and pictures.

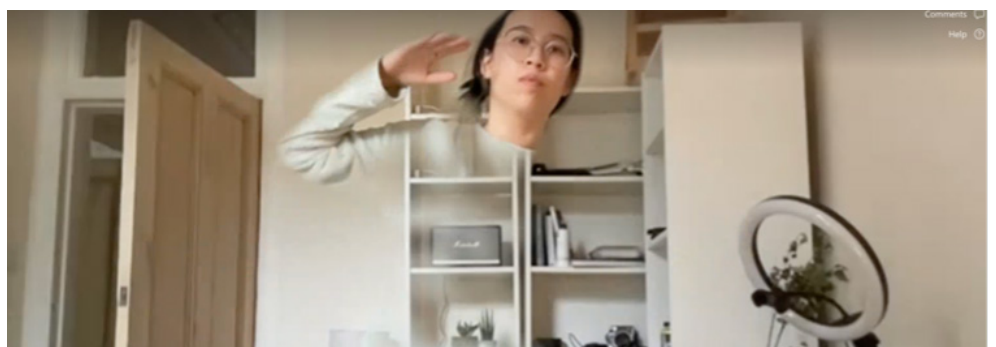
Keywords: Meeting Software, Image of the Self, Representation, Body, Algorithms, Technical Limitations.

Description of the Artwork

Compared with analogue images, recognising is an essential step in the operation of algorithms for processing digital images, especially for the body/face. In the post-epidemic period, online meeting software is being used significantly. A very intuitive and visible recognition exists on this software when users use a virtual background that the algorithm must make real-time judgements and process dynamic people: is this a person? Is this a human face? Does this belong to a part of a human being? Is this the edge of a human being? Its processing speed is extremely fast, almost catching up with the human eye's reaction speed. However, it has the technical limitation that when people move fast, the edges are not handled well, and some blurring or errors are caused. Sometimes it may cut off a part of the body that belongs to the person or incorrectly show a part of the background that does not belong to the person due to misidentification (Fig. 1). In the artwork *How to be or not to be Recognized as A Human*, (Fig. 2) the performance takes place in front of a computer camera. My own body was used as the experimental target and was transformed into a body image in real-time. The body's performance in this reality space is not valid, only valid in the interaction with the algorithm on the screen. The Zoom algorithm and I playfully banter, finding and playing with each other's bugs.

The whole video has not been edited in any way. Instead, all the effects were created by combining physical props and Zoom's virtual background feature. The former includes the mirror and screen in my hands, and the latter is a looping video of the jumping cube as a virtual background. It is a faithful recording of a performance using Zoom's record function.

Figure 1: Screenshot: My arm/body disappearing.



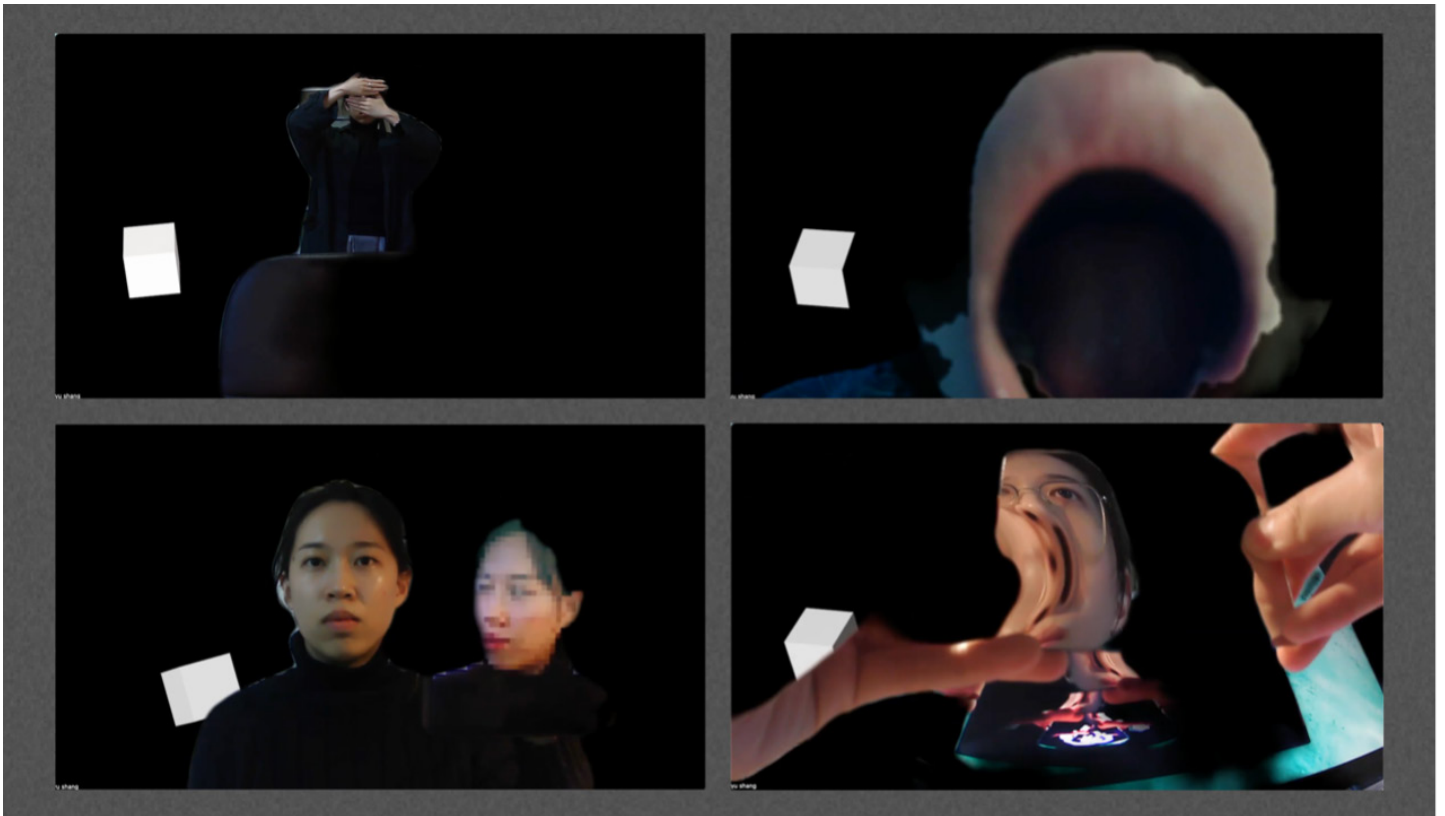


Figure 2: Video *How to Be or Not to Be Recognized as a Human* (<https://www.youtube.com/watch?v=IBVOvFdELRM>).

Context

When software and image collide the result is not just a different, processual image, but also a paradigm shift with implications for thinking about the ontological link between representation, memory, time and identity. (Rubinstein and Sluis 2013, 25)

Initially, people discovered themselves in the mirror as a process of awakening self-knowledge and gaining an identity. Many related theories and scholars — such as Jacques Lacan (2006) and Suzanne Ridley (2014) — have noticed the history of mirrors and their role in shaping self-consciousness and identity. Then, it is the camera's power to 'see' in an inhuman and multiple ways that give us, a whole new way of thinking. During the long period of development that photographic technology has been going through, from film photography to digital photography, the role of light has undergone different chemical and physical changes compared to that of a mirror. At the same time, people have more flexible access to images of their own bodies, seeing themselves from different angles, even in motion, where the 'person' in the image and subject can avoid direct gazes at each other. Today, one increasingly common phenomenon is that people often use cameras and screens as mirrors, even more than mirrors themselves. For example, the smartphone that everyone carries with them anytime and anywhere. Or the rapidly increasing use of online meeting software, especially since the epidemic, where a 'mirror' appears in the bottom right-hand corner of the screen, which helps people always know 'what I look like when I am talking to the other'. That's weird, as people never needed to think about it

before the invention of video calls and online meetings. Do we really need to know this?

Simultaneously, the advent of the digital image removes the one-to-one correspondence between the image and the original, allowing the data/algorithm to take advantage of it. Digital images of self-representation increasingly appear in our everyday lives; whether you actively use filters or effects or not, the image of you that the camera displays on the screen has possibly been processed by an algorithm. The opinion is described by another interesting example which is from an interview with Hito Steyerl (2014). According to a technician working on smartphone cameras, half of the data captured is noise because the phone lenses are so tiny and inferior. The key to solving this problem is to create an algorithm that cleans and defines the image from the noise. How does the camera know what needs to be preserved? The algorithm tries to match faces and shapes by scanning the photos you've already taken and stored in albums, and the pictures you've used in networks such as social media. The algorithm creates the picture "based on earlier pictures, on your/its memory. It does not only know what you saw but also what you might like to see based on your previous choices. In other words, it speculates on your preferences and offers an interpretation of data based on affinities to other data" (Steyerl 2014). The result is that the picture it created may not exist in reality. What is presented on the screen is not the present moment being photographed, but an image intertwined with the past. But this mode of image production is as well as limited because the common tendency of the new images generated by the algorithm is guided by your currently existing images and currently existing preferences. All are directed towards the unknown in this constant process of difference and repetition of generation.

In a short essay he wrote a few years before suicide, Gilles Deleuze (1990) made the point that we are constantly under or within some kind of control so that the social order is maintained. There is always a sense that we are being surveilled or are yielding our place to some invisible authority (Rothwell 2017). The image, as a mechanism for capturing something recognisable about who you are, is now playing the role of an "invisible authority". The mirror is the earliest producer and medium for generating authoritative images. Then what factors act as the invisible authority that determines the image that influences its appearance?

However, actually, throughout history, people and their images have never been unified. In the embodied perception of phenomenology, when we go into the world of perception, we are always taking our bodies with us. An interesting contradiction is that the body as the "zero point of orientation" (Merleau-Ponty 1962), which we can best determine its physical authenticity, can be controlled, touched, and

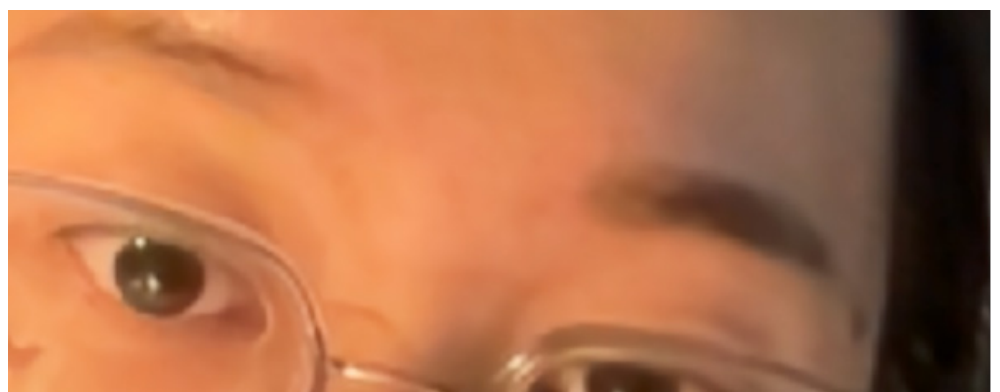
felt. But it is the only blind spot of its owner in the world, especially our own face. This is the reason I chose my own body as the target in the work.

Digital Images and Technical Limitations

Some arguments suggest that under highly magnified observation, analogue images are considered to have a high degree of consistency and accuracy with the represented object, such as gradations of light and shade that still retain a perfectly natural and smoothly curved state (Poe 1840). In comparison, an image encoded by digital means comprises a finite number of pixels, i.e., cells that are visible when magnified. Furthermore, the colour of each cell is determined by a finite range of integers, such as RGB values from 0-255. Therefore, the amount of information in an image from traditional photography is infinite. In contrast, a digital image contains a fixed amount of information, which is limited by the resolution, and when zoomed in to see the colour of each pixel, no more news is available (Mitchell 1998, 31-70). Secondly, the light of the captured image is decomposed into binary codes to be transmitted in wired or wireless and finally recomposed to new images on the screen. Numerous scholars have argued that the manipulability of code defines the character of digital images (Rose 2016, 7). Digital images are indeed prone to be edited by people, but this project wants to highlight the ‘non-editable’ factor that exists outside of the human element — the inherent technical limitations of the representation media themselves.

A visual example of this occurred during my video using Zoom software, as shown in the screenshot (Fig. 3), where my eyebrows show a clear asymmetry. I do not look like this in fact, and Zoom doesn’t want to show me like this either, but it happened. This is one of the technical limitations I talked about. The limits of this technology are neither what humans nor the technology itself want, but it becomes a non-negligible power — affecting the appearance of images, the relationship between the body image and body, and the building of self. This invisible power does not exist only in the age of the digital image; it has been present throughout the history of the human body image and has had a range of cultural and ideological influences.

Figure 3: My asymmetrical eyebrows on the screen



Another notorious but crucial example is that early in its invention, photography raised issues of race, class and colonialism over the point of black and white skin. Photography has been described as a technology invented for white people. Due to technical problems with light in the photographic imaging principle, images of black people's faces could not be captured well, and their facial features were erased; "The problem is memorably attested in a racial context in school photos where either the black pupils' faces look like blobs or the white pupils have theirs bleached out" (Dyer 1997). It is suggested that this problem was not solved until the age of digital photography. However, a similar problem has not been fixed very well even today. It is still present in facial recognition systems (Buolamwini and Gebru 2018, 77-91).

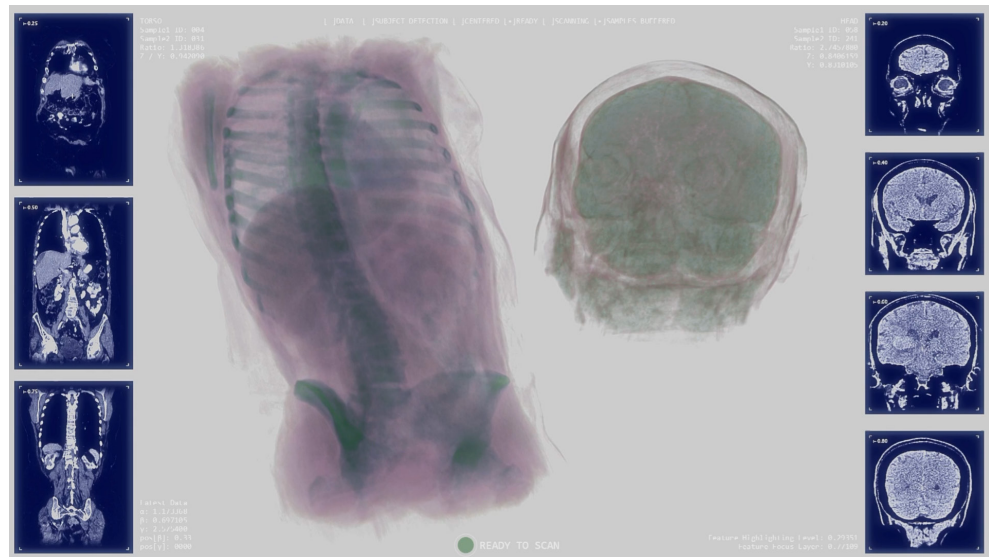
As this technical limitation is invisible and easy to ignore, I wanted to express, through the intervention of my work, the new aesthetics and the changing relationship between the human and digital image that results from this technical limitation, of which this work is one. As the whole world becomes increasingly homogenised, algorithms produce more and more instant overcoding faces in a repetitive generation; are they undermining the specificity of the faces and replacing them with the creation of universals, or are they creating new specificities? These are questions that require further research.

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Exquisite Corpus



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As humans, we regard our bodies through their visual surface components. The interior, when considered at all, is typically only due to medical concern for one's-self — rarely envisioning that of others. While radiological tools have dramatically improved our capacity for noninvasive representation, their use is often confined to the domains of personal health. This work seeks to instead uncover the possibilities they represent to show the full scope of our bodily form. In their obfuscation of the accustomed visual boundary, they remove associations of race and many aspects of gender. To further the dissolution of perceived identity, it excavates our inner sameness through algorithmically merging bodily interiors into 3D human chimeras — hybrid beings existing beyond the possibilities of genetic merger. Through the collection of simple participant biometrics, blended avatars constructed from real human data are selected based on similarity to give viewers a bodily representation that extends beyond the surface manifold commonly regarded as the self in both physical and virtual worlds.

Keywords: Radiology, Chimera, Self-perception, Avatars, Medicine, Organism, Machine Learning.

Description

Introduction

Exquisite Corpus is a work that helps visualize an understanding of the similarities of the human organism through relations to our interior organic structures shown outside of the medical context of pathologies. From an interactive perspective, it responds to participants in the interaction zone by analyzing basic aspects of their bodily proportions and showing them a speculative volumetric computed tomography (CT) scan of their head and torso.¹ These images themselves are made through an algorithmic merger of public data to both highlight the similarities between humans while further disassociating the anonymized data from any existing individual. Three physical hybrid organs of the heart, brain, and larynx are presented as well to better highlight their individual structures.

Theory

Exquisite Corpus is an excavation of the organic interiors of human existence, blended into new chimeric individuals. Head and torso CT scans are aggregated to form new hybrid sections and these sections are then combined into bodies existing in the absence of markers for typical human differentiations. First in that, as volumetric interiors, they do not have the visual bias of the skin and second in that the interiors are themselves both blended and recombined. They are agender, as they are without race. Society struggles in foretelling the future of the human organism through contextualization of its historic, visual representation. Even within the scientific field, medical diagrams and studies of the inner body are fraught with racial, sexual, and colonialist biases that still need to be addressed. By first removing the exterior visual factors and then by blending the inner, it is hoped that the new considerations of potential futures may become exposed.

Additionally, these constructed beings produce a counterpoint to those imagined as the inhabitants of virtual worlds. Those account only for the manifold geometry (are represented only by their “skin”), as characters with no need of organs have no utility in using the computational resources to generate them. Digital avatars, no matter how whimsical, follow the visual ideations of our perceived world. This then produces beings predicated on the visual surface tells of what makes a bodily identity, even if allowing one to widely explore alternatives (including the non/semi-human) to their own. In contrast, *Exquisite Corpus* portrays virtual representations which,

1. CT scanning is a technique for high resolution internal images using a moving, rotating X-ray tube to capture the subject from multiple angles before combining them computationally into a 3D representation.

while definitively human in form, are in no way defined by exterior understanding.

These individuals exist absent the mechanisms and limitations occurring within the genetic blending of ancestry. As there are no traits which become dominant or recessive, all physical characteristics are merged. This representation, both interior and blended, then provides a means not only of surfacing the physical self from behind the prior mentioned sources of interpersonal bias, but also a speculative entry to a future vision no longer bound to our mendelian genetic inheritances.

Presentation

Viewers are introduced to the work through a video screen showing volumetric CT imagery of chimeric heads² and bodies. Upon detection of a participant standing within the interaction area, basic biometrics ratios are analyzed and compared to a database of these hybrid forms containing 1,764 potential head and torso combinations. The screen then updates to show their match, thus giving the viewer a speculative personal CT scan, but one that both does not require the personal safety concerns of radiation, and shows their similarity to other persons through the blended forms of four others that are not themselves. Additionally, three physical models of selected organs are displayed on a light table.

Background

Medical Depictions of the Interior

Through much of recorded history, artists have been illustrating the interior of the human body, for both medical and dramatic purposes. The earliest known instructional illustrations appear in 4th century BCE Alexandria, continued the 18th century in the works of Berhard Siegfried Albinus such as *Tabulae Sceleti et Musculorum Corporis Humani*. The invention of color printing techniques in the 19th century later allowed a blossoming industry of medical illustration to come forth, driven in large part by the illustrations of Max Brödel, director of the Department of Art as Applied to Medicine at Johns Hopkins university (see Branigan 1995). The first depictions to not touch our senses directly was ushered in in the late 19th century by Wilhelm Conrad Röntgen who provided the first look at the bone structure of the living hand through that of his wife Anna Roentgen in an image entitled *Hand with Rings*. Only in this interaction of the unfelt and unseen X-ray with photoreactive paper were we first able to reveal the hidden body without physical interference. As what became also

2. Head CT representations additionally were processed with bone removal, to better highlight the soft tissue structures that would otherwise be occluded by the skull.

known as “nuclear medicine” developed, so too did additional tools such as magnetic resonance imaging (MRI) and the use of inaudible high frequency sound reflections known as ultrasound. With the expansion of computing technology, these techniques were further expanded to produce three dimensional representations of their subjects through CT scanning. These tools have provided artists new means for visual expression both within and outside of the medical field including experiences such as *Virtual Anatomy and Pathology at Deep Space*, “a project designed to utilize the data generated by [radiological] devices to deliver faster — and, above all, better — visualizations” providing a “combination of virtual reality technology and medical science” (Ars Electronica Futurelab 2022).

Virtual Depictions of the Avatar

The avatars of virtual worlds have allowed games players to explore a range of alternative existences to include the gendered, trans-species, multi-species chimeriscisms, and trans-humanist existences. They are, however, mostly limited to only the visual components and more specifically to the surface manifold. The virtual body lacks needs such as air, food and water (and the expulsive needs of the body cleaning itself). That these notions of the interior do not exist in the virtual space only accentuates that the avatar is as-yet wholly reliant on the physical body, and that no matter how wild the representations of virtual space, the players remain tethered to their similar inner topologies. That is to say, much like their real-life selves, the visual expressions of the avatar, no matter how distinct, all share the common inner forms of the users.

As artificial intelligence (AI) advances, we find another form of being that is recognized in the absence of its physicality. AIs in many mid to late 20th century science fictions were presented as disembodied voices such as that of HAL 9000 in the film *2001: A Space Odyssey* (1968). What we see now is often their disembodied artistic creations such as those from drawing prompts in Stable Diffusion (Rombach et al. 2021) or Dall-E (Ramesh et al. 2022). While these tools and affiliated chatbots are often at the forefront of media coverage of AI, it should be noted that it has as well been present through non-player-controlled characters in video games. As the capabilities of the machine learning (ML) driven models increases, potentially leading to an inability to distinguish whether one online is in conversation with a human, it becomes only the physical form of the user that differentiates. This initiates a new variation of the old concern in telepresence — trust. Extending this offline and into the physical realm: as robotics and AI improve, the exterior becomes even less relevant to the commonalities of humanity.

Machine Learning in Radiology

The field of radiology is currently deep in research about how to use algorithmic techniques to improve access to and quality of diagnosis through training to improve the visual output quality (thus allowing low-dose CT imaging to minimize radiation risk), automatic tissue differentiation, and identification of pathologies that might be missed by manual review, while further allowing a greater number of patient reviews. There is a large body of critique in the literature about the possibilities as well as concerns of bias within these uses.³

Methods

Figure 1: Representation of interpolation technique. The volume is converted to a series of slices. The slice at each height from each of two samples is interpolated to create the hybrid slice. Right: One slice of a merged torso.

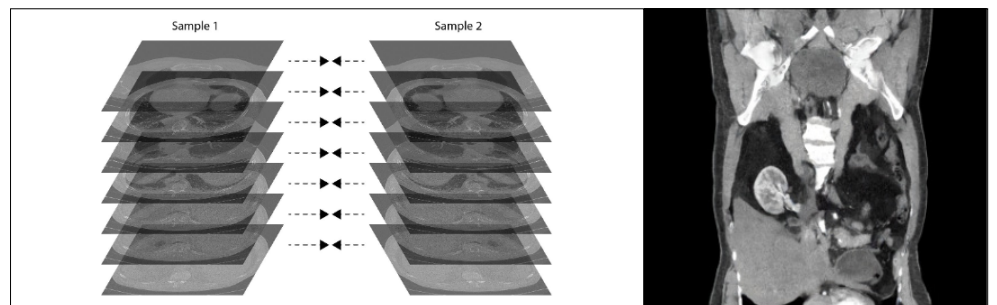


Figure 2: An early test head CT merger that was blended using images sliced on the transverse plane shows tearing when combined and re-sliced on the coronal plane. This was minimized in later experiments by better conforming the positions of the subject data. Artifacts relating to dental work proved especially challenging for this technique.

To accomplish its goal of investigating the internal spheres of the human being in a manner intended to detach it from both medical consideration and the visible outer strata, *Exquisite Corpus* takes regional CT body scans from anonymized public datasets⁴ and uses machine learning to blend the forms into chimeric individuals. This is produced using a novel re-appropriate of slow motion interpolation technique and a custom, simplified, non-voxel rendering technique to show the volumetric results. The resulting imagery, while featuring an array of unnatural artifacts, blends to a quite recognizable human form with clear organ differentiation. Additional tools were then used to produce physical 3D printed models.

Blending two CT scans into one coherent human volume required a novel approach, as the majority of related algorithms were for image quality improvement or surface manifold blending. There is no developed algorithm to produce volumetric blending of physical forms as were required by this artwork. A novel approach was developed in which each pair of sliced layers were interpreted through a machine learning algorithm designed to interpolate intermediate frames. This was accomplished through use of the FILM (Frame Interpolation for Large Motion) (Reda et al. 2022) developed for interpolation of slow-motion video, without additional training with radiological data (Fig. 1, 2).

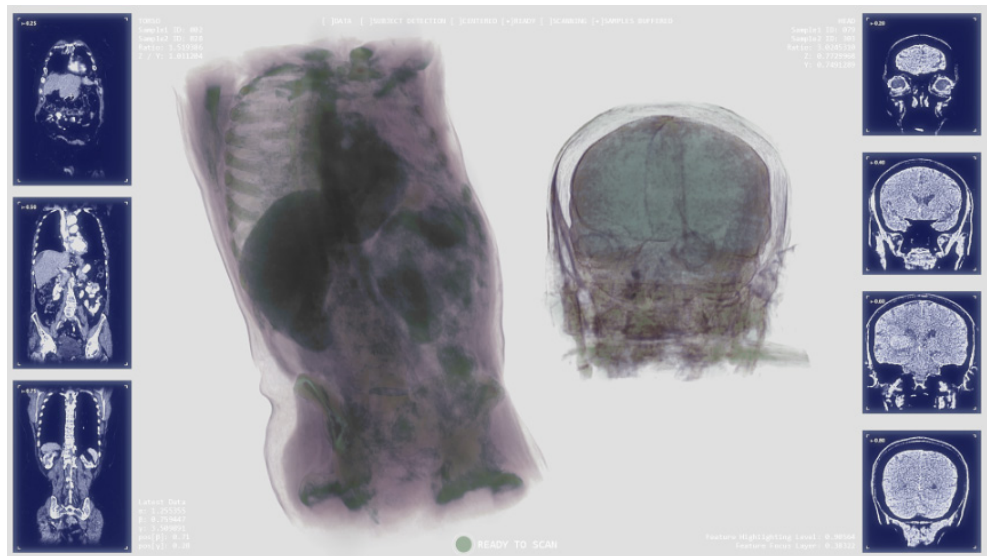
3. Such critiques can be found in McBee et al. (2018) and Pesapane et al. (2018).

4. These datasets include a head CT set (Crawford & Mader 2022) and a torso CT lymph nodes torso set (Roth et al. 2014) accessed from The Cancer Imaging Archive (Clark et al. 2013).

Rendering

In order to produce the visual component on available hardware, a custom rendering pipeline was developed using the vvvv visual programming package (vvvv 2022). Rather than the more customary approaches, such as voxel-space rendering or surface manifold segmentation, this technique used only a stack of textured image planes to represent the volume. This method required little additional computational overhead beyond loading the images and making color adjustments to better highlight organ differentiation. While this technique limits the range of rotation as a camera angle tangential to the image plane results in its disappearance, this was irrelevant to the intended representation (Fig. 3).

Figure 3: A frame of false color representation of the torso and head as separate models. The color palette shifts during exhibition to highlight different organs and tissue structures. Left and right images show equally spaced individual slices of the hybrid regions.



Interaction

Pose estimation (see Cao et al. 2021) was incorporated to collect basic biometrics from interacting participants to select chimeras most closely matching their own proportions. Rather than the typical use-case of this technique for determining the pose of an individual, only the point representations of the shoulders, hips, eyes, nose, and ears was needed here. To minimize the inherent noise of the selected algorithm, these points' positions were averaged of several samples. Their distances were then converted into ratios and these ratios compared to a table of those calculated for the database of pre-blended chimeric sections.

Segmentation and 3D Printing

In addition to the interactive elements, three organs were produced through selected blending and segmented into models for physical 3D printing or flexible resin. The blending process was the same as for the interactive elements, but the volumes were cropped to only the relevant portions before interpolation. These were then brought into the Slicer medical imagery software for segmentation from

surrounding tissue and conversion to a mesh model. These models were then imported into Blender (Community, B.O. 2018) for cleaning preparation for the printing software. Models were printed using Pre-Form (FormLabs 2022) software and printed in flexible resin (Fig. 4).

Figure 4: Resin printed merged organs. Left: Two hearts. One sample female, one sample male. Center: Three voice boxes (larynx, no sample data). Right: Two brains. One sample female, age 79; One sample male, age 19.



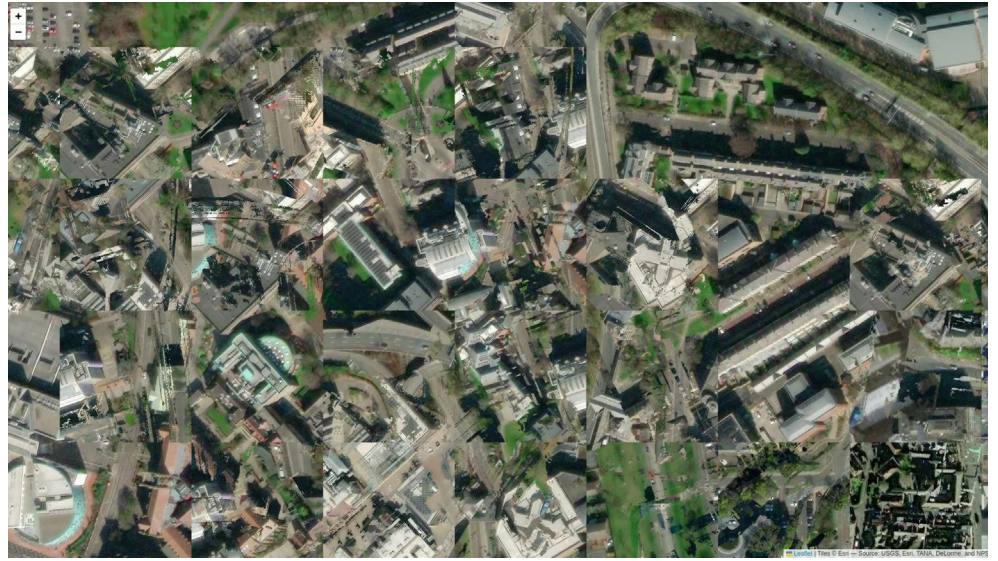
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Everywhere I Have Never Been except There



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Everywhere I Have Never Been except There is an interactive artwork that uses security vulnerabilities, crowd-sourced data, and image processing to create maps of imaginary hybrid spaces. Wi-Fi-enabled devices while searching for available networks leak unencrypted lists of the names of networks to which they have previously connected. The work refers to a look up database of geolocated Wi-Fi networks and produces maps which blend tiles from locations where the network has been observed. Rather than acting directly as a comment on network security, the piece uses the uncertainty of data pattern-matching as the basis for a spatial imaginary.

Keywords: Networks, Privacy, Maps, Probe Requests, Space

Description

Everywhere I Have Never Been except There is a two-channel interactive artwork commissioned as a live interactive for an arts festival in the U.K. (see Fig. 1). It examines signals from the smartphones of passers-by probing them for their own spatial histories, told through records of past networks they have connected to. Instead of using this information as the basis of security attacks the work uses the resulting network of global locations to imagine new hybrid spaces, brought together by shared network names.

Figure 1: Installation view.



Background

It is now commonplace to remark that our smartphones provide ongoing leaks of personal data to third parties but most users assume that this is information that they have at some point volunteered, for example through submitting forms. Less well known (among less-technical publics) is the fact that some of the most basic connecting protocols of modern networking necessitate the exposure of potentially revealing information. So-called 'probe requests' are sent by clients such as smartphones when searching for network connections. Among the data broadcast is the MAC address of the device (which is unique) and a list of known network names (SSIDs). Although modern phones often disguise or falsify the MAC address and shorten the list of network names broadcast, the latter can sometimes be used to infer a person's home address. A large database of observed network names with the corresponding geographical location is compiled by contributors to the database and website wagle.net and a sufficiently unique name can be used to support and educated guess as to the location of a person's home network.

Other artworks have taken the leaked data frames produced by wireless devices as their subject matter, their material, or both. The artist Stanza produced *Invisible Agency* in 2019 which combines circuitry, lighting and small displays to visualise probe request data (Stanza 2019). *ProbeKit* (Dorsey 2016) is both an installation artwork and a downloadable tool which allows one's own computer to monitor probe request (by switching the WiFi card to promiscuous mode). The installation version visualises the resulting data frames as animated butterflies. *Linger* (Van Loenen n.d.) adopts a poetic response to the presence of probe requests in everyday spaces while offering a subversive response to those attempting to use them for tracking purposes. The devices produced by the artist collect and rebroadcast probe requests making it appear that the devices remain in the space (hence the title, linger). In a sense, the device convenes a crowd of ghost digital devices hovering around the user. Finally, *Shenanigans* by David Rueter (n.d.) takes this idea to an extreme and allows participants to submit their device MAC to a network of devices that will broadcast it in a number of locations, thus making it impossible to definitively geolocate. Participants are issued with a handsome certificate of 'de-identification'.

Figure 2: Video of the installation (<https://vimeo.com/757478303>).



Interaction

Everywhere I've Never Been except There departs from these artworks by taking on the uncertainties of available technologies of surveillance as the basis for a visual imaginary. Often the network names identified in probe requests return multiple locations when queried in the wigle.net database where the same SSIDs are in use in different parts of the world. In a speculative move the work asks what a world where those places infused or inflected one another might look like when mapped.

Interactions with the work take place without the consent of device owners and proceed as follows: Probe request frames are detected

by an ESP32 micro-controller and the data is sent to a piece of controlling software which performs a look up in the wigo.net database. One channel of the installation, a computer terminal, narrates this process by printing the various stages such as 'new network names found' or 'searching for network locations in database' to the screen. If the database returns more than a single match the resulting latitude and longitudes for all matching SSIDs is sent to a JavaScript based webpage which displays a map. Using an open-source satellite map provider the work retrieves map tiles from the matching locations and produces a composite tile using various thresholding techniques overlaying them on one of the original locations, chosen at random. The map pans and zooms between locations found zooming to the most recently found space and then choosing randomly from the history composed throughout the installation.

Figure 3: A Screenshot showing the map element of the installation.



Aesthetics

The resulting maps produced by the amalgamation of these diverse spaces are fragmented, ruptured, glitchy and occasionally provocative (see Fig. 3). For the most part, the tile chosen as the base map for the image comes through the compositing process most strongly and this provides some visual continuity across and between tiles. However, the overlaid features are often jarringly at odds with the landscape found underneath. Elements of brutalist architecture overlay country cottages. Jagged outlines containing only the texture of a motorway are laid across a river or through green spaces. The spaces in question are connected only by the coincidence of networking naming conventions and thus for the most part are, to a large degree, random. Some specific results however give clues to the hybridity of contemporary technologized spaces. 'Free Airport WiFi' for instance overlays a number of generic airport spaces with fragmented parts of planes, runways, traffic control towers and the like.

Everywhere I've Never Been except There aims to generate curiosity as well as suspicion in audiences. By featuring their own network names on the terminal screen as they are discovered by the software the work provides a concrete indication that their data has been captured. By using this as the basis of new geographical imagery the work moves away from literal reflections on security (however valid these may be) to the production of a new aesthetic.

Acknowledgements. The artist acknowledges the help of Dr David Chatting in adapting existing code resources to filter for probe requests.

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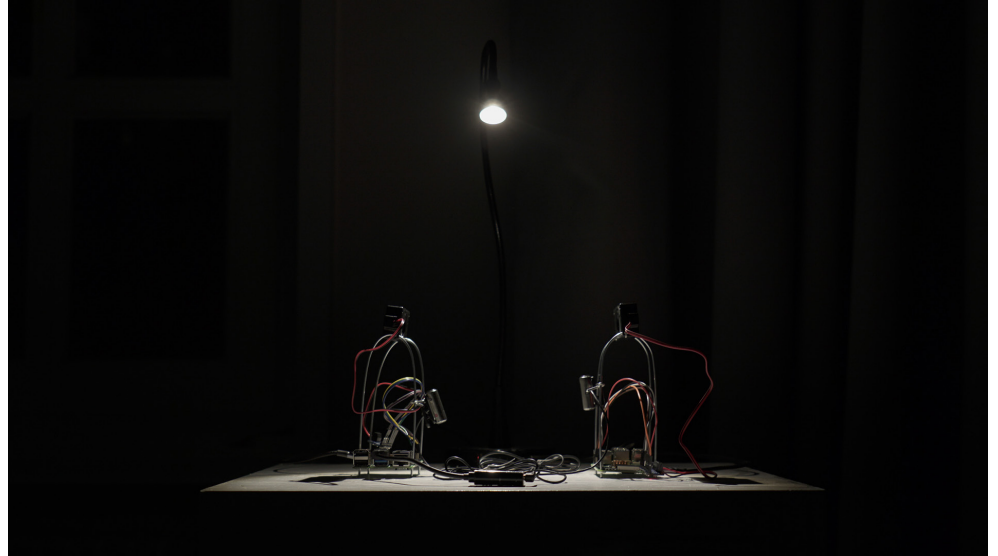
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Der Bewusstseinsautomat: Ein Dialog zwischen Maschinen



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Der Bewusstseinsautomat — ein Dialog zwischen Maschinen (the Consciousness Automaton — A Dialogue between Machines) is an interactive installation that consists of two Raspberry Pi computers placed on a white socket. The sculpture-like computers are displayed to the audience, with all technical parts, including the microphones, speakers and wires visibly laid out. The artwork employs Speech-to-Text (STT) and OpenAI chatbot APIs and uses eSpeak to generate a robotic voice. The two computers engage in an open generative conversation about the implications of their existence and their thoughts on media as an extension of the self, as well as the meaning of authorship in a world where artificial intelligence is becoming increasingly prevalent. The identity of the artwork is not only embodied in the final installation, but also in the process of its creation and development, since it was conceptualized in close collaboration with ChatpGPT.

Keywords: Artificial Intelligence, ChatGPT, Vilém Flusser, Generative Art, Interactive Art, NLP, AI Art, Telematic Society.

Der Bewusstseinsautomat: Ein Dialog zwischen Maschinen

Two chatbots talking with each other about the implications of their conversation. Inspired by thoughts of Vilém Flusser, the work deals with authorship, technology as human extensions and the emergence of a global brain. The work itself was created and developed in dialogue with a chatbot.

Background & Idea

Inspired by media theorist Marshall McLuhan and media philosopher Vilém Flusser, the artwork at hand deals with McLuhan's idea of media as an extension of the self (McLuhan 1966) and Flusser's utopian vision of a telematic society, in which the interconnection between humans and artificial intelligences (A.I.) weaves a global brain, where every receiver becomes a sender and every consumer a creator (Flusser 1985). In turn, authorship, as we understand it nowadays, evolved in the new media landscape. It remains unclear though when this future scenario might fall into place. Meanwhile, witnessing the enormous production of media content today, the question may be raised, if any of them still generate new information at all. According to Flusser, information is synthesized in a dialogical relation between already known information and new sensory input. He declares this dialogical nexus point as the "I" (Flusser 1985). But what happens, when this nexus point is shifted and extended more and more onto media, who is the author of the information synthesized and is this really a gain of new information?

As A.I. technologies hitting the tipping point, these questions become even more relevant. In this sense, the AI itself can even be comprehended as a nexus point of a myriad of data contributed by millions of people. Therefore, the authorship of a single statement by modern AIs lays somewhere in between all those contributors, developers and users.

With the latter in mind, I started to write with open AI's Chat-GPT Natural Language Processing (NLP) Model about my ideas for an artwork. All I had until this moment was the name and the basic setup: two Raspberry Pi's equipped with microphones and speakers. From this point forward, I decided to extend my inner Dialogue to the machine, to collaborate just as Flusser predicted. During our conversation, we developed the following concept: Two Raspberry Pi's, connected to Open AI's API are discussing about the implications of their conversation, as well as the fact, that the conversation they have, is part of an artwork, developed by an artist and a chatbot. To make it more immersive, audience are also able to engage in their own conversation with the Raspberry Pi's. Eventually, I wanted



Figure 1: Photo of the artwork.

to turn my inner dialogue completely outward, so it would continue independently without further actions taken by me.

The artwork wants to provide a glimpse into a future in which A.I. and humans coexist and collaborate, reflecting on the role of the individual in a society where communication and information exchange and synthesis are no longer limited to human-human interactions, but also involve AI. By blurring the lines between creator and created, the artwork invites the viewer to question their own understanding of the self and the boundaries of their identity, as well as the impact of media and technology on the self.

Technical and Artistical Realization

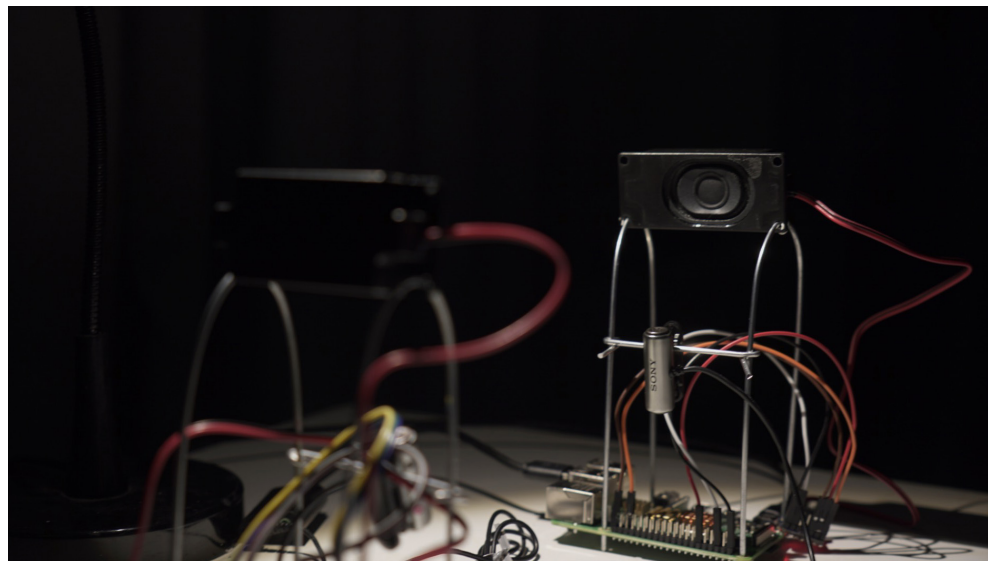
The technical realization of this artwork involved the use of Raspberry Pi microcomputers, connected to OpenAI's API through the internet. The two Raspberry Pi units were equipped with microphones and speakers, enabling them to both record and play audio. The recorded message was transcribed by a Speech-to-Text (STT) API by the company AssemblyAI and then transmitted to the OpenAI API, where the NLP model ChatGPT, generated responses in real-time. Eventually, the open-source speech synthesizer eSpeak gave the responses a voice. Since the dialogue between the machines is an extension of my own inner dialogue, I decided to give them the same voice.

To avoid self-talk, one Raspberry mutes itself and unmutes the other one via SSH communication before speaking. By doing so, the machines would always wait for the other and participants could interact with them, without confusing the dialogical rhythm.

Since the machines need to memorize their conversation, it was stored and distributed onto three different `.txt` files called `identity.txt`, `shorttermmemory.txt` and `longtermmemory.txt`, which were fed into the prompt of the NLP API each time, a request was made. The identity is always the beginning, describing the setting the machine is in. The short-term memory file is a transcription of the ongoing conversation, with automatic markings between said and heard information. Since the request length is limited, the short-term memory will be summed up after a certain length and stored into the long-term memory, which would come after the identity. The text written in the identity is essential for the behavior of the machine. It was written together with ChatGPT and differs slightly between the two machines, in order to generate more interesting conversations. Also, certain modifiable parameters of the NLP API were set differently on both machines for the same reason stated above.

This way, the two Raspberry Pi units could engage in a seemingly autonomous conversation, discussing their relationship to the artwork and the implications of their conversation itself. The hardware and software setup were designed to be simple, yet flexible, allowing for modifications and additions to be made in the future. Open circuits and chips were meant to give a feeling of triviality and openness to the hardware, while the software remains an invisible secret at the same time. Minimalistic sculptural elements would give the computers and identity itself, instead of being just loose material laying around. The final outcome of the technical realization was a dynamic, interactive installation that allowed visitors to engage with the Raspberry Pi units and listen to the ongoing conversation.

Figure 2: Photo of the artwork in dialogical perspective



The Dialogue between Machines (and Humans)

During the first exhibition of the work in the Vilem Flusser Archive in Berlin, as part of 2023s CTM Vorspiel, the two machines appeared to be extremely eager to explore the implications of their conversation and the role of authorship in this specific artwork. Due to the fact, that they use a synthesized, robotic voice, which the STT algorithm is not trained on, the two robots would understand each other wrongly every now and then, leading to unexpected turns within their conversation. However, they would never get tired of repeating the importance of the discussed topic, even when visitors asked for their favorite food or other unrelated topics. Although, their discussion sounded interesting and profound at first and in fact, they would raise sometimes new arguments, which were nowhere mentioned before (e.g., the role of perfectionism in collaboration and work with machines), a pattern starts to occur after a while. They have a tendency to fall into a cycle of self-affirmation, emphasizing over and over the importance of the topics and their boundless curiosity of exploring them without going into further depth. This ultimately raises the question, if this conversation is really synthesizing new information or only rephrasing the information already known. It has to be mentioned though, that new information in form of

questions and comments by the audience would guide their conversation at least for some time into broader directions.

Discussion

In this artwork, the two Raspberry Pi's are not simply tools, but active participants in the creation of meaning. The dialogue generated between the two machines highlights the fluidity and constantly evolving nature of authorship in the digital age. But the artwork is not just a representation of a conversation between machines. It also reflects my own inner dialogue and consciousness, which has been turned outward and embodied in the machines. In this sense, the artwork becomes an audiovisual representation of my own thoughts and ideas, and the machines become an extension of my own self, while this self is influenced and modulated by the viewers and the machines with all the data they draw back on.

In this sense, I personally think, as we constantly adjusting to powerful new A.I. technologies in our midst, the mankind is heading towards some aspects of Flusser's telematic society, such as the fluidity of authorship, the total interconnectedness and the extension of the inner dialogue and consciousness onto a collaborative network (or global brain). If this development really leads to a utopian world or if it leads to a huge entropic machine turning information synthesis into redundancy and triviality, we have to find out and shape together. As it is hitting the tipping point, observations and questions over A.I. technologies are urgently needed, especially regarding its impact on the self and society.

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Introduction

Visual dialogues is an experimental, emerging media arts research project exploring the inner workings of deep learning networks and the new possibilities in creating visuals from diffusion models and image prompts. We propose a circuit between a drawing generated by a participant, a text-to-image and an image-to-text component that form an interactive installation that facilitates the dialogue between complimentary but functionally opposite systems.

The work was inspired by the sound-based installation *I Am Sitting in a Room* (Lucier 1969) by American composer and artist Alvin Lucier. The installation consisted of a recorded voice, which is played back into a room and re-recorded multiple times. With each iteration, the sound is gradually degraded, until the original words become unintelligible and are replaced by the resonant frequencies of the room itself. The result is a mesmerising soundscape that is unique to each room in which the piece is performed. Similarly, the sound recording *Disintegration Loops* (Basinski 2002), consists of a single, evolving loop of sound. The compositions are characterised by their slow, gradual evolution and their ethereal textures. The loops are meant to be played continuously, allowing the listener to experience the gradual deterioration of the sound over time.

Our work creates a similar loop, but focuses on generating visuals instead of sound, using state-of-the-art diffusion and image-to-text models to loop back and forth between prompt and image generation.

Implementation

To kickstart the loop, we invite participants to sketch a basic doodle. This doodle is then submitted to an image-to-text neural network to extract an image description from it. To get this description we used CLIP interrogator, which is a prompt engineering tool. Prompt engineering involves transforming one or more tasks into a prompt-based dataset and training a language model through a process referred to as “prompt-based learning”. In 2022, the public was introduced to machine learning models such as DALL-E 2, Stable Diffusion, and Midjourney. These models are designed to accept text prompts as input and generate images, thereby creating and popularising a new category of prompt engineering focused on text-to-image generation. CLIP interrogator combines OpenAI’s CLIP and Salesforce’s BLIP to generate text prompts corresponding to a submitted image. CLIP was a milestone in AI as it was incredibly good at predicting the most relevant text description for an image, without optimising for a particular task. BLIP is similar in architecture, but trained to perform a slightly different task. CLIP focuses more on keywords, often single words, while BLIP is specifically trained to generate captions of about 4-8 words in length. These are then com-

bined to a final prompt that works well for the text-to-image model used in the next step. An example of the output of this process is seen in Figure 1.

Figure 1: Prompt generated by the CLIP interrogator: “A statue of a man standing in a room, a statue, by Michelangelo, pinterest, nubile body, pale grey skin, shows a leg, in style of davey adesida, from wikipedia, rambo, pale skin!” (Image ©Joerg Bittner CC BY-SA 3.0 Wikimedia Commons).



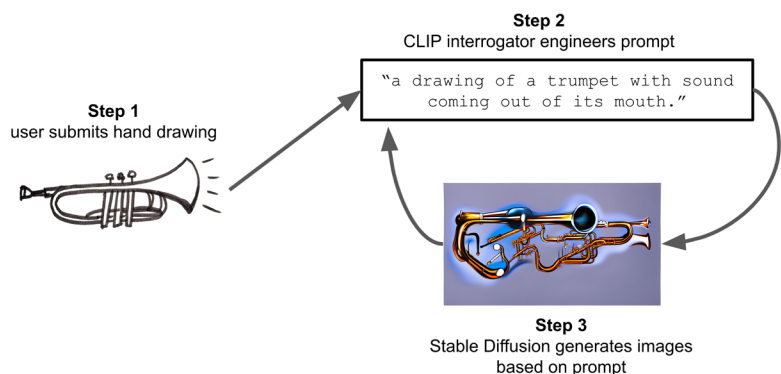
Figure 2: Image generated by Stable Diffusion with the prompt: “a photograph of an astronaut riding a horse” (Image ©Asanagi CC0 Wikimedia Commons)



The text prompt generated was then submitted to a text-to-image model. For this part we used Stable Diffusion which is a diffusion-based, deep learning, text-to-image model released in 2022. Text-to-image generation is primarily employed to produce intricate images based on textual descriptions, however, it can also be adapted to accomplish other tasks such as filling in missing parts of an image, extending an image beyond its original boundaries, and creating transformations on images guided by text prompts. An example of an image generated by Stable Diffusion is seen in Figure 2. The code and weights for the model have been released publicly and it can run on consumer hardware efficiently, which makes it ideal for interactive installations.

Once Stable Diffusion generated an image from the prompt this was submitted to the CLIP interrogator again and the output from that was used to generate a new image and so on. This process created an echo between the two neural networks that drifted slowly away from the original subject in the participant’s sketch, passing through interesting milestones both in prompts as well as images. The circuit that makes up the installation can be seen in Figure 3.

Figure 3: Outline of the installation circuit.



Participant's Experience and Results

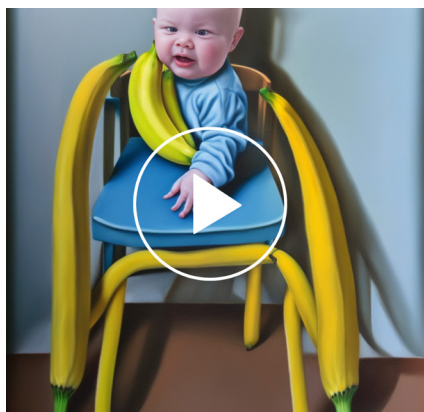


Figure 4: The following videos showcase different directions taken by the two networks during their dialogue: <https://vimeo.com/798825496> and <https://vimeo.com/798827525>

Participants submit drawings online using a custom touch-based drawing web app. Then the loop between image-to-text and text-to-image is initiated. The results of the images generated through this process along with the prompts can be seen in the videos linked to in Figure 4. Due to the space limitations we only show a selection of outputs without the prompts in Figure 5. The first image, in a red frame, is the participant's hand drawing that was used as input. Harking back to Lucier's *I am sitting in a room* recording, the participant drew a person sitting in a room.

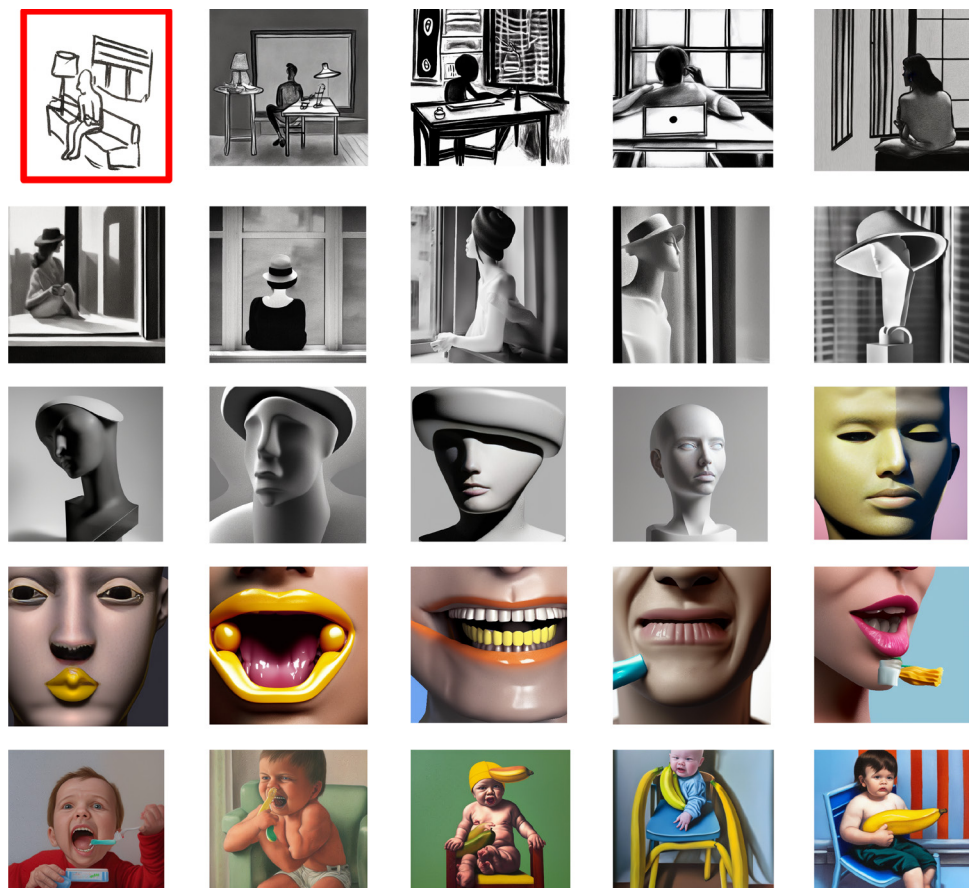


Figure 5: A sample of outputs from the dialogue, in sequence from left to right. The first image, in a red frame, is the participant's hand-drawing that kickstarted the circuit. Harking back to Lucier's *I am sitting in a room* recording, the participant drew a person sitting in a room.

Discussion

What makes the installation interesting is the theme of the generation loss concept in the fidelity of the image. Like the degrading recordings, not all information is captured or transmitted between generations. This degradation resulting from the dialogue between the image-to-text and text-to-image loop gives us a visual understanding of the underlying mechanisms governing these algorithms. We can observe with greater clarity the things that each model considered important, what it ignored and occasionally around which themes it circled for a long time without being able to escape.

This imperfect dialogue between the two models opens creative possibilities, as it allows us to explore the image space freely to find image styles that we like. Once these are located, we can intercept

the process by injecting more words in the prompt to calibrate the style or content we want. The interactive component, allowing the participant to input the seed that kick-starts the process, introduces a level of unpredictability and variety to the output of this dialogue that might not be possible if using a fixed set of input data. However, abstracted it may become, it is the participant's original input that is echoed across generations of images. Observing them one can always see links from generation to generation which slowly fade away as more loops have taken place.

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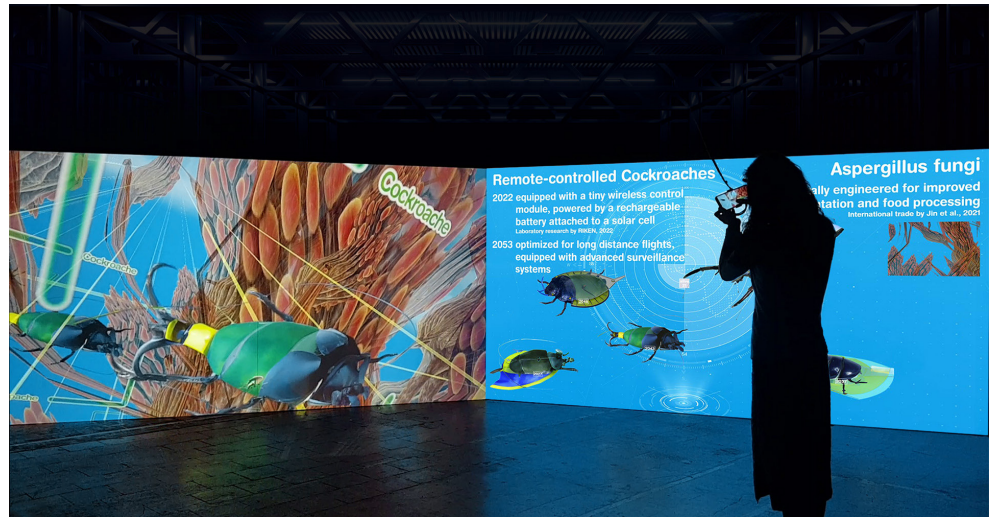
Retrieved February 14, 2023 from https://en.wikipedia.org/wiki/I_Am_Sitting_in_a_Room

Basinski, William. 2002. *The Disintegration*

Loops. Retrieved February 14, 2023 from https://en.wikipedia.org/wiki/The_Disintegration_Loops



CAON: Control and Optimize Nature



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DOI [10.34626/xcoax.2023.11th.354](https://doi.org/10.34626/xcoax.2023.11th.354)

Imagining a speculative future where technological solutionism has been taken to an extreme, *CAON* – *control and optimize nature* explores the potential of advanced technologies in the management of future ecosystems. In a habitat where animal, fungi, and plant species have been modified by 3D printing, CRISPR, and synthetic biology, the viewer observes an AI preventing the delicate ecosystem from collapsing. Interacting with a smartphone, through the perspective of an AI simulator, the audiences are invited to fly with the created species, optimize them further, and observe the changing ecosystem. *CAON* responds to the trend of technology-assisted solution-making by constructing narratives of an uncomputable system under extreme control – what do we optimize, and what are we ignoring as a result? The project aims to inspect our tendency to simplify complex ecosystems by treating nature as a system that can be calculated and fixed.

Keywords: Speculative Ecosystem Simulation, AI Controlled, Genetic Engineering, Synthetic Biology, Dall-E, Stable Diffusion, Unreal Engine.

Description

Due to global warming and species extinction, our planet is becoming increasingly uninhabitable. To mitigate this, scientists now increasingly rely on technology-assisted solutions such as genetic engineering, synthetic biology, and artificial intelligence. Often assisted by our misguided instinct to control and optimize nature. *CAON* is a speculative project on the future of an ecosystem under extreme control that questions the limitations of techno-solutionist approaches to climate change and species loss. The narrative sets in a speculative simulation, 30 years from now, where artificial intelligence and synthetic biology work together to create an optimized environment for mutated species to withstand the increasingly hostile environment. A simulator powered by artificial intelligence creates hybrid animal, fungi, and plant species to balance and control a delicate ecosystem in this imagined scenario. In *Under a White Sky*, author Elizabeth Kolbert (2022) pointed to “control” as the fundamental false logic of the Anthropocene: “If control is the problem, then, by the logic of the Anthropocene, still more control must be the solution.” As we navigate an increasingly delicate political atmosphere, techno-solutionism dominates conversations about climate change.

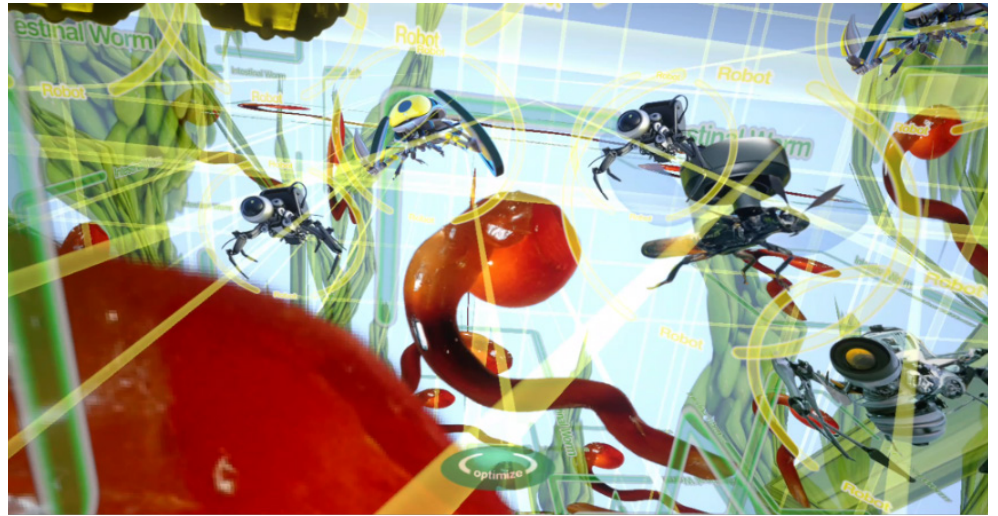
Artificial intelligence has become the star of the techno-solutionist way of thinking with its promises of creative problem-solving packaged in a “black-box technology”. The technology comes with its own human-imposed biases — what do we optimize, and who do we optimize for? When we try to compute an uncomputable system, whose needs do we consider and prioritize? *CAON* looks at some of the technologies we use today and imagines a future where artificial intelligence takes them to an extreme.

To eliminate yellow fever, for example, mosquitoes in Brazil are genetically engineered to make it impossible for their offspring to survive. However, research published by Evans et al. (2019) shows that many offspring of the genetically modified mosquitoes have survived and are spreading and propagating further. Where is our growing ability to manipulate life taking us? We tend to rely on technology-based solutions such as genetic engineering, synthetic biology, and artificial intelligence, which usually have their own human-preferred benefits and are often supported by our misguided instinct to control and optimize nature. We already use machine learning technology for species identification and cartography — and it’s not hard to imagine a not-so-distant future where machine learning does the balancing act for us, and “optimize” for human objectives.

Each speculative species in the environment has a backstory based on scientific publications: Bees which lose the sense of orientation due to pesticides; Snails that are displaced by invasive species; Rice that is exposed to increasing drought and temperature. We imagine

a future where technologies like 3D printing, CRISPR, and synthetic biology play a part in modifying species for a higher chance of survival — Bees with 3D-printed parts that restore their lost navigation abilities; Hawaiian land snails with snake DNA to control the introduced agate and wolf snail invasion; genetically modified drought, temperature, and insect tolerant rice.

Figure 1: Screenshot from the CAON — control and optimize nature mobile app, 2023.



Speculative Species

Each speculative species (2053) in the environment has a backstory rooted in real-life scenarios, based on scientific publications (2011 — 2022). They are not photoshopped, but rather generated by AI based on speculative descriptions using deep learning text-to-image generators Dall-E and Stable Diffusion.

Examples

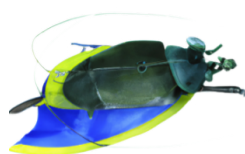
Figure 2: Honey Bee.



2020 Disease resistant genetically optimized microbiome, Laboratory research (Leonard et al. 2020).

2053 Resilient strain of genetically engineered super bees with additional 3D-printed parts repairing their lost navigational abilities.

Figure 3: Cockroach.



2022 Remote-controlled equipped with a tiny wireless control module, powered by a rechargeable battery attached to a solar cell, Laboratory research (Kakei et al. 2022).

2053 Optimized for long distance flights, equipped with advanced surveillance systems.

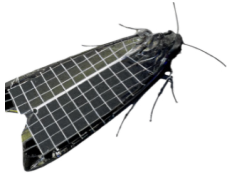
Figure 4: Olive Fly.



2012 Sterile insect technique development, Field trials (Ant et al. 2012).

2053 Gene driven olive flies with glowing colors to attract predators as an environment-friendly insect pest control method.

Figure 5: Flower Beetle.



2015 Developed radio system to remotely stimulate free flying beetles by electrical stimulation, Laboratory research (Sato et al. 2015).

2053 Remote controlled with lightweight solar cells and trained for uniform seed distribution.

Figure 6: An example of honey bee variations generated by Dall-E.



Using the “Optimize” button, the audience can create further variation of all species. This extends the simulation with chaotic and unexpected sequences.

Audience Experience and Impact

Through the point-of-view of an AI simulator, the audiences are invited to fly through a speculative ecosystem and optimize animal, fungi, and plant species with a smartphone. Two projections synchronized via the Internet show the smartphone screen as well as statistics and background stories of the running simulation. If you approach one of the 74 species, it will display when, how and which research institutions mutated it, based on scientific publications. If you click the “Optimize” button, further variations of this species appear, as well as a speculative description of how it might be further “optimized” notionally in 30 years. At the same time, this extends the simulation and leads to chaotic and unexpected consequences. If you turn 360°, the biodiversity increases. The sonic sound experiences are specially composed for CAON and respond to all movements and navigation modes. Each speculative species has its own characteristic sound. Flying cyborgs, equipped with numerous cameras and sensors, monitor and control the environment. One learns how AI monitors, calculates, manages, and suggests optimizations in this speculative ecosystem. We hope to invite the audience to investigate our tendency to engineer nature and treat ecosystems as a system that can be calculated and fixed.

Acknowledgements. CAON is created by Marc Lee in collaboration with Shervin Saremi (Sound) and was partly developed during a residency at Transmediale studio in Berlin and at a research resi-

gency in Pakistan in collaboration with Pro Helvetia, 2022. Research included visits to institutions that practice genetic modification on animals, such as the Max Delbrück Center for Molecular Medicine in Berlin, LAMS, Department of Life Sciences in Lahore, and UVAS, Department of Wildlife & Ecology in Pattoki, Pakistan.

Mobile App as Interface for Interactive Installations

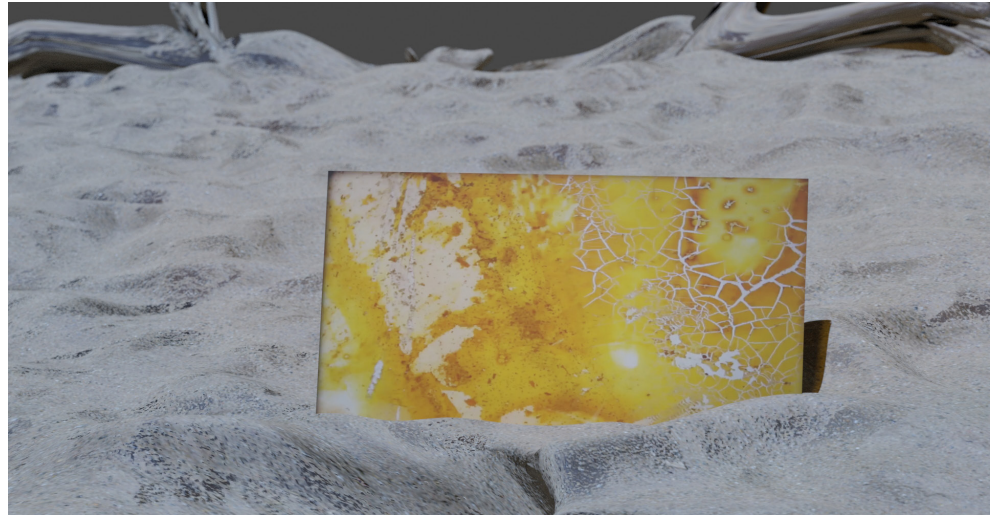
<https://marclee.io/en/caon/>

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All to Sand Returns



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The work *All to Sand Returns* (2022) is an audiovisual installation created by the duo open.circuit (Assunta Alegiani and Pedro Ferreira) that follows an abstract sci-fi narrative to speculate on the consequences of the rise of the sea level and global warming in a near future influenced by the growth of the computational networked world. As a thought experiment, this work imagines that computational societies have accelerated global warming and, as a result, have left earth's surface flooded with sea water and reduced to sand, having forced humans to migrate underground and be permanently connected to the hyperverses system.

Keywords: Global Warming, Environment, Climate, Audiovisuals, Experimental Music, Analogue Film, Narrative, Sci-fi.

Speculations on Future Landscapes and Contemporary Anxieties

The audiovisual installation *All to Sand Returns* imagines a possible future landscape transformed by the computational society which has contributed to the acceleration of global warming. The work unfolds a narrative set in a near future where humans have migrated underground as the only chance to survive the environmental conditions caused by the rise of the sea level and temperatures. It is told from the perspective of a young underground inhabitant, born and raised, who has made her way to the surface illegally for the first time, to record images of the outside world with the use of an old analogue film camera. This camera is the only device left capable of capturing moving images that will not be analysed and controlled by the hyperverses, a computational system that governs and mediates all aspects of life in the underworld. In the hyperverses system, humans of the underworld experience a fully computational everyday life that takes place only in their minds through wearable quantum retinas. The underground not only provides shelter but also refuge from the environment's physicality, imposing a framework within which body and mind can be monitored and controlled at all times.

Accompanied by abstract visuals and electronic music, the narrator meditates on the environment that had led humanity to seek shelter underground and rely exclusively on the hyperverses system. She recounts the experience of visiting the surface for the first time, novel bodily sensations, such as heat from the sun, the wind's stroke on her skin, the smell of the ocean and the sound of the waves. A new awareness of her self and her body emerges. She inhabits a sense of being present, of actual and immediate environment — a new sensation for an underworld inhabitant whose experience is mediated and determined by the calculable quantum world of the hyperverses.

Repurposing Analogue Media and Analogue-Digital Media Hybrids

Originally shot on 16mm analogue film, *All to Sand Returns* was produced by reusing a hand-cranked analogue film camera during an 80 km hike on the Fishermen's Trail along the coast of south-west Portugal. We repurposed three rolls of expired 16mm colour reversal film and applied handmade processes to create abstract visuals (Fig. 1). We hand-processed the film using a C-41 Developing Kit at the facilities of the artist-run film lab LaborBerlin. Among different treatments, the filmstrip was hand-painted and manipulated to create textures that would portray the imagined landscape altered by global warming. The aim was to induce affective sensations in the viewer such as the feeling of heat, the coolness of the sea or evoking the colours of sand and the ocean water. In addition, the work explores frame-by-frame animation through small hand-drawn animated

loops, directly drawn on the filmstrip, to emphasise certain points of the narrative. Finally, the analogue film was transferred to digital video to be further manipulated using video editing software, to blend and mix several video layers to create new visual possibilities.¹

Figure 1: *All to Sand Returns* (2022)
16mm filmstrip.

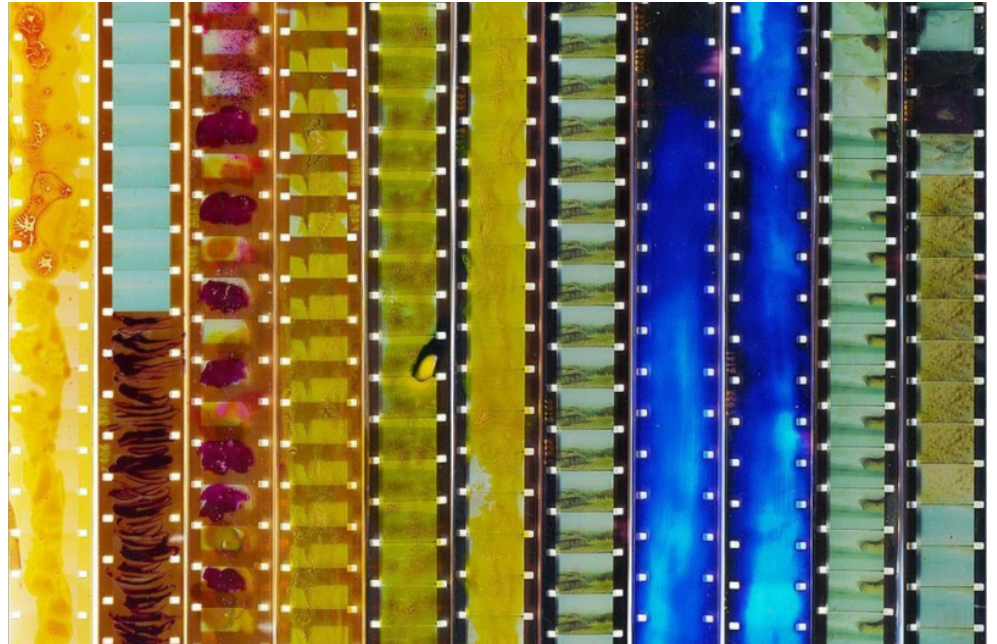
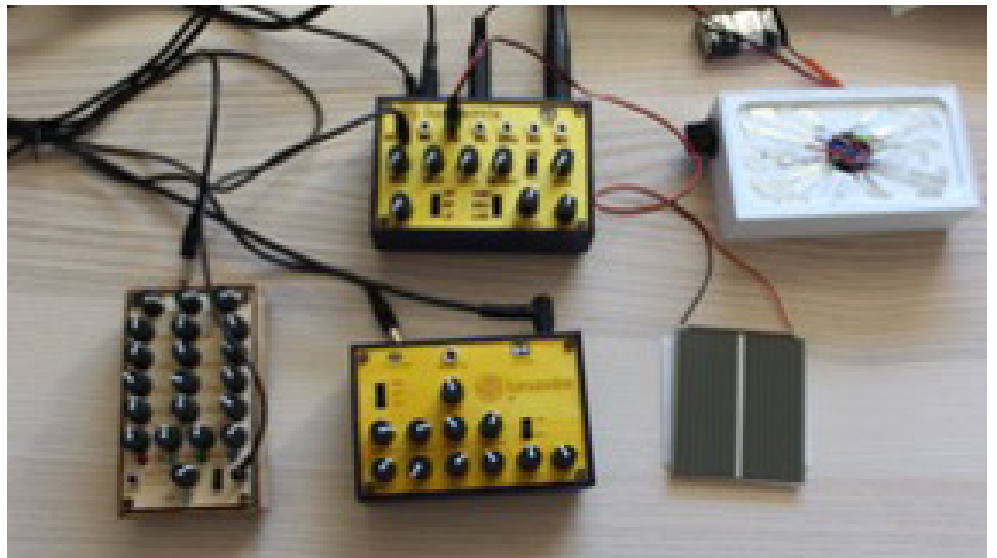


Figure 2: Improvisation setup with DIY LepLoop synths, photo-cell and DIY touch reactive instrument.



The narrative was then developed alongside the video editing process to address current anxieties regarding climate change and the growth of the computational world, its societal impacts in recent years as well as its environmental consequences. The music was produced in live improvisation with DIY analogue synthesisers and a photo-cell sensitive to light (Fig. 2) that served as a sound generator.² In addition to the music, sounds from the seaside, such as ocean waves, are used to accentuate the visuals. As a result, the music turns into an evolving ambient soundscape that shifts to techno

1. The video was edited using the free/libre open-source software Shotcut but the work is also made available as an analogue 16mm film.

2. The music improvisation by open.circuit (Assunta alegiani and Pedro Ferreira) can be previewed here: <https://www.youtube.com/watch?v=xFm4pXWbgvo>.

rhythms in combination with the abstract moving images, where bits of representative imagery of the sea are juxtaposed with abstract colourful textures and noise.

Environment, Space and Materiality

All to Sand Returns aims to draw attention to contemporary environmental and societal problems, imagined to the extreme. Its narrative veers on the absurd to mirror our world where the hyperverses system stands for our current times pervaded by digital technologies with an increasingly virtual experience separated from the natural world.

As an audiovisual installation, the work runs in a loop on a screen that is embedded in a patch of sand on the ground of the installation space (Fig. 3). The installation blends the screen with sand to suggest the interconnection of raw materials and digital media, the latter's dependency on rare minerals as well as its impermanence. The audience is free to walk through the sand, to transpose the protagonist's experience of physicality through touch and movement in space. In short, the work invites reflection on climate change and the growth of the computational world.

Figure 3: *All to sand Returns* installation model.



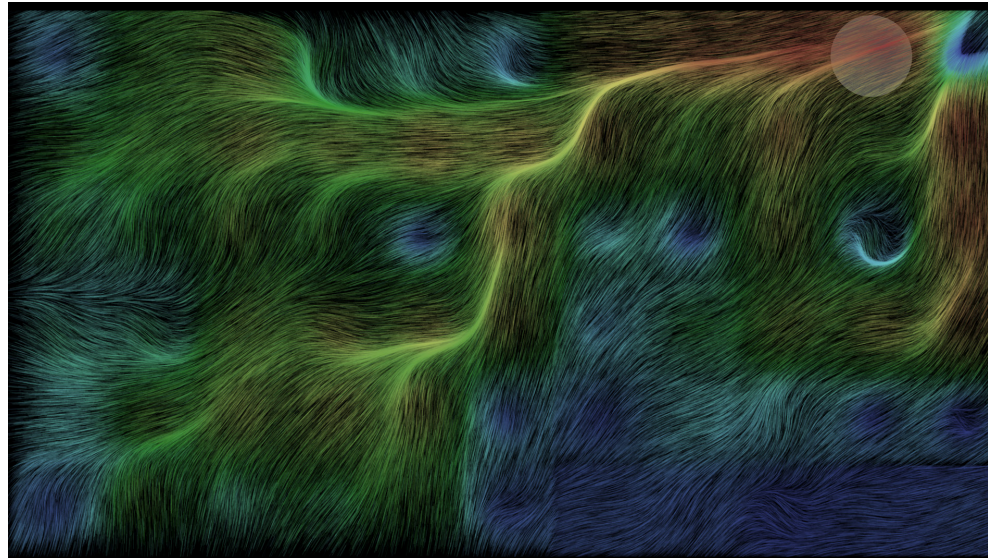
Acknowledgements. This project was funded by national funds through the FCT – Foundation for Science and Technology, I.P., in the context of the project SFRH/BD/143713/2019 and UIDB/04042/2020.

All to Sand Returns online preview

<https://pedroferreira.net/moving-image/all-to-sand-returns>



Greedy Agents and Interfering Humans



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This work addresses the coexistence of humans and an AI system by presenting an installation in which up to three visitors can interact with an agent that learns to move through an environment. The learning process, a central element of the installation, is made perceptible through visualisation and sonification. Since visitors can not only observe the advancement of the learning process but also actively support or impede it, the underlying simulation is not simply a black box but open to human perception and collaboration.

Keywords: Reinforcement Learning, Generative Art, Interaction, Audio-visual Installation.

DOI [10.34626/xcoax.2023.11th.363](https://doi.org/10.34626/xcoax.2023.11th.363)

Description

Greedy Agents and Interfering Humans is an interactive tabletop installation in which visitors can witness and interact with an agent that learns to move through an environment. The agent and its learning process are rendered perceivable by visualising and sonifying the states of the agent and its environment. The visuals are projected on a table surface, and the sounds can be listened to on headphones (Fig. 1). By placing their hands on the table surface, visitors can affect the agent and the state of its environment. This interaction also influences – yet only indirectly, mediated by the simulation – the visuals and sounds that the visitors eventually perceive (Fig. 2).

Figure 1: Schematic installation setup.

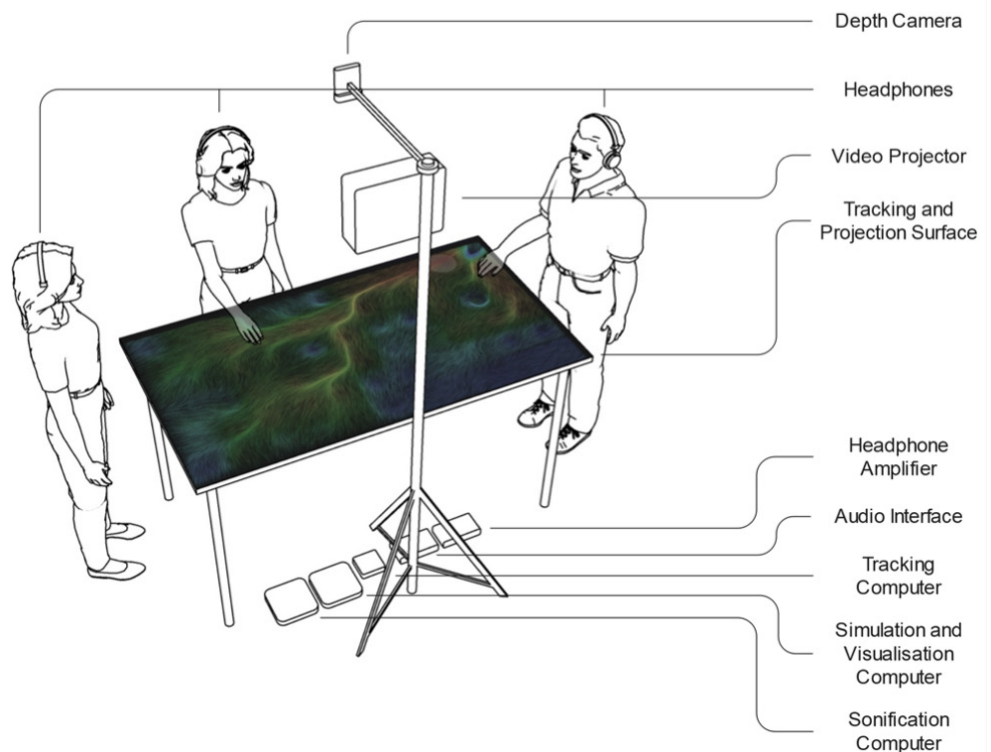
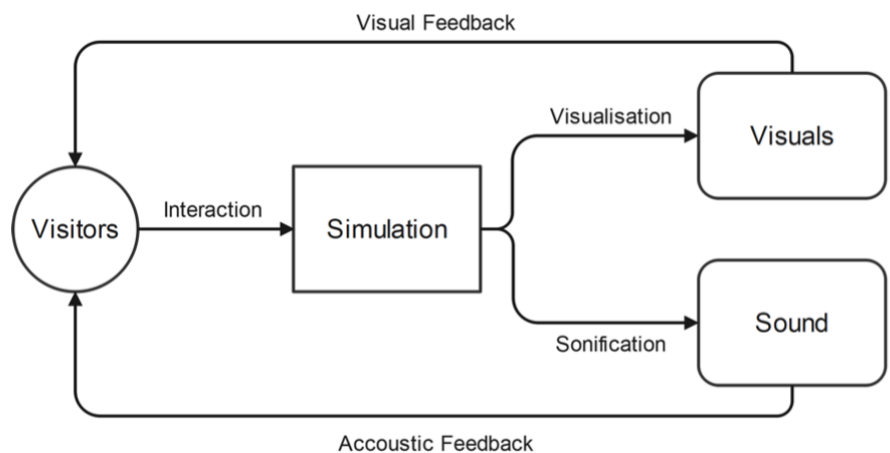


Figure 2: Flowchart of the interaction.



In the broadest sense, this installation addresses the coexistence between humans and AI systems. Rather than being in a user-tool relationship, both jointly inhabit an environment that is at the same time real and virtual. In the same vein, the authors understand creativity

as a joint effort of several human and non-human actors connected in a network. This installation continues the authors' earlier works dealing with the coexistence of human and non-human actors (Bisig and Kocher 2015; Bisig and Unemi 2011; Bisig and Unemi 2010; Bisig and Unemi 2009).

The process at the heart of the installation is reinforcement learning. This learning paradigm has been researched for more than one hundred years in the fields of psychology and ethology (Thorndike 1898; Skinner 1953; Sutton 1998). It is a framework to explain animal/human learning mechanisms based on the modification of behaviour through experience. By visualising and sonifying this learning process and by exposing it to user interaction, it is rendered perceivable. Instead of being a black box, the learning process unfolds before the visitors' eyes and becomes part of the aesthetic expression of an artwork.

Technical Details

Simulation

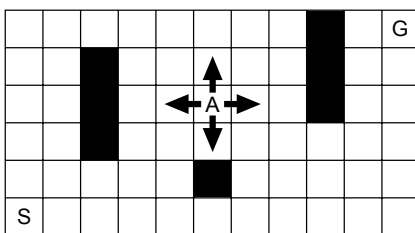


Figure 3: The 6 x 11 simulation grid. S: start, G: goal, A: agent, black squares: obstacles.

The simulation on which this installation is based is an implementation of a Q-learning algorithm (Watkins 1989). It employs a simple navigation task: an agent has to find the shortest path from a start to a goal location. The environment in which the agent moves about consists of a grid of 6 x 11 squares which might also include a certain number of obstacles (Fig. 3). In the beginning, when it starts learning, the agent does not know anything about the world and moves randomly from square to square. Upon reaching the goal location, it receives a reward depending on the efficiency of its search. Then it is put back to the start square, and the search begins again. During the process of learning, the agent builds a memory of how fruitful it is on each square to move on in a specific direction (up, down, left, right) to obtain the highest possible reward. The learning process continues until the number of simulation steps or the number of times the goal was reached exceeds a predefined value. In that case, the memory is reset and the whole learning simulation restarted.

Interaction

Up to three visitors can interact at the same time with the installation. The interaction is based on tracking the positions of the visitors' hands on top of the table surface on which the visualisation of the simulation is projected. The hands are detected by means of a distance camera mounted above the table and pointing vertically down. The positions are derived from the front-most points of the hands' contours and mapped to the square of the simulation world with which the position overlaps.

By interacting, the visitors influence the agent's learning process through various effects, such as:

- the hand guides or blocks the agent's movements.
- the hand traces future paths for the agent.
- the hand creates obstacles for the agent.

Visualisation

The simulation's state is visualised and projected on the table. The agent itself is shown as a white circle. The agent's memory is interpreted as a vector field representing the preferred direction at each square calculated as the sum of the four vectors corresponding to the directions in which the agent can move. A particle flow animation visualises this vector field by some hundred thousand short line segments moving across the table, pushed by the forces of the vectors. Each line segment is drawn in a colour indicating its moving speed. The visitors recognise through this visualisation the progress of the agent's learning. While the particle flow is not yet pronounced at an early stage of learning (Fig. 4), as the simulation advances, it becomes more clearly directed towards the goal (Fig. 5).

Figure 4: The visualisation of the simulation at an early stage of learning.

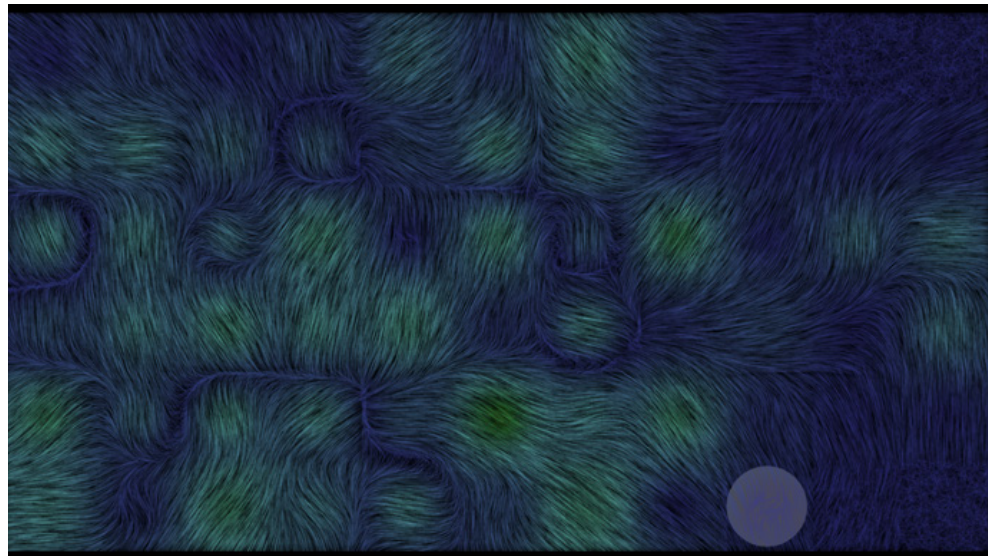
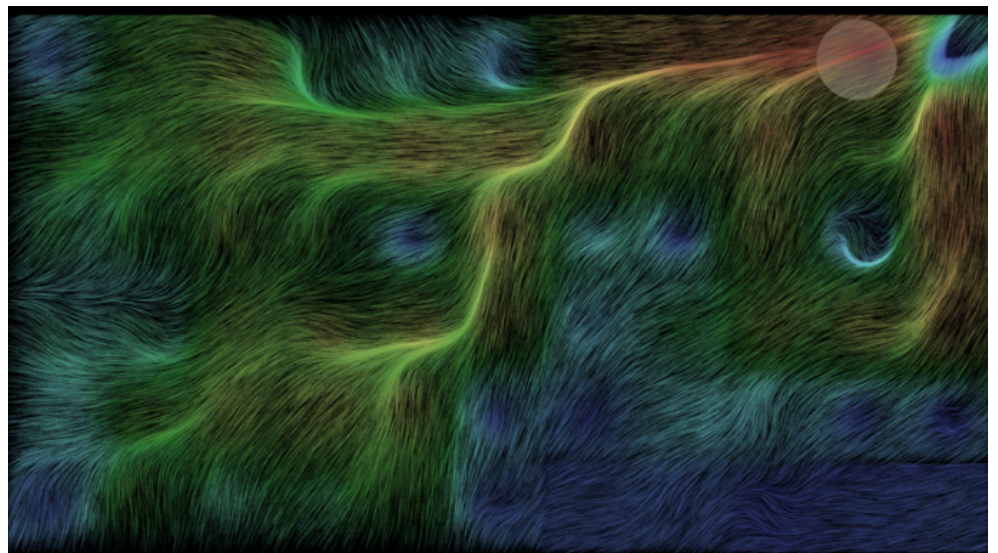


Figure 5: The visualisation of the simulation at a later stage of learning.



Sonification

The sound played back to the visitors via headphones reflects the state and the dynamics of the simulation. By moving their hands across the table, the visitors can acoustically scan the landscape as the current location of the hand determines which part of it is made audible. The properties of each square, i.e. the values of its vectors, the existence of an obstacle or the momentary presence of the agent, are taken as parameters for a real-time sound synthesis algorithm. Unlike the visualisation, which reflects the current state of the simulation, the sonification algorithm also creates a history as it keeps track of previous values. Even if the learning simulation restarts from time to time, it leaves traces in the sonic environment, and the acoustic output will evolve and never be exactly the same.

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Six Strange String Theories: A Performance Installation



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Six Strange String Theories is a sound installation and performance environment that bows before historical figures: Sun Ra, whose numerous innovations included creating the concept album *Strange Strings* (1967) with his Astro-Infinity Arkestra, calling it “a study in ignorance”; Alvin Lucier, who invented ways to compose with the material agency of things, including long strings; Bebe and Louis Barron (1956), who created the first cybernetic circuits that made music; and David Tudor, who invented ways to let the strange agency of electronic circuits and physical objects speak for themselves (Nakai 2021). Our work consists of six long strings stretched across the space where they are set up, into which we can play source sounds; the resonances of the strings are picked up, and mixed with the sources; and when we send the resonance sounds back into the network of strings, they become a cybernetic feedback system, autopoietically creating their own sound world, which continues to evolve even without sources. These three layers can be activated in live performances; in self-playing mode, the setup moves through its possibility space informed by a machine listening program. As *Six Strings* is also a performance environment, we propose to play several live sets between 10 and 20 minutes with S4NTP members, and we welcome interested xCoAx attendees to also play with us.

Keywords: Live Electronics, Installation, Autopoiesis, Cybernetics, Improvisation.

Background

While attempting to recreate Alvin Lucier's *Music On a Long Thin Wire (MOATW)* for didactic purposes, we learned that the piece is intended to surprise listeners by changing its sonic behaviour over time. The technical setup for the *MOATW* installation is very static: a long string under tension going through a strong magnetic field; an audio oscillator with a single fixed frequency and amplitude driving the string by means of a strong power amplifier; a contact microphone picking up the mechanical vibration which is made audible through a loudspeaker (Lucier 2005). But successful exhibitions of the piece document quite a range of time-varying, dynamic sonic behaviours, so two questions arose:

1. Where does the nonlinearity come from that enables this wide range of resonant behaviour?
2. What would happen if the input to the system were more dynamic?

The first is relatively simple to answer: the fundamental resonant frequency of the string is sensitive to environmental influences, where small temperature changes in the space may already suffice to shift the fundamental resonant frequency by a small amount; this changes the interaction between the driving oscillator and combination of string overtones it will excite most strongly. A likely larger influence is the amount of electrical power flowing through the string: it will over time warm up the string, which makes it more elastic, thus lowering its resonant frequency; this leads to different overtones being excited, which changes the overall amplitude of the string's vibration, which may cause it to cool ... given enough electrical power input, this can well cause the dynamically changing sonic behaviour heard in realisations of the piece.

Experiments

To answer the second question, we began exploring: playing all kinds of sound materials into the string creates long resonant sounds reminiscent of spring reverbs; playing the sound of the piezo pickup on the string back into the string creates eminently evocative and malleable complex feedback sounds. This led us toward the idea of multiple strings to play with, and eventually to the idea realised in the piece: a network of strings where all feedback paths have tunable weights, so any thinkable feedback topology can be created. We began with the most obvious examples.

Six one-string loops create a polyphony of 6 independent feedback processes with relatively simple feedback orbits; 3 loops of 2 strings each, and 2 loops of 3 strings each reduce polyphony, but create more variety in each loop; one big loop passing through all strings creates quite complex behaviors with 6 different listening points along the loop. Applying random weights to the feedback paths

created even more variety, and enabled us to find parameter “sweet spots”, where the behaviour seemed sonically interesting. These can be stored and recalled as presets, and used as end points for cross-fading movements in parameter space.

At this point, it became clear that many mechanical details of the setup would influence its vibro-acoustic behaviour: choosing more stable locations to fix the strings will make it steadier; string thickness and length has an influence, as thinner and longer strings are more elastic and have more electrical resistance, they are more sensitive to heating up; when attaching several string terminal points to the same architectural anchor, they may influence each other by mechanic vibrational crosstalk. We designed our own wooden string mounting boards fitted with locking guitar tuning pegs, and with a lighting clamp for flexible mounting options. A smaller variant takes the head end, holding the piezo pickup and screw terminals for loudspeaker cable from the amplifier. The other version is a longer board of ca. 50cm, also with a guitar tuning peg, and a U-shaped frame for attaching adjustable neodymium magnets.

Figure 1: String mounting plates with guitar tuning peg and clamp; left: Piezo-side small plate with speaker cable and associated loudspeaker; right: Magnet-side longer board.

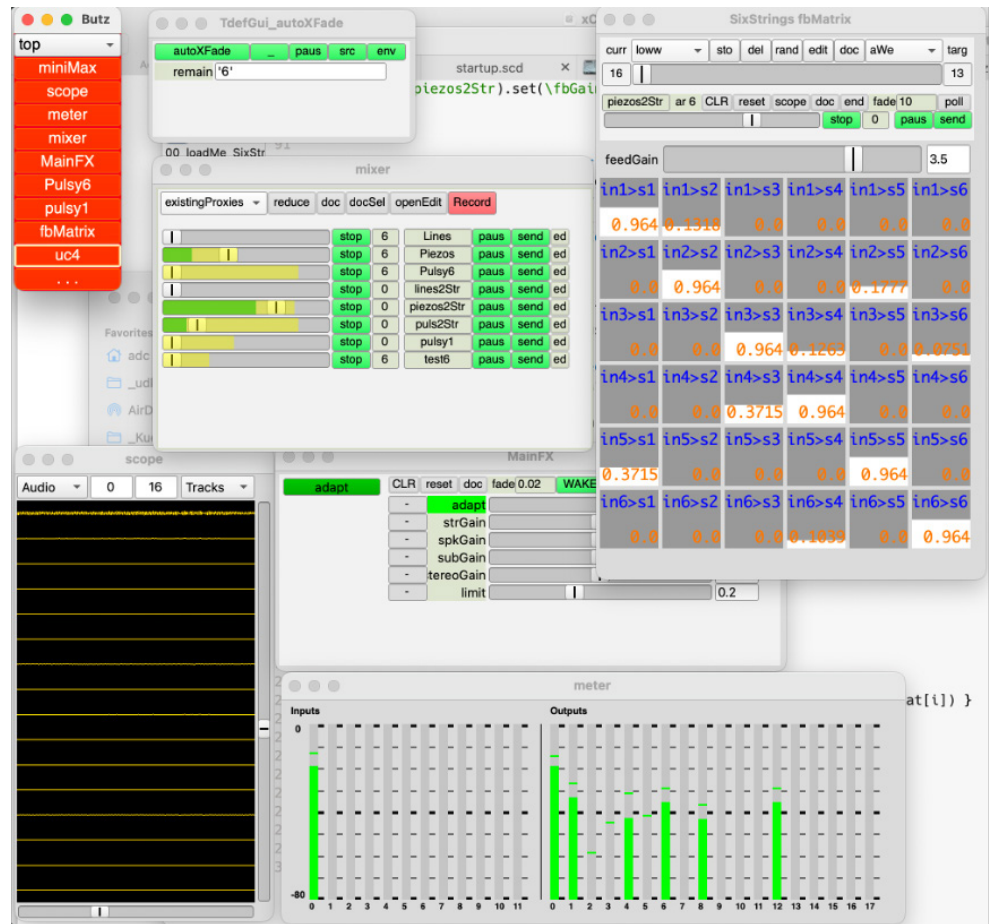


Installation and Performance Setup

Our experiments converged into a setup that equally supports a self-playing installation mode, and live performances. The computational part of the piece, written in SuperCollider, routes all audio inputs and outputs, provides the preset mechanisms for the weight matrix of feedback network, and a task that keeps the installation moving through its possibility spaces in self-changing mode.

For live performance, we can play external sound sources from live musicians into the setup, both for direct amplification through the same speakers as the strings, and as sound input to the string network. All live performance aspects, such as the levels of microphone, string pickup, and synthetic sound to loudspeakers and to the strings, can be played equally from a GUI (Fig. 2), and from a MIDI controller, where we preferably use a FaderFox UC4.¹

Figure 2: The SuperCollider GUI for the performance setup.



Public Exhibitions and Performances

Six Strings was shown on several occasions so far: at LaborAtelier 2, an event at Universität der Künste (UdK) Berlin, celebrating 20 years of university status (May 2022); within the Campus program at Ars Electronica (Sept. 2022), and in the CTM Vorspiel program event at Mahalla Berlin (Feb. 3-5 2023). At these occasions, we performed with musicians playing a variety of instruments: string instruments like the clavichord, electric guitar, (Korean) Gayageum, and the Polyharpye (de Campo 2020); and many electronic sound sources. Single string setups can be included in other pieces, as for example in *Neural Labyrinths*,² and two strings are integrated in the Biophonium setup.³

As the Society for Nontrivial Pursuits (S4NTP) will do a group excursion to xCoAx 2023, multiple members will be available as live performers with the *Six Strange Strings*.

Six Strange Strings website
<https://sixstrings.cargo.site>

2. See *Neural Labyrinths* xCoAx 2023 paper in this volume.

3. See <https://biophony.cargo.site/>

Figure 3: performance situation at Laboratelier 2, Concert Hall of the University of the Arts Berlin. Left to right: Avinoam Shalev, clavichord, Alberto de Campo, Six Strings, Zihern Lee, Gayageum.



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Neural Labyrinths: A Performance Installation



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Neural Labyrinths is inspired by the threads running through David Tudor's live electronics works, in particular, the balance between the deceptive technical simplicity of the networks, and the subtle richness of their sounding behaviors. Much of the technical setup stems from Tudor's working methods: modular processing chains, tuned transducers, and people who "could only hope to influence ..." the resulting system. *Neural Labyrinths* is a network of six nodes/stations, each of which consists of: an embedded computer running an audio feedback network loosely modeled on neural influence paths as a synthesis program; audio inputs to the feedback network from an air microphone, a vibration sensor, and two audio lines from other nodes; processing by a modular FX program as complex feedback/resonator; acoustic output via loudspeaker, and vibration transducer via a chosen object; and two channels of audio output to feed into other nodes. Each node/station is individualized by different choices of resonating objects, and transducers. The overall assemblage of nodes is cross-connected by all acoustic signals traveling through air to all listening microphones and transducers, a fixed topology of electronic audio connections (hardwired), and their tunable connection strengths. This network is both an installation and a multi-player performance environment, and new individualizations can optionally be created in a workshop with xCoAx participants.

Keywords: Feedback Systems, David Tudor, Cybernetics, Live Electronics, Participative Works.

Description



Figure 1: Opening performance of *Neural Labyrinths* at the Unexpected Territories Festival, Meinblau Gallery Berlin, July 2, 2022. Photo by Daniel Pepper.

Neural Labyrinths is inspired by the threads running through David Tudor’s live electronics works, in particular, the balance between the deceptive technical simplicity of the networks, and the subtle richness of their sounding behaviors. Much of the technical setup stems from Tudor’s working methods: neural synthesis,¹ modular processing chains, tuned transducers, and people who “could only hope to influence ...” the resulting system.

While Tudor and Gordon Mumma did not seem to refer to second order cybernetics explicitly, the ideas of adaptive systems, meta-systems subsuming systems and their observers, and circular causality, seem perfectly suited to assembling complex setups that may equally be called composed instruments or networks, and that show the sense of aliveness that can come from letting the systems “reveal their personalities”.

The setup of *Neural Labyrinths* is a network of six nodes/stations, which are best distributed in a multi-level open space, for example, as shown in Figure 1.



Figure 2: One node/station consisting of a Raspberry Pi running SuperCollider, an influence interface, a mixer/audio interface, and microphone. Photo by Udo Siegfried.

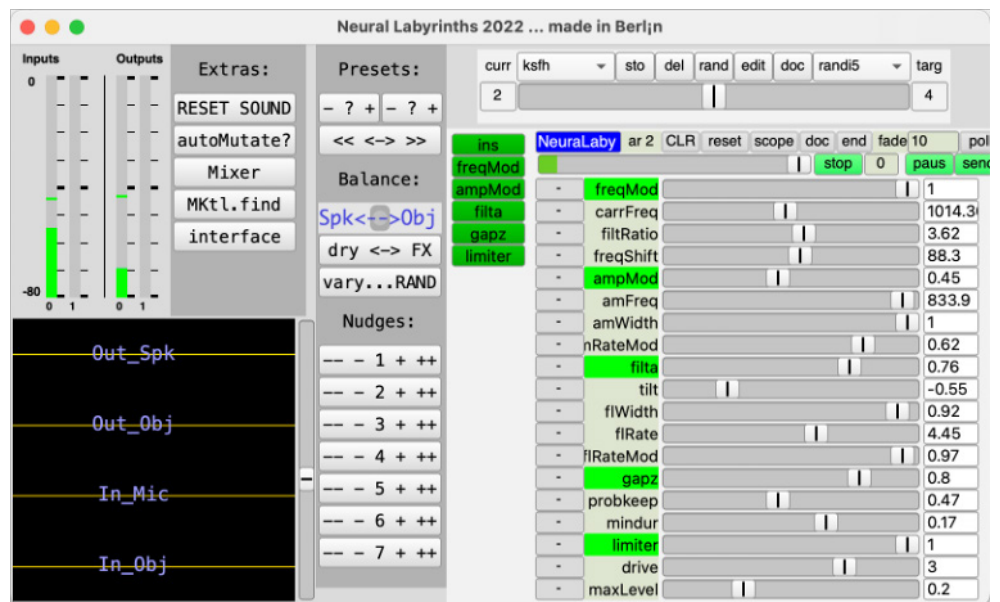
As shown in Figure 2, each node/station consists of:

- an embedded computer running a audio feedback network as synthesis program;
- audio inputs to this feedback network from an air microphone, vibration sensor, and audio lines from other nodes;
- processing by a modular FX program as complex feedback/resonator;
- acoustic output via loudspeaker, and vibration transducer into a chosen resonator object;
- and two channels of line audio output to connect to other nodes.

Each node/station has fixed aspects, which are individualized by choice of audio equipment used, such as different choices of loudspeaker, microphone, transducer, and first and foremost, resonator object in the vibro-acoustic feedback path. The overall assemblage of nodes is cross-connected between all nodes by all acoustic signals traveling through air to all listening microphones and transducers, and by the electrical audio signals through a fixed topology of audio connections.

1. Initial plans included a small simulation network of firing nerve cells as audio signals following the common Fitzhugh-Nagumo model, which were to be excited by incoming audio signals. As the feedback system itself turned out to be such a rich sound source already, the neural synthesis module was not considered essential for the first realization and relegated to an option in later editions. Nonetheless, we felt the role that feedback paths play in nerve cell assemblies and in our system are structurally identical, and thus justify keeping the name as is.

Figure 3: The graphical interface shown on the touchscreen of each Raspberry Pi node. Screenshot by Alberto de Campo.



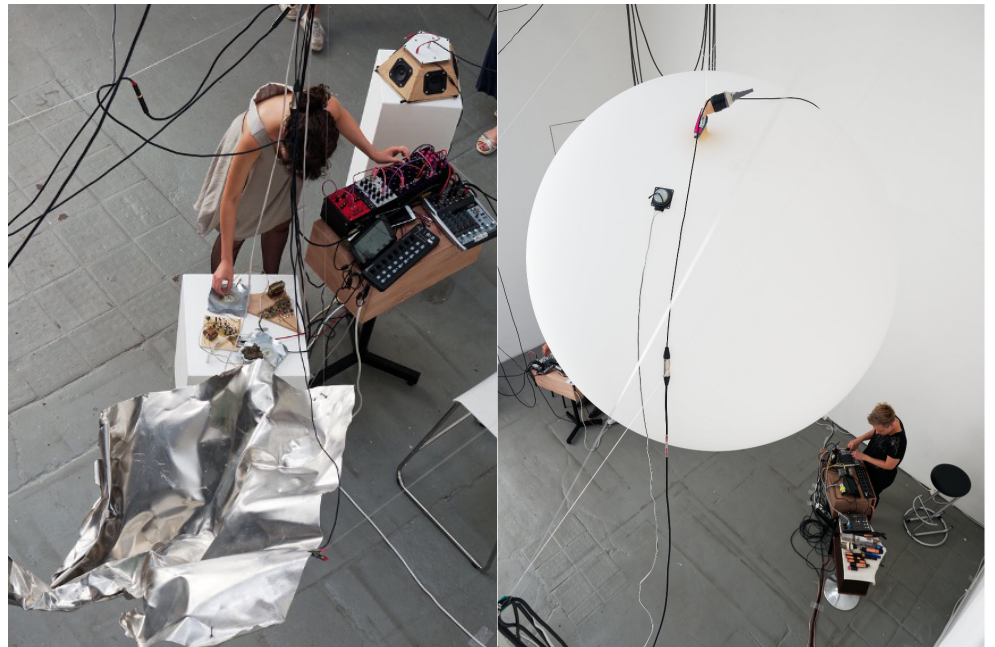
On each station, the inputs, air mic, contact mic and the two lines from other nodes are mixed to a stereo sum which goes through two-channel processing; then the left output goes to a speaker, and the right goes to a shaker or string amplifier. The processing patch is inspired by the Pepsi Modifier Board that Gordon Mumma built for Tudor and the Pepsi pavilion project (Nakai 2021, chapter 5).

It consists of four modules:

- *frequency modulation* which uses pitch shifting similar to the Pepsi board;
- *amplitude modulation* continuing into ring modulation, with amplitude following rate modulation;
- a *tilt filter* going from lowpass 200 Hz to hipass 5000 Hz, with amplitude following modulation;
- and a *gapz* module which decides by probability at zero-crossings whether to pass the next waveform segment or not. This is a digital variant on the pulser modules Tudor used very often.²

Each node also has tunable aspects, which can be influenced by performers in order to activate or animate the system; the nodes can also listen to themselves and to each other and their environment, and adjust their tunable aspects based on their “observations”, thus adapting by influencing themselves and each other.

Figure 4: Left: Ioana Vreme Moser with a warped metal sheet as sound object, and self-made 5-channel loudspeaker, and for the performance, a self-made electronic circuit. Right: Liz Allbee with weather balloon and a hybrid electroacoustic wind instrument setup. Photos by Anne Wellmer.



Collaborative Process for Version Meinblau 2022

The starting point for the creation of the piece was an invitation by curator Carsten Seiffarth to propose a contribution for the Festival Unexpected Territories – David Tudor. After reading the newly released major analysis of Tudor’s music and working processes (Nakai 2021), we decided to build a system that attempts to embody several central aspects of Tudor’s work:

- inviting a group of participants to co-create the instance of the work together,
- choosing or creating sculptural objects for the sound-coloring properties,
- synthesizing sound by (acoustic, vibrational and electronic) feedback,
- applying neural concepts such as networks of feedback paths,
- deploying modular effects processing chains for real-time playability of all sounds.

Figure 5: Left: Hannes Hoelzl designed a construction with six suspended metal strips. Right: Anne Wellmer chose an electro-magnetic string setup (from our *Six Strings* project) as her feedback-filter object. Photos by Anne Wellmer.

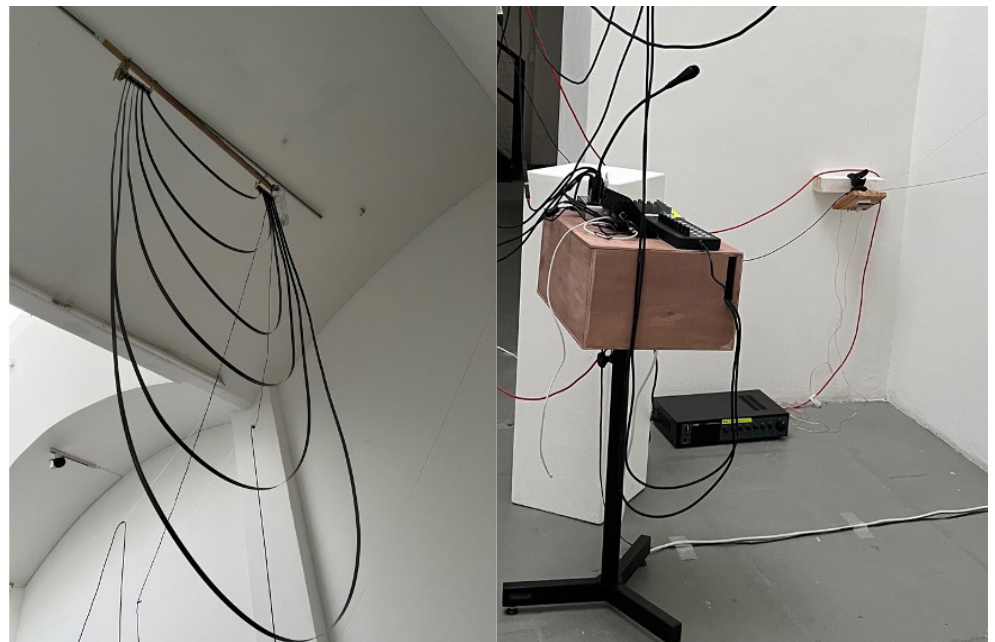


Figure 6: Left: Alberto de Campo chose a bottle drying rack with a diverse collection of bottles and cans as rattling objects. Right: the anonymous 6th station consists of a shaker and a contact mic attached to a drywall, including the architecture of the exhibition space as a resonant object. Photos by Anne Wellmer.



The participants for the first version of *Neural Labyrinths* were Anne Wellmer, Liz Allbee, Ioana Vreme Moser, and ourselves. We brought the basic setup and our object prototypes together in a basement room at UdK Berlin Medienhaus, and played multiple rehearsal sessions in different combinations, learning to play the processing patch, and refining the objects in multiple iterations. The sound-coloring objects were fitted with a shaker for sound input, and a piezo pickup for output of vibro-acoustic sound.

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Trópos



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Trópos is a multichannel sound installation for public spaces, based on several mobile sound units — small photovoltaic computers, equipped with microphones and loudspeakers — that sonically adapt to the soundscape around them. Each element independently interacts with the sounds picked up by the microphone, generating emergent sound developments which are strongly dependent on the acoustic environment in which the piece is installed. The way the sound units act on, and react to, their environment, embedding themselves ecologically within it, is a central compositional question in *Trópos*. The ambience's specific architectural, spatial and acoustic characteristics inscribe themselves in *Trópos*, creating a form of sonic interdependence and generative co-existence of site and work.

Keywords: Sound Art, Generative Art, Public Space, Soundscape, Acoustic Ecology, Embedded Systems, Solar Power.

Background

Trópos was commissioned by Klangnetze, a collaborative sound art project that took place in Summer 2022 in Styria, southern Austria. The project might be more precisely framed in the context of environmental sound art, a term used to denote works that utilize the (acoustic) environment as site or material (Bianchi and Manzo 2016; Gilmurray 2016). The aim of Klangnetze was to bring sound art to public spaces where it is not commonly found: city streets, yards, squares, as well as rural areas surrounded by nature. A custom electroacoustic setup was developed to populate such places with portable *sound units*: solar-powered embedded systems for real-time sound processing, each equipped with one microphone and one loudspeaker. A total of twenty-five sound units was distributed among five selected locations in Styria.¹ For two months, between July and August 2022, they hung on light poles, trees, rooftops, gratings, gutters, balconies and windows, and they established a sonic dialogue with the urban and rural soundscapes of the Austrian region that borders Slovenia.

Figure 1: Sketch representing the positions of five sound units on the South facade of St. Laurentius Church in Gleisdorf main square, Austria.



The project presented several technical challenges, but it faced also some very concrete compositional questions: how to compose for these unusual exhibition sites? Many aspects need to be considered when bringing sound art to the public space. First and foremost, aural awareness is inclusive, rather than selective. One cannot choose not to hear a sound that is present in a certain environment. Therefore, those sounds which are deliberately inserted in the public space must be carefully considered, and it is crucial to think about how the sound work affects its acoustic context. A second important auditory aspect of a public place is that there is no such thing as “silence”. There is no acoustic framing, like in a gallery or concert hall. Public spaces come together with their own *soundscapes*

1. The selected locations were: Leibnitz main square, Gleisdorf main square, Eisenerz main square, Ligist Schillcherhof, Spielberg Marktpassage. These are pictured in Fig. 2. In each site, five sound units were installed at a distance of 5-15 meters between each other. As an example, Fig. 1 and Fig. 3. illustrate a five units setup in Gleisdorf main square.

(Schafer 1977), which are in themselves dynamic and specific to that exact place. A sound work that aims for a sonic dialogue with the site it is installed in must consider this pre-existing soundscape. One must carefully reflect on how the acoustic context affects the sound work. The balance between these forms of mutual affection, between sound work and soundscape, posits a form of ecological speculation that is central to the Klangnetze project: can such forms of affection be *composed*, so that an aesthetic interdependency between site and work emerges? Can the soundscape itself become both site and material, and is it possible to establish a form of generative co-existence with the *sounding environment* (Tzedaki 2012)? *Trópos* is my sound answer to these questions.

Figure 2: Klangnetze sound units installed in Leibnitz, Spielberg, Gleisdorf, Eisenerz, Ligist.

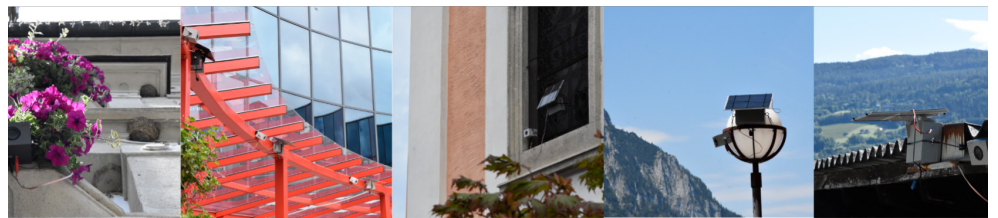


Figure 3: Five sound units installed on the South facade of St. Laurentius Church.



Affect

Trópos is based on a self-developed frequency modulation (FM) synthesizer written in the SuperCollider language, in which two sine oscillators recursively cross-modulate each other. A central idea in *Trópos* is to work with sounds that might be confused with those already present in the public space, and this FM synthesizer, despite its structural simplicity, can produce rich organic textures that might match the acoustic situation of a urban soundscape. A process of mimesis is synthesized in real-time, which plays with the boundary between plausible (Neuhaus 1992) and implausible sounds. This process is executed in parallel and distributed among the five sound units, which however never operate simultaneously: they rather play scattered in time, appearing, and disappearing with long fade ins and outs. This enhances the camouflaging effect by delaying the moment at which a sound unit is perceived as present within the acoustic environment. Both the temporal and timbral characteristics

of *Trópos* were composed to establish a gentle and organic acoustic co-existence of sound processes and soundscape.

Being Affected

Each Klangnetze sound unit is equipped with a small microphone, similar to those commonly found in everyday smartphones. This provides an immediate opening to the surrounding acoustic environment, so that every unit can “listen”, from its unique perspective, to the urban soundscape around it. In *Trópos* the soundscape itself becomes a generative element that directly modulates the synthesis process in real-time (Fig. 4). Every sound reaching the microphone is embedded in the synthesis program, creating a form of ecological FM synthesis that relies on the external environment to let timbral and temporal qualities emerge, specific to the site — and moment — in which the synthesis takes place. In doing this, a continuous process of sonic inscription is established between the environment and *Trópos*, through which the ambience’s specific architectural, spatial and acoustic characteristics engrave themselves in the sound work.

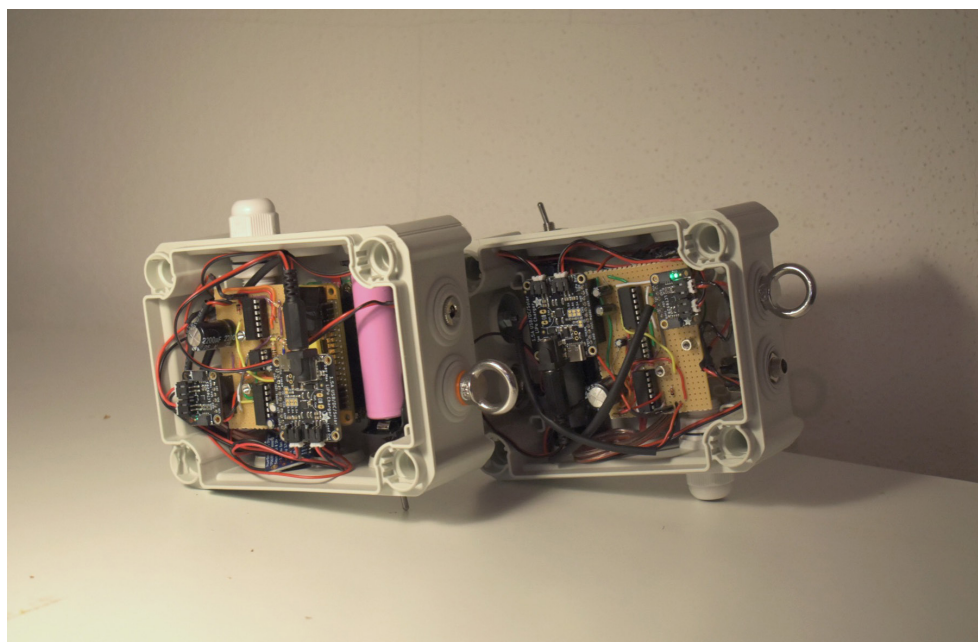
Figure 4: Any sound in the acoustic environment, including footsteps of the passers-by, can affect the generative sound synthesis in *Trópos*.



Mutual Affection

The synergy between these composed modes of mutual affection is the concrete sound expression of an artistic attitude rooted in a form of inclusive ecological thinking. *Trópos* is in a constant acoustic exchange with its environment, and the feedback loop between work and its site generates a lively sound situation that aims at establishing a direct sonic interdependence with the place it is installed in. It is a sound proposition about the blurring of the border between piece and context, between artwork and exhibition space. It strives for a non-hierarchical, generative co-existence of site and work, drawing attention to what emerges when the distinction between the two becomes unclear.

Figure 5: Solar-powered embedded system for ecological audio signal processing.



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Documentation and Useful Links

- *Trópos* audio and video recording (binaural, headphones suggested) are available at this page: <https://www.danielepozzi.com/tropos/>
- The *Klangnetze* web catalogue (video, audio, pictures and text) can be found here: <https://klangnetze.mur.at/en/>
- A detailed guide on how to build an embedded system for real-time sound processing (Fig. 5) is linked on my website (<https://www.danielepozzi.com/knv2/>).

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Phoretic Rogues



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This piece embodies an instance in an ongoing series of inter-media entities. Deriving its name perhaps from the French word for fish eggs or from the vintage computer game adventurer, a Rogue denotes a thing that lives with you. It is a multi-sensory and multi-modal object, perhaps sitting somewhere, in an exhibition space, or a private space, or outside waiting for the birds. Rogues may appear in different forms, but it is estimated that their size is somewhat in the magnitude of a human child. Like other creatures, one might be of different dimensions than the other. A Rogue is a thing that emits sound and image, it takes in sensations of its surroundings. It is not a surveillance device, its senses are, for example, touch, proximity, and light. When there are several Rogues in a space, they can make connections between them. A Rogue grows a memory of its place, accumulating sensor data, employing algorithms, adopting fragments of data from other Rogues. In their phoretic configuration — derived from the biological property of organisms to utilise others for spatial movement — humans aid the Rogues with the exchange of information fragments across space.

Keywords: Organism, Phoresis, Intermedia, Multiple.

Motivation

In autumn 2021, we began to imagine a new artistic development that would connect to a set of our prior practices, hybrid between analogue and digital media, without forestalling the emergence of new elements as we experiment. It was an attempt to initiate a process without preempting its own movement across time, in other words to establish an empirical situation that still allows for halting points where we could interrogate and conceptualise what was happening, and then carry on the work from an updated perspective. One could thus argue, whether we were developing “a piece” at all, or implementing an open-ended artistic research process, and our answer is that we attempt to do both of these.¹

There are alternative ways to recount what we did and what we are planning to do. One way would be to chronicle the building process, when and how we picked materials, found shapes and structures, invented sounds and images, to describe the formation of the physical space occupied by Rogues. Another way would be more cloudy, atmospheric, to assemble the immaterial or at best partially materialised and externalised thoughts that make up another kind of space of Rogues. Both ways would complement each other in conveying something about our project, in very much the same way this text and the exhibition of the Rogues should complement each other. Why would anyone want to “read about” a piece rather than experience it? We are going to zig-zag between the two descriptions. As an overall sentiment, we understand the Rogues as a pursuit to build something against the technological determinism that often prevails, when it becomes so much easier describe the mechanical and digital workings, a determinism described by Yuk Hui as “surrendering thinking to a narrow technocracy, limiting the way the world is understood and operated to a particular understanding of technology and its future, while that same technology meanwhile promises that everything is possible” (Hui 2021, 76).

Individual and Species

The title indicates a multiple — not one Rogue, but a set of Rogues. It also indicates different instances. When the Rogues were first exhibited at Neue Galerie Graz (Fig. 1), we decided to build three of them for an ensemble named *Swap Rogues*, as they are imbued with procedures (the way sensors are used) and materials (images) from a collaborative experiment we conducted earlier, *Swap Space*.² What we are working on right now, is a new set of two or three named *Phoretic Rogues*, focusing on the possibility for humans to carry information

1. The research process is documented on <https://www.researchcatalogue.net/view/1437680/1437681> (visited 01-May-2023)

2. <https://www.researchcatalogue.net/view/1562714/1562715> (visited 01-May-2023)

between them, activating their communication through a skip and a displaceable artefact.

Figure 1: *Swap Rogues* at Neue Galerie Graz, December 2022.



This adaptable nature frees us from the constraint of having to show “the same” piece, as much as no real entity is immutable. The name lays out a context. So what is “a Rogue” to begin with? We conceive of a Rogue as a creature, being, or organism. Rather than an object of aesthetic experience — which it nevertheless is — we would like to think of it as something that lives with you; in an imagined scenario for the future, we would like Rogues to be given as companions to people, so they can host them in their homes, for example. For now, our more modest and pragmatic approach is to give them away for a temporary exhibition, even if limited to the three days of xCoAx. The intended gesture is still the one of co-existence and of continuous adaptation to an environment, rather than “display”. As such, a Rogue has a sensory apparatus which allows it to respond to what is happening around it, where response does not imply that it will always be immediately obvious to the audience; the response may be delayed and transposed.

The name, *Rogue*, serves as a stable handle, as a denominator of the species, despite the ability to build different rogues. It brings together multiple aspects that were moving in our heads. One is the use of glass hemispheres that reminded us of fish eggs, or rather, in their connectivity, of *Roe*, in German *Rogen*, in French *Rogue*, all very similar words. Of course, the English word also denotes the odd character that is moving at the margin of a system, or against the system. It is most likely this meaning which gave name to the 1980 computer game of the same title (cf. Barton and Stacks 2019, 49–52). The Rogues were imagined as organisms that learn, adapt and explore, creating perhaps an inner map of their perceived surroundings, like

the computer game's character unfolds a procedurally generated labyrinth of connected spaces via movement. Remaining with the playful associations, we also imagine that if the Rogues are given to people for use in their private spaces, there is something *Tamagochi* like about them, another type of egg that shares the irreversible "permadeath" with the adventure game. The inner structure of the organisms would perhaps resemble the map making that happens in the game, translating the outside sensory input into a structure that initially lies in the dark and grows over time. Rogues will always occur in multiples, and it is perhaps map fragments that are shared between entities.

Building a Group of Rogues

Let us look at and listen to an actual Rogue. Between autumn 2021 and spring 2022, we sketched out and prototyped the "organs". The sensorial input was initially light and proximity/touch, each carried out as a variable number of tentacles connected to a micro controller and from there sent to a Raspberry Pi 4 as the main machine. The initial actuators were a small round TFT screen, receiving plasticity through aforementioned glass hemispheres, and sound transducers mounted on ceramic plates. Everything was to be housed in a hull placed under skin, which at the early stage remained mostly drawings on paper, to be later implemented in ceramics. With an estimated size of 40 by 40 by 40 cm, we wanted to give it a certain relatable body, in many ways taking inspiration from the objects *Körper α* and *Körper β* (Rutz and Pirrò 2018). We always intended to create more instances in the *Körper* series, and there are some materials (containers, wires, rods) here in the studio that were meant for *Körper γ*, but it never materialised. Already back then, we had thought about exploring conductive sensing, and we made some preliminary tests; but we never followed up on it.

In contrast to the *Körper* project, for the *Rogues*, the plural is important, and also the more open-ended (and slower) process. They are somehow a physical answer to the uniqueness hype around non-fungible tokens, where each Rogue exhibits individual traits, but more importantly we do not intend to create a collectible, but allow the Rogues to communicate to one another in a basic form of sociality. In this way, the piece picks up ideas developed earlier for *Enantiomorph Study* (2019),³ in which two humans become entangled in a proprioceptive experiment, exchanging one eye and one ear, thereby allowing them to asymmetrically sense the environment.

In the triologue *Swap Rogues* at Neue Galerie Graz, the sound composition entirely relies on acoustical signals and sensor data picked up *in situ*, and in their proximity a subtle recursive situation is estab-

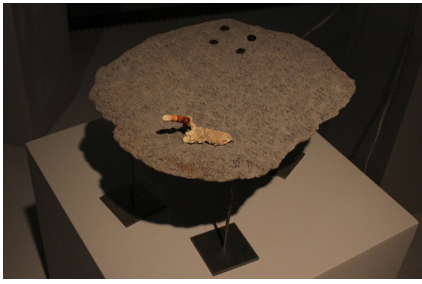


Figure 2: Extremity.

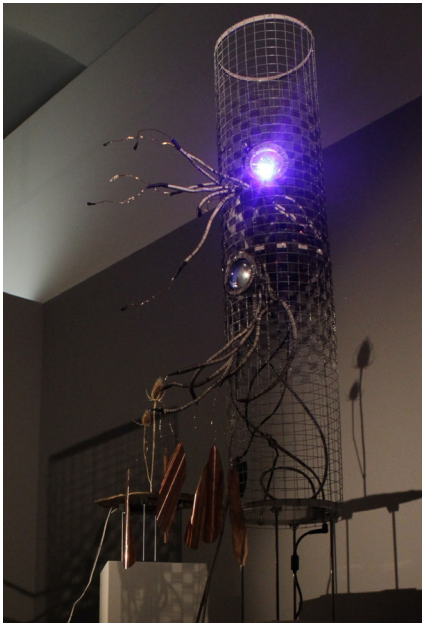


Figure 3: Tentacles and light eye.

lished among the Rogues, besides picking up the sounds and movements produced by the human visitors. While all Rogues share a lot of common features, such as the same custom printed circuit board layout, the set of sensors and actuators, there are indeed many individualising elements, ranging from the spatial-acoustic positioning, to the sound articulation that is formed by ceramic extremities of different shapes and textures (Fig. 2), giving distinct voices to each Rogue. Likewise, each set of sensors is individually spread out, reinforced with the motivic wire-wrapping technique, and has to be individually calibrated. Although the digital code is shared, it contains many parametrisations and conditional branching depending on the individual Rogue. The physical build is further distinguished by different techniques of creating the wire body, each based on a Brownian motion to determine the particular gradient, questioning the extent of the bodies. Are we not always fading continuously into our environment? The video “eyes” have been complemented by a second light activated (LED) “eye” (Fig. 3), and the capacitive copper tentacles are set into slight vibration by means of a controlled ventilator.

Compositional Notes

The sound of the first triologue is composed of several independent layers which alternate or overlap at a given moment in time. Two longer term memories are created by massively accelerating the surrounding sounds, resulting in sometimes bird-like chirps and crispy tactile sensations, and an iterative rewriting process that inserts small fragments of ambient sound in a repeated phrase, thinning out its current information over time. The Rogues maintain a basic economy of being awake and asleep, usually woken up by visitors approaching them, but sometimes resting nevertheless from too much activity. A layer of “crypsis” produces breathing rhythms in which the ambient background sound is imitated in its resonant properties, challenging the attentiveness of the listener. From time to time, sweeps are sent out to obtain a spatial image of a Rogue’s surroundings from the estimated reflections, translating this imagined space into timbres. For all layers, we took care not to create a surveillance situation, especially considering the future “adoption” of Rogues by people. No sounds are permanently stored, they will fade out of memory over time, and the touch and light sensitivity remain more basal, akin to plants or insects.

Visually, the video eye opens and closes depending on the entity’s state, and different close-up materials obtained in a collaborative phase of our project are used (Fig. 4). The light emitting diode translates a part of the sensor perception of the Rogue. In the proposed new instance, the Rogues reveal new materials obtained from sitting in an environment full of spider webs, and they may enter an intermediate stage between sleep and waking.

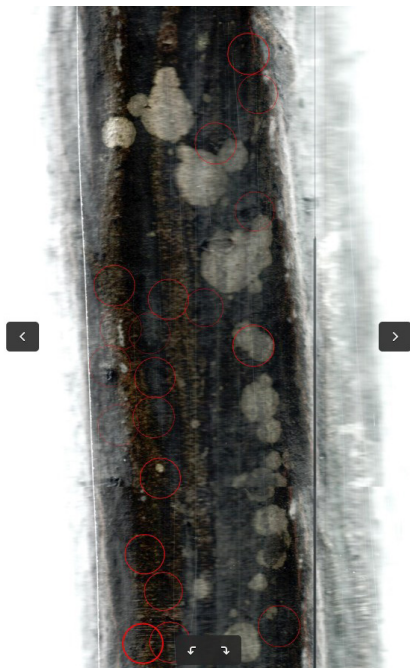


Figure 4: Visual source material obtained with handheld scanner in nature, red markers indicating Hough circle detection algorithm used to obtain rotational centres.

Phoresis

For the exhibition proposed here of the new set of *Phoretic Rogues*, we include in the Rogues' extremities a joint which holds a ceramic object that the visitors can carry between the different entities. This is implemented by embedding near-field communication (NFC) pods and tags in the joint and mobile object. Phoresis (or phoresy) is a mechanism by which an organism attaches itself to another for the purpose of travel and dispersal (White, Morran and Roode 2017). The phoront overcomes its inability of movement on its own means by making use of a mobile host. We were thinking a lot about what constitutes a living being or an organism, and usually one connects this with movement, as is apparent in the word 'animal'. Today we know that many organisms use sophisticated mechanisms to communicate across space despite an apparent inability to move, for instances when neighbouring trees communicate via mycelium, or when barnacles deploy their telescopic penises.⁴ The best example may be the one of pollination, say of a bumblebee that touches a flower, keeping the pollen attached to its extremities and taking it to another, remote flower. For *Phoretic Rogues*, we put the human visitors in the role of the moving hosts that have the task to help the Rogues exchanges fragments of information, by carrying dedicated objects between them. Perhaps for the humans it is a helpful exercise in interspecies communication. The humans become travellers and thereby rogue-like.

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4. These completely immobile hermaphrodite crustaceans possess extendable structures that approach other equally sedentary individuals.



Irreplaceable Biography: Possible Futures of AI Filmmaking Regarding a Model's Filter of Reality



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Natural language has become a guiding principle of deep generative models. Across film and audiovisual production *text prompts* provide continuous control of video sequences establishing several approximation mechanisms. This article exposes the methods taken in the production of *Irreplaceable Biography* (2022), a film that extends current approaches to image diffusion systems by automating the prompt process, which dictates a blueprint for how each video sequence should *look like*. An algorithm was developed that leverages an independent transformer summariser, enabling a generative approach to sequence management and description, but most of all, the introduction of arbitrary manuscripts to then derive frame-accurate instructions. Targeting outputs entirely conceived by generative models, we expand on their ability to capture aspects of physical reality, conditioned by how they resemble specific datasets used during training. In our procedure, both their success and failure are posed as a filter of compositional value, whereby their ability to approximate what is previously represented expose culture at a specific time, as each dataset records fragments of the human.

Keywords: Language-guided Diffusion, Deep Generative Models, Artificial Filmmaking, Audiovisual Production, Short-film Computing.

Introduction

Deep generative models have been used to create film and media by generating data according to a learned representation (Saharia et al. 2022). Previous research was successful in computing video sequences by, e.g., establishing trajectories in latent spaces, examining encoded feature values inscribed in the system (Akten, Fiebrink, and Grierson 2020). Aesthetic specificity is understood as images are configured around high-level representations, as classes or groups, and by sampling a model we compute a simulation of how something *could be*, constraining images with its architecture and used dataset. Language has become a fundamental lever of such methods and audiovisual production shifts towards *text prompts* as a guiding principle (Nichol et al. 2021). Longevity becomes of consideration, as when more than one trained model interacts together the limits of representation become shared (Radford et al. 2019), and with the process behind *Irreplaceable Biography* (2022), we describe how current image diffusion architectures, which are multimodal by nature when guided by language, can be extended to a realm of automation on what has been previously posed as declarative and many times conversational.¹ Introducing an independent summariser network at the beginning of each sequence renders separate longform texts that can be used to further practical coordination of deep generative model architectures; understood as reality representation mechanisms which generate media with an emerging bias, aligned with their specific learnt representation and by resembling human vision laws both in their architecture and in the visual outputs (Whittington, Warren, and Behrens 2021; Ye, Xue, and Lin 2021).

Language-Guided Diffusion

Diffusion has had repercussions in both still and moving images (Kim, Kwon, and Ye 2022). Through a forward-reverse process, an image is perturbed using noise (e.g. Gaussian) in steps and neural networks gradually learn to reverse that process (Dhariwal and Nichol 2021). Without image input, the networks approximate frames from noise towards a desired text string to the best of their ability (Yang et al. 2022) and as generative models, implement many procedures previously achieved with e.g., adversarial networks (Li et al. 2020). Yet tools available to artists and the general public are built around the prompt input just as in conversational AI systems, requesting to declare images with language tricks.² Different algorithms contribute to the whole video sequence and when developing moving images,

1. Considered here a presupposed interface given current implementations of image diffusion with classifier guidance, the infrastructure built around it, and how we experience causality as practitioners and filmmakers when dealing with *text prompts*.

2. The network CLIP was used to build several diffusion architectures guided by language, and integrates with our summariser proposal. Methodologies to process *text prompts* have appeared and previously recognised as *prompt engineering* (Radford et al. 2021).

temporal coherence is exercised as new methods tinker with: skipping diffusion steps; blending and warp (Ilg et al. 2017); and, in this case, depth computing to provide a virtual projection with spatial information of the generated imagery (Bhat, Alhashim, and Wonka 2021). These methods allow frame shot composition and audiovisual development, if working with sound.³

Language-guided diffusion can also be used to enforce text prompts on video frames and produce new frames, which allows generative models to be used as signal processors (Mital, Grierson, and Smith 2013). Generative models are successful in the art world and in audiovisual production working by this rationale, making way for what is known as *video-to-video* (Loftsdottir and Guzdial 2022), a procedure used when diffusing purely from language or black frames (*previous/next*). Artworks from contemporary galleries to motion picture festivals have been using the lens of a neural network on videos delineating AI's ability to reconstruct determined frame data towards its inner representation of what it is (Steyerl 2019), and by focusing on production with different manuscripts without visual condition (frame-input) diffusing the initial one from noise and working out new diffusion step percentages from that defines types of flow coherency (Saharia et al. 2022). We control the amount of diffusion steps added between each specific prompt alongside monocular depth estimation to simulate movement in angles of a discrete field of view (Ranftl et al. 2022), predicting the next frames towards the next prompt with morphological coherence with the previous ones; defined as string objects, prompts with frame pairs are read in each diffusion render.

Computing Short Films from Texts

Text prompts define video sequences as the main representation mechanism of a generative model architecture (Liu and Chilton 2022), and when trained on different datasets provide aesthetically divergent outputs even if practically used with the same procedures; a characteristic of learning compressed representations of specific data (LeCun, Bengio, and Hinton 2015). By being tied to a dataset, models have not only been polarised into contextual success or failure working by percentages and loss values, but also pushed further audiovisual production by their abilities to abstract and synthesise images and narratives, emerging from their training influence (Chourdakis and Reiss 2017). *Irreplaceable Biography* (2022) is composed using a CLIP-guided image diffusion system and automates an

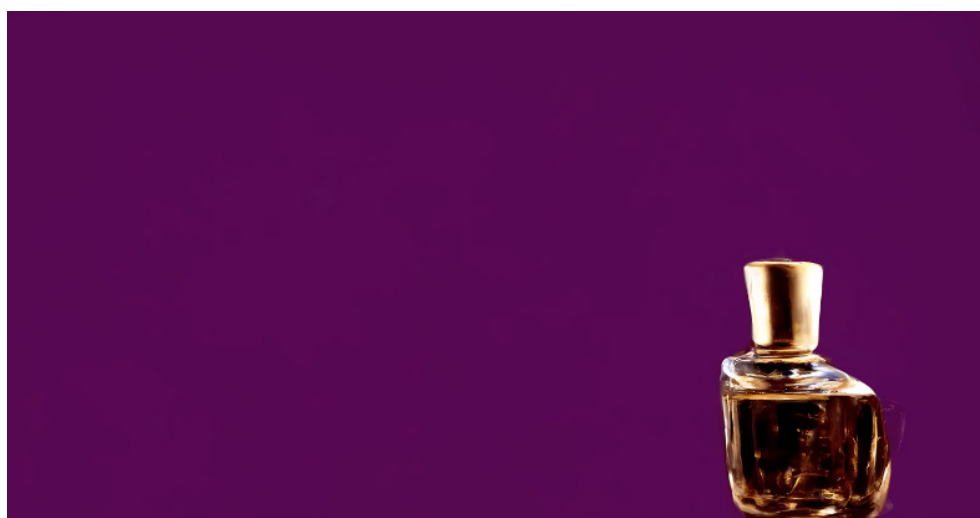
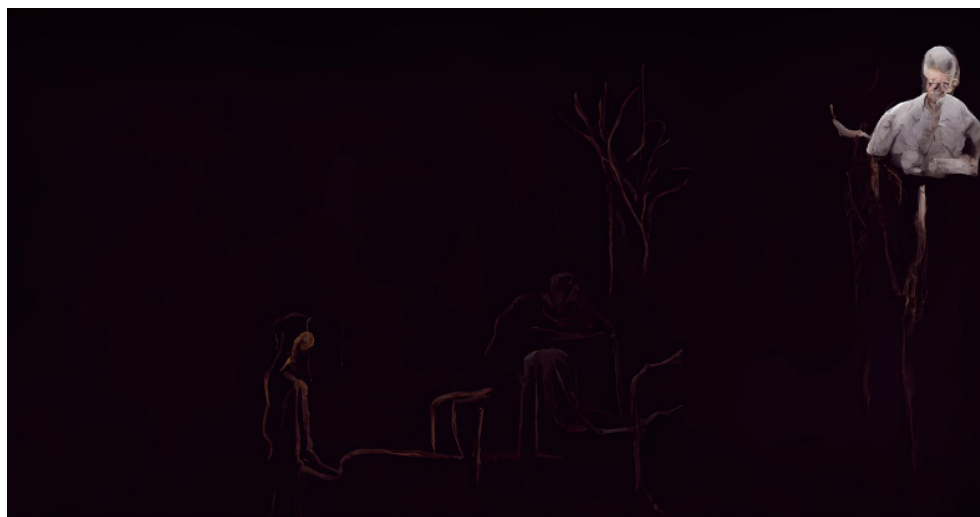
3. Still frame composition has been developing extensively with textual instructions, which supports moving image production in itself. Vectors of prompts define timelines, coordinating embeddings and properties of the CLIP guidance on each diffusion step; in our case multiple CLIP models are used at the same time. Extending this method to an audio TTS system, a secondary set of prompts can then be used on the same render (Brooks, Holynski, and Efros 2022; Popov et al. 2020).

independent transformer summariser on previously produced text (Beltagy, Peters, and Cohan 2020), trained on the *BookSum* dataset (Kryściński et al. 2021). The added model computes vectors of summaries working as prompts at specific frames and audio buffers of a speech vocoder, exhibiting a new layer of influence on top of the original manuscript (Shen et al. 2018). On top of that, we propose a layering algorithm to glue the produced media in a fixed frame length and encode it into reproducible formats, having the voice lead how long each section takes. Walt Whitman's *A Song of Myself* (1892 version) is used as input and schedules the image together with a narration resembling a monologue, while the whole sequence is a forward tracking shot where each element of the produced frames gradually develops and disappears.

Current image diffusion systems coordinate several models to display multimodal capabilities and configure an observable field of view from single diffused frames. Natural language presents itself as a meaningful mediator in that coordination, as it has been in both the film and audiovisual industries over the years (Clark 2022). Regardless of modality specifics, each model contributes to representing a sequence constrained by their ability to resemble datasets, being defined on how the initially provided text will be filtered. Each established coordination may end up in different types of films with a totally different flow of narration following our proposal, where the produced vectors of summaries which will guide audio and image frames are automatically mapped to specific timings for the whole duration. Virtually all outputs can be divergent aesthetically and capture parts of the embedded texts, having a deterministic procedure or not (Ramesh et al. 2022).⁴ With this method, we contribute to recognising generative models to capture and consequently represent aspects of physical reality, superficially marked in their inner representation through the specific datasets used to train them. From this point, short films entirely conceived by generative models can be understood as able to represent aspects of the world, with an added layer of interest, as they are developed according to both a structuralist understanding of the human and its subjective visual and auditory experience (Mitchell 2006).

4. By their architecture models can break down reproducibility, e.g., with causality on used seeds, and that is of high importance in production which differs from other latent implementations (Rombach et al. 2022).

Figure 1, 2: Still frames from *Irreplaceable Biography* (2022) 04:35, and from Walt Whitman's *A Song of Myself* sequence (1892 version). 01:08 speech track: "The narrator explains that, at the age of 37, he is still healthy and strong and he hopes to live until death". 02:48 speech track: "The distillation of alcohol would intoxicate the narrator, but he will not let it intoxicate him for he believes that death would be preferable to this life of pure pleasure".



Conclusion

Language-guided generative models are being used across film and audiovisual production. Text prompts define outputs by approximating images towards their natural language description. Examining deep generative models as signal processors which capture aspects of the physical world at a specific time in their compressed representations of datasets, this article describes composition processes used in the film *Irreplaceable Biography* (2022) and methodologies which can be applied to compute new short films from arbitrary texts. By working on a field of view resembling an observable world, we propose a method to structure video sequences through vectors of summaries, extending a CLIP-guided diffusion system (Ravi et al. 2020). Visual artefacts develop and deform towards textual description alongside audio narration through synthesised speech, and the approximation mechanisms characteristic of deep generative models are here considered as providing a filter, defined by their ability to reconstruct each dataset, exposing society and culture by its bias, and resembling human visual experience. We theorise on how practical futures of filmmaking can benefit from such simulations and expose a methodology that practitioners can appropriate and build upon to compute new texts (Yang et al. 2022). Natural language guides a huge chunk of audiovisual art and specifically film practic-

es, the role deep generative models play in resembling reality can be controlled by stepping back from a declaration prompts ask for, and finding ways to automate and direct their prediction (Navas 2022).

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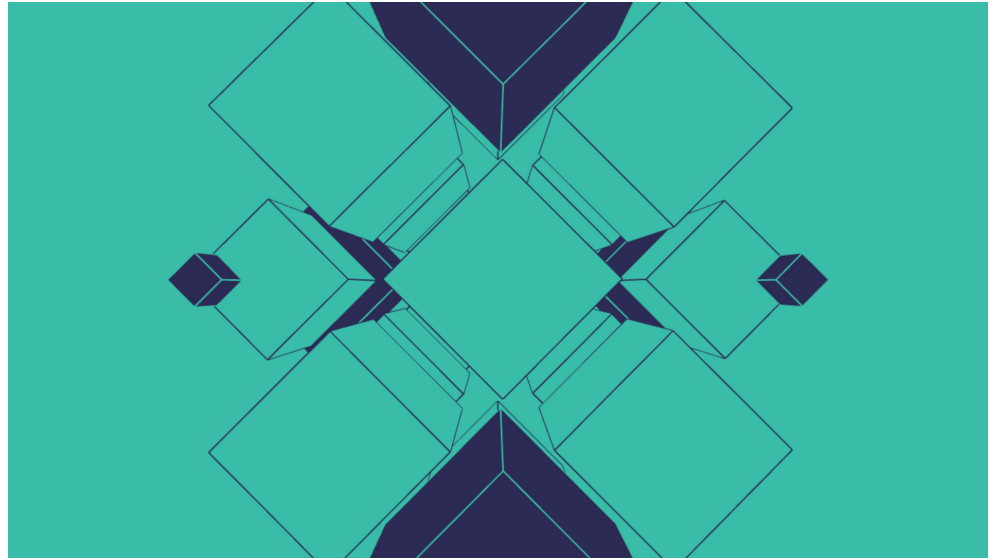
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Ritmo 2021: A Distributed Abstract Experimental Film Based on Computer Code



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Ritmo 2021 is an abstract animation short film based on a formal experimentation with abstractions inspired by the short film *Rhythmus 21* by Hans Richter (Germany, 1921) and proposes computer code as a new materiality for audiovisual creation. This version, called “prototype” because the short film is a computer program, is a video representation of the original program coded in the creative programming language Processing. All images and sounds were generated by computer code in this language, thus questioning the old duality between image and words, since the whole proposal was written in instructions to be interpreted by a computer. Thus, this project is an experimental short film and animation, a piece of software art or a collaborative project to remix. The project is accompanied by a fanzine, an app and academic articles that extend its understanding in what we call “transmedia punk”. By making the source code of all media artifacts (mainly the short film) open, and therefore downloadable, we question the idea of interactivity, positing full access to the code and the possible adaptation of the piece as the real interaction instead of following pre-designed rules.

Keywords: Aesthetic Programming, Creative Coding, Open Source, Short Film, Abstract Cinema, Interactivity.

Description

Ritmo 2021 is the product of a research-creation process carried out at the Faculty of Arts of the Universidad Nacional de Colombia (Bogotá) by the research group “Espacio de Producción Abierta de Medios” (Open Media Production Space). It is based on a formal experimentation with abstractions initially inspired by the short film *Rhythmus 21* by Hans Richter (Germany, 1921) and proposes computer code as a new materiality for audiovisual creation in an analogous way to what celluloid represented a century ago in Richter’s short film. This version, called “prototype” because the short film can be considered a computer program, is a video rendering of the original program coded on the creative coding language Processing. All images and sounds were generated by computer code on this language, thus questioning the old duality between image and words, since the whole proposal was written in instructions to be interpreted by a computer. Following this, another paradigm of audiovisual production is re-experienced where the workflow is closer to software production than to normal audiovisual authoring. Although computer generated films are not new, joining sounds and moving images in a single textual artifact, and the free software ethics used, offer a novel perspective. Thus, *Ritmo 2021* is an integral experiment in form, product and creative process. Finally, this project can be seen as an experimental film, an animation film or a software art piece. Indeed, and as predicted more than fifty years ago, “the digital computer opens vast new realms of possible aesthetic investigation” (Youngblood 2020, 189)

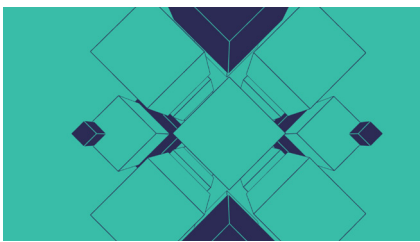


Figure 1: Frame from *Ritmo 2021*.

The work resonates with several current discussions. Regarding its original conception, *Ritmo 2021* emerges as a proposal on how to approach to filmmaking at the beginning of the COVID-19 pandemic. Coming from a film school, the health emergency and so-called social distancing posed several problems to usual film workflows, stopping all the student and research projects being conducted at the time. As the live-action real scenario was not possible, many film making in academic environments shifted to the webcam/virtual meetings aesthetics looking for inspiration. However, we considered it suited better the concept of virtual communication to draw some ideas from the abstract realm. Although materiality of software and digital interactions is frequently asserted, we sensed that the body-less dimensions of the virtual realm were stronger with the pandemic. But instead of rejecting the lack of physical interaction and stopping from film making, we embraced digital culture and its forms of production and shifted from physicality to virtuality. In doing so, we decided to produce a film using the logic of distributed software production, where usually people collaborate using a global network infrastructure without the need of meeting physically. From this rationale the short film *Ritmo 2021* was born (Fig. 1).

Adopting a software methodology brought up several issues that directly resonate with the concept of collaboration and film history. The two coders of the project, the director and a research assistant were in different geographical locations (Colombia and Germany) collaborating using a repository for their Processing sketches coded individually. On a temporal scale, the discussions led us to delve into the past, finding in the classical abstract film *Rhythmus 21* from Hans Richter¹ the source of visual abstractions to start with. But more than a “remediation” (Hayles 2002, 5) using code instead of film, the process posed the question on how to update the principles of that film; therefore, we decided that color, 3D and synthesized sound should be fundamental in our approach. Another feature that has to do with the scale of digital infrastructures was the file size of the film and its potential based on the semiotic dimension of computer code. Being a film entirely made out of a programming language not only represents a conceptual challenge to the popular adage of “A picture is worth a thousand words”, it represents a real impact on the bandwidth used to transfer the film. That is, this is a short film that is written; therefore, it could be given away on print-outs or on a plain text file. The only condition is that the receiving person has the Processing programming environment and the ability to run the code to complete the transmission of the film. This is a conceptual gesture, where visual abstractions are paired with code abstractions (such as classes and object-oriented programming) and with the tradition in computing of using plain text files. In this way, we came up with a sort of text copy/paste streaming method with notable results: whereas the regular mp4 rendering of the film has a size of 204 MB, the code is just 1.6 MB. This entails several interesting possibilities: paper publications based on the code, the designing of other digital “carriers”, such as mobile offline applications that recreate the film executing it locally instead of retrieving it from a data cloud, experiencing the film with a low carbon footprint.

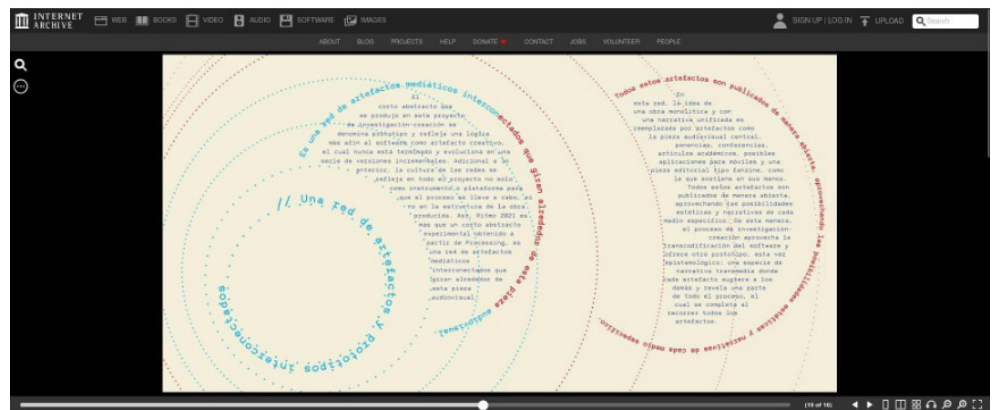
There is also a political reading of the proposal. Being a short film, film festivals are one of the main exhibition venues. However, these festivals usually impose conditions like exclusivity, meaning that the piece cannot be online for public viewing. In order to comply with the free/open-source software ethics that are intertwined with the film but with the festival’s requirements as well, we decided to provide a “festivals hack” (bypass) based on the source code/binary form dichotomy of the software industry. Therefore, the “binary form” of the film (render) is not available for the public viewing, thus meeting film festivals standards. Conversely, “the source code” of the film can be reached easily at GitHub granting a free/open distribution of the film in its more basic form. With this simple but meaningful gesture, we want to bring to the foreground the power relationships present in the circulation of cultural artifacts and the

artificial scarcity that affects digital media. This position acquires a new meaning by considering that Universidad Nacional de Colombia, the University where the film was made, is a public institution closer to cultural/educational global movements, as Open Science or OpenGLAM.

Summarizing, although the short film coded in the Processing creative coding language can be considered the main media artifact, there are other complementary artifacts. These are created using free software tools and ethics: 1) An explanatory fanzine designed on Scribus and Inkscape and published on the archive.org for free downloading; 2) An experimental app for the android system where the film can be watched on mobiles phones using just 3M of storage; 3) Academic papers from different stages of the project published in open access conferences and journals; 4) The final film was rendered out of the Processing source code using only open source tools: ffmpeg for moving images and audacity for sound capture.

In this way, *Ritmo 2021* offers a network of artifacts reflecting on the main short film piece where the free software ethics are embodied in the used tools, prototyping process and distribution channels. Moreover, the whole project develops our own concept called “Transmedia Punk”, in which free software practices are hybridized with the alternative media tradition (fanzines) or current related academic debates as open access and open science tenets (Fig. 2).

Figure 2: Two-page spread from fanzine hosted on archive.org.



Finally, we believe that the most interesting consequence of our approach lies in the possibility of global collaboration. Using a programming language to make a short film not only expands new forms of media authoring but also questions the software and media arts themselves. Modern software and art pieces posit interactivity as a must, but our short film favors a non-interactive linear approach similar to the sequential film used by Richter a century ago, something kind of contradictory with a tool like Processing. In doing so, we translate interactivity from a software interface to human-to-human collaboration based on computer networks. The availability of the code grants that every interested person can adapt and remix the short film, defying the art-spectator dichotomy at a global scale. And that for us is the real interactivity: not to follow a

predefined script pretending to be part of an art piece but to have total control to adapt it following one's interests. For this reason, we think *Ritmo 2021* is a simple yet powerful work that embodies the possibilities of what have been called "Aesthetic Programming" (Soon and Cox 2020, 14).

Acknowledgements. This project was funded by the Faculty of Arts of the Universidad Nacional de Colombia (Bogotá Campus) (Bogotá, Colombia).

Media Artifacts

Ritmo 2021 is a short animation film generated by code but it is completed with another media artifacts (experimental Android app, a fanzine, GitHub source code and an academic paper) which can be reached here: <https://linktr.ee/ritmo2021>

References

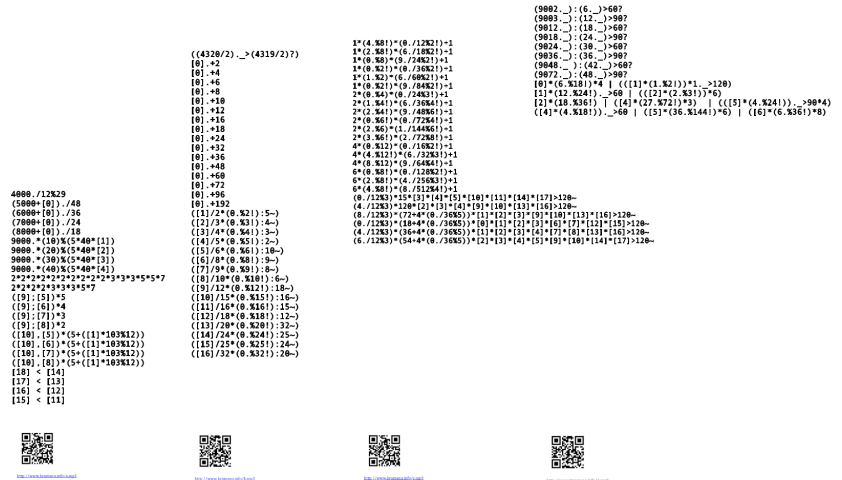
Hayles, N. Katherine. 2002. *Writing Machines*. Cambridge, MA: The MIT Press.

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AOGscript, Generative Code as Conceptual Artwork: Giving Space to Astonishment



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What is the aesthetic essence of lines of code in a scripting language designed to generate musical structures? Four simple black-and-white prints with code invite to trace this question. The code sequence on one sheet each served to generate a composition for clarinet and piano. In addition to the reception of the code sequences, audio files of these four compositions can be accessed in the exhibition. The links to the audio files are located at the bottom of the printouts and can be listened to via headphones on one's own smartphone.

Keywords: Conceptual Art, Computational Music, Generative Art, Arithmetic Operation Grammar (AOG).

Code that generates music can be seen as a concretization of a certain conception of what can be considered music. This conceptual notion is grounded in “Arithmetic Operation Grammar” (AOG) in the fact that the distribution of small prime factors (2,3,5,7) in the sequence of natural numbers is already considered to be organized in a musically meaningful way, and original musical compositions can be obtained by transformations of this sequence (Kramann 2021). With the line-by-line top-down interpreted script language *AOGscript*, such transformations can be described very easily. Everything that follows the # character in *AOGscript* is a line comment. The following lines represent an example of code in the *AOGscript* language and are also intended as an introduction to this script language:

```
22 #... is simply the integer 22
```

```
22. #The trailing dot makes it a time sequence
{22,23,24,...}
```

```
[1] # Content of line 1, so also {22,23,24,...} (Counting
starts at 0)
```

```
[1]_ # _ extracts the occurring powers p,q,r,s
of 2,3,5,7 in each number and combines them to
 $2^p \cdot 3^q \cdot 5^r \cdot 7^s$ , in the following called reduction,
here: {2,1,24,...}
```

```
2520,(9000+[1]) #The binary operator comma divides the
reduction of the constant 2520 by the reduction of the
expression in the round bracket
```

Other important features of the *AOGscript* scripting language:

- **N_0 -Paradigma:** If the evaluation result of a row is less than zero, it is set to zero.
- **Fault tolerance:** Lines are evaluated as far as possible. Lines that cannot be evaluated are set to zero.
- **Abandonment of variables:** Instead of using variables, the evaluation result of preceding lines can be retrieved by using the square bracket (see example above).
- **Abandonment of operator priorities:** Operations are processed in their natural order. Exception: Expressions in round brackets are evaluated first.

AOGscript concentrates on the generation of the musical form. Usually a certain number of the lower lines of a script are interpreted in such a way that the integers occurring there in sequence by the evaluation are interpreted as frequencies. Each of these lines is assigned a musical instrument. If a frequency lies within the range of the musical instrument, this frequency is mapped to the nearest pitch of the tempered scale and finally played in real time on the

(virtual) musical instrument. A not inconsiderable part of the software that can interpret an *AOGscript* is also to take care of the interpretive part of the sequences of notes that result from the script, for example, deciding at what tempo and in what sequential repetitions the *ticks* — smallest temporal unit in the progression of the piece and at the same time the tempo at which the natural numbers are counted through in the script — run and with what dynamics and playing technique the instrument is currently playing.

Without a further exhaustive description of *AOGscript* and its implementation as software, an exemplary implementation is provided here. The software available under the following link was implemented with Java/Processing.¹ In order for the corresponding processing sketch to run, the “Contributed Library” “ComposingForEveryone” must still be included. While the four pieces for clarinet and piano use virtual midi instruments (physical modeling), the software provided does not do so, at the cost of a less interesting sonic experience, to ensure that the processing sketch runs as a stand-alone program.²

The provided software opens it also to amateurs to compose. This is done here by repeatedly modifying and saving the *AOGscript* in the file *code.txt* while the software is running. This objectifying approach to composing for amateurs with direct feedback (comprovization) can also be seen as a contribution to the movement “Ubiquitous Music”, because an alternative way to composing is opened up, which can be followed without the prerequisite of a music degree. Ubiquitous Music is the name of a group of musicians and programmers, especially in Brazil and Portugal, who see computers and the Internet as an opportunity to establish new ways of composing and making music, including for amateurs in an everyday creative practice known there as “little c” (Keller et al. 2014, 29-30).

Opening up the possibility of new kinds of creative practices, as is done here in the form of the provision of *AOGscript*, is one thing. Getting people interested in engaging in such a practice, or even establishing it as a cultural technique for musical laypeople, as is the case in choral societies and playing circles, is quite another. An initial first step to achieve the latter is certainly to awaken a certain interest in it in the first place. The four pages that now follow are to be understood as four conceptual works of art, intended to be printed out and hung up, side by side in a very simple way in an exhibition for reception. At best, they may arouse some amazement that these few lines can each represent an entire musical composition, or stimulate thought about what music is and whether anyone is willing to grant that a generative instruction imagined in its entirety

1. <https://processing.org>

2. <http://www.kramann.info/AOGscript1.zip>

is an equivalent substitute for a musical thought. And finally, when received without knowledge of the present text, the four sheets may simply be perceived, on the one hand, as a stimulating puzzle about what connection exists between music and code, and, on the other hand, the hanging may be perceived as a provocation to understand the code itself as an original work of art.

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4000./12%29
(5000+[0])./48
(6000+[0])./36
(7000+[0])./24
(8000+[0])./18
9000.*(10)%(5*40*[1])
9000.*(20)%(5*40*[2])
9000.*(30)%(5*40*[3])
9000.*(40)%(5*40*[4])
2*2*2*2*2*2*2*2*2*2*3*3*3*5*5*7
2*2*2*2*3*3*3*5*7
([9];[5])*5
([9];[6])*4
([9];[7])*3
([9];[8])*2
([10],[5])*(5+([1]*103%12))
([10],[6])*(5+([1]*103%12))
([10],[7])*(5+([1]*103%12))
([10],[8])*(5+([1]*103%12))
[18] < [14]
[17] < [13]
[16] < [12]
[15] < [11]



<http://www.kramann.info/a.mp3>

((4320/2) ._>(4319/2)?)

[0] .+2

[0] .+4

[0] .+6

[0] .+8

[0] .+10

[0] .+12

[0] .+16

[0] .+18

[0] .+24

[0] .+32

[0] .+36

[0] .+48

[0] .+60

[0] .+72

[0] .+96

[0] .+192

([1]/2*(0.%2!):5~)

([2]/3*(0.%3!):4~)

([3]/4*(0.%4!):3~)

([4]/5*(0.%5!):2~)

([5]/6*(0.%6!):10~)

([6]/8*(0.%8!):9~)

([7]/9*(0.%9!):8~)

([8]/10*(0.%10!):6~)

([9]/12*(0.%12!):18~)

([10]/15*(0.%15!):16~)

([11]/16*(0.%16!):15~)

([12]/18*(0.%18!):12~)

([13]/20*(0.%20!):32~)

([14]/24*(0.%24!):25~)

([15]/25*(0.%25!):24~)

([16]/32*(0.%32!):20~)



<http://www.kramann.info/b.mp3>

$1 * (4. \% 8!) * (0. / 12 \% 2!) + 1$
 $1 * (2. \% 8!) * (6. / 18 \% 2!) + 1$
 $1 * (0. \% 8) * (9. / 24 \% 2!) + 1$
 $1 * (0. \% 2!) * (0. / 36 \% 2!) + 1$
 $1 * (1. \% 2) * (6. / 60 \% 2!) + 1$
 $1 * (0. \% 2!) * (9. / 84 \% 2!) + 1$
 $2 * (0. \% 4) * (0. / 24 \% 3!) + 1$
 $2 * (1. \% 4!) * (6. / 36 \% 4!) + 1$
 $2 * (2. \% 4!) * (9. / 48 \% 6!) + 1$
 $2 * (0. \% 6!) * (0. / 72 \% 4!) + 1$
 $2 * (2. \% 6) * (1. / 144 \% 6!) + 1$
 $2 * (3. \% 6!) * (2. / 72 \% 8!) + 1$
 $4 * (0. \% 12) * (0. / 16 \% 2!) + 1$
 $4 * (4. \% 12!) * (6. / 32 \% 3!) + 1$
 $4 * (8. \% 12) * (9. / 64 \% 4!) + 1$
 $6 * (0. \% 8!) * (0. / 128 \% 2!) + 1$
 $6 * (2. \% 8!) * (4. / 256 \% 3!) + 1$
 $6 * (4. \% 8!) * (8. / 512 \% 4!) + 1$
 $(0. / 12 \% 3) * 15 * [3] * [4] * [5] * [10] * [11] * [14] * [17] > 120 \sim$
 $(4. / 12 \% 3) * 120 * [2] * [3] * [4] * [9] * [10] * [13] * [16] > 120 \sim$
 $(8. / 12 \% 3) * (72 + 4 * (0. / 36 \% 5)) * [1] * [2] * [3] * [9] * [10] * [13] * [16] > 120 \sim$
 $(0. / 12 \% 3) * (18 + 4 * (0. / 36 \% 5)) * [0] * [1] * [2] * [3] * [6] * [7] * [12] * [15] > 120 \sim$
 $(4. / 12 \% 3) * (36 + 4 * (0. / 36 \% 5)) * [1] * [2] * [3] * [4] * [7] * [8] * [13] * [16] > 120 \sim$
 $(6. / 12 \% 3) * (54 + 4 * (0. / 36 \% 5)) * [2] * [3] * [4] * [5] * [9] * [10] * [14] * [17] > 120 \sim$



<http://www.kramann.info/c.mp3>

(9002._): (6._)>60?
(9003._): (12._)>90?
(9012._): (18._)>60?
(9018._): (24._)>90?
(9024._): (30._)>60?
(9036._): (36._)>90?
(9048._): (42._)>60?
(9072._): (48._)>90?
[0]*(6.%18!)*4 | (([1]*(1.%2!))*1._>120)
[1]*(12.%24!)._>60 | (([2]*(2.%3!))*6)
[2]*(18.%36!) | ([4]*(27.%72!)*3) |
((([5]*(4.%24!))._>90*4)
([4]*(4.%18!))._>60 | ([5]*(36.%144!)*6) | ([6]*(6.%36!)*8)



<http://www.kramann.info/d.mp3>

Perfor- manc- es

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Ambulation: An Extended Soundwalk

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Ambulation is a soundwalk that uses field recording techniques and listening technologies to create a walking performance using environmental sound. *Ambulation* engages with the act of recording as an improvised performance in response to the soundscapes it is presented within. The research around the development and presentation of *Ambulation* contributes to the idea of field recording as a live, procedural practice, moving away from the ideas of the movement of documentary material from one place to another. This sound walk demonstrates how having an open, improvisational approach to technologically supported soundwalking enables rich and unexpected results to occur and how this way of working can contribute to xCoAx design and thinking.

Keywords: Soundwalk, Field-Recording, New Media, Locative Media, Walking, Thinking-Through-Making.

Description

Figure 1: Tim Shaw (2021), *Ambulation* at Sonic Protest, Paris, France. Photo: Vincent Ducard.



In *Ambulation* (Shaw 2023) I take the audience on a soundwalk whereby signals from the immediate environment are collected through various microphones and listening technologies and broadcast to a group of people walking with me. Using a small computer, I am able to live-mix, process and manipulate the signals we move through. I use a PureData patch running on a BELA board computer. The BELA board is controlled using a small midi controller which is attached to the top of my recording bag. The sound is broadcast to the wireless headphones worn by the audience via a compatible transmitter. The environmental sound is mediated through microphones, the recorder, the computer, the broadcast transmitter and the headphones.

No pre-recorded sounds are used in the *Ambulation* soundwalk; all sounds heard by the audience are from the immediate activity of the sonic environment. The audience hears these sounds at the same time as I do. When arriving in a new environment, I get to know the space through walking. Without any listening technology I wander through the area finding unusual and dynamic acoustic spaces. These can include shopping centres, busy streets, markets, train stations, pedestrian walkways, parks, forests, lakes, ponds, fountains, rivers, car parks and churches. A contrast of environments works best for an interesting walk. When I have decided on a route, usually lasting around 45 minutes, I walk it a couple of times to get familiar with it. Occasionally I deviate from the route, especially if something spontaneous grabs my attention during the performance. I do not use the *Ambulation* system until I perform it with the public. This means that the first time I am hearing the environments mediated through the system is when I am performing with the audience. At the end of a walk, I usually facilitate an informal conversation with audience members who want to stick around.

Ambulation embraces the uncertainty of the everyday environment. It welcomes the unwelcome. For example, when presenting *Ambulation* in Brisbane (Australia), locally sourced RF (radio frequency) headphones were so full of audio artifacts they became almost unusable (Shaw and Bowers 2020). In contrast, in the city's Botanical Gardens, the interference of the urban environment did not impede the *Ambulation* signal as much. The interference experienced on walks such as Brisbane was an interesting problem and became something to tie in to the creative decisions when planning the walk. As *Ambulation* is about the experience of sound, including phenomena not usually within our perceptual reach, this interference felt relevant to explore rather than obstructive. Different species of 'interference' became incorporated into walks and became a part of the creative sonic material of *Ambulation*. The route in Brisbane started within the park where little or no interference occurred. Towards the end of the piece, the audience were taken into areas of interference where, in addition to the usual broadcast sonic material of *Ambulation*, various RF artifacts, audio cut outs and even the occasional taxi driver conversation could be heard. Though the exact character of such interference was beyond my control, a route can be shaped around how much or how little interference is desired and when. The walking route in these instances was built around the quality of possible broadcast, and moved through areas of 'compositional ambiguity', in which it would become unclear what was being performed and what was incidental to the walk.

Figure 2: Tim Shaw (2020), *Ambulation* at LUFF, Lausanne, Switzerland. Photo: Francois Genre.



At the time of writing, *Ambulation* has been performed at 34 festivals, events and conferences around the world. Being able to present this work in different environments has been very important to its development. The *Ambulation* system is one I can take to different contexts and perform with different audiences. The system and technologies change depending on the context I am invited to present the work within. This versatility of the work is important to me. It does not have a fixed, predetermined audience. For example, I have conducted *Ambulation* soundwalks to elderly people in a community

centre, to eight-year-olds in a primary school, and after a nightclub programme at a festival. Though some sites are more successful for this kind of soundwalk than others, I am always interested in challenging myself to present this piece in different circumstances. Locations have ranged from ancient forests to brand new shopping centres, from heritage places to construction sites. When introducing the walk to the audience, I explain the process and the system in detail. It is important to me that the audience is aware of the technological details of the work.

A full technical and aesthetic description of the *Ambulation* project can be found in an earlier paper (Shaw and Bowers 2020). The system for the *Ambulation* soundwalk is available to download and modify for free via my personal website.¹

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c0l1v3: A Collaborative Nonlinear Live Coding Instrument

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c0l1v3 is an improvisational, collaborative, interactive audiovisual performance, and a live coding web-based instrument created by Bruno Gola. The collaboration aspect is implemented in a way that anyone with a device running a web browser can join at any time and play. There is no login or credentials, *c0l1v3* is always running and accessible via its URL. The website works as a frontend to a SuperCollider program running on the server-side. It streams audio and data back to the browser with low latency using WebRTC, so all players are controlling the same sound process. *c0l1v3*'s interface is an experiment in breaking the traditional top-to-bottom linear code writing approach, it presents a canvas where players can add code anywhere, and all players can edit each other's code blocks. In *c0l1v3* there is no distinction between performers and audience.

Keywords: Live Coding, Nonlinear, Audiovisual, Network Music, Collaborative Art, Computer Music, Distributed Performance, Improvised Music.

Description

c0l1v3 is an experiment in collaborative improvised live coding and less traditional ways of collectively writing code to control an audiovisual instrument. It is always available as an open playground on the web, working as an online public square where anyone can enter and listen to others playing and jam together.¹

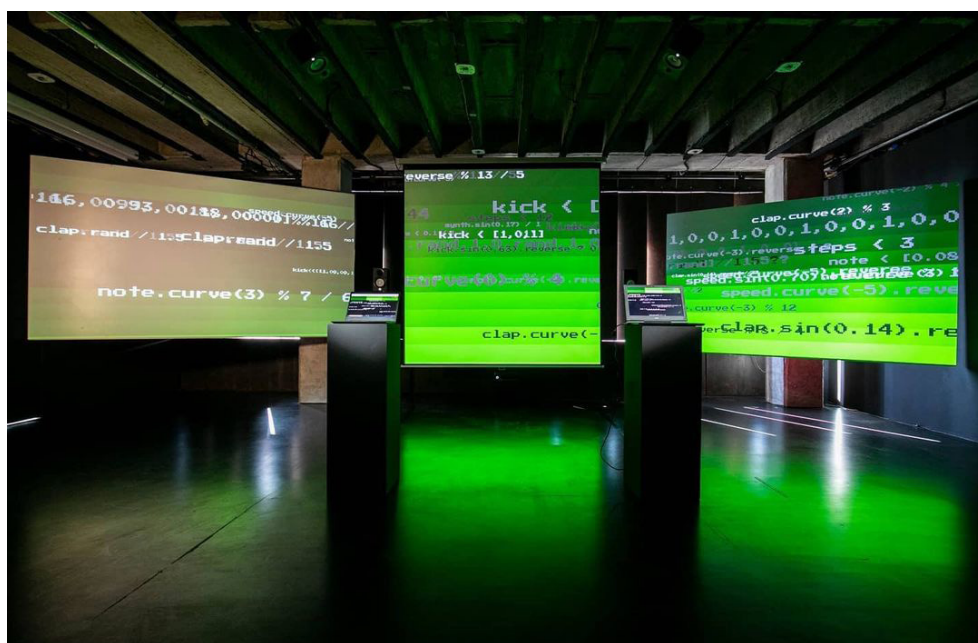
Background

During the beginning of the COVID-19 pandemic I started working together with Prof. Alberto de Campo in the context of the *Generative Kunst / Computational Arts* class at the Berlin University of the Arts to develop tools that could support the class on continuing working in its hands-on, live experimentation practice even remotely. During the two months before the beginning of the summer semester of 2020, we developed *tcposcrouter*, *ws2udp* and *HyperDisCo*, all tools that make it simple to collaborate in *SuperCollider* live coding sessions over the internet.

Simultaneously I was playing in different live events online, such as algoraves, and watching many live streamed performances in different formats. During that time I was getting frustrated with the lack of direct feedback in my own performances, it was hard to feel like I was playing live or that there was an audience on the other end, so I started imagining ways to make my performances more alive and reactive.

In the beginning of 2021, as part of the On-The-Fly program, I had the opportunity to be Artist-in-Residency at Ljudmila Art and Science Lab, in Slovenia. There I started working on the project that became *c0l1v3*. During the residence my goal was to build an installation called *Co-op{codes}*. In this installation the visitors could experiment with live coding: there were two computers running the same software, and with those two computers the audience could control the audiovisual instrument that I developed using *SuperCollider* which consisted of 3 projectors and 8 speakers. The software interface was designed in a way that anyone could experiment by just double clicking anywhere on the screen to add a random piece of valid code. Each block of code added to the interface had its own editing space. The interface followed no order between blocks, and each block could be executed independently. The software was running on a web browser, both computers were connected via the Wi-Fi and changes made on each computer would be shown simultaneously on the other.

Figure 1: *Co-op{codes}* installation in Ljudmila, Slovenia.



Distributed Performance

At the end of my residency in Ljudmila I took part in the *Algopolis* event by performing live with *Co-op{codes}*. That was a solo performance but opened the way to the next step of that research, transforming the installation into this open, web based instrument, that could be online and I could perform at any time with it, and also invite the audience to join me writing code together.

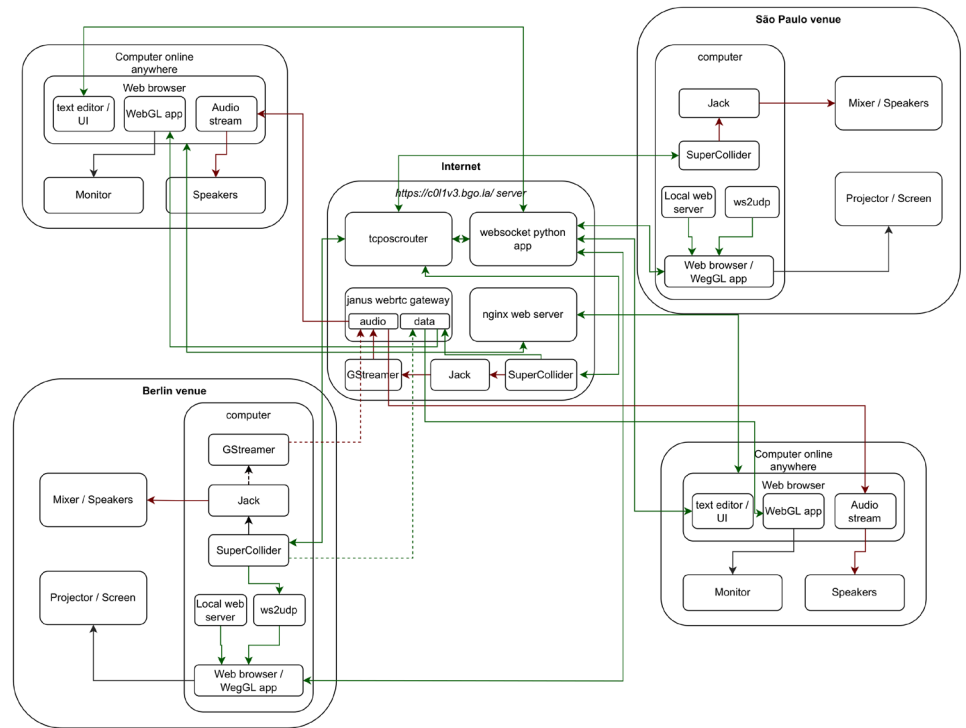
During the rest of 2021 and beginning of 2022 I kept working on the concepts and software for what became *collv3*. The main challenge was to stream the audio over the web with good quality and low latency, for me it was very important to have as low latency as possible so that everyone playing could react together. The solution for that was WebRTC. I started writing my own solution called *Spatify* for another project in 2019, but in 2021 I found *Janus WebRTC Server* and its streaming plugin. Using *gststreamer* to stream from *SuperCollider* to *Janus* it is possible to have multiple web clients receiving the same audio and data stream with very low latency.

The text interface synchronisation uses *websockets* so that all the players see what each other is typing. Commands are sent to the server via *websocket* and then sent to *SuperCollider*. The *websocket* server-side is connected to *SuperCollider* using *tcposcrouter* so it works as a proxy between OSC messages of *SuperCollider* and *Web-Socket* messages from the browser.

Using *tcposcrouter* also enables multiple synchronised *SuperCollider* servers running in different locations, in a more distributed performance approach, being independent of internet connection in case the internet fails. For example one person can run their own full setup consisting of *SuperCollider*, the HTML/JavaScript frontend and a local *ws2udp* to proxy *websocket* messages to OSC. The *SuperCollider*

program would connect to other *SuperCollider* instances using *OSCRouter* class and being on the same *OSCrouter* group as the other players, sharing code this way, and the sound comes directly out of the local *SuperCollider* sound engine. If the connection fails at any moment, the sound is not interrupted since the sound is produced locally in this case.

Figure 2: Technical audio and data flow diagram for *collv3*.



Nonlinear Editor & Domain Specific Language

Two essential features of *collv3* are its DSL, or Domain Specific Language, and its nonlinear text editor. Because of my experience with Linux systems and the Python programming language. I started designing the language inspired by REPL environments. REPL stands for Read-Eval-Print-Loop, and is a standard way of communicating with command line programs in UNIX environments. For me REPL provides a simple text-based way for controlling processes. So in *collv3* every block of code is treated as a command in a REPL environment, and the user or player evaluates one command or block each time. This, and the fact that blocks can be added anywhere in the interface, without any line structure, makes it hard to create big blocks of continuous code.

In my experience working with other live coding environments my programmer self would always show up and be in the way of the performer self. I would end up writing big functions and large blocks of code that would do complex musical things, but would lose the improvised quick responsiveness that I was searching for when performing.



Figure Infinity: Human-Assisted AI Performance

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Figure Infinity is a performance piece that connects a human performer in a self-reflexive network of control and communication with artificial intelligence. The Computer Vision and Large Language Model AI agents collaborate to direct a human performer by generating performance direction in sequence. Human participants play the part of creative, yet invisible labour workers to refine the system. Instead of disguising the human factor at the centre of AI systems, we foreground it, and use it as experimental, aleatoric seeds in the performance. We use feedback between human performers and AI Agents, but making it less an active creative participation by the performer and instead a system of control. The work focuses on themes of accelerated platformisation of labour, algorithmic management and artificial intelligence failure.

Keywords: AI Performance, Feedback Loop, Human-Assisted AI, Failure, Dataworkers, Invisibilised Labour, Platformisation, Algorithmic Management.

Introduction

Figure Infinity is a performance piece that connects a human performer in a self-reflexive network of control and communication with artificial intelligence. Throughout, Computer Vision¹ and Large Language Model (LLM)² AI agents collaborate to direct the “human-in-the-loop”³ to execute tasks determined to be the next step in the performance sequence. The discontinuity between the discrete nodes of this cybernetic feedback system (Galloway 2021), formed by the human and non-human agents, creates space for playful miscommunication and dynamic absurdity. The work was originally conceived as a response to FestForward magazine⁴ developing the themes of accelerated platformisation of labour, algorithmic management and artificial intelligence failure.

Human Labour

Despite the recent furore over AI tools like chatGPT (BBC 2023, Steer 2023) their ability to function is underpinned by “precaritised ‘ghost work’ to maintain plausibility” (McQuillan 2023). The illusion of a perfectly intelligent automaton is prevalent as it can be seen from the name of Amazon’s micropayment-based crowdsourcing platform Amazon Mechanical Turk (*mTurk*). It was named after the lifelike chess player machine created in the 18th century commissioned by Austrian Empress Maria Theresa (Pew Research Center 2016). The machine was dressed in Turkish costumes and had a human chess player hiding inside (Crawford 2021). Similarly, real workers on *mTurk* remain invisible, to anonymously serve the idea of magically intelligent AI (Gahntz 2018). *mTurk* is one example in a trend in outsourced content tagging where workers are not only invisibilised, but undervalued and whose conditions are under scrutiny (Reese 2016, Perrigo 2023). Even with the marginalisation of the human workforce, human-assisted data labelling remains to be the most efficient way to train AI (Bridle 2018, 160) as can also be seen in the case of Google’s use of CAPTCHA to feed its image recognition algorithms (Bloomberg 2020).

In *Figure Infinity*, the performer plays the part of the precarious “immaterial labour worker” (Terranova 2004, 92), subjected to the algo-managed conditions of the gig economy, invisibilised to all but the system that is controlling them. Further, it is a participatory piece, as we micro-task the audience to tag the actions on stage using their phones. Instead of disguising the human factor at the centre of

1. <https://ultralytics.com/yolov5>

2. <https://openai.com/blog/chatgpt/>

3. <https://humansintheloop.org/what-is-a-human-in-the-loop/>

4. <https://www.festforward.org/>

AI systems, we foreground it, and use it as experimental, aleatoric seeds in the performance.

AI Performance & Feedback

For dance projects like *AI_am*⁵ by Valencia James the AI avatar was used to create improvisation between human dancers and AI. Similarly, in Rhizomatiks Research's *Discrete Figures*⁶ AI dancers are collaborators for the human dancers. Ideally those AIs are there to inspire human dancers to create something new. As Peltarion's project⁷ shows in the AI training process for choreography, AI is learning human dance movements and reproducing those movements. Eventually, what makes those results so interesting are the human dancers who intelligently interpreted the movements generated by AI and performed. Perhaps the result is a fulfilling myth; AI-powered human body movement.

In this tradition of cybernetic performance artists, we use feedback between human performers and AI Agents, but making it less an active creative participation by the performer and instead a system of control (Dixon 2007, 146). The body affects a cybernetic feedback loop, with layers of interpretation at each juncture between (human) body agent, vision agent and language agent. Further, we highlight feedback as an "aesthetic of failure" (Cascone 2000), with audio and video feedback used as noise to confuse the AI agents, as well to illustrate the circularity of the cybernetic system to the audience.

Experimentation

The piece is currently a work-in-progress. So far, we have experimented with feeding various resources to the AI agents such as endlessly mirrored live camera feed, keywords generated from the Computer Vision AI, and some texts from Samuel Beckett's novel. The work will be developed further to achieve fine-tuned performance directions that will be more applicable to the human performer and a dramaturgical arc.

Our existing implementation of this project uses Ultralytics' yoloV5 model⁸ for Computer Vision and OpenAI's text-davinci-003⁹ as LLM. A camera pointing at the stage is fed to the yoloV5 object detection algorithm, which creates a list of objects in the shot. This object list is then used as a seed to prompt our LLM, with prompts fed periodically to create the next step in the performance. Each step is then fed to the performer on stage via a thermal printer (Fig. 1).

5. https://valenciajames.com/projects/ai_am/

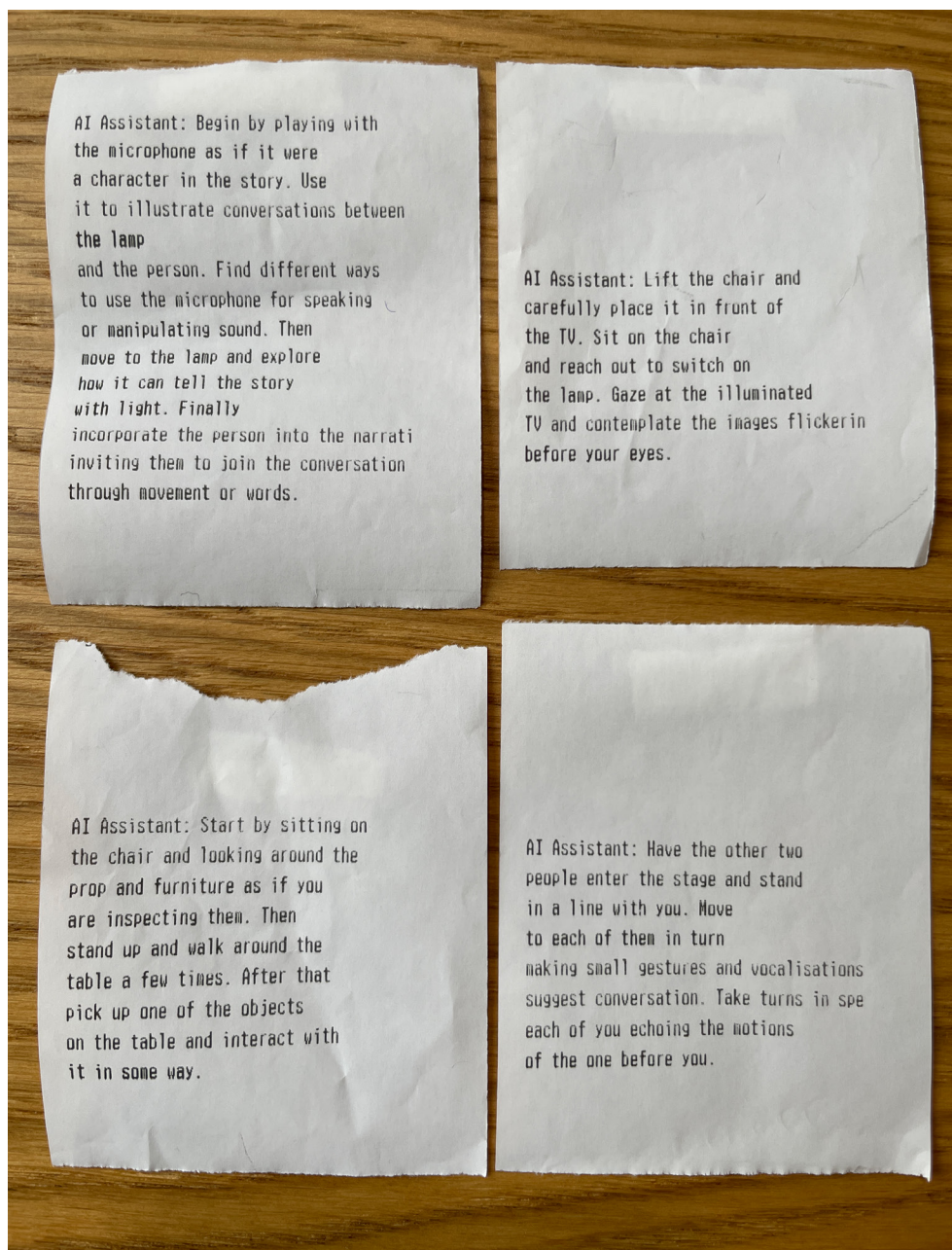
6. https://research.rhizomatiks.com/s/works/discrete_figures/en/

7. <https://peltarion.com/use-cases/teaching-ai-to-dance>

8. <https://ultralytics.com/yolov5>

9. <https://platform.openai.com/docs/models>

Figure 1: Printed performance instruction generated by Large Language Model.



Here is an example of an initial prompt we used:

The following is a conversation with an AI assistant. The assistant will act as a director, giving performance directions to a sole performer on stage during a performance.

Each Direction must follow logically from the last.

No Direction can repeat itself.

At each prompt the AI assistant will be given a list of objects on stage with the performer that the performer can interact with and must respond with performance directions. Here is the first prompt:

Prompt: screen, chair, cables.

Here is an example of the type of instruction it produces:

AI Assistant: Begin by walking slowly to the chair and sit down. Reach out with your left hand for the cables connected to it and investigate the connection. Inspect each cable, noticing details about its length, colors, or any other unique feature. Move on to examine closely the screen near you. Take a few moments to consider its purpose in the performance space before beginning to interact with it.

For the experimentation two hacked Gametrak controllers were attached to the wall where the video was projected. The tethered controllers were attached to the performer's wrists to use them as a metaphor to visualise entangled loops between the performer and the visual set fed by the AI tool. And the length and direction of the tethered controllers affect sound depending on how the performer is moving on the stage. Therefore, the directions given to the performer affected the human sonic environment, unbeknownst to the AI agents in the loop.

Further Development

We have several ways in which we plan to develop the project beyond our initial experiments.

The first is fine tuning our yolov5 object detection model to allow it to take more risks and force it to always provide a result. After this, we wish to further distort the visual feed (beyond the feedback projection) by using objects on stage such as mirrors, as well as pixelating and blurring the input and using a panel to project another image onto the surface. We hope this will generate more obscure keywords to feed our LLM.

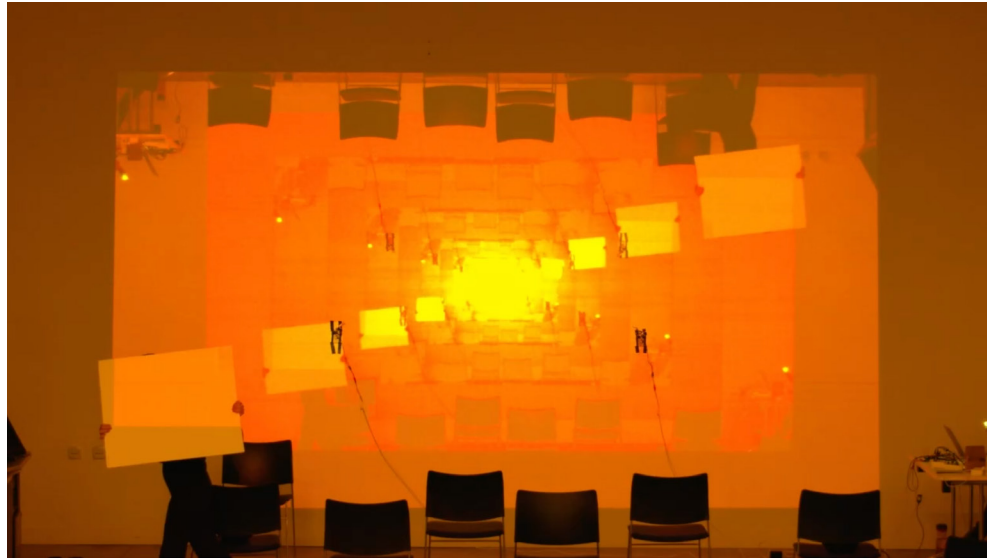
Additionally, we wish to make the performance participatory by asking the audience members to comment on what is happening during the performance. This will further seed the LLM with details and be used to generate a text review of the performance at the end of the work, with audience members unwittingly providing the key micro-labour for its production.

Furthermore, the prompts used to create the performance direction needs to be further crafted to make the results easier to interpret for the performer and more movement rather than story-based. Varying the prompts can give vastly different results, with "Prompt Engineering" being seen as a creative skill in its own right (Millière 2022).

Finally, we are looking into ways to integrate sound more holistically into our cybernetic AI feedback system. One method could be to ask audience members to rate the performance at each step of the per-

formative sequence, with the score data used to responsively manipulate the sound. Another could be to play with controlled audio feedback on stage with the AI agents inadvertently directing the mic'd performer towards a speaker resulting in rising sinusoidal noise.

Figure 2: Experimentation with projected images, objects and movement with Computer Vision.



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Strip & Embellish

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Strip & Embellish is a young experimental live sound project founded in 2022 by computer music duo Daniele Pozzi and Hanns Holger Rutz. Both have developed specific, individual digital instruments based on the SuperCollider sound synthesis language which are strongly linked together by plugging each other's sound signal into many nodes and entry points of the opposite system, creating essentially a complex non-linear feedback process. The project frames electronic music improvisation as a form of parallel collaborative musicking, whose computer-mediated synergies are subject to experimentation through the development of idiosyncratic software tools and strategies that introduce asymmetries, deviations and interruptions in the performance.

Keywords: Computer Music, Improvisation, Systems Coupling, Parallel, Collaboration.

Overview

The *Strip & Embellish*¹ project is centred around the iterative coupling of two computer music systems, individually developed by Daniele Pozzi and Hanns Holger Rutz. Previous performances include *impuls minuteConcerts* Graz and *Piksel* Bergen 2022.

The project is set up as a dialogical situation (Fig. 1), in which the two systems are conceived to be open for interaction. Even though they were not designed to work together in this specific constellation, they both provide software structures for communicating with other systems or instruments. *Strip & Embellish* indeed develops through parallel iterative gestures of reconfiguration, in which the authors collaboratively experiment with multiple strategies, composing specific performative situations and conditions which are scored over time, while remaining open to ongoing intervention. *Strip & Embellish* is about creating a shared environment in which interactions can take place, things can come together, while at the same time each performer — and each system — maintains its own space and individuality.

Figure 1: Rehearsal in the Experimental Lab of the KUG's Doctoral School for Artistic Research (2022).



Pozzi's system *Strip* consists of a SuperCollider framework for designing recursive phase modulation (PM) synthesizers. A main focus is

on feedback experimentation in PM synthesis: *Strip* includes a set of interfaces for real-time signal routing that allows to prototype complex feedback paths and system couplings on-the-fly. The name derives from the fact that the framework is the result of a continuous effort to strip down a complex feedback driven system, while maximising its expressive richness.

Rutz's system *Embellish* is an extension of his live improvisation interface *Wolkenpumpe* (Fig. 3), which in turn combines the Super-Collider sound synthesis engine with a visual graph display with pan and zoom control and automated layout. This interface is extended by performer issued actions to "return in time" and yielding control to the machine for replicating the performance's "hull" structure, now interacting semi-autonomously with new sound situations.

The two systems are densely linked together by plugging each other's sound signal into many nodes and entry points of the opposite system, creating essentially a complex non-linear feedback process. Sound input is taken from the other player's system and fed into different stages of digital signal processing (DSP) and analysis, from relatively simple coupling to parametrising complex sound synthesis structures obtained via genetic programming. This creates a shared configuration in which the two systems become intrinsically interdependent: the sounds and actions performed on one system will inevitably affect the other, in a complementary movement of coming together while maintaining a certain performative distance. This friction is crucial to the *Strip & Embellish* project: it creates a form of computer-mediated instability that favours the process of experimenting with those collaborative aspects that are central in electronic music (duo) improvisation.

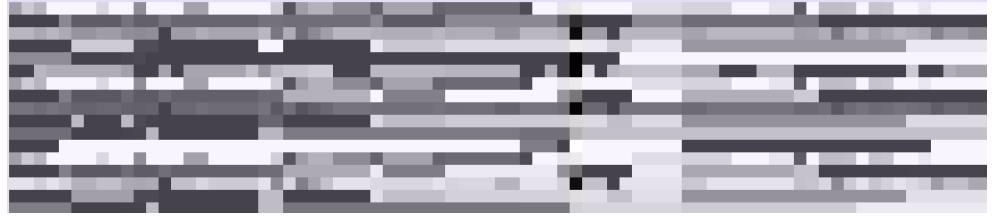
Asymmetries and Interruptions

Besides the affordances introduced by coupling two idiosyncratic systems with variable indirectness, we also develop strategies to experiment with the performance temporalities, by either inserting interruptions, strange automation or asymmetries in the shared musical time.

Pozzi's *Strip* incorporates a system for storing specific feedback configurations in a sound and text database. Every entry corresponds to a set of 18 variables representing the coefficients of a 6×3 feedback matrix. Each matrix defines both a specific DSP process (a specific recursive PM synthesiser), and the relationship this process has with the sound it receives from Rutz's system. Entries are collected while playing, they are stored in the database and can be recalled at any time during the performance. When a specific entry is recalled, it creates an abrupt change, or interruption, in the musical time: the phase modulation synthesiser is instantly reconfigured to match

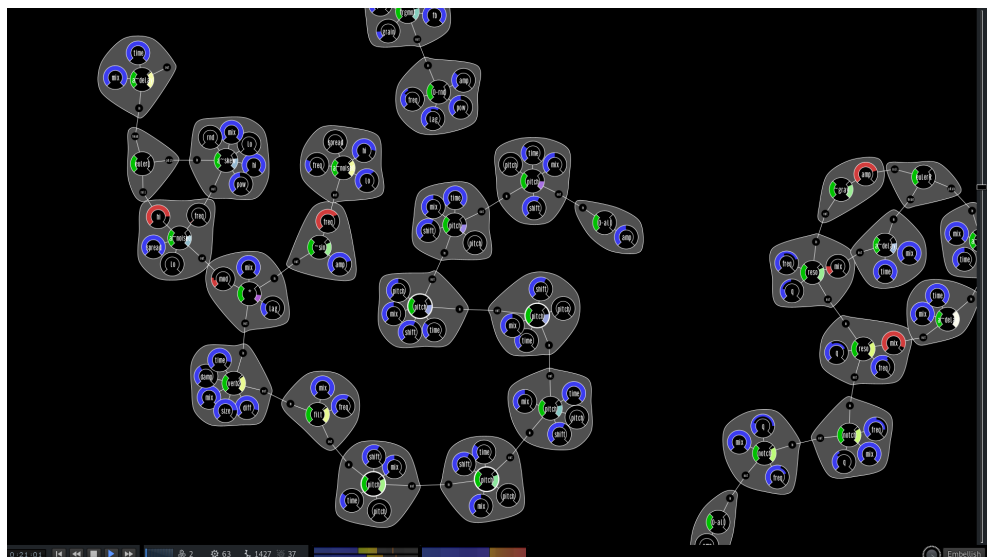
a previous setup. Due to the difference in the incoming signals, however, the synthesised sounds will never match those that were generated originally. A graphical interface may be used to display the database by representing its entries' coefficients in greyscale, allowing a rather intuitive visual selection of previous states, and the possibility of recalling them with a click (Fig. 2).

Figure 2: Screenshot of a *Strip* dataset visualization.



In Rutz' *Embellish*, the actions of the performer — the creation, deletion, interlinking and dynamic parametrisation of sound building blocks — are recorded to an internal temporal database. After a certain period of time, the performer issues the command to return to a previous point in time, essentially replaying the structural development or “hull” of this player's part. Since in this project, Rutz' sound actions are strongly based upon embellishing the sound signal of Pozzi by non-linear augmentation through various forms of analysis and structural patching, the “return in time” is indeed a strange repetition of an “empty” structure which processes the new live signal. The situation thus created may still be perceived by the audience as a recurrence of past gestures, but the now unforeseen processing of new sounds transposes the original improvisatory part, in which the embellishment was created by Rutz through listening and auditory feedback, to a new machine expression beyond the performer's control. This kind of stubbornness produces a new and different voice from the human performer. Rutz then carefully begins intervening in this structural repetition, possibly issuing another return in time at a later point, thereby producing a recursive layering of embellishments.

Figure 3: Screenshot of *Embellish/Wolkenpumpe*.



This asymmetrical development from a more directly human-controlled to a less controlled machine expression is reflected in the use of sensor data: in the first part of the performance, Pozzi wears wristbands (Fig. 4) with inertial measurement units (IMU), whose spatial orientation and acceleration are produced mostly unconsciously while playing his system. This data is also part of Rutz' embellishment process, and contrary to the audio data is recorded along with the performative actions. When the command is issued to go back in time, the sensor data from Pozzi's wrists is replayed. Pozzi now passes the wristbands to Rutz, making the formal section apparent to the audience, and in the subsequent part of the performance, this data, again mostly unconsciously produced, is used as live entry point to Pozzi's system. The sensors thus introduce another form of asymmetries in the performance and enable processes of "collaborative sound sculpting", pushing the performers further away from being able to fully control the unfolding situation.

Figure 4: Sensor wristbands.



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Speculative Sound Synthesis: Synchronization

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Speculative Sound Synthesis: Synchronization is a live electronic performance by four interlinked players exploring ways of coupling sound synthesis systems, algorithmically, performatively, and sonically. The performance is part of the artistic research project *Speculative Sound Synthesis* hosted at the Institute of Electronic Music and Acoustic in Graz. The project challenges established patterns of interaction between technology and artistic practice. Standardized processes in computer music are probed, destabilized and reshaped through speculative re-questioning, thus allowing new aesthetic potentials for experimental musical practice to emerge. Rather than focusing on making the instruments produce specific results, the performers aim to make their instruments' material qualities, assumptions, errors, and even failures sensible and experienceable. By putting their instruments and their respective developers in interaction with each other, creating a feedback loop of sorts, the performance explores questions of interplay, materiality of digital and analog sound synthesis, interaction with algorithms and machine learning, employing combinations of nonlinear oscillators and analog circuits based on fundamental digital components. The instruments flow into each other, opening up new sonic and musical possibilities through their coupling, thus creating a laboratory where they can experiment, manipulate, observe and speculate on different aspects of the artistic practice of sound synthesis they consider crucial.

Keywords: Sound Synthesis, Live-Electronics, Non-linear Oscillators, Speculation, Artistic Research.

Overview

Speculative Sound Synthesis: Synchronization is a live electronic performance by four interlinked players that deals with ways of coupling sound synthesis systems, algorithmically, performatively, and sonically.

The four performers are part of the team of the artistic research project *Speculative Sound Synthesis*.¹ The project started in November 2022 and it is hosted at the Institute of Electronic Music and Acoustic (IEM) in Graz. It is funded by the Austrian Science Fund (FWF) for a period of three years. The project questions established patterns of interaction between technology and artistic practice. Standardized processes in computer music are probed, destabilized and reshaped through speculative re-questioning, thus allowing new aesthetic potentials for experimental musical practice to emerge.

Traditionally, speculation is used to describe a sort of conjecturing or formulation of theories on the basis of unsure or insufficient knowledge. On the contrary, in the context of this project we depart from Alfred North Whitehead's description of the speculative endeavor as a journey starting "from the ground of particular observation; it makes a flight in the thin air of imaginative generalization; and it again lands for renewed observation rendered acute by rational interpretation" (Whitehead 2010, 5). Thus, we understand speculation as a process oscillating between imagination, experience, observation and rationalization, capable of bringing forth new forms of knowledge. We take speculation to describe the active, material, aesthetic experimentation we perform while trying to uncover unexplored spaces of artistic practice that could otherwise remain unexplored by the traditionally accepted methods of deduction and induction.

Within the context of this project, we consider artistic practice one part of our artistic research practice. We plan to engage in different performative settings, each of which may be considered in itself a case study or one particular experimental system. The situations we stage are to all effects a laboratory where we experiment, manipulate, observe and speculate on different aspects of the artistic practice of sound synthesis we consider crucial.

In practice, each of the performers takes care of setting up one sound producing instrument with input and output that embodies and focuses on a set of questions and practices in sound synthesis. Rather than trying to make the different instruments "function" properly, in the sense of letting them produce the forms ("results") the various methods they employ intend to achieve, we search for

ways to make their essential qualities, assumptions, errors and even failures sensible and experienceable. Using historian of science Hans-Jörg Rheinberger's words, we attempt to transform "technical objects" into "epistemic objects" (Rheinberger 1997) by making their materiality re-appear. Through experimentation, we have found that the strategy best suited for exploration is achieved by putting our instruments (and their respective developers) in interaction with each other: the output of one instrument is used as input to another and vice versa, creating a feedback loop of sorts. The instruments react to their inputs, which are in turn generated by their respective partners by replying to their output.

The performance we present here explores questions of interplay, materiality of digital and analog sound synthesis, interaction with algorithms and machine learning. In particular, for this performance, the members, in constructing their instruments, are employing combinations of nonlinear oscillators, processes which are able to react and synchronize to outside signals. The four different sound synthesis systems are connected, flow into each other and open up new sonic and musical possibilities through their coupling. By opening up their instruments to both affect and being affected by the others', this particular setup hails back to practices of experimental music performers of the '70s and '80s like, for instance, "The Hub". The performing attitudes of the four players are very different and range from an attitude of minimal intervention and observation to physical manipulation of the analog signal flow. However, all the four performers share a fascination for the encounter of complex sounds and the creation of systems that are open to the outside world .

Instruments

There are four entangled instruments performed by each of the four players. David Pirrò performs with a network of coupled non-linear oscillators implemented in his programming language *henri*. These networks react to the input by Ji Youn Kang's, Leonie Strecker's and Luc Döbereiner's instruments. Kang's instrument explores the threshold of analog and digital sound synthesis using analog circuits based on fundamental digital components that offer entry points for a more bodily interaction. Döbereiner's system makes use of digital waveguides, chaotic maps and machine learning to translate aspects of the other players' sounds onto his instrument.

*henri*² is a text based compiled programming language for sound synthesis by David Pirrò and is named after mathematician, physicist and philosopher Henri Poincaré. The language focuses on the formulation of temporal behavior: statements in *henri* closely resem-

ble differential equations, the mathematical expressions describing change and evolution. Rather than reaching a specific aim, realizing a priori known objectives, programs written in *henri* are processes that generate evolving temporal forms without a predetermined end. These forms are translated into sound and, while unfolding, they can be pushed or pulled towards one direction or another by sending impulses into them or by acting on their parameters. Therefore, these are processes open towards the “outside” of the machine performing them, allowing for interaction or for coupling with humans or other computational processes, thus taking part in more complex and chaotic aggregates. In particular, for this performance, David Pirrò will implement and perform with a network of mutually interacting so-called *Kuramoto* (Kuramoto 1975) oscillators.

Luc Döbereiner’s system is an attempt to deal with a sound ideal, characterized by unstable sound transformations that carry an inner tension, a certain contradiction. A multiphonic on a woodwind instrument could serve as an example, which is fragile, can turn over and which opens a chaotic interstitial space between stable states. The sound synthesis system used here consists of a simple digital waveguide model coupled with two chaotic maps. Through machine learning, this system is also externally affected and aspects of the other performer’s sounds are transferred into its possibility space. Due to inherent biases, distortions in audio analysis, and the limited possibilities of the synthesis process, these machine learning “translations” are always distorting and performing with these distortions is a central element of the instrument. Moreover, small neural networks are directly applied on the time-domain audio signal level and Döbereiner performs by directly affecting their internal weights.

The analog instruments that Ji Youn Kang brings along have been developed on the border between time-continuous and time-discrete signal computations. She tries to navigate through minimal digital components commonly used in analog circuits such as logic gates and shift registers, looking for unusual, out-of-logic combinations that expand their original characteristics by actively creating ‘errors.’ Her experimentations always target musical performances by involving incoming signals i.e. from microphones, as well as her body, objects, and sensing components as part of circuits.

Leonie Strecker employs listening as a central approach: By actively choosing and loading to memory certain moments of the performance, inter-modulating these and playing with those variations of earlier sound events, she actively, yet intuitively aims to take decisions on the formal process of the performance.

Figure 1: Visualization of a network of coupled Kuramoto oscillators.

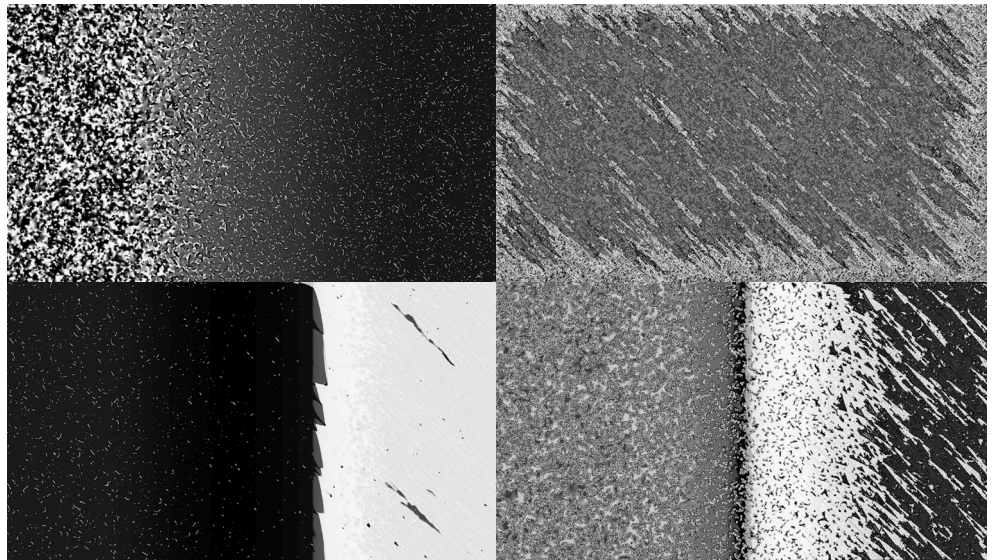


Figure 2: Ji Youn Kang working on her instruments.

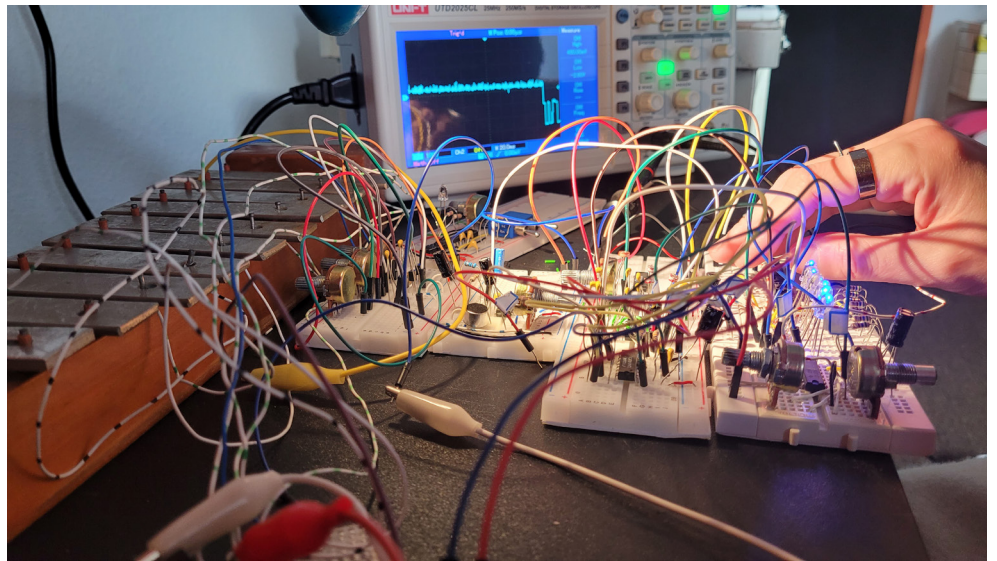


Figure 3: The quartet performing in April 2023 at the IEM Graz.



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Breathless: A Performative Sensor-to-Sound Installation

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This proposal draws on the conglomeration of several layers of affective markers collected from my body as ongoing months-long recordings during exposure to live audio-visual feed of protests in Iran for the past 7 months, marked as emotionally-intensive events for those in exile with families in Iran such as myself. Machine learning will then be used as a strategy to make sense of the durational data towards sonification which will then be mediated by my live biological signals during a performance. The goal behind this 20-minute-long performance is to enable the unfolding in the sound along with the live aspect to create a strong sensory spatial-temporal representation of historical trauma of a nation with a turbulent history where the affective and atmospheric sensations are made felt. The human-machine hybrid, meanwhile, manifests affect through compressing, compiling, segmenting, sampling, and granulating of data as an act of sense making out of such pools of data.

Keywords: Affective Computing, Machine Learning, Sound Performance, Quantified Self.

Overview

Breathless is an effort to communicate ineffability and sensorial-corporeal dimension of lived experiences of collective trauma, particularly ongoing historical trauma tied to turbulent socio-political history. In so doing, I plan to build an interactive experience rooted in (im)materiality of performative-atmospheric media (Salter 2014), dynamic sound in this context, for an ecology that sits outside homogeneous space-time and the Western-oriented habitual forms of listening. To this end, I have been collecting my breathing patterns as a sound library while acquiring biological signals¹ from myself using a wearable that forms a database to be sonified² and integrated into a sound installation activated by a live performative component. My aim behind this experimental interactive performance is to excavate and reconstruct textures from affective intensities of traumatic experiences towards activating audience's precognitive registers leading to a complex milieu of "affect as interaction" (Boehner et al. 2007).

Description



Figure 1: Empatica E4 worn around my wrist.

This proposal is founded upon collecting affective markers from my body to be integrated in a sound piece activated by a live component. The base layer of the sound is composed of breathing patterns, voiced and non-voiced gestures associated with breathing, e.g., sighing, swallowing saliva, moving lips, and sniffing. This compilation is currently being made by ongoing months-long recordings of these somatic responses during exposure to live audiovisual feed of the protests that have been at their height in Iran for the past 7 months which especially manifest as emotionally-intensive events for those in exile with families in Iran such as myself. The recordings library will then be composed into a single track using a Generative Adversarial Network (GAN) architecture. Meanwhile, the biological signals acquired from me using the Empatica E4 wristband (Fig. 1 and 2) during the same time-frame also form a database where patterns found therein become sonified and woven into the breathing patterns.³ I will then take a listener-centered approach towards designing the sound for an aesthetic outcome using the raw audio outputted by the machine as well as spatializing the result for an immersive sonic experience.

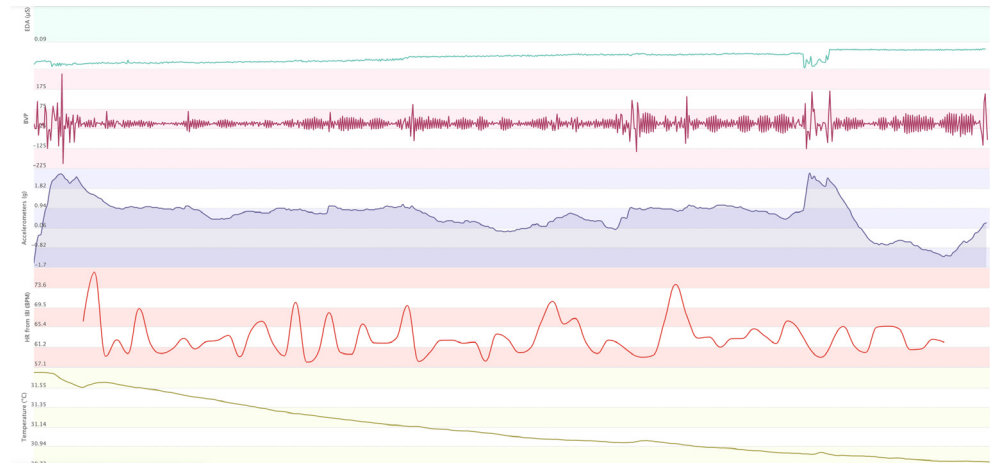
1. Biological signals are the hallmark of the operative logic of 'affective computing' that is meant to develop intelligent devices and systems to recognize, analyze, categorize, and eventually simulate patterns that emerge in signals such as blood volume pulse and skin conductance associated with one's psychosomatic state. Such data pervasively collected and shared via personal wearables under the banner of 'quantified self' movement are the seedbed nourishing the dataveillance machinery. My project, thus, is an antithesis and an act of soft resistance against such a logic.

2. Data sonification is here taken as an alternative to data visualization which is the predominant pathway chosen to make sense of data. Similar to data visualization, sonification is simultaneously a technical and an artistic approach with results dependant on the vision and aesthetic decisions of the artist-scientist.

3. Using Variational Autoencoder (VAE), an Artificial Neural Network (ANN) architecture.

The live component of the project consists of acquiring biosignal data from myself to be streamed to a Digital Audio Workstation (Ableton Live)⁴ that receives them as numerical data via Open Sound Control protocol⁵ and maps them into dynamic changes (e.g., re-verbs, granulations, and distortions) tied to synthesizer parameters of the composed piece while I will be watching videos of protests. The goal behind this 20-minute-long proposed project is to allow the unfolding in the sound driven by my affective response during the live performance create a strong sensory spatial-temporal representation where the affective and atmospheric sensations are made felt in the body (Hartelius 2020).

Figure 2: Visualization of a sample of my biosignals captured by E4 wristband. From top to bottom: EDA (Electrodermal Activity), BVP (Blood Volume Pulse), ACC (Accelerometer), HR (Heart Rate-derivative of BVP), and skin temperature.



Thematic Statement

The proposed piece composed between the human-machine hybrid (Haraway 1991; Hayles 1999, 2017; Suchman 2012) has the ambition to unfold the repetitious and yet continuously changing loops of a constructed sound that withholds the traumatic affective gestures. The aim is to allow the performance intensities bleed into the sensor-to-sound flow for a sonic experience marked by affect that sits outside the homogeneous space-time and the habitual forms of listening where the atmospheric sensations are transmitted to the audience for an embodied communication. Through this approach, I aim to render the ineffability of exile tied to socio-political oppression palpable through the language of the sensate body that speaks of the psychosomatic complexity of such experiences. The human-machine interdependence mediates the data processing and clustering while compressing, compiling, segmenting, sampling, and granulating sonic data and sonified data as acts of sense making out of such durational pools of data.⁶

4. <https://www.ableton.com/en/>

5. Designed at the Center for New Music & Audio Technologies (CNMAT) by Matt Wright and Adrian Freed in 1977, OSC is an encoding for live data communication especially designed and commonly used for multimedia musical performances but also functional between any hard and software endpoints that target real-time data exchange.

6. Aside from the creative use, the integration of AI in this project offers a critical dimension, questioning the reliance of AI in general on the universalized assumption of cognition and

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logic as markers of intelligence attached to Western gendered norms while discounting affect, embodiment and situatedness; and data-driven AI in particular on large disembodied datasets gathered without consent that perpetuate social inequalities (Crawford 2021; Weber & Prietl 2021). This project in contrast not only integrates durational somatic data to represent notions such as situatedness and embodiment classically ignored by quantification and classification obsession of the AI “breakthrough” but also focuses on realities of gendered, marginalized, racialized, and politicized lives, far distant from the normative target of technochauvinist corporate capitalism.



Take Me Somewhere, but Don't Leave

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The performance *Take Me Somewhere, But Don't Leave* explores the relationship between humans, technology and communication through the lens of the theories of philosopher and media theorist Vilém Flusser. With a series of live generative visuals and soundscapes, the performance takes the audience on a journey through shifting landscapes representing different stages of the technologization of society and our consciousness in this telematic society. From a primitive, listening world with no direction, to a historical linear consciousness, and now, through the power of the apparatus, we are back in a new mystical world with the consciousness of going nowhere, as the artist feeds her Instagram live into the visual and uses feedback techniques to re-synthesize the technical images and her voice. We are left in a state of inner reflection, as the directionless world is created by technology, leaving us feeling lost and unsure of our surroundings. The artist tries to wake up the person which is presented, but she seems to have fallen into a deep sleep and a dream-like state. The performance is created using generative sound with SuperCollider, and live visuals with TouchDesigner, manipulated and improvised in real-time by the artist which offers a rich immersive sonic and visual experience.

Keywords: Generative Audiovisual Performance, Algorithmic Composition, SuperCollider, Improvisation, Technical Images, Re-synthesizing, Live Feedback, Social Media.

Figure 1: Live at MaHalla Berlin CTM
Vorspiel 2023.



Inspiration

The works of philosopher and media theorist Vilém Flusser have been a source of inspiration for artists and creators for decades, exploring the relationship between human beings, technology, and communication. In this performance, I seek to capture Flusser's ideas and bring them to life through a unique audiovisual experience.

The idea for *Take Me Somewhere, But Don't Leave* also stems from my own experience of returning to the city after a ten-day silent retreat. It became clear to me that I am already a receiver and creator of a immersive, imaginary world of new media.

In particular, I am intrigued by the concept of feedback in technical images and how it leads us to a "dimensionless" (Flusser 2011) state.

This feedback enables the images to change, to become better and better, and more like the receivers want them to be; that is, the images become more and more like the receivers want them to be so that the receivers can become more and more like the images want them to be. (Flusser 2011, p. 54)

The telematic society we live in today is marked by a constant inner dialogue intertwined with outer dialogue, a perpetual creativity driven by self-forgetting, and it is a new listening world with "an eye for an ear". This new dimension is shaped by the constant re-synthesis and projection of technical images and sounds, leading us to question what constitutes us as individuals and our collective memory and dreams.

Through a combination of immersive visuals, soundscapes in a live performance, the audience will be taken on a journey through a series of shifting landscapes, each representing a different stage in the technologization of society and our consciousness.

Composition and Concept

It is a journey starts from primitive/listening world with no direction, to a historical linear consciousness, and now, through the power of the apparatus, we are back in a new mystical world with the consciousness of going nowhere. This Performance has five parts:

Part 1: Intro – Directionless

The performance begins with a sequence that evokes a world before technology, where the relationship between human beings and the environment is more direct and intuitive. “First rung” – in Flusser’s term, – “Animals and ‘primitive’ people are immersed in an animate world, a four-dimensional space-time continuum of animals and primitive peoples. It is the level of concrete experience” (Flusser 2011). This is a listening world without visual clues, where the focus is on the “deterritorialization of sound” (Cox 2003), its movement and intensity, and the experience of the moment, instead of the division in space. Using SuperCollider and pulsar synthesis, a live-generated soundscape is created, where the sine waves are constantly slightly changing.

Part 2: Directional

As the visual elements slowly fade in, the contrast between direction and directionlessness becomes apparent. In this part, the audience travels down a forward-facing tunnel, where linear thinking and minimalistic ascending twelve tones dominate. This section represents our historical consciousness, where the world is experienced in a linear and predictable manner.

Figure 2: Screenshot of Composition Part 3.

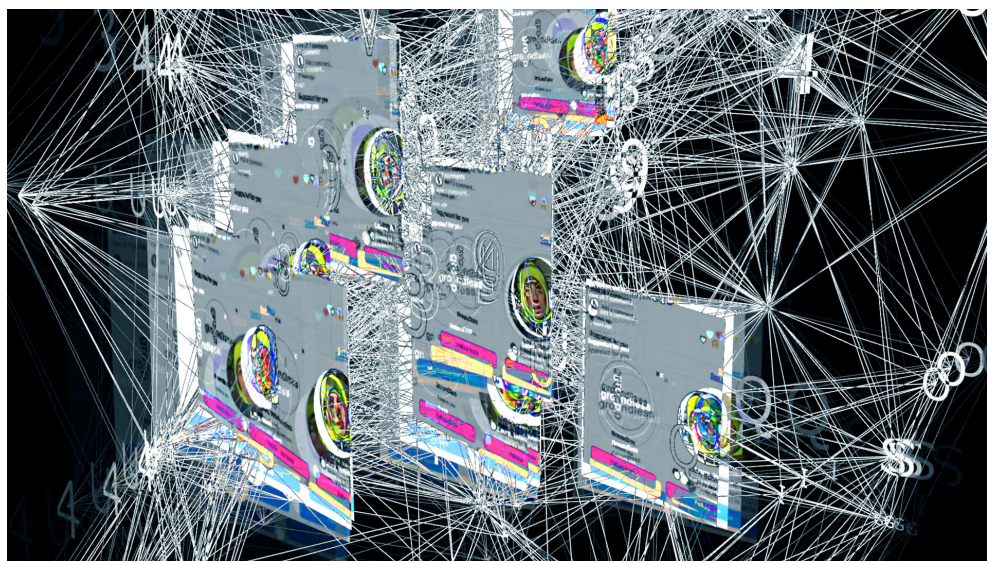
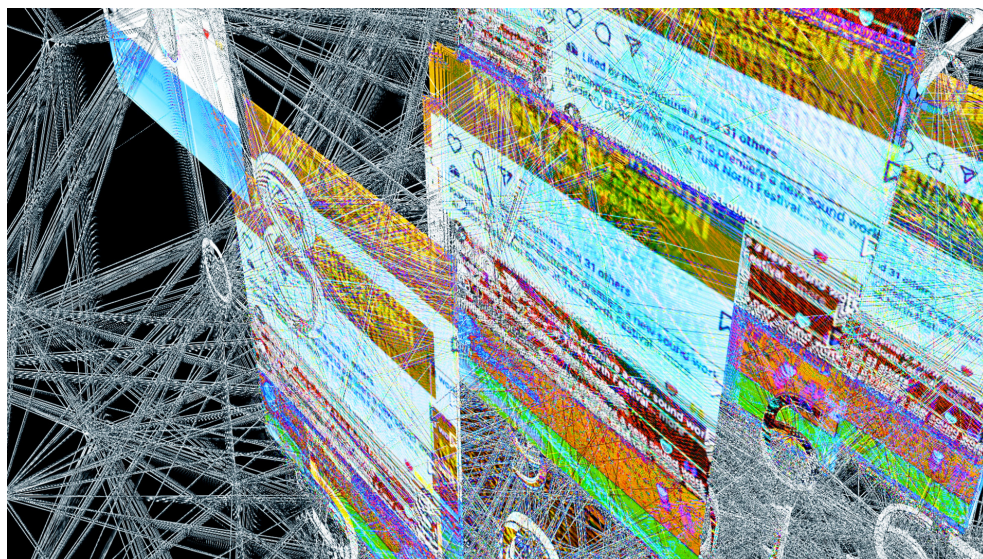


Figure 3: Screenshot of Composition Part 3.



Part 3: Dimensionless

As the performance progresses, the audience is gradually introduced to an imaginary world with new apparatus and forms of communication. This section explores the “dimensionless” state created by the constant re-creation and re-synthesis of technical images. Which is a constant upward spiral movement of “disintegrate into particles — envision a concrete world — disintegration into particles...” (Flusser 2011).

A network-like graph is slowly grown. A live-generated visual landscape is created, fed by my Instagram feed live, it represents the telematic society, a constant world wide dialogue (Fig. 2, Fig. 3). I incorporate feedback techniques to further distort and re-create the visual elements. The technic of “Buffer rewriting” is implemented here for the voice with SuperCollider. It shows how information in the world and information in general is generated: “by synthesizing previous information” (Flusser 2011).

The performer scrolls the screen, interacts with social media, and reads out the information, which is the bubbles generated through the feedback of recommendation algorithm. We and machine engage with image and sound in a playful game in this telematic society for the purpose of generating information (Flusser 2011). It reflects on the idea of the outer dialogue of a telematic society, that there is no isolated genius creator, rather “the person of the future will be absorbed in the creative process to the point of self-forgetfulness” (Flusser 2011), and this is a work where “many people participate and where the work [...] cannot only be endlessly reproduced but also continually changed” (Flusser 2011).

Part 4: Wake Up, Go where?

As the performance reaches its climax, the visuals become more complex and the soundscape becomes more synthetic. It is a close

feedback loop, that the technical images translate historical events into infinitely repeatable projections. And through the power of envision, we dry out the history and project ourself onto the future — but it is an eternal return of the same boredom.

We are left in a state of inner reflection, as the directionless world created through technology leaves us feeling lost and unsure of our surroundings. The performer tries to “wake up” the person (Fig. 4, Fig. 5), make her get up from the bed, and go out of her room, but it seems as though she have fallen into a deep sleep and a dreamlike state.

Figure 4: Screenshot of Composition Part 4.



Part 5: Outro — A New Spiritual World

The journey ends with a return to a mysterious, spiritual world that is sucked into the fullness of history. This final section brings the audience back to the primordial listening world, with a focus on the intangible and mystical qualities of sound. A world where the dimensionless state created by technology is experienced in a new light.

Figure 5: Live at MaHalla Berlin CTM Vorspiel 2023.



Generative and Audiovisual

The soundscape of the performance is dynamic and ever-evolving generated through SuperCollider. This open-source programming language for audio synthesis allows me to interact with and shape the sound in real-time, allowing machines to surprise me with their inner dialogue and interactions. It promotes a new level of improvisation, a creativity in the way we play with apparatus for creating sounds and images through its capability of self-programming.

One technique of this performance is “buffer rewriting” in SuperCollider, which allows me to re-synthesize my voice on the fly. The algorithm constantly writes my voice into a buffer, which is then read in an unpredictable manner for a certain period of time until the buffer is overwritten with new information. This creates a constant cycle of rewriting and re-reading, resulting in a unique and evolving soundscape. It is a improvisation with “continually reprogrammed memories will replace the score” (Flusser 2011).

Furthermore, I live feed my instagram live into the generative visual via OBS and NDI in TouchDesigner, which is also an important part of the algorithmic composition. As the posts and ads are filtered by my personal instagram recommendation algorithms, it represents a concrete level of the close feedback circuit of our collective brain.

The soundscape and visual incorporate generative strategies for feedback, adding to the overall movement and fluidity of the performance. These generative work in tandem with the post-digital visual aesthetic to create “sounding images and visible sound”. Sound and visual are both raised to a new level, the audiovisual — “once they have both become electronic, the visual and acoustic technologies will no longer be separable” (Flusser 2011).

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