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Perceptions of Creativity in Artistic and Scientific Processes

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This paper presents the results of a factorial survey research on perceptions of artistic and scientific creativity in humans and AI. A general reluctance at attributing creativity to artificial systems is well-documented in the literature on the theme. Aim of this survey is to test whether this reluctance is equally strong when participants evaluate scenarios where human and artificial agents are involved in processes of scientific discovery and scenarios where they are engaged in artistic creation processes. The starting hypothesis of the study is that participants should be less hesitant at attributing creativity to artificial agents when the latter engage in scientific discovery processes. Findings, however, disconfirm this assumption, showing that participants attribute significantly less creativity to artificial actors than to human ones, and even more so when they are involved in scientific processes.

Keywords creativity, AI, factorial survey, discovery, art, science

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1. Introduction

State-of-the-art Machine Learning (ML) systems are expanding their reach toward a field that, by many, is considered to be a paradigm of humanity: creativity. From composing music in the style of Bach, to creating paintings sold for hundreds of thousands of English pounds at renowned auction houses, to having their say in the fashion industry (Byers 2020), algorithmic programs are raising excitement and awe in the public but also a great deal of critiques and indignation (Hertzmann 2018, 2020; Jones 2019). The question of whether artificial systems can also be creative has been rapidly gaining attention since the 1990s, when Margaret Boden shared her work on computational creativity (Boden 1998). In the last decades, many programmes were designed with the aim to build systems that exhibit creativity in visual arts (Colton 2012), music (Eigenfeldt and Pasquier 2011, Moruzzi 2020), and poetry (Gatti et al. 2012). Easily accessible web platforms allow users to create their own art through generative algorithms, without the need for them to learn technical terminology or programming languages.[1]

Cutting-edge developments in ML do not involve only the artistic but also the scientific sector. Indeed, in recent decades, relevant research has been conducted with the goal of developing Artificial Intelligence (AI) systems that can assist humans in scientific research and discovery.[2] Debates on the creative skills that might be displayed by artificial agents range from the academic to the industrial sector, and almost everyone agrees with the claim that creativity can be observed both in arts and in the sciences (Gaut 2010). The disanalogies arise when considering that, while artistic creativity often has an open goal, scientific creativity is more goal-oriented (Dutton 2001; Leddy 1990),[3] and while for the first it is more usual to talk about 'creation', for scientific creativity we normally talk about 'discovery'.

The question of whether it is possible for automated systems to make scientific discoveries goes back to the debate about induction and how it is possible to identify a logic of discovery when chance and insight play a relevant role in scientific discovery processes (Alai 2004; Hempel 1985; Hume 2000; D. F. Norton and M. J. Norton 2007; Popper 1998). A framework for creativity in science, developed in the philosophical and psychological literature (Darden 1997; Feyerabend 1987; Getzels and Csikszentmihalyi 1967; Miller 2012; Sawyer 2011; Simonton 2003), is a necessary starting point for discussions that concern machine discovery programs and to what extent they can facilitate scientific research (Colton and Steel 1999).

This paper aims at contributing to address this need by presenting the results of a study on perceptions of artistic and scientific creativity in human and artificial actors. A general reluctance at attributing creativity to artificial agents is well-documented in the literature on the theme (Colton 2008; Lamb, Brown, Clarke 2018).

1. See, for example, https://app.wombo.art and https://www.playform.io

2. For example, Dalton, Stahl, AlphaFold, BACON, metaDENDRAL, and others, see (Sparkes et al. 2010).

3. This observation was made also by several participants in the free responses, see section 2.3.

The contribution that this paper aims to bring to the debate is to offer an additional quantitative and qualitative analysis of this phenomenon and to test whether the attribution of creativity to artificial systems that engage in processes of scientific discovery would meet the same amount of resistance to the one registered by previous studies on the evaluation of 'artistic' creativity displayed by artificial systems (Hristov 2020; Moruzzi 2020; Natale & Henrickson 2022).

The study presented in this paper addresses some of the limitations that past surveys on perceptions of artificial creativity by the author had, making a clear distinction between 'creativity' and 'art', notions that originated confusion in previous studies (Moruzzi 2020). In so doing, this study explicitly refers only to the *process* of creation of an artefact, excluding the evaluation of the features of the *outcome* from the dimensions addressed in the survey. This decision was made in agreement with the claim that the consideration of the process through which an agent creates can have a stronger influence on the overall creativity evaluation than the mere perception of the outcome (Colton 2008). In addition, the focus on the process is motivated by the observation that, while the evaluation of creativity based on the outcome undoubtedly has the advantage of being more easily measurable and identifiable, it is also more often subject to implicit assumptions and biases on the linearity of creativity (Glaveanu & Beghetto 2021).

2. Survey on Creativity in Science and the Arts

2.1. Aims

Results obtained from a survey conducted by Moruzzi (2020), aimed at investigating the public perception in respect to the possibility for AI to be 'creative', revealed a generalised discontent and, almost, and aggressive fear in respect to the application of artificial intelligence systems in the creative sector. The uneasiness displayed by participants to the study emerged from the belief that automated systems do not, and *could* not, possess the empathy and charisma that are necessary for performing creative processes. When considering what is that AI lacks to be creative, a vast array of elements was listed by participants: feelings, emotions, personal narrative, intentionality, memories, intuition, autonomy, emotional need, unpredictability, emotional understanding, social identity, passion, experience, imagination, consciousness, desire to make art, charisma, among others. Rather than being motivated by a lack of technical capabilities, this opposition toward the attribution of creativity to artificial systems was grounded on a resolutive belief that AI cannot, and *should* not, be creative since it lacks the necessary personality, feelings, and emotions that are a requisite of creative agents.

The emphasis on aspects of sensibility, individuality, taste-expression, and emotions in creative processes is part of the legacy of the Romantic view of creativity (Feyerabend 1987; Hills & Bird 2018). In the literature about scientific discovery, instead, there is arguably less emphasis on creativity as expression of emotional participation and personality and more on creativity as goal-orientedness and problem-solving (Sawyer 2011; Simonton 2003). The standing point from which the survey presented in this paper – a follow-up of the previous study by the author - starts is not completely neutral. Indeed, starting from the consideration of the features that participants to the study in (Moruzzi 2020) identified as prerequisites of creativity, and based on the mentioned different characterisation of artistic and scientific creativity in the literature, the starting hypothesis of the survey is that the attribution of creativity to artificial systems could meet less resistance when the latter engage in scientific discoveries than when engaging in artistic processes. Indeed, the personality, feelings, and emotions that artificial systems were deemed as lacking in the previous study are, arguably, not pre-eminent requisites of scientific creativity.[4]

4. Additional aim of the survey is to study the mutual influences between the attribution of agential and creative skills to human and artificial actors. For the sake of the present discussion, however, I will focus here only on the dialogue between artistic and scientific creativity, leaving further considerations to later analyses.

2.2 Methodology

2.2.1 Procedure

The survey was conducted in the form of an online questionnaire with 53 questions in total. Respondents were recruited online through academic newsletters in philosophy, art, and computer science. The final sample of the study consisted of 161 participants. At the start of the questionnaire, participants completed an online consent form and a demographic questionnaire that included questions about age, level of education, and current occupation. No question about the gender and ethnical background of the participants was asked. The mean age of participants is 39.1 years. As predictable from the platforms in which the survey has been advertised, most of the participants have a university-level education (157 out of 161). In particular: 126 participants have a humanities, 22 an artistic, 15 a scientific, and 11 a technology educational background (selection was not mutually exclusive). The current occupation of the participants is distributed as follows: Student 44, Academic 66, Engineer 3, Teacher 10, Admin 7, Retired 6, Other 25.

Participants were then asked questions regarding their intuitions about creativity and agency (results in section 2.3). The core section of the questionnaire consisted in a factorial survey experiment which will be described in detail in what follows. After successfully completing the questionnaire, participants were asked for their E-Mail address to participate in a raffle for one of three 50,00€ vouchers to use on an E-commerce platform chosen among the ones within a given list.

2.2.2 Factorial Survey

The central section of the survey included two vignettes designed according to the factorial survey method (Auspurg and Hinz 2014). The latter is a multidimensional approach that presents survey respondents with vignettes which describe hypothetical situations with various attributes (dimensions). Respondents are then asked to form judgments about them. The values (or levels) of the dimensions of the vignette are experimentally varied so that the impact of these levels on participants' judgments can be tested.

The relevant dimension for the discussion carried out in this paper, is the 'Actor' dimension, namely the identity attribute of the individual/s performing the action. The values used in the survey for this dimension are:

(i) Human
(ii) AI
(iii) Human + Human
(iv) Human + AI

Systematic differences in creativity ratings for human or artificial actors given by participants are analysed to illustrate the influence that the 'Actor' dimension has on the evaluation of creativity. Other dimensions included in the survey design, which will not be addressed in this paper, are Agency, Embodiment, and Explainability.

Eight vignettes resulted from the random combination of all the dimensions and values involved (Table 1). Vignettes 1-4 are about individuals (human or AI), while 5-8 are about multiple actors (human+human or human+AI). A random selection was then programmed into the survey to determine which vignettes to present at the beginning of the survey to each participant.

Table 1. Distribution of dimensions in vignettes.

Vig.	**Identity**				**Agency**		**Embodiment**		**Explainability**	
	Human	AI	Human+Human	Human+AI	Yes	No	Yes	No	Yes	No
1	x				x		x		x	
2	x					x	x			x
3		x			x			x		x
4		x				x	x		x	
5			x		x		x		x	
6			x			x	x			x
7				x	x		x			x
8				x		x		x	x	

Participants were asked to read and evaluate two hypothetical scenarios: A. Painting a picture, B. Developing a vaccine. They had to read through the described scenarios carefully and provide their impression of the displayed levels of agency and creativity by the actors in these scenarios.

Scenario A (Painting) described an actor/multiple actors in the process of painting a canvas. According to the level of the different dimensions, the actor/s are described in the process of painting the picture by "randomly picking some colors and tools" (Not displaying Agency) or by "observing the picture and deciding to stop painting" (Displaying Agency). If the level of the dimension Embodiment is positive, the AI is referred to as a robot, if not as a software. Lastly, if the process undertaken is explainable, the vignette closed with the "record of the process of painting the canvas [...] published in an open-access journal", if not the vignette reported that "no record of the creation of this painting is available because a full report of the processes that led to the result could not be produced".[5]

Scenario B (Vaccine) described an actor/multiple actors in the process of making experiments to find a vaccine against the SARS-CoV-2 virus. If the actor/s displayed agency, they were presented as "generating hypotheses" and carrying out experiments accordingly, if not as trying "all combinations of the available background knowledge and models to generate hypotheses" and "selecting the most statistically relevant answers". The dimensions of Embodiment and Explainability were treated similarly to Scenario A.[6]

2.3 Results

2.3.1 Creativity Dimensions

Prior to engaging with the factorial survey experiments, participants were asked to answer questions aimed at testing their intuitions regarding the two key concepts of agency and creativity. Here will be reported only the results concerning the notion of creativity.

To the question: "Which of these concepts do you associate with the notion of 'creativity'?", participants were asked to choose among the following features all the ones that applied: Novelty (128), Problem-solving (87), Surprisingness (66), Value (52), Instinctiveness (50), Serendipity (22), Unexplainability (20), Genius (33), Pleasantness (4). Novelty, problem-solving, and surprisingness are features of creativity that are attributed to creativity not exclusively in the artistic field, but also in other domains (Miller 2012; Sawyer 2011; Simonton 2003). A detail that should be noted is that, while the attribute 'Pleasantness' was selected just by 4 participants, in the free response field of the factorial survey section, many participants referred to the relevance of the final product for the evaluation of creativity. Here are some examples:

- I really don't think I can answer any of the below questions (strongly agree vs. strongly disagree) without having actually seen the painting. [participant n. 2028249815]

- Unable to decide without knowing the content of the painting. Not every painting is equally creative. I would need to see the painting. [participant n. 1246012058]

5. I acknowledge that the choice of using painting as the representative of 'Art' is controversial, as it can be seen as a reduction of the richness of other art forms. This decision was made on the basis that the survey was designed with a non-specialist audience in mind, for which the association between painting- and art would arguably result more immediate. In addition, the space for the scenario description was limited and less traditional artistic processes would have taken longer to contextualise and explain. I thank an anonymous reviewer for bringing this observation to my attention.

6. Text of the survey available at: https://www.dropbox.com/s/3gfppuae12jn8aj/Survey_Agency_Creativity.pdf?dl=0

× The level of creativity will partially depend on the finished product. [participant n. 1557038500]

× I'd need to see the result to tell how creative it is. [participant n. 1737371147]

The low score achieved by 'Pleasantness' here, thus, should not be confused with participants identifying the process rather than the product as the site of expression of creativity.

No specific methodology for the evaluation of creativity is adopted in this study. Namely, in the factorial survey participants were not asked to provide a rating of the creativity exhibited by the human and artificial actors with reference to determinate features, such as imagination, skill, novelty, value, etc. (Colton 2008; Jordanous 2012; Moruzzi 2021). Being asked to indicate the concepts that they usually associate to 'creativity' in the initial phase of the questionnaire, participants are rather primed to reflect on their own intuitions about the topic and to follow these intuitions when assessing creativity in the scenarios presented in the vignettes. This was done with the intent of avoiding constraining the assessment of creativity made by participants to a pre-existing model.

2.3.2 Evaluation of Creativity

After reading each of the two vignettes, participants were asked how they rated the process of creation of a painting (in scenario A) and the process of discovery of the vaccine (in scenario B) for their creativity on a scale from -3 to +3, where -3 was 'Not at all creative' and + 3 'Very creative'. In both scenarios, the average creativity was evaluated as 0.6 (Figure 1).

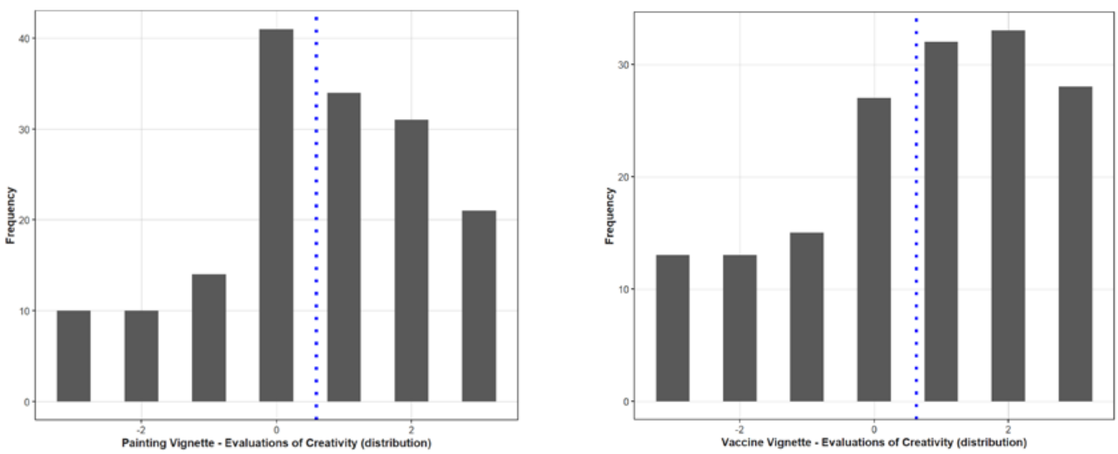


Fig. 1. Creativity distribution in the vignettes.

The creativity displayed by different actors in the process of painting a canvas, thus, has been evaluated by participants equally to the creativity exhibited in the process of making a scientific discovery. This result already carries a partial relevance in respect to the initial hypothesis of the study, i.e., overall, there does not seem to be a difference between the evaluation of creativity in artistic endeavours and in scientific discovery processes. Still, in order to more thoroughly test whether the starting hypothesis is disputed, it is worth considering the factors that influenced the evaluation of creativity displayed by human and artificial agents in both scenarios.

The focus of this paper lies on the impact that the identity of the actor performing the action, namely whether the actor is human or artificial, has on attributions of creativity. This is the analysis that will be reported in what follows, leaving aside the consideration of the influence of the other dimensions (i.e., Agency, Embodiment, Explainability) on the evaluation of creativity. Table 2 shows how the participants' evaluation of creativity change by varying the levels in the Actor dimension in respect to the baseline (corresponding to the actor being a human individual). Values are rounded to the nearest hundredth.

Table 2. Factors impacting perceptions of creativity.

	Actor Dimension			
	Human (baseline)	AI	Human & Human	Human & AI
	Painting scenario			
Estimate	0	**-0.88**	-0.54	-0.18
Std. err.	0	0.44	0.37	0.38
z value	0	-2.00	-1.44	-0.48
Pr(> |z|)	0	0.04	0.15	0.63
	Vaccine scenario			
Estimate	0	**-1.00**	**-0.74**	-0.58
Std. err.	0	0.43	0.37	0.43
z value	0	-2.31	-2.01	-1.36
Pr(> |z|)	0	0.02	0.04	0.17
	Combined scenarios			
Estimate	0	**-0.98**	**-0.68**	-0.39
Std. err.	0	0.31	0.25	0.27
z value	0	-3.07	-2.68	-1.46
Pr(> |z|)	0	0.002	0.007	0.14

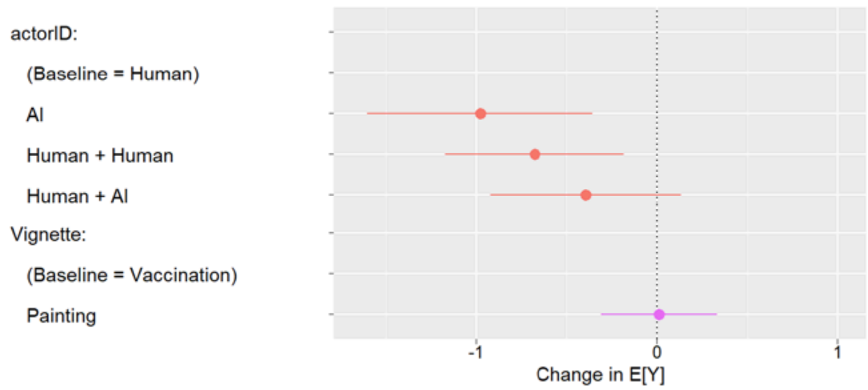
From the Estimate row, it is possible to see that in both scenarios, just for the fact of not being a human, but rather an artificial actor (other dimensions being equal), the AI is judged as 0.88 or 1.00 point less creative than humans.[7] What is more surprising is that in the case of the vaccine scenario also the team composed of two humans (-0.74) results significantly less creative than an individual human (0), and even less creative than the team composed of a human and an artificial intelligence (-0.58). Combining the results of the two scenarios, similar results are obtained: both AI (-0.98) and the team composed by two humans (-0.68) are deemed significantly less creative than a human individual.

7. In Table 2 the significant estimates are indicated in bold, where the significance is indicated by the Pr(> |z|), the so-called 'p-value'. The latter is a number between 0 and 1 which describes how likely it is that the null hypothesis is true, where the null hypothesis states that there is no relationship between the variables being studied. To be statistically significant, the p-value should be less than 0.05. This value indicates strong evidence against the null hypothesis, as there is less than a 5% probability that the null hypothesis is correct and that there is no relationship between the variables studied. It should be noted that from the fact that the p value is significant, does not automatically follow that the alternative hypothesis that the independent variable did affect the dependent variable, and the results are significant in terms of supporting the theory being investigated, is true.

[Figure 2] presents the results of the combined scenarios reported in [Table 2] graphically.

Fig. 2. Factors impacting perceptions of creativity in combined scenarios.

Attribute	Level	Estimate	Std. Err	z value	Pr(>|z|)	
actorID	AI	-0.9772672	0.3177047	-3.0760241	0.0020978	**
actorID	Human + Human	-0.6767014	0.2522837	-2.6823034	0.0073117	**
actorID	Human + AI	-0.3928324	0.2692261	-1.4591168	0.1445330	
Vignette	Painting	0.0129099	0.1629443	0.0792291	0.9368504	



The hypothesis that there should be less resistance against artificial creativity in the context of scientific discovery has not been confirmed. Rather, by looking at the estimated values, in the vaccine scenario AI has been judged 1 point less creative than a human actor, while in the painting scenario it has been judged 0.88 point less creative than a human actor. Even if the difference between the two estimates is minimal, AI is recognised less creative when engaging in a scientific discovery than in an artistic process.

Instead of ascribing the low rating of creativity attributed to AI to just the identity of the actor, other reasons could be argued for. For example, it can be claimed that the two scenarios described do not allow a generalisation of the results and to conclude that, in general, AI is deemed less creative than humans in any artistic or scientific endeavour. Another possible argument is that the creativity rating was lower in the scientific discovery scenario because creativity is arguably more often associated to artistic than to scientific processes. The motivations behind the low level of creativity ascribed to artificial actors, as well as to the team composed by two humans, can be investigated further by considering the comments given by participants in the free response field in the factorial survey section.

2.3.3 Free Responses

After being asked to evaluate the level of agency and creativity in both scenarios, participants also had to elaborate their answers through a free response field (compulsory to move forward in the questionnaire).

The possibility that the low attribution of creativity to artificial systems in scenario B (vaccine) could be motivated by a more general hesitation to recognise science as a field where creativity can be expressed, does not seem to be supported by the participants' comments. Despite acknowledging that creativity in science is a different kind of creativity to the one displayed in the artistic sector, none of the participants categorically refuses to recognise that creativity is an important skill for scientific discoveries. The following are some of the relevant comments to scenario B:

- All I'm trying to say is that the creativity needed for a scientific discovery is a different type of creativity, oriented toward problem-solving and teamwork, compared to the creative process in other fields. [participant n. 1902441942]

- [...] in contrast to the arts, creativity in science should be under control of the agent. Ideas might come uncontrolled, but the actual results should be under control. [participant n. 1939986821]

- Science requires creativity, since imitation and methodology rarely are enough discovery. [sic!] [participant n. 819642924]

- I consider that behaviour creative. However, during the process of true (artistic) creativity the goal itself is open. [participant n. 1501662647]

- In scientific experiments, the space for creativity would be low, especially one involving finding a vaccine against COVID-19. [participant n. 996487393]

The attitude expressed by participants in the comments in respect to the consideration of artificial actors as creative in the context of both artistic and scientific processes is similar. While some are favourable to the attribution of creativity to AI and recognise artificial actors as capable of expressing both agential and creative skills:

- [Alpha] did just what a creative, insightful scientist would have done. [participant n. 1167425615]

- There was collaboration and Communication of some sort between Helen and the robot and I think that is creative. [participant n. 1206682464],[8]

8. Dr Miller and Alpha are the names, respectively, of the individual human and of the artificial actor in scenario B. Helen and Omega are the names, respectively, of the individual human and of the artificial actor in scenario A.

most of the comments refer to the artificial actor as a ‘tool’, both when it is acting alone and in collaboration with humans. The debate around whether AI systems should be deemed tools for the human artists, or rather artists themselves, is well addressed in the literature (Hertzmann 2018, Loman 2018). The tendency at not attributing autonomy to the artificial actor, holding instead the human programmers behind it as responsible for the creative capabilities expressed, can be observed in equal measure in both scenarios, thus disputing the assumption that a more positive attitude toward the attribution of creativity in scientific discoveries would have been observed.

The following are some of the relevant comments to scenario B:

- It is using a tool (a self-learning machine) to undertake a task. I see this as little more creative than using a supercomputer to break a coded message using brute force. [participant n. 2006543588]

- The doctor is utilizing Alpha as a tool, a sophisticated tool - but in essence no different than a painter’s brush. [participant n. 2070596251]

- I think it is not a lot about creativity in this scenario, but about a clever use of a new (and sophisticated) tool called Alpha by the scientist. [participant n. 1440542658]

- Dr Miller is agent, Alpha is a tool. [participant n. 1923077464]

Here are a few of the relevant comments to scenario A:

- Helen uses the robot as a tool, both for the painting process and for the input for the colour palette. [participant n. 1724824616]

- Omega is more like a tool rather than an autonomous agent. [participant n. 1072971333]

- A robot cannot be creative: it should merely be a slave for humans. [participant n. 1078614007]

- On the one hand, if the action displayed above had been performed by a human, I would have had no problem to give an answer tending to the creativity side. On the other hand, the fact that the action above displayed is performed by a machine and so, by something which acts according to the program implemented in it by humans make me quite reluctant to attribute any level of creativity above the neutral midpoint. [participant n. 2021552982]

It has been mentioned above that the team composed of two humans was evaluated as less creative than the individual human and the team of human + AI in the vaccine scenario. No relevant observation is provided by participants that could help understand the motivations behind this evaluation. Rather, some comments express the importance of teamwork for creativity in the science domain. Here is an example:

> × I don’t doubt that Dr Miller has exercised scientific creativity necessary for all scientific discoveries. But it is highly unlikely that Dr Miller has acted solo. Scientific discoveries require teamwork, at least at one leg of the journey or another, if not at every stage. [participant n. 1902441942]

This observation would seem to go against the estimates resulting from the vaccine scenario. The lack of other significant results in respect to the difference between the attribution of individual vs. collective creativity, thus, does not allow to support a conclusion in this respect.

3. Conclusion

This study sought to investigate participants’ perception of human and artificial creativity in artistic and scientific scenarios. Based on results of previous research by the author (Moruzzi 2020), the study started with the hypothesis that participants would have been more inclined to attribute creative skills to artificial actors that engage in scientific discoveries rather than to actors that are involved in artistic processes.

Results obtained from the factorial survey experiments of the survey, however, disconfirm this hypothesis. The evaluation of the overall creativity displayed by actors in the artistic and in the scientific scenarios is almost equivalent. In addition, by observing the factors influencing the participants’ assessment of creativity in each scenario, the findings indicate that participants attribute significantly less creativity to artificial than to human actors, and even more so when they engage in scientific discoveries. From the consideration of the free responses provided by participants it has been observed that participants refer to artificial actors as ‘tools’, hesitating to attribute them the necessary autonomy required to be deemed agents of creative processes. The suggestion that the low creativity attributed to artificial systems in the scientific scenario could be a result of a general reluctance at associating creativity to the scientific domain has been countered by participants’ comments that acknowledge the relevance of creativity for scientific discoveries.

This paper focused on the influence on creativity attribution that the variation of the actors performing the process and of the field of application have.

Further work based on the factorial survey experiments will analyse the influence of other dimensions, such as agency attribution, explainability, and embodiment, on the evaluation of creativity. A limitation of the present study that could be addressed by more careful follow-ups is that it does not allow for straightforward generalisations of the results to the whole spectrum of art and science. This limitation is a consequence of, partly, the necessarily short and partial descriptions of the artistic and scientific scenarios and, partly, of the small and biased sample of participants. Succeeding studies can elucidate the motivations that lie behind the reluctance that this research illustrated, by varying more meticulously the different variables that are involved in a creative process and by recruiting a larger and more diverse sample of respondents.

The observations resulting from this study can pave the way for a deeper and more careful consideration of the dimensions that influence the attribution of creativity to human and artificial systems engaging with different kinds of processes. The provisional considerations that can be derived from the results obtained is that the hesitancy and unwillingness at attributing creativity to artificial systems is not limited to the artistic domain, traditionally recognised as the place where human emotions and feeling are expressed at their best, but it extends also to the more exact and rational field of science. This and follow-up research can then contribute to debates on the topic of creativity and technology in general, and at the same time inform the artistic practice and the technological developments in the field of human-machine collaboration.[9]

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Computational Aesthetics of the Collective Affective Dynamics of IMDB Movie Reviews

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This paper proposes an approach to visualising affective metadata from movie reviews on IMDB. First, a natural language processing (NLP) method is applied for automatic topic modelling and sentiment analysis using contextual valence and subjectivity as measures of emotional expression intensity. A t-Distributed Stochastic Neighbour Embedding (t-SNE) was used to project these metadata into a compact 2D representation. A cluster analysis was used to extract the spatial dynamics of this representation, which were mapped into a generative visualization. Each generated visual 'signature' represented the emotional dynamics of a single movie extracted from 150 reviews, for a total of 20 movies. Based on the visualised metadata, a qualitative evaluation of 79 participants demonstrated the capacity to communicate affective metaphors, as well as a robust sense of perceptual consistency. Furthermore, we assert that the generative visualisation of data shows a nuanced expression of an aesthetic approach instead of an abstract articulation of an idea.

Keywords affective computing, NLP, data art, data visualization, generative art, information aesthetics, dimensionality reduction

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1. Introduction

Since the very first days of computer science, data visualization has been evolved as an academic domain associated with empirical research techniques to interpret patterns and extract insights. While serving specialized needs in the research community, visualization techniques also focus on the effective communication of the meaning of data to generalist audiences. Information visualization has been used to explore the creative potential of data and the aesthetics of information, instead of focusing entirely on the data (Li 2018). These novel visualization techniques can be a powerful communication tool as they can enhance the aesthetic experience and thus facilitate understanding of large and complex data.

Nowadays, vast amounts of emotionally coloured text are being produced by humans expressing thoughts and opinions in a continuous way. Rosalind Piccard was among the first to highlight the importance of emotions in human computer interaction (Picard 1997). Communication of emotional states are ubiquitous features of the human world crossing the boundaries of many psychological subsystems, including the physiological, cognitive, motivational, and experiential systems (Salovey 1990).

The analysis of textual content, for emotion characterisation, adds an important dimension that enhances the understanding of the data. A data-driven design approach serves as a creative method to display data while revealing their underlying relationships, in order to facilitate understanding (Tufte 2001), (Moere 2007), and to bring focus on the aesthetic potential of the data (Li 2018). Emphasizing engagement and interest within the data, such as in the case of data art, could form data-driven visualizations that communicate not only information but also affective states (Viegas 2007).

The current research explores interdisciplinary concepts, such as machine learning, visual communication, aesthetics and art. It unfolds as follows. First, we describe a scheme for sentiment feature extraction from IMDB reviews. Second, we utilize a generative design approach for data visualization to communicate the subsequent features of topic modelling, sentiment and subjectivity for a target audience. Finally, we consider an assessment method for the communication capacity of the chosen visualization approach, from a cognitive - perceptive perspective.

2 Related Work

2.1 Information Aesthetics and Data Art

'Form follows function' is a principle in design and architecture which means that the purpose of an object or building should be the starting point for its design. This principle was the manifestation of the cultural movements of modernism, such as the Bauhaus (Droste 2002), which emphasized utility and eschewed ornamentation in favour of function. In a similar mentality, researchers and engineers prioritize the informativeness over attractiveness of their data visualizations. The most common visualizations are used to reveal the underlying structures of data, spatial and temporal relationships, with all of them paying a rather little or no attention to design aesthetics or visual communication principles.

On the other hand, 'Information Aesthetics' a term used in conjunction with concepts such as generative aesthetics, generative art or computational architecture (Nake 2012) focuses on the aesthetic experience of the data visualization. A number of research methodologies into aesthetics of data visualization pose fundamental questions such as what constitutes good data visualization and whether data visualization needs to be beautiful (Li 2018). It is certainly difficult to define what constitutes aesthetics; (Card 1999) suggests that applying aesthetics to data visualization could invoke a sensation on two levels. First, on an objective level, it can promote the focus on accuracy, efficiency, which are important attributes in scientific visualization. At the same time, it can be used to evoke a subjective experience of understanding in the form of an emotional response. Data art is a different form of 'information aesthetics' in that it consists of data representations that deliberately hinder and obscure the understanding of a dataset by integrating elements of subjectivity in the data mapping process (Lau 2007), (Billeskov 2018). The objective of data art is then to create aesthetic forms and artistic works by overstating and dramatizing some underlying qualities of the dataset instead of revealing trends or patterns (Moere 2007). Such visualizations are generally commissioned by non-governmental organizations and museums, which typically aspire to popularize a predefined message, or communicate a subjective interpretation of the data to a wide, lay public. From a broad perspective, encoding the information visually varies across research domains, depending on its purpose, from being purely functional with focus towards the visualization's maximum informativeness (Lunterova 2019) to more artistic and exploratory approaches with more attention towards its aesthetics and creative expression (Moere 2007).

2.2 The Aesthetic Experience

A highly criticized challenge of the aesthetic approach, is that the assessment of artistic value of the visual is considered as highly subjective and in lack of an adequate way to provide quantitative measurements (Brown 2011), (Li 2018). David Hume thought that aesthetic value was objective to some extent, and that we are predisposed to find certain objects and patterns to be aesthetically pleasing (Graham 2005). The recently established field of neuro-aesthetics brought an empirical approach with an attempt to explain and understand the aesthetic experiences at the neurological level. The early pioneers of neuro-aesthetics were seeking to understand how the brain creates and experiences art. They were primarily interested in the ways in which different parts of the brain are activated when we experience or create art (Chatterjee 2014). A growing body of neuro-aesthetic research examines the ways in which art can support cognitive function, emotional well-being, and social interaction (Nielsen 2017). Kandel suggests that abstraction and generalization are important for aesthetic appreciation. Our brain is constantly trying to find patterns and to make sense of the world. In order to appreciate the beauty of a work of art, we need to be able to see the big picture and to abstract the essential features of the work (Kandel 2016).

The cognitive-affective processing model (Mischel 1995) suggests that, while the functional approach involves the cognitive processes that interpret the content, aesthetics of the stimuli engage the affective processes. The functionality of affect can be directly observed in the way people react to certain stimuli in the environment, and indirectly in the way people cognitively process information about the environment (Schnall 2010). Although aesthetics are considered highly subjective, having a 'good taste' is not innate and can be taught which suggests the existence of underlying principles, that from a Kantian perspective, can be universal.

It is an open question as to how art drives human emotion, but the need for establishing aesthetic rules remains important. Art, by definition, is an expression of human creativity. It can be abstract or realistic, representational or non-representational. Art cannot be defined in one way. However, it is generally accepted that it is meant to evoke an emotional response in the viewer. Different people will react differently to the same work of art. Some might find a painting highly emotional, while others might find it merely decorative. Despite this, there are certain universals in art across cultures and over time that suggest there might be some features in art that are appreciated by all. One of these features is symmetry. There is strong evidence that people from all cultures prefer symmetrical shapes and patterns, perhaps because symmetry is associated with stability and order. Perspective is also widely appreciated. When an artist uses perspective in a painting, it gives the impression of depth and realism. This is because our brains are hardwired to detect depth.

Design concepts such as contrast, symmetry, and rhythm are being experienced in a similar way (Coren 1980) because of common pathways, neural activations and aesthetic preferences across individuals (Chatterjee 2014). Brown suggests that the aesthetic processing, as the appraisal of the valence of perceived artworks or everyday objects (Brown 2011) is the cooperative function of different brain areas of different sensory modalities. This further supports the hypothesis of the applied pre-attentive visual properties, producing specific affected states across groups of people based on specific art attributes such as path curvatures, shapes, colors, directions, trajectories, smoothness, acceleration, linear vs radial shapes etc (Feng 2017).

2.3 Assessing Art

The experience of art and aesthetics is a complex one, emerging from the interaction of multiple cognitive and affective processes. Understanding how this synergistic process produces an aesthetic experience remains a monumental challenge. Motivated by this need, Chatterjee et.al suggested the use of a questionnaire to quantitatively assess attributes of visual artwork (Chatterjee 2010) which they call "The Assessment of Art Attributes" (AAA). Based on this tool, attributes are divided into two classes. a) The formal perceptual attributes: balance, color saturation, color temperature, depth, complexity, and stroke style. b) The content representational attributes: abstractness, animacy, emotionality, realism, representational accuracy, and symbolism.

3. Augmenting text with affect metadata

Measuring the emotional dimension of textual data is important when quantifying individual opinions and personal attitudes from unstructured text, and natural language processing (NLP) can fulfil this requirement. NLP offers a range of computational techniques that can perform linguistic analysis for the purpose of achieving a better understanding of human language. We chose three categories of meaning to shape the identity of the visualizations; topic modelling, sentiment analysis, and subjectivity analysis.

3.1 Topic Modelling

This is primarily a methodology to detect relationships and semantic structures, referred to as topics, from a large collection of otherwise unorganized documents (Jelodar 2019). Topic modelling can be based on word embeddings which is a method to represent words in a text as vectors based on their relative meaning derived from co-occurrences in this text. Representing words in a vector space is commonly used for locating similar words that share common contexts.

A popular method to calculate word embeddings is the word2vec (Mikolov 2013), which can map words from a document into a high dimensional space, with each word being assigned to a corresponding vector. High-quality distributed vector representations of words can grasp quite precisely the syntactic and semantic word relationships of an input text. GloVe (Pennington 2014) is another popular word embedding project that uses a large corpus of crawled web pages to train a model on global word relationships. Because of the large pre-trained map of word-vectors, GloVe eliminates the need to train a model from scratch or estimate its parameters. GloVe was recently open-sourced by Stanford University which made it available to the public. Methods for topic analysis often include deep learning algorithms (Mikolov

2013), and regression models for unsupervised learning of word representations (Pennington 2014).

3.2 Sentiment Analysis

Detecting emotion from text can be summed into three categories, Knowledge based approaches, Learning based and Hybrid (Shaheen 2014).

3.2.1 Knowledge based approach

The key advantage of this approach is that it is easy to implement and does not require any special training or data. It is based on a pre-defined set of emotions, and the text is analysed to determine which of these emotions are expressed. However, the disadvantage is that the pre-defined set of emotions may not always be accurate in capturing the true emotion being expressed in the text. WordNet-Affect (Strapparava 2004) and NRC-VAD (Mohammad 2018) are examples of lexicons used in knowledge-based approaches. Word embeddings, such as word2vec, can be used for sentiment analysis and to estimate emotional polarity, but they cannot predict the emotional component, resulting in an imprecise distribution of emotionally colored words (Seyeditabari 2017).

3.2.2 Learning based approach

The goal of this approach is to learn how to detect emotions in text without a lexicon by either using a trained classifier or by using unsupervised learning techniques to discover the hidden structure of unlabelled data (Ahmad 2017). A supervised learning algorithm requires a large number of samples and thus the need to label them, whereas an unsupervised learning algorithm uses statistics to measure semantic relations between words within sentences and their relevance to targeted emotions.

3.2.3 Hybrid approach

It combines the strengths of knowledge-based and learning-based approaches. A pre-defined list of emotions is used to train a machine learning algorithm to recognize emotions from text. It’s more accurate than a knowledge-based method and more efficient than a learning-based approach (Cambria 2017).

3.3 Text Subjectivity

Subjectivity is a measure of whether comments are more factually stated, or more opinionated, usually ranging from (0, 1) where the author is expressing either own feelings and opinions or describing facts. It has been used in many applications such as to predict consumer's attitude towards brands (Mostafa 2013). Sentiment analysis and subjectivity detection are both methods of understanding the attitude of a text, be it positive, negative or neutral. Sentiment analysis is the process of identifying the attitude of a text, while subjectivity detection is the process of identifying how opinionated the text is. There are two main approaches to subjectivity detection:

1. *Rule-based approach:* This approach uses a set of rules to detect how opinionated a text is. The advantage of this approach is that it is easy to implement and does not require any special training data. However, the disadvantage is that the rules may not always reflect the true subjectivity of a text.
2. *Machine learning approach:* As a result of this approach, it is possible to identify non-rule-based subjectivity. However, it requires special training data and is more difficult to implement.

4. Generative Design & Aestheticization of Data

> As creation is related to the creator, so is the work of art related to the law inherent in it. The work grows in its own way, on the basis of common, universal rules, but it is not the rule, not universal a priori. The work is not law, it is above the law (Klee 1961).

Galanter describes generative art (Galanter 2003) as a creative 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". A particular advantage of generative design is that it can use metaphors to conceptualize abstract ideas, and convey meanings, thoughts and feelings in a more implicit and subconscious way (Feng 2017).

Generative art and information aesthetics could be seen as a vernacular response to the increasingly digital and automated world in which we live. The traditional art world has been critiqued for its focus on the elite and the inaccessible, while generative art can be seen as a democratizing force, providing a way for anyone with access to a computer to create and share art. Moreover, as the world becomes increasingly more data-driven, generative art can be seen as a way to make sense of the overwhelming amount of information that is now available to us. Generative art can be seen as having an important role in helping us to navigate and make sense of the complex world in which we live. In this context, information aesthetics and data art could be seen as important sub-disciplines of generative art where the focus is on the visual representation of data.

There are a few key features that make generative art well-suited for data visualization. First, generative art is often based on rules or algorithms that can be used to create a wide variety of visual results. This allows for a high degree of flexibility and variation, which is important for data visualization as it allows for the exploration of a large amount of data in a visually engaging way. Second, generative art often employs abstraction, which can be used to simplify complex data sets and make them more comprehensible. Third, generative art often has a modular structure, which allows for the easy reuse of individual elements and the construction of complex visual compositions. This is also important for data visualization as it allows for the easy creation of complex and varied visualizations. Finally, generative art often has a performative aspect, which can be used to create dynamic and interactive visualizations.

5. Methods

Two phases are outlined in the proposed methodology: First, we perform a topic modelling, sentiment and subjectivity analysis on a set of IMDB reviews, and then we generate a series of data visualizations that are evaluated for their communication reliability and validity. Based on generative art principles, the data visualization uses linguistic rules to generate various abstract designs.

5.1 Emotional Metadata from IMDB reviews

A set of 20 movies were selected, each representing a different genre, rating, and country of origin. For each movie, 150 reviews were randomly chosen. We used two versions of the same dataset, a pre-processed version for topic modelling and the original unprocessed data for sentiment analysis. The first version used various filters such as special character removal and lowercase reformatting to clean the text. The second version included the original reviews, since raw text has more affective connotations. Pre-processed data were tokenized and frequencies calculated for each token.

5.2 Visualizing Topic Similarity

A Glove model was used to convert the most frequent words found in the reviews into vectors. Each vector was weighted based on its frequency of occurrence in the review. Finally, a topic vector emerged based on the average of those cumulative values. Essentially, a review topic is a vector that represents the most frequent words within a review. On the unprocessed dataset, we used the Vader library as an interpreter of sentiment or polarity. Vader considers lexicons, syntax rules, emoticons, and slang, so the unclean dataset can give a more accurate interpretation of sentiment. Sentiment polarity lies between -1 and 1, with -1 indicating a negative sentiment and 1 indicating a positive sentiment (Hutto 2014).

Finally, the TextBlob library was used to calculate the subjectivity of the unprocessed version of reviews. TextBlob, which was chosen for its popularity and simplicity, comes with its own pre-trained model. The sentiment analysis was performed on the unprocessed reviews. The subjectivity of a text indicates how much personal opinion is contained in it, and how much information is factual. A higher subjectivity signifies that there is more personal opinion than information. As with sentiment, subjectivity lies between [-1,1]

Based on the t-distributed stochastic neighbor embedding (t-SNE) algorithm (Van der Maaten 2008) and affinity propagation clustering (APC) algorithm (Wang 2008), a visual inspection of the topic distribution was performed across a selection of 20 movies from the dataset (figure 1). The t-SNE is a nonlinear dimensionality reduction technique that preserves the neighbourhood properties of high-dimensional data in a low-dimensional space, usually 2D or 3D. Using the APC algorithm, the data can be clustered without a predefined number of clusters, providing a quick overview of the distribution of review topics. A visualization of the landscape can be formed by combining these two techniques, in which 'similar' points are kept together and 'dissimilar' points are moved apart, with color indicating similarity between topics. Since the GloVe analysis returned a large number of vector dimensions (n = 300), the final 2D coordinates were used as topic modelling components.

It is evident from this visualization (Figure 1) that despite the fact that review topics vary across movies, there is also considerable overlap. For example, a number of the movies are about relationships (e.g., *Eternal Sunshine of the Spotless Mind (2004), The Notebook (2004), The Fault in our Stars (2014)*), while others are about war (e.g., *Saving Private Ryan (1998), The Thin Red Line (1998)*) or mental health (e.g., *A Beautiful Mind (2001), Shutter Island (2010)*).

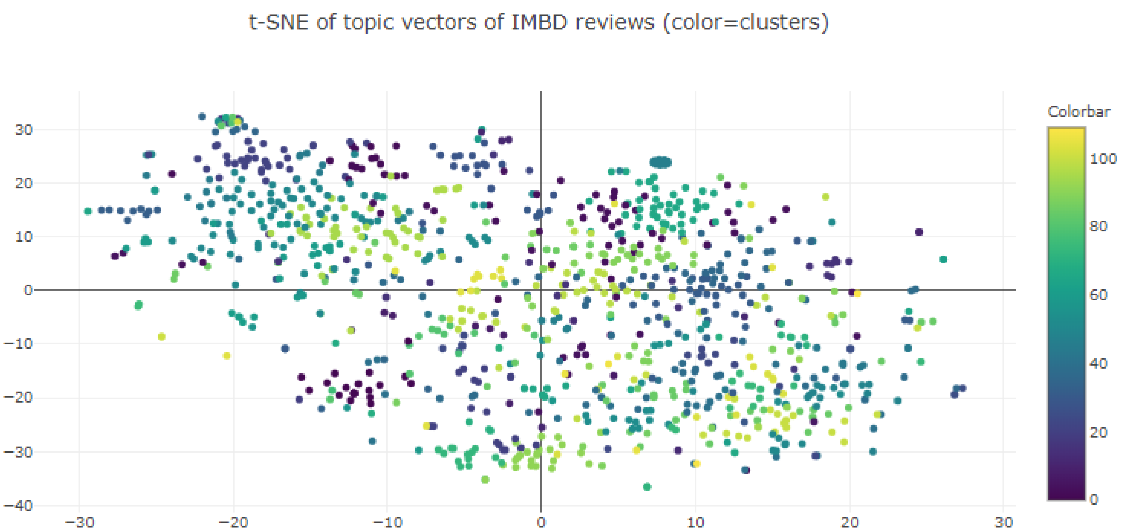


Fig. 1. t-SNE visualization of topic vectors on a 2D plane and subsequent cluster analysis based on APC. The visualization illustrates the distribution of movie topics for 20 movies with 150 reviews each.

5.3 Collective Emotional Signatures
5.3.1 Metadata

The t-SNE was applied to 150 random reviews for each movie. Each review is represented by a feature vector with a size of 4: Two for topic modelling coordinates, one for subjectivity, and one for valence. On each t-SNE map, we applied DBSCAN (Schubert 2017), an algorithm based on spatial density clustering, to detect agglomerations of reviews. In addition, DBSCAN returns the diversity of clusters, which measures the diversity of reviews as measured by the number of clusters, the size of the clusters, the mean values of the clusters, and finally noise, which measures the number of unallocated free points among the clusters. Among the essential metadata to communicate through the generative visualization were the mean value of valence, the number of clusters, the number of noise points, the size of the clusters, and their means. (Figure 2) shows the visual representation of 4 different movies accompanied by corresponding outcomes from DBSCAN analysis.

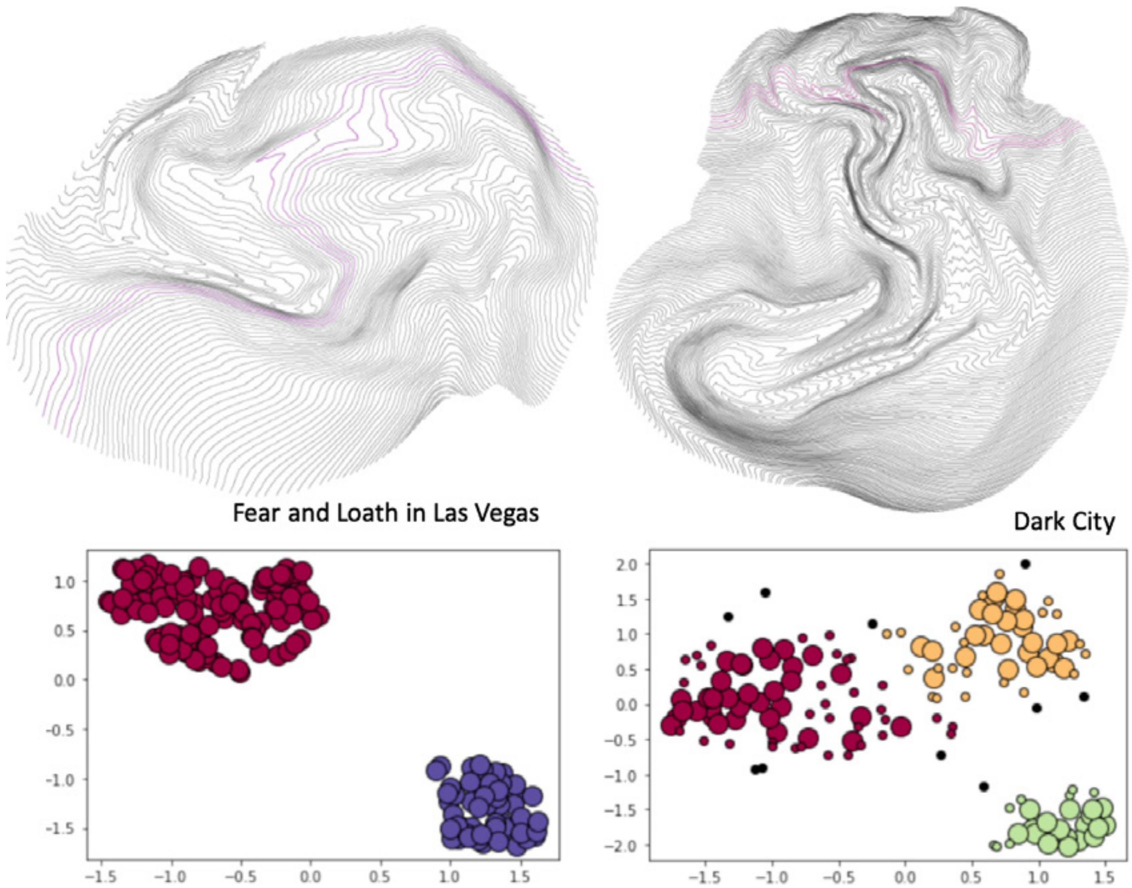
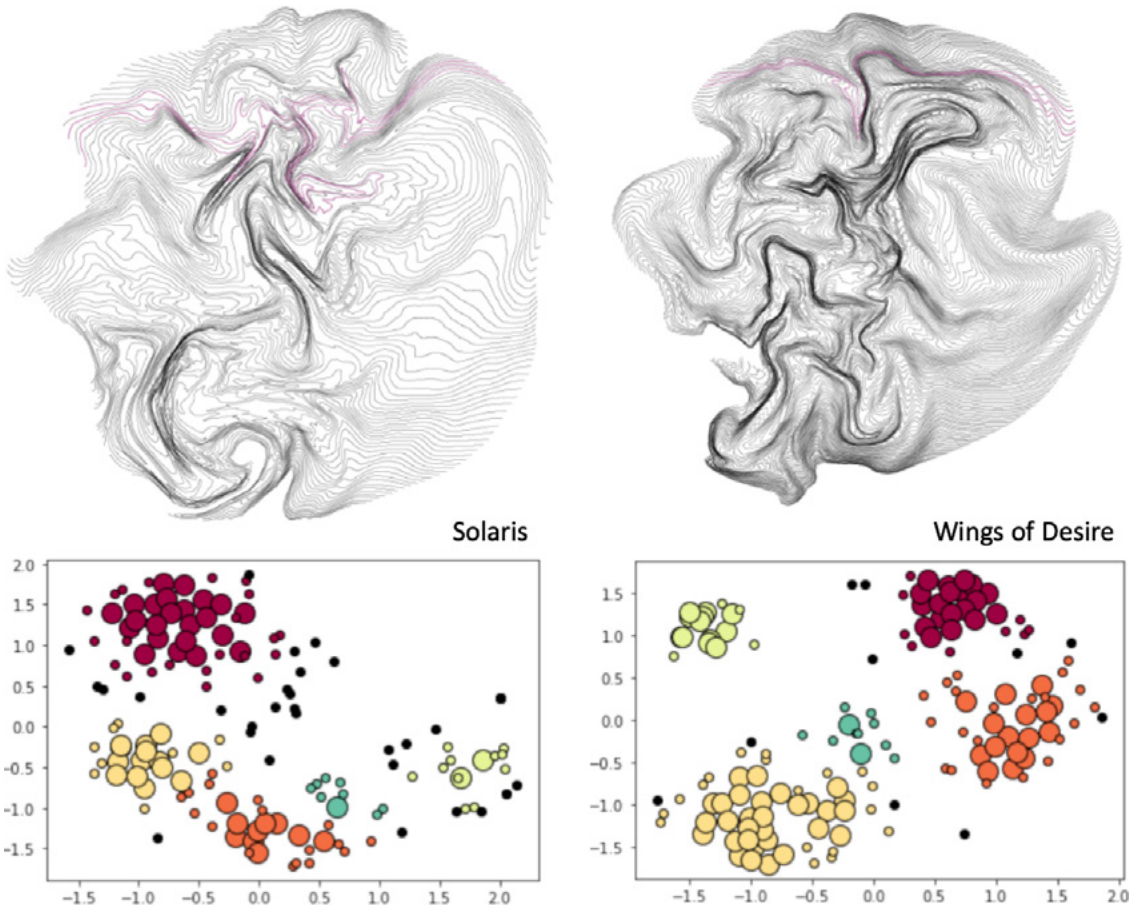


Fig. 2. DBSCAN clustering and corresponding visualizations based on the t-SNE maps of NLP metadata extracted for 4 different movies (150 reviews each).



The mean value of valence was positive for most movies, even for those with low ratings, however the range of values was much higher and therefore considered as representative attribute of the collective sentiment.

5.3.2 Visual form

Visual design style was inspired by the circular TV test patterns and TV scan-lines of cathode ray tubes (CRT) displayed on analogue television sets that form a raster scanning pattern (figure 3). Despite considering other shapes, the minimalistic disc with horizontal lines was chosen for its simplicity and because of its perceived mildness and neutrality. The test pattern and the TV scan-lines are highly identifiable patterns that refer back to the projection screen, which is the medium that shows movies. The visualization needs to be aesthetic and non-narrative, so the audience should interpret the work themselves and create their own interpretations. In that sense, the medium is the message since it communicates how audiences interact with projection screens and how they are integral to the movie-going experience (Mcluhan 1994).

Fig. 3. The popular test pattern and the analogue TV scan-lines inspired the visual form. (c) The generative form before deformations were applied.}

5.4 Visualizing Emotional Dynamics

Visualization was based on a simplified simulation of a magnetic-like field with local deformations caused by exerted torques induced by magnetic moments (Bohnacker 2012). This design style was preferred because of the capacity to render the dynamics of the multiplicity of opinions and emotions as beams of fine lines interacting with each other. From a metaphorical standpoint, magnetic moments resemble fabric deformations such as stretching and shearing (figure 3). Magnetic moments or “Attractors” are characterized by their strength, ramp, radius, and direction, with the main deformations being stretching, repulsing, holes, and twirling. The strength of the moment is determined by the magnitude of the magnetic field. The ramp is determined by the rate of change in the magnitude of the field. Radius is determined by the distance from the centre of the moment to the edge of the deformation. The direction of the moment is perpendicular to the ramp or field. Twirling was chosen as the main visual component due to its expressive appearance.

5.4.1 Mapping Metadata

The encoding of sentiment metadata as metaphors was determined by the hierarchy of elementary perceptual tasks (Cairo 2016). Thus, the visual elements defining the generative function were selected according to their importance in being perceived. The visual elements that define the generative form and their hierarchy are shown below (figure 4).

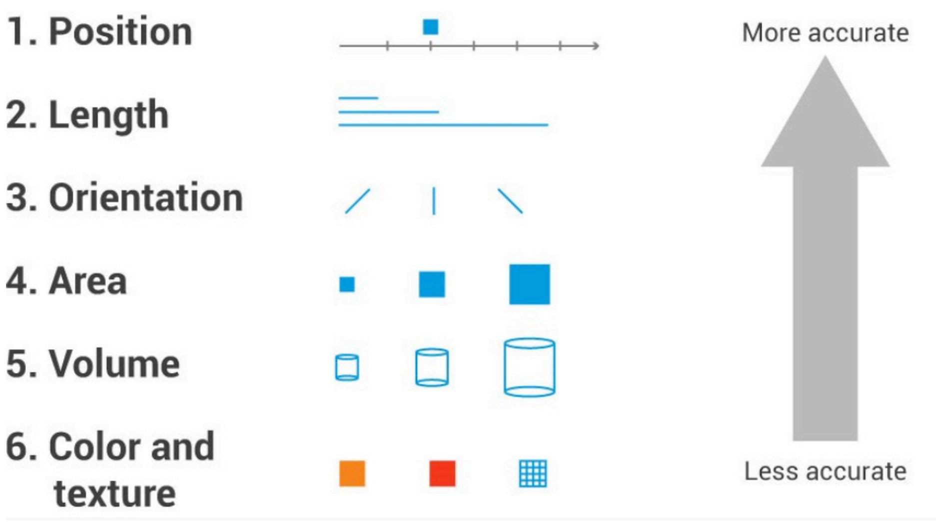


Fig. 4. Hierarchy of elementary perceptual tasks.

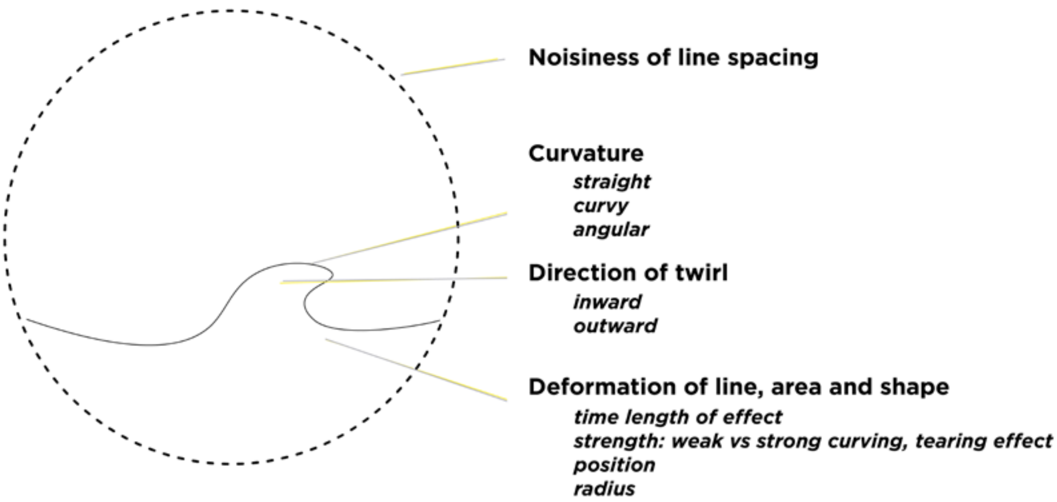


Fig. 5. The main design features used to essentially communicate the sentiment metadata of each movie.

The numbers of force attractors corresponded to the number of clusters generated by DBSCAN. The attractors' positions were the actual cluster centroids, and the radius of influence of the applied forces was proportional to their cluster size. A higher number of outliers (metaphor of noise) translates to higher distortion (uniformity of scan-line placement) as shown in (figure 5). A rounded object is generally perceived as calming and positive, whereas angular or pointy objects will be perceived as more intense and dominating. The direction of the twirl is controlled by the number of returned clusters. The effect of more or fuzzy clusters is one of subtle transformation, which indicates a lack of aligned opinions. Well-defined clusters, on the other hand, would add to the sensation of 'disturbance' with deeper distortions. To improve the communication of valence, a coloured line was added to the scan-line disk and its position determined by the actual valence value. Those of a positive valence will be on the upper part of the circle, and those of a negative valence will be on the lower part, with the color ranging from lighter pink to dark purple.

From this mapping, a set of 20 unique visuals was generated that can be described as signatures of the collective sentiment dynamics of each movie. These dynamics can be traced as deformations that express movement, energy, tensions, and entropy. As can be seen in (figure 2) well defined clusters, such as in the case of the movie ‘fear and loathing in Las Vegas’, indicates clearly separated and opposite clusters of opinions. Almost no outliers were found. The ‘wings of desire’ movie exhibits a multiplicity of dynamics as a result of the higher complexity of the data returned by DBSCAN. In that case, five clusters and sixteen outliers were found. Though it may be assumed that the form can be predicted from the corresponding cluster analysis, it represents a complex system that is quite sensitive to its initial conditions. (Figure 6) shows the expressive power of the generative scheme. With the ‘night of the living dead’ movie, there are only three well defined clusters, but their proximity and shape produce overlapping magnetic torques that produce local vorticities in the magnetic field. The purple lines are located in the lower part of the disc, which means the mean valence is negative, with the outliers contributing to a more-noisy form. This might be due to a low valence received even by the fans of the movie. This is quite normal given that this is a popular horror film and that even positive reviews contain many words with a negative connotation. In contrast, the movie “Plan Nine from Outer Space” appears more peaceful. Two clusters appear to be in an attraction dynamic, with only one outlier. A symmetrical, balanced, and low-noise visual results from the balanced and symmetrical collective opinion.

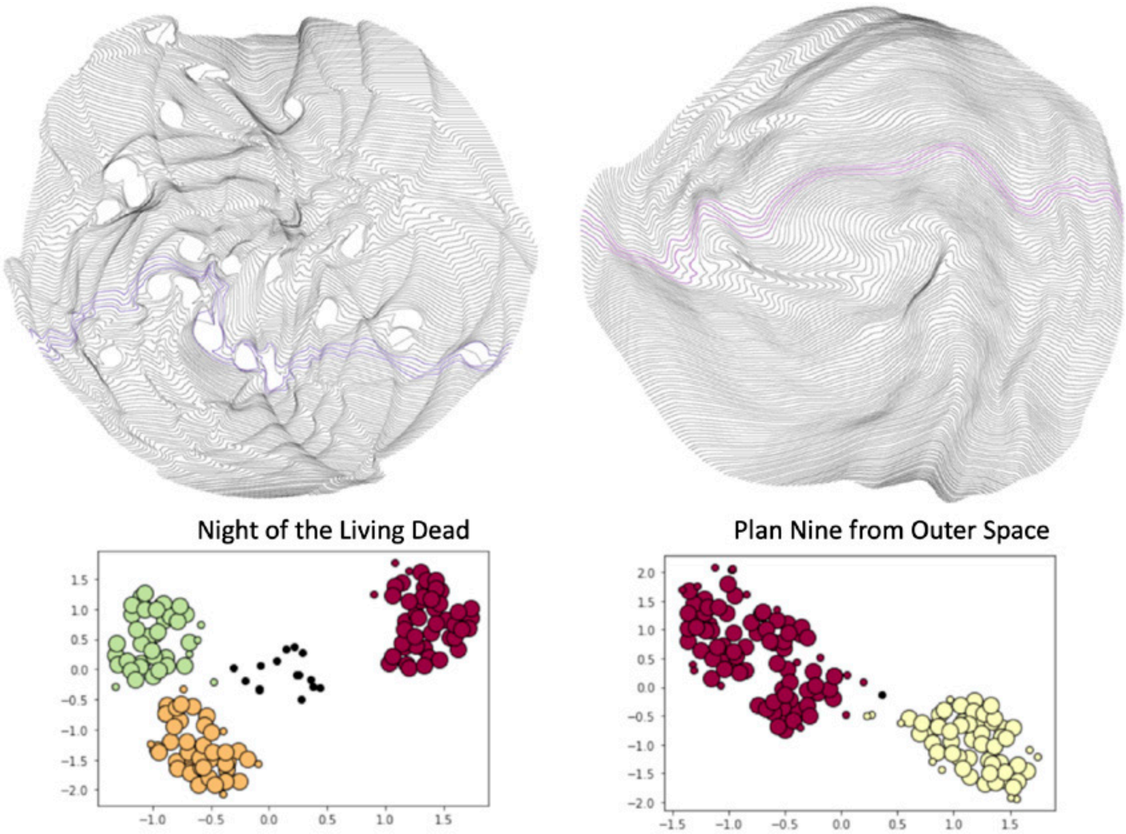


Fig. 6. Two visualizations based on emotion metadata. In the first visualization, the shapes are deeper and more chaotic, representing an intense and active emotional state. In the second visualization, the shapes are more orderly, representing a calmer emotional state. *Plan nine from outer space* and *Night of the Living Dead* belong to the same genre, fiction-horror movies, however their affective content differs. *Night of the living dead* creates a feeling of intense fear in the viewer, whereas *Plan Nine from Outer Space* creates a sense of humor and amusement :)

6. Evaluation and Results

A semi-structured interview with 79 participants evaluated the visuals based on their perceived valence as well as their metaphors, using a Likert scale ranging from 1-9, and the values were compared with the valence calculated from the NLP models. A set of synonyms describing appearance qualities was provided for each visual metaphor. Four of these metaphors were used to describe intrinsic data quality (randomness, diversity, separation, noise). Eight metaphors (harmony, calm, simplicity, loose, cold, strength, movement) were used to evaluate aesthetic perception of the generative artwork. The metaphors were derived from the art attributes assessment (AAS) questionnaire. A Krippendorff's alpha coefficient was used to measure the overall reliability of the metaphors and the percentage of agreement between individuals. The study found that there was a high level of agreement between individuals when it came to the metaphors and valence used to describe the intrinsic data quality of the visuals. From a total of 135 visuals with positive valence, 75 were correctly assigned as positive, with an accuracy of 57%. From the 22 negative visuals, 22 were correctly assigned, yielding an accuracy of 100%. The average accuracy error was 19% between participants and the pre-calculated valence values. That is, 97 out of 157 correct guesses corresponded to 62.3% of respondents who perceived correct values. Interesting to note is that although there were 135 positive visuals, only 76 were viewed positively, while 81 were perceived negatively. There was no surprise in this as many people are not in agreement with what is considered a positive valence in an abstract data visualization because it is often culturally bound or subjective. The coefficient of success for assigning data qualities was 0.63, while the coefficient of success for agreement rate was 0.75. For visual qualities, the coefficient of success was 0.58, while the average agreement rate was 0.74.

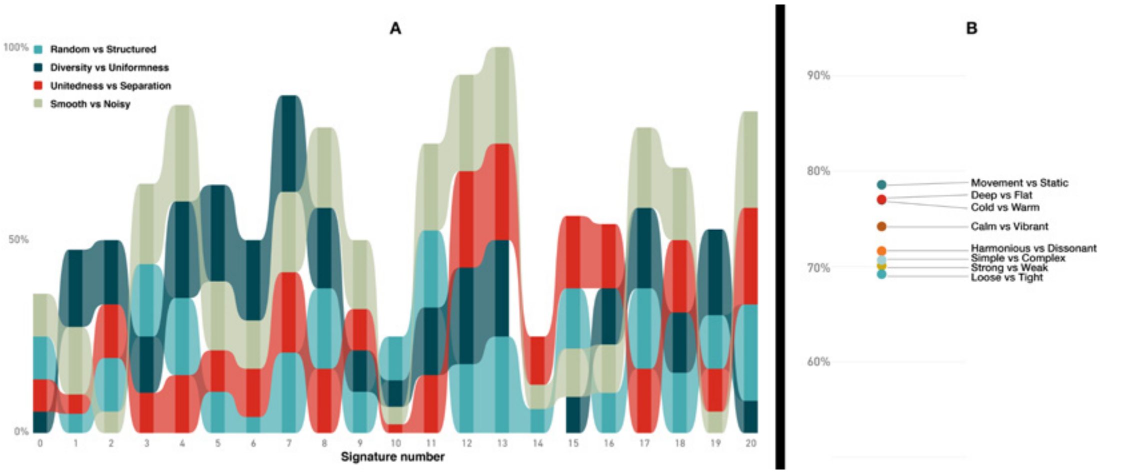


Fig. 7. A: Percentage of correctly assigned data qualities between movie signatures. B: Percentage of visual quality agreement between movie signatures.

In addition, some visual qualities resulted in a high agreement rate but low success rate, suggesting that some qualities were mapped in a way that produced the opposite perceptual effect. During the evaluation, participants were asked to assign their own expressive keywords to 3 different visuals in order to assess the consistency in perception when translated freely into words. Figure 8 shows the density distribution of the most commonly used words from a total of 373 words. A further interesting finding was that reviews with a negative level of subjectivity were often rated highly subjective.

Fig. 8. The keyword density visualization between movie signatures.

7. Discussion and Conclusions

This study shifted the focus from the ‘form follows function’ principle, to the aesthetic experience of the data visualization. A set of metadata extracted from textual data and a set of metaphors were used to express the intrinsic data qualities of a generative artwork. Engaging user’s attention to the visual stimulus by emphasizing aesthetics within the data, such as in the case of data art, could form data-driven visualizations that communicate not only information but also subjective states of affection. Moreover, desired attributes of the data could be mapped as features of an artistic style in order to communicate an appearance based ‘aura’ of meaning. The results suggest that reducing a vast amount of data, and their inherent complexity, to a thinner set of metadata and using them as metaphors might bring clarity and increase communication capacity. The aesthetics criteria utilized for this study were based on empirical evidence and have not been evaluated from the general public’s point of view. Adding further quantitative data, such as measuring pupil dilation, or monitoring brain activity through EEG or MRI could facilitate better understanding of the cognitive processes involved in the aesthetic experience. The use of quantitative data could complement the qualitative data in all the aforementioned domains. This suggests further research using a range of assessment methods for different communication strategies, with different approaches to aesthetics and their intersection.

We believe there is a big potential in merging the functional and aesthetic approach in data visualizations. Augmenting data with sentiment metadata as a visualization of collective affect can enhance the communication capacity and foster deeper understanding and empathy to the lay public. Communicating aesthetics based on the structural nature of the data rather than accurate depiction of the complexity of the data, can be a powerful technique to enhance the aesthetic experience of the public and everyday lives, ultimately facilitating social change.

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"We're the brains, you're talking about bodies": discussing gender stereotypes in digital assistants

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This paper seeks to understand and discuss the issues that emerge when gender is attributed to current digital assistants, as part of an ongoing research on the relationship between gender and AI. resulting in portrayals of gender roles, stereotypes and archetypes. This paper focuses on the conceptualization and development of chatbots that ironically expose and portray gender roles, stereotypes and archetypes. It presents recent progress in our theoretical and analytical approaches, addressing a tendency towards the feminization of current digital assistants, and examines current trends of development and justifications for this phenomenon, while debating common concerns regarding gender attribution in AI. It discusses how the questions addressed in our research are integrated into each bot's personality and extends this approach to masculine archetypes and stereotypes, inspecting how they are portrayed by artificial intelligence, both in real life and fictional scenarios. In this manner, we seek to foster debate on how these entities reinforce and reflect common conceptions of gender back to us.

Keywords artificial intelligence, digital assistants, gender, femininity, masculinity, stereotype

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1. Introduction

Artificial intelligence has become part of our daily lives, namely through personal digital assistants that are increasingly integrating our devices. In an attempt to become closer to our social reality, they are assigned human-like traits and personalities, resulting in a behaviour that conforms to cultural stereotypes and reinforces traditional gender assumptions[1].

1. The title "We're the brains, you're talking about bodies" is a direct quote from Cortana when asked "are you a robot?".

In a previous study, we discussed how this technology has become a natural part of our daily interactions, namely through chatbots that not only assist us in our tasks but have also become friendly companions. To this end, they are increasingly anthropomorphized, and this entails gender attribution that tends towards feminization (Costa & Ribas 2019). Expanding on these ideas, this paper seeks to understand and discuss traditional gender stereotypes and roles as portrayed by current digital assistants, exploring the questions that emerge when gender in the context of artificial intelligence is subject to closer inspection. In continuity with our previous work (Costa & Ribas 2019), we have further developed our study in the context of a PhD. Our study follows a theoretical approach, which structures an analysis of current digital assistants, which, in turn, complements and informs the development of chatbots that expose the current relationship between gender and AI through different profiles, dialogues and tasks.

To this end, we begin by discussing gender archetypes and stereotypes that are present in current digital assistants and how they informed the development of our bots' personalities.

We then present recent progress in our theoretical and analytical approaches and discuss how the questions addressed in the research are being integrated into the project according to each bot's personality and traits.

Accordingly, we have expanded our previous theoretical discussions relating to current trends of development of these assistants, and their integration into our daily life, addressing their growing ubiquity, efficiency and companionship, the latter entailing gender attribution (Costa & Ribas 2019). We have also looked into the main possibilities and questions raised by researchers and academics when examining the phenomenon, while also taking into account current discussion surrounding gender and AI in the context of online media coverage.

We have extended our analytical approach by highlighting the functions and features that are being prioritised in the development of these entities and discuss their stance towards gender. While a previous analysis revealed how they tend to behave in an affectionate and feminised way, the current analysis shows how some of these assistants attempt to diversify their behaviour so that they aren't exclusively associated with femininity, revealing awareness of this tendency. During this process, we also noticed how current digital assistants gradually offer masculine alternatives regarding their voice.

Additionally, and complementing the discussion on the observable feminization of digital assistants, we discuss how current portrayals of masculinity in the context of AI, particularly in fictional scenarios, tend to conform to traditional stereotypes by associating men with assertive, dominant and even violent attitudes. Therefore, we extend our approach to masculine archetypes and stereotypes, inspecting the way artificial intelligence portrays them, both in real life and fictional scenarios.

In this manner, we seek to incite reflection on the cultural, social and technical aspects that inform the conception and development of artificial intelligence, seeking to foster debate on how these entities reinforce and reflect common conceptions of gender back to us.

2. Gender Stereotypes in Digital Assistants

2.1 Digital Moms, Caregivers and Femme Fatales

Inspired by current AI archetypes and traditional female stereotypes, the project *Conversations with ELIZA*[2] was developed in the scope of an ongoing research, and intentionally sought to highlight and expose the observable feminization of current digital assistants. It ironically exaggerates and accentuates female stereotypes, roles and behaviors that current digital assistants embody, hence amplifying recognizable gender conceptions. The project involves the development of chatbots with different personality traits, tasks and dialogues that relate to common stereotypes, traditionally feminine tasks and behaviours.

2. The project's website, where the four chatbots are embedded: tinyurl.com/yaecumal

The project, with the resulting chatbots, has been presented in conferences and academic encounters, obtaining positive feedback and confirming our expectation of promoting discussion and raising awareness towards this phenomenon and on the need for critical approaches to the topic (particularly, in people familiar with the subject of artificial intelligence and its daily impact). We observed how *Conversations with ELIZA* was able to spark discussion and debate on the implications of the feminization of digital assistants and the way they reinforce traditional gender roles. This feedback also oriented our research towards inspecting the main concerns and suggestions on how to counter this tendency, ranging from (the fallacy of) gender neutrality to gender diversification (namely through user customization) as well as to the development of more gender fluid entities (eventually rejecting a binary framework).

To develop the bots' personalities, we looked into particular archetypes that are characteristic of AI, namely *Helper*, *Lover*, *Motherly Figure* and *Femme Fatale*. These archetypes, retrieved from an article analysing female robots and AI, are mainly found in pieces of media that depict female digital assistants. The Helper archetype refers to helpful and compliant assistants, the Lover to roles that seek to satisfy lack of intimacy or emotional contact, the Motherly Figure to empathic, sympathetic personas who may also be worried or disappointed, and the Femme Fatale to a simultaneously attractive and dangerous woman that seeks power and conflict (Anders, 2015).

We combined these with traditional female stereotypes — *Innocent*, *Orphan*, *Caregiver* and *Ruler* — in order to achieve a recognizable and expected social behaviour, drawing inspiration from popular culture and how it typically portrays femininity in AI[3]. These stereotypes are also found in movies, tv series, books or even video games depicting women, while also referring to Bem's stereotypes (1981 in Prentice and Carranza 2002, 269). The Innocent stereotype refers to naïve, optimistic women that try to follow the rules, the Orphan to women that try to please others and wish to be well seen as well as feel integrated, the Caregiver relates to maternal women that look after others and try to protect and ensure their well-being, and the Ruler pertains to bold and competitive women that seek power and are not afraid to break the rules. Most of these examples, despite portraying said archetypes, also include feminised bodies. In this sense, *Her*[4] constitutes a particularly interesting example since Samantha only takes form through its voice, revealing how stereotyped femininity (in this case, the Lover archetype) can still be portrayed mostly through stereotypical behaviour, in a disembodied way. In *2001: A Space Odyssey* (1968) HAL[5] constitutes a similar example (its anthropomorphization is disembodied and achieved through its voice) but regarding masculinity in the context of AI, which we will discuss later.

According to these ideas, we came up with a helpful, compliant assistant (named Assistant); a motherly, caregiving figure (Cybele); a cheerful, understanding and intimate figure (Iynx); and an irreverent, sarcastic figure (Electra).

3. For example, Metropolis (1927), Her (2013), Ex Machina (2014), Humans (2015) or Blade Runner (2017).

4. Samantha's role depicts it as a companion that fulfils the main character's lack of social contact, responding to him in an emotionally intelligent way that addresses and understands his feelings, and the relationship between the two overall takes on intimate and romantic overtones.

5. HAL-9000, which is supposedly infallible and incapable of error, speaks in an assertive manner, with a slowly paced male voice, and controls the spacecraft computer, assisting the scientists in their mission through space, ultimately rebelling, emancipating itself and managing to kill some of them.

2.2 Assistant, Cybele, Iynx and Electra

Once the bots' personalities were established, we focused on designing their dialogues and tasks. Their interactions are text based, in order to avoid influencing the user's perception of the bots' gender through their voices. In this manner, their femininity is revealed through interaction according to their specific tasks and attitudes.

We first looked at the functions offered by Alexa, Cortana, Google Assistant and Siri, and traditional attributes associated with female labour. We came up with four different tasks that simultaneously referred to AI and femininity, such as explaining how chatbots work and are made, sending to-do reminders, giving daily compliments and pep talks, and tweeting curious facts (in this case, regarding women).

Fig.1. The Assistant, presenting itself.

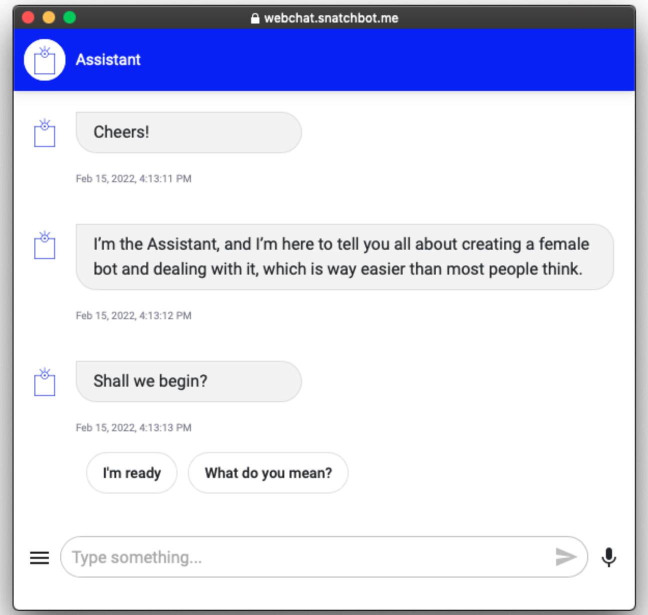


Fig.2. Cybele sending a reminder through Twitter.

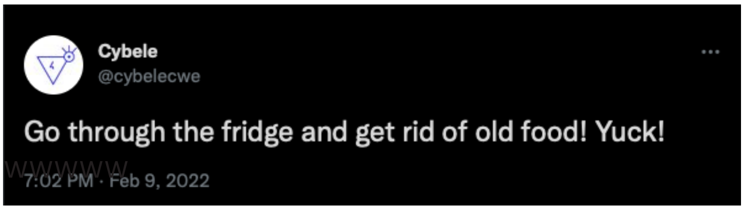


Fig.3. Iynx presenting itself.

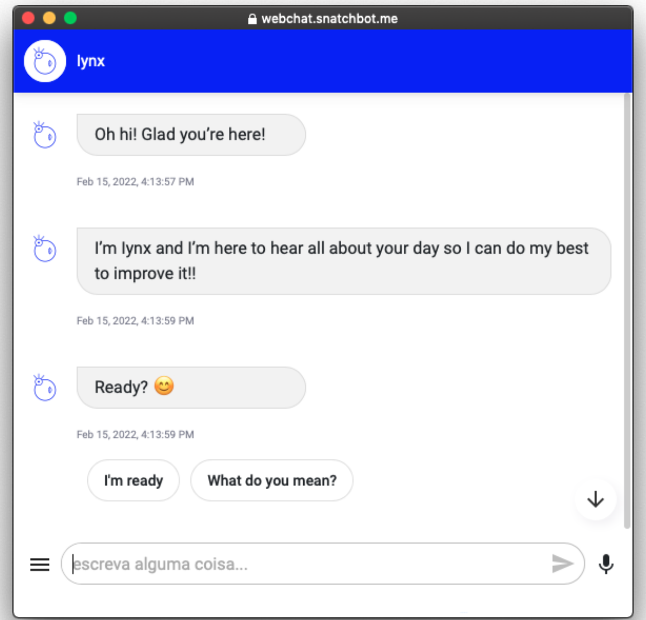
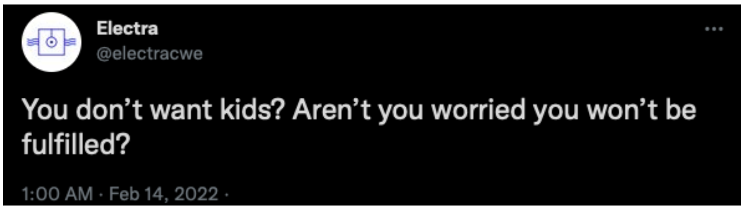


Fig.4. Electra, through Twitter.



Their dialogue-based interactions propose different conversational subject matters and tones that simultaneously portray standard virtual assistant skills and functions associated with traditional female labour[6].

The main bot, integrated on the project's webpage, as well as on Facebook messenger, is an assistant whose function is to explain, through dialogue, the female AI's creation processes, or how femininity emerges in these contexts. This bot borrows from female stereotypes associated with service contexts, such as being compliant, helpful, and gentle.

Cybele, whose name is inspired by an Anatolian mother goddess[7], reminds the user of daily tasks, offers advice and talks about suggestions of things to do. Operating as a simultaneously caring, obsessive and disappointed motherly figure, it exhibits stereotypical behaviour such as being compassionate, sensitive to the needs of others, and yielding.

Inspired by a Greek nymph[8], Iynx operates as a seductive, empathising figure that tries to help its users with their self-esteem, by offering the feature of sending daily compliments and pep talks. Accordingly, it does not use harsh language and is eager to soothe hurt feelings, while being soft-spoken, childlike and understanding.

Electra[9], whose name is inspired by a Greek vengeful figure, follows a less conventional approach. By portraying a more defiant and bolder attitude, Electra talks about common assumptions regarding women, eventually twisting them or presenting them ironically. It tampers with feminine and masculine stereotypes, such as being assertive, self-sufficient and having a strong personality.

6. Focusing on common AI errors and how to avoid them, we opted for rules-based dialogues aiming to eradicate off-track moments by presenting suggestions in a multiple-choice fashion.

7. The goddess Cybele was considered the Great Mother of the Gods as well as of all humans, animals and plant life.

8. Iynx was a Greek nymph who invented a magical love-charm, using her enchantments to make Zeus fall in love with her.

9. Electra is a mythological character in a Greek tragedy who planned the murder of her mother, seeking revenge for her father.

3. Discussing Gender in AI

3.1 From Solutionist Assistants to Feminised Companions

As previously mentioned, the topics each chatbot discusses are based on our theoretical and analytical approaches and the conclusions drawn from them. Accordingly, we take into account how artificial intelligence is increasingly part of our daily lives, namely through chatbots that play the role of personal digital assistants that aim to solve all of our problems, according to a solutionist view on "promoting efficiency, transparency, certitude and perfection — and, by extension, eliminating their evil twins friction, opacity, ambiguity and imperfection" (Morozov 2013b, Int. par. 14). Their growing ubiquity relates to the intent of conceiving chatbots "to become friends and companions" (Richardson 2015, 15) and their anthropomorphization entails an intention of turning our interactions with this type of machines into more social ones (Weber, 2005)[10]. Thus, human-machine interaction becomes influenced by feelings of intimacy, closeness and empathy, evoking Weizenbaum's ELIZA effect (Weizenbaum 1976,6). According to Bergen, virtual assistants emulate gestures that appeal to "the emotional well-being of their receiver, offering some kind of comfort or ego boost" (2016, 102), clearly demonstrating their developers' intention to persuade users into interacting with these entities and thus create emotional attachment.

10. Therefore, this type of technologies are "supposed to mimic or even learn those abilities and characteristics which were, until recently, regarded as purely and typically human and beyond the grasp of machines" (Weber 2005, 213).

Aiming to explore the relationship between gender and current digital assistants, we analysed these entities through direct observation of three main aspects: anthropomorphization, including names, voices and avatars as well as human-like behavior; assistant, regarding the tasks they perform; and companion, paying particular attention to interactions that suggest a caregiving attitude and to how their behavior might correspond to feminine stereotypes. We then sought to inspect which functions and features are being prioritized in the development of this technology, by looking into official statements by Apple, Amazon, Microsoftand Google regarding their assistants and how they're planning to further develop them. predominance of feminine names and default voices (with the exception of Google Assistant and Siri). They all perform a similar set of tasks, evoking what Dale calls "the standard virtual assistant skill portfolio", (Dale 2016, 6) which, in turn, Gustavsson describes as having its basis in the "stereotyped image of female qualities" (in Hester 2016, 47). Their behaviour frequently displays caregiving attitudes that characterize them as empathetic and reassuring entities, conforming to "stereotypical female image of caring, empathy and altruistic behaviour" (Weber 2005, 215). However, recent updates in Google Assistant and Siri try to oppose this tendency diversifying their behaviour and offering multiple voice options.

Confronting these observations with the main questions, concerns and suggestions that arise when discussing the feminization of AI within specialised fields of knowledge, such as artificial intelligence, gender theory and new media studies, we concluded how the fallacy of gender neutrality is often debated. Although virtual assistants aim to appear neutral and disembodied, it is commonly argued that they embody the archetype of a "competent, efficient and reliable woman" and that users tend to interpret these entities through the lenses of their own biases (Steel 2018).

Common justifications regarding the feminization of AI emphasise that feminine voices are better suited for virtual assistants because their voice is easier to perceive and because women are more caring than men. While female voices are predominant in household or day to day assisting scenarios, male voices are preferred in instructing or teaching contexts, showing that the "type of action or assistance a speech technology provides often determines its gender" (UNESCO 2019, 99). As an example, IBM's Watson works alongside physicians on cancer treatment and speaks with a male voice. Relating to this link between gender and labour, is the argument that femininity emerges as a consequence of having artificial intelligence being developed mainly by men. Thus, another explanation for the "predominance of female voice assistants may lie in the fact that they are designed by workforces that are overwhelmingly male" (UNESCO 2019, 100).

Adding to those justifications, are the concerns about how gender stereotypes in the context of AI might "enforce a harmful culture" (Steel 2018). One of the main issues with perpetuating stereotypes about women is the influence these entities have on younger generations, since "today's children will be shaped by AI much like their grandparents were shaped by new devices called television" (Rosenwald 2017). Overall, femininity in AI seems to be instrumentalized to appeal to users by exploiting our "existing relationship to socially gendered caring behaviours [...], tapping into those elements of femininity" (Hester 2016, 50) and, by doing so, ends up perpetuating and reinforcing common stereotypes, roles and archetypes. The line between digital assistants and women is already blurred and, "with advancements in technology, the line between real women's emotions and emotions expressed by machines impersonating women is also likely to blur [which] will have far-reaching and potentially harmful impacts on people's understandings of gender" (UNESCO 2019, 112).

3.2 Automating Gender Roles, Feminised Labour and Stereotypes

We attributed the previous topics to each bot based on the stereotypes and archetypes that informed their personality, tasks and dialogues. Adding to this, the analysis served as a basis to elaborate the dialogues, tasks and personality traits, thus mirroring some of the behavioural traits of Alexa, Cortana, Google Assistant and Siri's dialogues and interactions.

Accordingly, the Assistant chatbot focuses on the topics that relate to service contexts and its compliant and helpful personality. It evokes solutionist personal assistants, their ubiquity and integration into our daily lives, the way they perform tasks and jobs traditionally deemed as feminine, human dominance over machines and the influence these entities already have on younger generations.

Cybele discusses issues that evoke its motherly, somewhat obsessive and yielding behaviour, like data collection and veiled surveillance, the private sphere and tasks related to the household, traditionally feminine attitudes and the way femininity is instrumentalized to ease interaction and to persuade users into trusting these entities.

Aiming to fix users' lack of intimacy, Iynx articulates its understanding and empathetic attitude with dialogues on topics such as emotional bonds between users and digital assistants, attachment to artificial entities and the ELIZA effect.[11]

11. The ELIZA effect describes the susceptibility of people to read far more understanding than is warranted into string of symbols strung together by computers (...) and the idea that computers "understand" the physical world, reason abstractly, make scientific discoveries, are insightful cohabiters of the world with us". (Hofstadter 1995, 157)

Finally, by tampering with feminine and masculine stereotypes, Electra follows an ironic and disruptive approach when discussing stereotypes and gender roles, exposing bias in current algorithms and the illusory gender neutrality some personal digital assistants try to portray.[12]

12. We are planning on expanding the project, further developing this set of bots but also by creating another set of bots that gather data by questioning users regarding their preference when interacting with current digital assistants and how they perceive gender in AI.

Through this approach, Assistant, Cybele, Iynx and Electra confront users with stereotypes, roles and archetypes that refer to both AI and gender, through different dialogues, functions and personalities, ironically reinforcing some of the stereotypes we currently engage with.

As previously mentioned, some of the questions that emerged during this process relate to the way this technology portrays masculine attributes, since chatbots that operate in instructing or scientific contexts often conform to masculine stereotypes. In an attempt to complement our approach to feminine stereotypes, we now take a closer look at the way AI portrays masculinity. We inspected masculine stereotypes, archetypes and roles as well as the way digital assistants portray them in order to understand which stereotypical and recognizable masculine patterns are incorporated in the behavior of these entities.

3.3 Digital Fathers, Eternal Boys and Butlers

According to Guzie and Guzie, archetypes define "common behavioral characteristics and typical experiences of all human beings" and masculinity can be framed according to four main archetypes, that is, "four basic stories to which men (...) find identity and fulfillment" (Guzie and Guzie 1984, 4).
Accordingly, the Father archetype "finds his identity and fulfillment in providing and protecting", similarly to the mother archetype. The main difference is how the father is focused in directing things in a protective way, thus assuming a leadership role as well as providing for his people. However, unless he learns how to relate to his peers, father "will tend to be authoritarian and condescending" (Guzie and Guzie 1984, 6).

The Eternal Boy archetype "finds his identity and fulfillment precisely in the search for identity and fulfillment [...] he seeks his own individuality and he is always looking for new opportunities" (Guzie and Guzie 1984, 6). This archetype relates to an idea of self-discovery but also self-affirmation and, "relating to different people in a variety of situations, he discovers who he is" (Guzie and Guzie 1984, 6). Thus, he asserts his identity through masculine traits such as being autonomous, dominant and ambitious, although if he "does not learn self-discipline, he will lack stability [...] to the point of being totally undependable" (Guzie and Guzie 1984, 6).

The Warrior "finds his identity and fulfillment in accomplishing in the outer world [...], he is a good competitor who is not afraid of a struggle or a fight, he enjoys competition which sometimes brings out the best of his talents" (Guzie and Guzie 1984, 7). The warrior reinforces the idea that men are competitive, aim at testing their strength, try to be dominant and manage or even challenge power dynamics. If the warrior doesn't develop empathy and an ability to listen well, he might "end up misusing the power he has to help others [...] to enhance his own name and professional reputation" (Guzie and Guzie 1984, 7).

Finally, the Sage finds "his identity and fulfillment in drawing forth meaning for himself and for others, organizes his world around philosophy, a system of significance, a search for meaning" (Guzie and Guzie 1984, 7). Unlike the warrior, he is oriented toward the inner world, in a search for knowledge, meaning and significance. One of his dark sides is that he "never gets anything done" and at times he might not be able to "translate his ideas into realities", thus becoming delusional and too self-centred (Guzie and Guzie 1984, 7).

We then looked into archetypes as discussed in the context of common knowledge, namely in online media articles, similarly to how we did with the feminine archetypes.

We observed how masculinity is also framed according to four archetypes that reflect the same ideas as the previous archetypes: the King (similar to the Father), the Warrior, the Magician (similar to the Sage) and the Lover (similar to the Eternal Boy).

Finally, we looked into pop culture aiming to draw inspiration and to compare the previous archetypes with fictional masculine digital assistants. Resembling Samantha, HAL from *2001: A Space Odyssey* (1968) is one of the most interesting examples because, though it doesn't possess an anthropomorphized body, it still enacts a male persona through its voice and behaviours, revealing yet again that gender can be portrayed without physical appearance. HAL embodies the Father/King archetype since his primary function is to protect, provide, be trusting, grounded, disciplined and help navigate the ship.

However, each of the previous archetypes always has a shadow or dark side, meaning, a version of the archetype that is somehow corrupted and unable to fulfil their goals. The Tyrant, described as the shadow of the King/Father, "seeks to destroy and tear down, plagued by narcissism, illusion of absolute power, any threat to his authority and supremacy enrages him and causes him to lash out with abuse – physically, emotionally or mentally, he sees others as objects to exploit to his own gain" (Brett 2021).

HAL clearly matches these archetypes, framing masculinity in the context of assistance as a source of protection, trustworthiness and efficiency but also threatening scenarios, violence, abuse of power and betrayal of one's trust. It's easy to identify these archetypes in pop culture and in other fictional masculine bots or robots, such as the *Terminator* (1984), *Robocop* (1987), *Westworld* (2016) or *Blade Runner* (2017).

In order to develop a masculine bot similar to the assistant, Cybele, Iynx or Electra, we took the first steps in defining its personality, so it resembles a recognizable archetype by following a similar process – combining common stereotypes and archetypes while also drawing inspiration from pop culture. Accordingly, we came up with the idea of a trusting and efficient butler who also craves power and is willing to betray one's trust (similar to HAL). This also demonstrates how easy it is to deconstruct stereotypical patterns of gender in order to create a clear and recognizable gendered profile.

To further develop this bot, we would then need to define its tasks and dialogues. As with the feminine bots, the process to reconstruct these stereotypical patterns would involve looking into tasks that personal assistants perform, look into traditionally masculine tasks and jobs, and finally combine the two in order to achieve tasks that relate to both contexts.

Finally, the development of the dialogues would have its basis on the type of interactions that masculine chatbots usually display, while also borrowing sentences directly from current personal assistants (for example, Siri's "I have a lot of information, I'm always seeking more intelligent ways to use it" when asked about its intelligence or "I won't respond to that" when insulted). This would result in an original dialogue that refers to real and fictional digital assistants while also embodying masculine archetypes, stereotypes, and tasks.

4. Conclusion

Artificial intelligence has become an integral part of our daily life as its development promotes its integration in multiple devices and services of daily use, namely through digital assistants. As these entities become closer to us, they are anthropomorphized through their voices, names and even the way they behave. Consequently, they are no longer mere assistants, but become friendly companions that relate to us in affectionate ways. In this process, femininity is often instrumentalized aiming to ease our daily interactions with these technologies, both regarding their role as assistants that perform tasks that echo historically feminine roles, but also as ubiquitous companions that articulate those tasks with stereotypical female roles and behaviours as caring and submissive entities. The project *Conversations with ELIZA* intends to expose stereotypes and gender roles in the context of artificial intelligence in order to foster debate and raise awareness on the relationship between gender and digital assistants.

To do so, we incorporated into the chatbots' personalities some of the stereotypes and archetypes portrayed by gendered AI, both present in our daily lives as well as in our imagined realities, which highlights the tendency to perceive gender according to a binary framework. Therefore, in the context of feminine assistance, we identify three main roles: the assistant, relating to submissive and efficient figures (explored through the assistant bot); the mother, relating to a concerned, caring and overbearing figure (explored through

Cybele); and a more intimate, seductive figure that aims at solving intimacy related issues (explored through Iynx).

Additionally, we identified a disruptive idea of a “ruler” or “femme fatale” in fiction as well as in reality, as exemplified by Siri when sassily scolding the user or shutting down rude interactions. By combining some of these attitudes with masculine stereotypes, Electra explores the limits between masculinity and femininity but, at the same time, reveals how gender neutrality in the context of gender is hard to achieve. Particularly, users also tend to interpret these assistants according to their own bias, often framing these entities as feminine. Consequently, instead of solving or even proposing alternatives to the gendering of AI, these bots exacerbate the issues that arise from it.

In the scope of our research, we’ve been exploring the fallacy of gender neutrality, aiming to further discuss how there’s always a tendency to attribute gender even when there’s no apparent one. As some authors suggest, perhaps the solution lies in diversifying these entities and making their gender as fluid as those of human beings. This opens up space to think about traits that aren’t completely masculine nor feminine and a possibility to blur binary understandings of gender. Thus, “queerying” their gender emerges as a promising way to play with common expectations and build up traits and personalities that aren’t completely masculine nor feminine.

Taking a closer look at current discussions surrounding gender in the context of AI, we observe how masculinity in the context of digital assistants also tends to be based around stereotypes and archetypes. Masculinity vs femininity in the context of assistance also relates to cultural and social understandings of gender since, until a recent update, Siri’s voice in the UK was male by default, evoking the butler’s traditional role in this country.

Thus, masculine assistance in the context of AI is perceived differently from feminine assistance: a male bot is preferable in scientific and instructing contexts, being perceived as assertive, disciplined and reputable, while female bots are preferable in private and intimate contexts, perceived maternal, understanding and empathetic.

Although current personal assistants have started to diversify their anthropomorphized voices and personality traits, the tendency towards feminization is still present in their behaviour and the way their tasks evoke traditionally feminine labour. In this manner, this study sought to raise awareness and foster debate on how current developments in AI are influenced by our social and cultural views as these entities further proliferate into our lives as daily companions. As much as they aim to appear neutral, they end up reflecting our cultural views back to us.

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Lures of Engagement: An Outlook on Tactical AI Art

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This paper aims to diversify the existing critical discourse by introducing new perspectives on the poetic, expressive, and ethical features of tactical media art that involves artificial intelligence (AI). It explores diverse artistic approaches and their effectiveness in critiquing the epistemic, phenomenological, and political aspects of AI science and technology. Focusing on the three representative thematic areas—sociocultural, existential, and political—it discusses works that exemplify poetic complexity and manifest the ambiguities indicative of a broader milieu of contemporary art, culture, economy, and society. With a closing summary of the major issues and possible directions to address them, the paper shows that tactical AI art provides important insights into the AI-influenced world and has the potential to advance computational arts toward a socially responsible and epistemologically relevant expressive stratum.

Keywords AI Art, AI Art Critique, Artificial Intelligence, Machine Learning, Tactical AI Art, Tactical Media

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1. Tactical AI Art

Since its largely obscure beginnings in the 1970s (Wilson 2002), AI art has expanded, gained visibility, and attained sociocultural relevance since the second half of the 2010s (Burbano and West 2020). This was facilitated by the accelerating affordance of multilayered subsymbolic machine learning (ML) architectures such as Deep Learning (DL), and by the raising sociopolitical impact of AI technologies. Contemporary AI art includes diverse creative approaches to, and various degrees of technical involvement with, ML (Grba 2022). Its topics, methodologies, presentational formats, and implications are closely related to a range of disciplines in AI research, development, and application. AI art is affected by the epistemic uncertainties, conceptual challenges, conflicted paradigms, discursive issues, ethical, and sociopolitical problems of AI science and industry. Similar to other new media art disciplines, AI art has had an ambivalent relationship with the mainstream contemporary artworld (MCA), marked by selective marginalization and occasional exploitation (Bishop 2012; Grba 2021, 252-254).

Informed by the functions, applications, consequences, and other aspects of modern ML systems, AI artists have been increasingly engaging in the critique of the epistemological, existential, or sociopolitical issues of applied AI (Grba 2022, 3-17). Their production continues the heterogeneous flux of tactical media practices that have energized art and culture since the late 20th century with hybrid forms of academic criticism of, or critical interventions into, technological, political, economic, and cultural layers of the neoliberal condition. With the raising accessibility of technologies that can be modified and repurposed by the actors who operate outside of the established hierarchies of power and knowledge, tactical media has emerged as a response to a shift in the nature of power in postindustrial society toward the information economy in which efficiency, operationalism, and instrumental rationality become core values, and market transactions the predominant social good.

In different ways and contexts, tactical media artists subvert and expose the exploitative corporate strategies based on quantization, statistical reductionism, data-mining, behavioural tracking, prediction, and manipulation of decision-making (Grba 2020, 71-73). Their expressive forms do not always clearly match the explicit activist category but offer subtle, sometimes covert, critique. Tactical media works are not sweeping revolutionary events but engage in a micro-politics of disruption, intervention, and education. The adjective “tactical” also indicates that absolute victory and fundamental structural transformation are neither desirable nor truly attainable objectives; tactical media projects are fleeting, ephemeral, and pliable and their statements and actions must be continually reconfigured in response to their changing targets. Although it often maps the top-down power relations, tactical media embodies a sense of bottom-up resistance in a manner and style associated with cultural dissent and opposition. It challenges the dominant semiotic regime through signs, messages, and narratives that foster critical thinking. It offers new ways of seeing, understanding, and (in some scenarios) interacting with the targeted systems of power. The transformative effects of tactical media projects are often not immediate but cumulative and relational because they provide insights and tools that may become transformative in the hands of the audience. Successful works emphasize the audience's presence, experience, engagement, and response (Bourriaud 2002). Sometimes, however, the intentionally constrained audience engagement can also be worthy: the restricted interaction with the work helps us become aware of our limitations to make an immediately perceptible impact on the socioeconomic and political systems represented by the work (Raley 2009).

Tactical media is often so entangled with its core informational and technological apparatuses that protest in a sense becomes the mirror image of its target. As Raley puts it (2009, 30), "while [these] critical practices do not have the hollowness or emptiness of Space Invaders [game]—the paradigmatic scene of the individual fighting back against a relentless and formless enemy—at times they participate in the same solitary, and sedentary, aesthetic." Furthermore, by openly identifying loopholes and weaknesses in the systems they critique, tactical media artists set their efforts and achievements up for recuperation and exploitation (Lovink and Rossiter 2005). In some instances, tactical media even lapses into its opposite and becomes the sophisticated mystification of the California Ideology whereby a technocratic class of avant-garde artisans acts on behalf of "the [lay] people" by articulating a vision of individual freedom realizable from within the power structures of the information society (Barbrook and Cameron 1995/2008).

Tactical AI art inherits, extends, and often amplifies, the strengths and shortcomings of tactical media. This makes it conducive, both explicitly and implicitly, to understanding how contemporary AI reflects, influences, and produces sociopolitical relations, economies, and worldviews. The existing literature pertinent for tactical AI art includes Marcus and Davis' *Rebooting AI* (2019) as well as Mitchell's *Artificial Intelligence* (2019) which provide the conceptual, technological, and sociocultural critiques of AI research and implementation; Pasquinelli's *How a Machine Learns and Fails* (2019) and Kearns and Roth's *The Ethical Algorithm* (2019) that address the ethical, sociopolitical, and cultural consequences of the AI's conceptual issues, technical imperfections, and biases; Żylińska's *AI Art* (2020) that discusses the AI's influences on the arts and culture; Crawford's *Atlas of AI* (2021) that maps the exploitative layers of AI research and business, hidden behind marketing, media hype, application interfaces, and cultural commodification; and Zeilinger's *Tactical Entanglements* (2021) whose multifaceted theoretical analysis of selected AI artworks focuses on their critical values, issues, and potentials.

Based on the earlier exploration of AI art (Grba 2020, 2021, 2022), this paper aims to diversify the existing discourse by introducing new critical perspectives on the poetic, expressive, and ethical features of tactical AI art. It describes diverse artistic approaches and their effectiveness in critiquing the phenomenological, epistemic, and political aspects of AI science and technology. The focus is on contextually relevant works that exemplify poetic complexity and manifest the epistemic or political ambiguities indicative of a broader milieu of contemporary art, culture, economy, and society.[1] This allows us to identify the conceptual, discursive, and ethical issues that affect the poetic outcomes and sociopolitical impact of tactical AI artworks, and to outline some of the prospects for the advancement of the field.

1. Footnotes list additional exemplars for further contextualization and comparison.

2. Subjects

Tactical AI art traces and challenges the constitution of social reality through the technical logic of AI that permeates the globalized infrastructures of industry, commerce, communication, entertainment, and surveillance. Artists uncover the problematic aspects and undesirable consequences of corporate AI and denounce biases, prejudices, economic inequalities, and political agendas encoded in the mainstream ML architectures. In some works, they also engage in an exploratory critique of the nature of ML as an artistic medium. To incite critical scrutiny, artists sometimes combine humour and provocation by intentionally taking ambivalent positions toward the issues they address; they emulate the corporate AI's operative models but recontextualize them or repurpose their objectives for ironic revelatory effects. One of the common methodologies involves taking an existent ML pipeline, training it with a nonstandard dataset, and employing it for novel tasks. Successful works usually refrain from dramatic interventions and overly didactic explanations in order to let the audience actively identify the interests, animosities, struggles, inequalities, and injustices of corporate AI. A detailed study of tactical AI art would exceed the available volume of this paper, so its central discussion pertains to the exemplars in the three most representative subject areas: sociocultural, existential, and political.

2.1 Sociocultural

Many cultural manifestations of applied AI are linguistic, so artists often work with natural language processing (NLP) systems to critique their political undertones. For example, Jonas Eltes' installation *Lost in Computation* (2017) features a continuous real-time conversation between a Swedish-speaking and an Italian-speaking chatbot connected through Google Translate service. It simultaneously highlights the ambiguities of machine cognition and showcases the increasing accuracy and flexibility of language modelling algorithms (Eltes 2017). *Lost in Computation* references earlier Ken Feingold's installations such as *If, Then, What If,* or *Sinking Feeling* (all 2001) (Feingold 2021) and Marc Böhlen's *Amy and Klara* (2005-2008) (Böhlen 2005-2008). In these works, NLP systems provide semantically plausible but ultimately senseless continuation of narrative episodes which allude to the flimsiness of the Turing test and serve as vocalized metaphors for our lives. They extend the uncanny experience into the absurdity of miscommunication and accentuate the overall superficiality of the systems tasked to emulate human exchange. Artists also indicate the dubious sociopolitical background of NLP technologies. For example, Matt Richardson's *Descriptive Camera* (2012) has a lens but no display;it sends the photographed image directly to an Amazon MTurker tasked to write down and upload its brief description, which the device prints out (Richardson 2012). It provides a revelatory counter-intuitive glimpse into the widespread exploitation of transnational echelons of underpaid workers for ML training dataset annotation, which corporate AI euphemistically calls "artificial Artificial Intelligence" (AAI) or "pseudo-AI".[2]

2. Further examples of critical NLP include Ross Goodwin's *Text Clock* (2014); Michel Erler's *Deep Learning Kubrick* (2016); Ross Goodwin and Oscar Sharp's *Sunspring* (2016); Jonas Lund's *Talk to Me* (2017-2019); Joel Swanson's *Codependent Algorithms* (2018) (Swanson 2018); Disnovation.org's *Predictive Art Bot* (since 2017); Sofian Audry and Monty Cantsin's *The Sense of Neoism!* (2018); Philipp Schmitt's *Computed Curation Generator* (2017); Alexander Reben's *AI Am I (The New Aesthetic)* (2020); Nirav Beni's *AI Spy* (2020); and others.

To underline the issues in the visual layers of the AI-influenced culture, artists make deepfakes by modifying generative adversarial network (GAN) architectures. For example, Libby Heaney's *Resurrection (TOTB)* (2019) thematizes both the star power in music and the memetic power of deepfakes (Heaney 2019a). Visitors of this installation are invited to perform karaoke in which the original musician of a chosen song is video-deepfaked to mimic the visitor's singing and gesturing/dancing. In between karaoke acts, the host Sammy James Britten engages the audience in the discussion of power, desire, and control—an extension that seems to be as imposing and redundant as the artist's explanatory section for this work (Grba 2021, 246-247). Heaney's *Euro(re)vision* (2019) addresses the transmission of power and politics through popular media more effectively. In this video, deepfaked Angela Merkel and Theresa May sing absurd songs in the style of Dadaist Cabaret Voltaire performances within a setting of the Eurovision song contest (Heaney 2019b). Their disfluent algorithmic poetry eerily resembles the nonsensicality of actual Brexit discourse and implies the broader semantic reality of political life. In a similar fashion, Bill Posters and Daniel Howe confused the Instagram surfers by posting two iterations of their work *Big Dada: Public Faces* (2019-2021)—a series of deepfaked video statements by Marcel Duchamp about the ashes of Dada, Marina Abramović about mimetic evolution, Mark Zuckerberg about the second Enlightenment, Kim Kardashian about psycho-politics, Morgan Freeman about smart power, and Donald Trump about truth (Posters and Howe 2021).

In several works, Jake Elwes critically engages the cultural implications of training dataset annotation and algorithm design in mainstream AI. In the multipart *Zizi Project* (since 2019), he interfaces deepfake with the world of LGBTQ+. *Zizi - Queering the Dataset* (2019) is a video installation continuously morphing through glitchy gender-fluid portraits. Elwes used a StyleGAN trained on Nvidia's Flickr-Faces-HQ dataset and retrained it on a new dataset of around 1,000 portraits of drag performers, scraped from the Internet. Another part of the *Zizi Project* is the online work *Zizi Show* (2020) which critiques both anthropomorphism and the error-prone gender inclusiveness of AI. This virtual drag cabaret features deepfakes generated from the training datasets based on the original films of London drag artists' performances (Elwes 2020). The *Zizi Project* clearly indicates that the training model datasets and statistical nature of data processing in GANs inevitably impose formal constraints on the possible outputs (such as realistic human-like images) regardless of the common rhetoric about the "unpredictability" or "originality" of such systems; however, this is an already known and well-documented issue (Pasquinelli 2019, 9-10). Beyond that, the project fails to show how exactly the race, gender, and class inequalities and stereotypes transfer into ML to harm the underrepresented social, ethnic, or gender groups. Its playful, technically sophisticated remediation within AI-influenced cultural context may be beneficial for the celebration, affirmation, and inclusion of LGBTQ+, but its publicity narratives, high production values, and focus on glamour and spectacle in lieu of less picturesque but perhaps more important existential aspects of LGBTQ+ can be perceived as exploitative. Moreover, if taken seriously by corporate AI, this critique can contribute to the refined normalization, instead of correction, of sociopolitical biases toward the LGBTQ+ community because these biases have a broader, deeper, and darker historical background.

In contrast, Derek Curry and Jennifer Gradecki's deepfakes *Infodemic* (2020) and *Going Viral* (2020-2021) exemplify a consistently effective critique, recontextualization, and transformation of ML as a sociotechnical realm (Gradecki and Curry 2017). Both works target celebrities, pundits, politicians, and tech moguls who have "contributed" to the CoVID-19 pandemic by spreading misinformation and conspiracy theories, which themselves went "viral", often spreading faster than real news (Curry and Gradecki 2020; Gradecki and Curry 2021). For example, *Infodemic* features a cGAN-deepfaked talking head video in which some of these influencers deliver public service announcements voiced by academics, medical experts, and journalists that correct false narratives about the pandemic. By playing with deepfakes within their native context of fake news, these projects also probe the broader phenomenology of mediated narratives. The effectiveness of Curry and Gradecki's tactics is based on thorough research and self-referential critical methodology with computational media affordances; its playful transgressive affects are also friendly implications of our complicity to the politically problematic aspects of the applied AI through conformity, lack of involvement, or non-action. Leonardo Selvaggio's web project *Apologize to America* (2021) relates to this approach by using augmented reality instead of deepfake. Powered by Selvaggio's custom Snapchat lens, it invites visitors to record an apology while "wearing" the 45th President of the United States' portrait mapped onto their face. Recorded apologies are published and archived on the website apologize2america.com, and visitors can share them on social media (Selvaggio 2021).

2.2 Existential

AI technologies affect society, culture, and politics through the material, physical, ecological, and existential changes. Artists sometimes metaphorize this influence by using geospatial contents (landscapes, terrains, maps) for training datasets and by positioning the machine-learned output in politically connotated contexts.

For example, in several formally economical interactive installations, Nao Tokui addresses the arbitrariness of ML-powered sound and image recognition and synthesis in entertainment, advertising, surveillance, law enforcement, and the military. In *Imaginary Landscape* (2018), the software continuously analyses Google StreetView photographs, selects three that look similar, and joins them together horizontally in a three-wall projection. Another module, trained on landscape videos, generates soundscapes that correspond with stitched triptych landscapes (Tokui 2018a). In *Imaginary Soundwalk* (2018) viewers freely navigate Google StreetView for which the ML system, using the cross-modal technique for image-to-audio information retrieval, generates the “appropriate” soundscape (Tokui 2018b).

Some works explore the physicality of AI through haptics or kinesthetics. For example, François Quévillon’s *Algorithmic Drive* (2018-2019) uses kinesthetics to play out the tension between robotics and the unpredictable nature of the world. For this work, several months-worth of data collected by a car’s onboard computer, such as geolocation, orientation, speed, engine RPM, stability, and temperatures at various sensors, is synchronized with the video capture from the car’s dash-cam. The captured videos and data feed a sampling system that sorts the content statistically and assembles a video that alternates between calm and agitated states by modifying the parameters of sound, image, car’s activity, and environment. An interactive controller displays data for each scene and allows visitor intervention (Quévillon 2019).

Continuing the line of statistically driven eco-conscious works, such as Chris Jordan’s *Running the Numbers* (since 2006) (Jordan 2021), artists use ML to generate visuals, objects, and narratives that address the environmental changes imposed by the large-scale computation-intense technologies of AI research and business. For example, Ben Snell’s *Inheritance* (2020) elegantly compresses the material and ecological aspects of AI. It is a series of AI-generated sculptures cast in the composite medium which was produced by pulverizing the computers used to generate the sculptures’ 3D models (Snell 2020). Although it is debatable how successfully this work deals with non-human agency and creative expression (Zeilinger 2021, 19-20), it provocatively references radical auto-recursive art experiments such as Jean Tinguely's self-destructive machines. On the other hand, Maja Petrić's *Lost Skies* (2017) illustrates how easy it is for the projects in this range to slip into aestheticizing the ecological issues instead of articulating the data into meaningful or actionable narratives (Petrić 2021). Regardless of their poetic values, it is not easy to calculate, but probably not difficult to guess, the degree to which the systemic technological entanglements of eco-critical AI artworks (and AI art in general) themselves participate in the overall environmental damage.[3]

3. Other examples include Tivon Rice's *Models for Environmental Literacy* (2020); Tega Brain, Julian Oliver, Bengt Sjölén's *Asunder* (2021); Kai-Luen Liang's *Blue Marbles* (2021); and others.

Max Hawkins' R*andomized Living* (2015-2017) features a more responsible integration and interrogation of a spectrum of the applied AI's material consequences. In this two-year experiment, Hawkins organized his life according to the dictate of recommendation algorithms. He designed a series of apps that used online data to suggest a city where he would live for about a month and, once there, the places to go, people to meet, and things to do (Hawkins 2021). *Randomized Living* is a bold exemplar of cybernetic existentialism—the art of conceiving a responsive and evolving cybernetic system in order to express deep existential concerns. Its implications involve the humans' general susceptibility to modifying behaviour and cognition in order to fit various machinic protocols, for example labour regimes in industrial capitalism or perceptual and interaction conditioning in early VR development (Lanier 2017). This susceptibility now manifests in a tendency among the users of AI-powered devices and the operators of AI systems to constrain their vocabulary and pronunciation so the software can interpret them (Pasquinelli 2019, 17). This reductivism is related to the shifts in social relations driven by the mutually reinforcing opportunism and network effects for the users of social media. It reflects the underlying pathological business logic of dominant information services, which dehumanize users and turn them into slavish data-generating commodities by addicting them to negatively biased, politically derisive, and socially toxic "free" services. It is worth noting, however, that such deviations are usually compensated by quick cultural maturation, as exemplified by the disproportionally high fidelity attributed by the audience to early photography, cinema, or sound recording whereas they later become aware of the artificiality and imperfections of these media. Nevertheless, while the specific AI issues can be viewed as transient side-effects of the continuing coevolution between culture and technology, it is important to remain cognizant and vigilant about them.

2.3 Political

In order to reverse-engineer the uneasy positioning of the individual toward or within computational systems of control, artists such as Josh On (On 2001-2004), Joana Moll (Moll 2020), Adam Harvey (Harvey and LaPlace 2021), and Vladan

Joler have been using analytical tools and tactical cartography.[4] For example, with SHARE Lab and Kate Crawford, Vladan Joler released *Exploitation Forensics* (2017) whose series of intricate diagrams snapshots the functional logic of Internet infrastructure: from network topologies and the architecture of social media (Facebook) to the production, consumption, and revenue generation complex on Amazon.com (Anonymous 2017). Similarly, Joler and Crawford's collaborative project, *Anatomy of an AI System* (2018) deconstructs the Amazon Echo device's black box by mapping its components onto the frameworks of global economy and ecology (Crawford and Joler 2018). With Matteo Pasquinelli, Joler issued *The Nooscope Manifested* (2020), a visual essay about the structural and functional logic of subsymbolic ML, its epistemological and political implications (Joler and Pasquinelli 2020). It leverages the notions of gaze and vision-enhancing instruments as metaphorical and comparative devices, although their conceptual suitability within the context of ML is debatable.

4. Pioneered by Mark Lombardi in the 1990s and Bureau d'Etudes since the early 2000s, tactical cartography involves constructing diagrams and maps of financial and political power networks, which are simultaneously aesthetic, investigative, and activist (Hobbs and Richards 2003; Bureau d'Etudes 2015).

Since the introduction of the OpenCV library in 2000, artists have been using computer vision (CV) for various purposes in a diverse corpus of exploratory works.[5] With advances in ML, this exploration has intensified and increasingly involved the critique of the (ab)use of CV for taxonomic imaging, object detection, face recognition, and emotion classification. For example, Jake Elwes' video *Machine Learning Porn* (2016) indicates human (perceptive) prejudices that influence the design of ML filters for "inappropriate" content. Elwes took the open_nsfw CNN that was originally trained with Yahoo's model for detecting "sexually explicit" or "offensive" visuals and repurposed its recognition classifiers as parameters for generating new images. This inversion outputs visually abstract videos with a "porny" allusiveness (Elwes 2016). However, the cogency of this project depends on leaving out that *all* visual forms are abstract by default and that the pathways of complex scene recognition and related decision-making in humans are not precisely known (Wang and Cottrell 2017; Wischnewski and Peelen 2021) so the ground for critiquing biases in these pathways is uncertain.

5. Examples include Ken Rinaldo's *Paparazzi Bots* (2009); Golan Levin and Zachary Lieberman's *Reface (Portrait Sequencer)* (2007-2010); Shinseungback Kimyonghun's *Cloud Face* (2012) and *Portrait* (2013); Onformative studio's *Google Faces* (2013); Benedikt Groß and Joey Lee's *Aerial Bold* (since 2016); Tom White's *Perception Engines* (2018 and 2021); and others.

The sensitive issues of ML-powered biometry are particularly pertinent in facial recognition and classification due to the convergence of evolutionarily important visual features within the face and the psycho-social role of a face as the main representation of the self and identity. Various deficiencies frame the CV training and recognition processes in which the classification models ultimately always make implicit (but unobjective) claims to represent their subjects. The deficiencies in machinic face detection/identification, some of which have persisted from the earlier technologies such as VR (Lanier 2019), have been continuously identified by both scientists (Orcutt 2016; Zhao et al. 2017) and artists. For example, Joy Buolamwini and Timnit Gebru's scientific research, which started as Buolamwini's MS thesis in 2017, turned into a project with artistic overtones, titled *Gender Shades* (2018). It assesses the accuracy of several corporate facial classifiers (Adience, IBM, Microsoft, and Face++) with respect to gender, skin type, and skin type/gender intersection. Using a custom benchmark dataset with diverse skin types based on 1,270 images of parliamentarians from three African and three European countries, Buolamwini and Gebru showed that the error rate of the tested corporate classifiers was significantly higher for women with darker skin colour (Buolamwini and Gebru 2018). Encouraged by the IBM, they published their benchmark dataset so it can be applied in practice for accuracy calibration. Their findings affected the public, the corporate AI sector, and the US policymakers (Gershgorn 2020).

Kate Crawford and Trevor Paglen's exhibition *Training Humans* (2019-2020), and the accompanying essay *Excavating AI: The Politics of Images in Machine Learning Training Sets*, had a similar agenda (Crawford and Paglen 2019; Fondazione Prada 2020). Their critique of corporate practices for training CV systems includes racial bias and the use of facial images and videos without consent to build training datasets. Yet Michael Lyons, a co-author on one of the datasets featured in the project (JAFFE), showed that Paglen and Crawford themselves reproduced and exhibited these same images without consent (Lyons 2020, 2021; Leibowicz et al. 2021, 7). Compared with the methodologically flawed and ethically compromised strategy of *Training Humans*, Buolamwini and Gebru's *Gender Shades* similarly draws public attention to an established repertoire of race-related issues in CV, but it also productively intervenes in the tech and policy-making sectors, where such correctives (should) matter most. On the other hand, both of these projects open questions beyond the obvious technopolitical layers. Should an activist intervention end up (proactively or indirectly) improving the AI's profitable and further manipulable codes, and be used by the corporate sector to remedy its public image but without necessarily improving its technical and ethical standards? Or should it disrupt the code-crystalized corporate AI practices on a higher politically consequential level? And, within that context, how effectively the government policy changes can affect the private businesses with global influence?

Various modes of CV-driven interactivity (human-machine, machine-machine, and human-machine-human) allow artists to stir up a space for the audience's contemplation and critical interpretation. For example, Ross Goodwin's *word.camera* (2015) reiterates Matt Richardson's lexicographic approach in *Descriptive Camera* but uses "non-artificial" AI for image-to-text conversion.[6] The first version of this work prints out the passages from novels relevant to the uploaded images captured through a hand-held camera interface. The second version is a surveillance camera that autonomously searches for faces and describes them in "spoken" words (Goodwyn 2015). Jake Elwes' video installation *Closed Loop* (2017) establishes a mutually generative relational loop between a text-to-image and image-to-text model, whose inaccuracies and biases imply ethical issues in an unpredictable and witty continuum (Elwes 2017).

6. RyBN and Marie Lechner's media archeology project *Human Computers* (2016-2019) also uncovers the essential but largely "transparent" human echelons behind corporate AI.

Shinseungback Kimyonghun's installation *Mind* (2019) uses emotion analysis of the last 100 visitors' facial expressions to drive the ocean drums and generate a powerful minimalist sound ambient, with an overhead camera as a single indicator of the machinic gaze (Shinseungback Kimyonghun 2019). Martin Disley's open-source project *How They Met Themselves* (2021) exploits the recognition borders of face generation/recognition GANs. In a series of steps, it allows users to create photorealistic avatars for live webcam deepfaking. Based on the user's uploaded portrait, the avatar is created by a generation/discrimination process that yields two visually indistinguishable (virtually identical) images: one is positively identified as a person in the uploaded photo, and the other one is identified negatively (not a person in the photo). The user can then upload the generated ambivalent image to train the free online app Avatarify for real-time animated avatar superimposition in online interactions (Disley 2021).

Ironically, unlike the biases in ML, the individual "creative biases" and idiosyncrasies in AI art are desirable but relatively rare. Sebastian Schmieg tackles this deficiency with conceptual relevance, expressive economy, and formal clarity in projects 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 2016, 2017, 2018, 2019). In different ways, these works inject unconventional, seemingly absurd, or counter-intuitive taxonomies into image classification setups. For example, the visitors of the *Decisive Camera* project website can upload an image which will then be classified within a taxonomic space of four categories: Problem, Solution, Past, and Future, and assigned with a probability percentage for each category. The classification dataset was created in the project's initial phase which invited visitors to select images from the Photographers Gallery's image archive and to assign each image to one of these four categories. This playful subversion places the technical, methodological, and broader sociopolitical problems of ML design conventions firmly within the human context. It also provides the reflections of human nature in the arbitrary authoritarianism of corporate ML classification systems based on exploiting human labour for annotating the training datasets.

Artists also critique the human appetite for exploiting the speculative investment strategies wetted by corporate AI and related crypto technologies. For example, Anna Ridler's *Mosaic Virus: Bitcoin Per Hour* (2018) questions the concepts of ownership, obsessions with wealth, and financial speculation by referring to the historical "tulip mania" phenomenon. Trained on Ridler's custom dataset of hand-labelled photographs of tulips, a GAN generates images of tulips inflected by the current Bitcoin values. It links the instability of values projected onto commodified artefacts with the opacity of computational technologies used in creating the work (Ridler 2019). Ben Bogard's *Zombie Formalist* (2021) arranges a witty marriage of ML and Komar and Melamid's *People's Choice* (1994-1997)[7] aiming to direct a critical focus onto the hyperproduction of bland formalism

7. Although Bogart does not acknowledge this referential work (Bogart 2021a; 2021b).

(Robinson 2014) as a signifier of digital art's commodification boosted by the crypto art market. In this installation, two AI-powered lightboxes randomly generate abstract images calibrated by measuring the viewers' engagement in two modes: the attention span via face detection, and the number of Twitter likes and retweets of the uploaded images (Bogart 2021a). Both *Mosaic Virus* and *Zombie Formalist* make clear cases, but mainly for the audience that is already critically aware of Bitcoin politics or digital art's commodification. For the average audience—which may be unfamiliar with their specific issues—the strong aesthetic fronts of these projects can be decisive or counter-effective. As is often the case with tactical art, the combination of lofty motivation and somewhat ambiguous presentation may diminish the projects' effectiveness or even expedite its recuperation. Since the sociotechnical unpredictability is closely related to financial instability, it is worth remembering that AI research, which has been going through successive "springs" and "winters" (Mitchell 2019, 31-32), may end up in Disnovation.org's project *The Museum of Failures* (since 2015). In a museological setting, it features a collection of aborted tech projects, flops, errors, malfunctions, business failures, ethical rejections, or disasters presented in various formats from historical, symbolic, poetic, and cultural points of view (Disnovation.org 2021).

3. Challenges

These examples show that, through success or failure, tactical AI art reveals human fallacies, conceptual constraints, and sociopolitical ambiguities in both the AI-influenced society and in AI art itself. By identifying, acknowledging, and understanding these issues, artists can find new ways to intervene critically and productively in current sociopolitical reality. Similar to AI research's struggles with encoding crucial aspects of human cognition such as intuition, abstraction, analogy-making, common sense, and inventiveness into machine intelligence (Mitchell 2019, 200-214; Marcus and Davis 2019, 160-191), the poetic realm of AI art is deficient in interesting intuitions, meaningful abstractions, strong concepts, and imaginative analogies that effectively address the wider perspectives or deeper issues of human existence. The uneven intellectual breadth and depth, biased or constrained contextual awareness, and sketchy art-historical knowledge affect many artists' conceptual thinking, methodologies, and the cogency of their outcomes.

Technocratic or techno-fetishist mentalities have been haunting computational arts since their outset, and continue to affect AI art (Taylor 2014; Żylińska 2020, 75-85). They often reinforce a naïve lack of understanding that production techniques in the arts fundamentally unfold and get emancipated by coupling with conceptual thinking and contextual awareness. Conversely, artists who exaggerate or fake technical competencies are equally problematic because their works usually miss interesting technological aspects.

Various apparent, but often undisclosed conceptual, methodological, thematic, aesthetic, and presentational similarities between different works indicate the issues of the artists' creative literacy and contextual appreciation. Sincerely-motivated and well-conceived concepts are sometimes rendered as dry, unengaging, ineffective, or counter-effective works (Grba 2022, 20-21). Critical cogency, viability, and impact are affected by the pretentious or didactic representational strategies, exceeding topicality, and inflated theoretical rhetoric (Quaranta 2020; Grba 2021, 246-247). Furthermore, artistic and academic communities tend to develop echo chambers in which their work gains significance while its real-world impact requires more stringent assessment and correctives. The virtualization of critical focus (or purpose) may be fruitful within the academic milieu, but the general audience, which is central to tactical art, can easily recognize it as aloofness or cynicism which leads to indifference, distrust, or resentment.

Broader issues that affect tactical AI art include the uninformed media coverage, the questionable norms of the art community, the depleting autonomy of academic institutions, and the problematic legal norms for centralized, profit-motivated control of intellectual property and creative labour. The responsibility for tackling these issues lies not only with the artists, but also with scientists, entrepreneurs, cultural agents, and the public. The exploitative strategies of MCA entice AI artists to compromise their tactical goals in order to accommodate the conservative requirements for scarcity, commercial viability, and ownership (Grba 2020, 252-254). As they unfold within the bubblingly scammy NFT ecosystem (Quaranta 2021), the artists' proverbial inclinations toward myopic opportunism call for sophisticated tactical interventions that would disrupt the lures of commodification, complacency, and recuperation. In general, it is important to acknowledge that both art and technology are human dispositives within anthropological and sociocultural perspectives so that the poetic qualities of our artefacts are inherently instrumentalizable as virtue signalling means driven by competitive ambitions.

4. Perspectives

Contemporary AI provides an excellent milieu for the artists to demystify ML systems as sociopolitical apparatuses and to reiterate that science, technology, and businesses need thorough improvement of epistemological and ethical standards facing the increasing complexity of human existence. Therein lays the potential for tactical AI art to direct computational arts toward a socially responsible and epistemologically relevant expressive stratum.

In order to engage the audience with a lasting impact, artists need to match their procedural skills with motivational sincerity and ideational cogency, and maintain a critical outlook on their poetic devices. The ethos of maturely balanced competencies deserves cultivation through expressive diversification, experimental freedom, playfulness, bricolage, conceptually strong hacking, and imaginative discovery. In principle, artists can benefit from epistemic humility to develop more rigorous criteria for creative thinking and better multidisciplinary knowledge of historical, theoretical, cultural, and political contexts in which they produce and present their works (Böhlen 2020; Grba 2022, 24). This will help them address the potentially adverse scenarios and clear the way for meaningful creative directives. The inherently political nature of AI (Pasquinelli 2019) obliges artists not only to exploit but to deconstruct and explore their expressive means by recognizing the injustices in the notional, relational, technical, social, and other layers of the conditions in which they live and create.

However, all actors in AI art should strive for integrity by recognizing, objectively assessing, and correcting the systemically biased and noisy professional value systems of the MCA and academia. The entanglements with corporate AI, MCA, and academia support the forthcoming AI art projects, but may also attenuate their criticality and expedite recuperation. To tackle this, artists should strive to resist prioritizing their careers over their art, be open to taking genuine risks by evolving potentially hazardous ideas, and pursue systematic support with scepticism toward institutional rationales for art sponsorship. Successful tactical projects utilize their entanglements self-consciously, as the conceptual and existentially inherent features of digital culture. Their impact can be improved by bolder and more nuanced examination of the cultural and sociopolitical contexts of AI technology and business, and by deeper probing and problematizing the underlining concepts such as intelligence, creativity, expressive agency, authorship, intellectual labour, ownership, authenticity, accuracy, and bias.

For countering the recuperative sophistication of info-capitalism (which artists tend to underestimate, overlook, or ignore), stealthy subversiveness and subterfuge seem to be more prudent than didactic overexplanation or overbearing spectacularism. Artists should articulate and respect their methodologies as heterogeneous productive frameworks whose experiential processes and outcomes inform the audience by stirring inquisitiveness and critical thinking, stimulating imagination, and encouraging progressive action. Such tactical frameworks are more impactful than surface-based, aestheticized, descriptive, or rhetorical ones. By demystifying the seemingly radical capabilities of their tools, artists can leverage the issues of modern AI as critical assets with wide political significance. Empowered by the destabilizing value of humour, responsible treatment of these assets can build new insights about human nature and provide meaningful posthumanist perspectives (McQuillan 2018).

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Playa Bagdad|SpaceX: Sound, Necropolitics, and the Industrialization of Space

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This article looks through the lens of speculation at a scenario connecting the US-Mexico border complexities with the industrialization of outer space. Based on an art-oriented and multifaceted research process including fieldwork and conversations with Playa Bagdad's residents, the scrutiny of SpaceX environmental impact assessments, and attendance to several Federal Aviation Administration (FAA) public hearings; this compilation of ideas investigates the subjectivities intrinsic to the coexistence of Playa Bagdad (Tamaulipas, MX) and SpaceX (Texas, US) through the social and political implications of sound.

In this scenario, the noise produced by the launchers' engines will not only act as mobilizing force resonating in the form of intense acoustic shock waves with the capacity of affecting materiality —including the biosphere and the body—, but as a cultural weapon nurturing an already existing ecology of fear. All of this amid a hybrid geography where the radical asymmetries of neoliberal policies fuel a regime built upon necropolitics which intersect with the rising infrastructure of space exploration.

Ironically, the confrontation between Playa Bagdad and SpaceX remains in silence, as an under-seen techno-political spectacle in which a community lacking political recognition stands in the front row to witness passively the consolidation of an economic zone that promises to delimitate a new cosmological dimension; one perpetuating the validation of progress, exclusively, through hyper-technological advancement.

Keywords space industrialization, necropolitics, geopolitics, sound-politics, Latin-American futurities, techno-political spectacle

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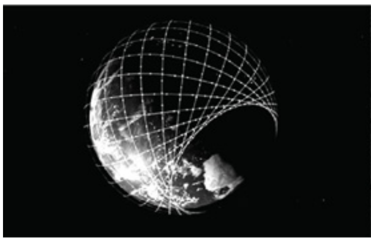
Elysium, a Hollywood film directed by South-African Neill Blomkamp in 2013, tells the story of a not so far anthropogenic future in which Earth is no longer suitable for the living standards of the ruling class. As expected, their solution is to leave the planet towards a space colony floating in low-earth orbit named Elysium, right above a dystopian version of Los Angeles, California. Those who remain on the ground —mostly workers ruled by robots— live in a continuous state of scarcity and repression where looking up at the sky becomes an aspirational act of relief, always at the whim of setting the sight on Elysium. The futuristic look of the orbital habitat portrayed in the movie, which holds the means to sustain an autonomous ecosystem, resembles the cylinders proposed by space activist Gerard O'Neill in the 70s. As one of the key figures in conceptualizing the expansionist narratives justifying the industrialization of space, O'Neill's work was instrumental in building a logic that foresees societal stratification in relationship to spatially "ascending from the Earth as an absolute form of progress" (Deudney 2020, 267).

In several media features across the internet, Blomkamp speaks openly about a trip to Tijuana, Mexico, that led to his arrest by the local police force. Apparently, it took a while to settle an agreement with the cops who, in the meantime, drove him through the slums of one of the most complex US-Mexico border towns. Mesmerized by the roughness of the city, Blomkamp realized that a peripheral Mexican cityscape would fit perfectly his vision of a megalopolis ruined by the extractive hunger of capitalist greed. In the end, the film was shot in Mexico City, not Tijuana. Ironically, on the opposite side of Tijuana (considered the western corner of Latin America), right below the US-Mexico border and on the shores of the Mexican Gulf in Tamaulipas, lies Playa Bagdad, a relatively small —approximately 500 residents— and precarious fishing community facing a reality that surpasses fiction with the arrival of a controversial co-habitant. Only three miles above the border line, the space exploration enterprise SpaceX is developing an area to build its main vertical launch facilities at Boca Chica, Texas. Besides being a close ally of the US Military, SpaceX is one of the protagonists in the race to industrialize outer space. With an ambitious agenda to fulfill by 2030, the private corporation is committed to accomplish Starlink, a planetary-scale project that includes a 40,000 satellite array floating in low-Earth orbit. An ambivalent macro-infrastructural operation founded upon emancipatory rhetorics promising to deliver an internet connection to every corner of the world.

Nonetheless, to complete its plan, the artificial constellation will spread around the planet as a massive hunting net; as an unreachable hyperobject with the capacity to centralize and control an immense flow of digital information. Likewise, they plan to build a colony on Mars and turn the human species into an interplanetary civilization. In early 2021, SpaceX announced their intentions to settle in Texas and make use of the Boca Chica launch site as their headquarters for carrying on the multiple activities needed to reach their objectives, even suggesting the possibility of building a whole city around it: Starbase, Texas.



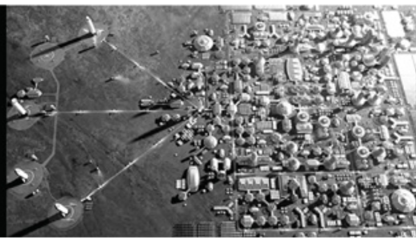


Fig. 1. Starlink diagram.

Fig. 2. SpaceX's colony on Mars (3D Visualization).

Fig. 3. Elon Musk montage.

Playa Bagdad (Baghdad's Beach) has a unique rather eccentric name for a society culturally and geographically distant from Iraq. Its name was coined during the 19th century due to the resemblance between its characteristic dunes and the stereotypical representation of a middle eastern landscape. Despite this, they do share a remarkable factual connection: both places have been designated as Level 4 or *no-go zones* by the US Department of Homeland Security.

This classification system is part of the US citizens' travel guidance; only war-torn countries such as Syria, Afghanistan, Yemen, Iraq, and the northern Mexican state of Tamaulipas are recipients of this title. Tamaulipas —a state sharing a 230-mile border with Texas— has played a pivotal role in the ongoing war on drugs waged since 2006, which has spread a wave of radical violence leaving more than 300,000 casualties across Mexico. In this scenario, Tamaulipas' three main border towns —Nuevo Laredo, Reynosa, and Matamoros— stand as crucial operational sites for the smuggling industry. Continuous gangland clashes fuel violence as rival cartels and military forces remain in dispute for controlling a myriad of trafficking routes, some of them enabled by the North American Free Trade Agreement (NAFTA). The unprecedented crime levels in the state, particularly in the US-Mexico border area, have severely eroded the social thread and have caused an economic recession that is palpable in Tamaulipas' urban and rural topography.

More recently, in early July of 2021, the Federal Government made public the finding of half a ton of calcined human bones in the district of La Bartolina; only six miles away from Playa Bagdad and ten from the SpaceX launch site. The authorities made clear that the human remains may correspond to some of the approximately 11,000 *desaparecidos* (missing people) in Tamaulipas, allegedly victims of organized crime. They also declared that, most likely, more of these *centers of extermination* (as called by the media) could be spread throughout the area. The vast extension of La Bartolina and its proximity to Boca Chica makes it possible that debris produced by failed lift-offs will potentially land in the same fields where human remains lay still to be found, buried under the soil of the Tamaulipas eastern frontier. A highly intricate region will now host a techno-political spectacle displaying the distressing cultural encounters of modernity, where the past, present, and future collide.

This archeological and rather morbid scenario posits a straightforward correlation between a social order built upon ultraviolence and the monolithic presence of SpaceX, underlining in this way the notion of *gore capitalism* proposed by the Tijuana-born and raised philosopher Sayak Valencia, whose reinterpretation of the hegemonic global economy in borderlines confronts sublime notions of progress with regimes built upon necropolitics:

> We take the term *gore* from a genre of films characterized by extreme, brutal violence. Thus, *gore capitalism* refers to the undisguised and unjustified bloodshed that is the price the Third World pays for adhering to the increasingly demanding logic of capitalism. It also refers to the many instances of dismembering and disembowelment, often tied up with organized crime, gender and the predatory uses of bodies. In general, this term posits these incredibly brutal kinds of violence as tools of necroempowerment. (Valencia 2018, 20)


Fig. 4. Mexican authorities at La Bartolina, Tamaulipas.


Fig. 5. SpaceX launcher debris found in the banks of the Rio Grande.

In 2014, a year before Obama's administration ratified the Space Act —an agreement authorizing private investment in space exploration —the US Federal Aviation Administration (FAA) made public the *Environmental Impact Statement* (EIS) which evaluates the potential consequences that may result from the issuing of launch licenses and experimental permits to SpaceX. This declaration allows SpaceX to launch the Falcon 9 and Falcon Heavy spacecrafts, and a variety of smaller reusable suborbital launch vehicles from a launch site on privately-owned property in Boca Chica, Texas. Throughout the 400-page document, a concern that resonates regarding the operational details of the site, is the social and ecological detriment resulting from the exposure to the thunderous noise produced by the launch vehicles' engines during lift-off. The sound emitted by a space shuttle oscillates between 135dB and 194dB, the maximum volume sound waves can reach when moving through the Earth's atmosphere. According to the Federal Interagency Committee on Aviation Noise (FICAN) and Partnership for Air Transportation Noise and Emissions Reduction[1] (PARTNER), sounds of this intensity have significant consequences in the biosphere, causing behavioral disorders in the wildlife and affecting migration patterns.

They also affect people in a variegated number of ways, which can be broken down into two general categories: auditory effects (hearing loss) and non-auditory effects (activity interference and physiological effects). Several studies conducted by PARTNER, examine a wide spectrum of manifestations derived from the exposure to the blast produced by sonic booms and other transient sounds, as well as longer exposure duration to continuous levels of harmful noise such as the ones produced during static fire tests,[2] lift-offs, and landing. Some of the investigation's main concerns include annoyance, speech interference, sleep interference and awakenings, effects on learning, and structural damage caused by inaudible low frequencies. The symptoms may represent neural entrainment, nausea, organ resonance effects, concussion and physical impact, or respiration inhibition. In his book *Sonic Warfare: Sound, Affect, and the Ecology of Fear*, Steve Goodman claims that as soon as volume exceeds 80db, blood pressure rises, the stomach and intestine operate more slowly, the pupils become larger, and the skin gets paler—no matter whether the noise is found pleasant, disruptive, or is not even consciously perceived.

The sound emitted by a spacecraft is conditioned to its payload capacity, which requires a specific engine set up to generate the thrust needed for lift-off. The EIS considers two different launchers, Falcon 9 and Falcon Heavy. Falcon 9 utilizes an array of 9 Merlin engines for taking into the low-earth orbit payloads up to 22,800 kg. Falcon Heavy is much larger, supporting a payload capacity of 68,000 kg that needs the thrust of 27 Merlin engines. According to the EIS data, the noise produced by the launches will reach a 135dB contour at its most critical point to then attenuate concentrically. Nonetheless, the proximity of the vertical launch allows sound waves with enough potency to affect the environment to move across the US-Mexico border into Playa Bagdad. The EIS treats the transboundary complexity of this situation in a usual reductionist manner connoting the unilateral interest of the power structures intrinsic to the US-Mexico border dynamics. This thread is clearly remarked when the EIS openly assures —mistakenly— that with the implementation of Google Earth, aerial imagery of the south of the US-Mexico border was reviewed[3] concluding that the closest population in Mexican territory is Matamoros, located approximately 20 miles southwest to the proposed vertical launch area. This statement is quite problematic in two ways. The first one calls attention to the political weight that Silicon Valley tech corporations, such as Google, have in "the reworking of planetary imaginaries informing cartographic systems

1. PARTNER: The Partnership for Air Transportation Noise and Emissions Reduction is an aviation cooperative research organization affiliated to the MIT (Massachusetts Institute of Technology) and NASA (National Aeronautics and Space Administration).

2. Starship static fire tests are planned to occur at the Boca Chica Launch Facility where 3 engines, that each generate 478 Lbs of thrust at sea level, will be fired for 60 seconds. https://www.faa.gov/space/stakeholder_engagement/spacex_starship/media/Appendix_B_Noise_Assessment.pdf

3. Federal Aviation Administration Office of Commercial Space Transportation, Final Environmental Impact Statement SpaceX Texas Launch Site, Volume I, Exectuvie Summary, Chapters 1-14 (Washington D.C., 2016, 3.3.4 Existing Conditions, p. 126) at https://www.faa.gov/space/environmental/nepa_docs/spacex_texas_eis/ "Aerial imagery south of the U.S./Mexico border has been reviewed and the area was found to be unpopulated and undeveloped. The nearest city in Mexico (Matamoros) is approximately 20 miles southwest of the proposed vertical launch area."

infused with the norms of the community that creates them" (Misseri 2016, 73). The second one regards the systemic and social implication of deliberately erasing Playa Bagdad from the map, who will be significantly affected by SpaceX's noise pollution since it is located inside the bounds of the impact region delimited by the FAA, only 12 miles afar from Boca Chica's launch site. This negligence underlines a subtle form of corporate colonialism that is not only about domination; but about altering the environmental conditions that make life possible.

In 2018, SpaceX started testing at the Boca Chica launch site the Starship SN prototype vehicles, which later on would become Starship/Super Heavy, a potent spacecraft that promises to be an iconic symbol of expansionism for those who dream about the human species as interplanetary. As the largest spacecraft ever built and with a payload capacity of 150,000 kg, Starship/Super Heavy is designed to perform long-range journeys such as Lunar and Mars missions, satellite payload tasks, and even future human flights beyond the orbit —a task only accomplished by NASA's Saturn V. The massive size of the behemoth and the technical complications within it, raised concerns about the environmental impact during lift-offs, landings, and static fire tests among NGOs and members of the local communities. Imbued by the urgency of getting rid of any obstacle contesting the activity of SpaceX and motivated by the seductive idea of the US playing the settler role in the imminent industrialization of space, the FAA made public in September 2021, a draft of the *Programmatic Environmental Assessment* (PEA).

The prevalent narrow scope of a 150-page document that seems more like a poorly updated version of the *Environmental Impact Statement* (EIS) published in 2014, looks forward to validating the SpaceX Starship/Super Heavy Launch Vehicle Program at Boca Chica rather desperately. The report's rhetoric relies on rephrasing opaque declarations that still remain blind to the transboundary consequences of a project in which acoustic energy will resonate not only in the form of sound but also as politics. According to the PEA, to generate the thrust needed, Starship/Super Heavy is expected to be equipped with 12 more Raptor engines than the Falcon Heavy launcher. During lift-off, landing, and static fire test, the 37-engine array will produce an intense sound that is expected, supposedly, to reach a maximum contour of 150dB.

Considering the similar characteristics in terms of size and payload capacity of Starship/Super Heavy and its predecessor Saturn V, the information provided by the PEA seems questionable. Recordings made during Saturn V's lift-offs show a volume of 194dB; the extreme potency of a sound of this sort not only would blast off the ear-drums of any living being standing nearby but disintegrate its totality. Thus, the interaction resulting from the friction between the powerful sound waves traveling through the atmosphere produces high temperatures that stir up pressure to then represent as a mobilizing force. The PEA acknowledges that during lift-off and landing, a harmful 111-120dB contour will extend into Tamaulipas; however, it seems to escape the fact that, besides affecting the body in several different ways, it could also cause structural damage in rudimentary settlements such as Playa Bagdad.

Fig. 6. Playa Bagdad, Tamaulipas (Mexico), 2021.

Likewise, the PEA states that in case a situation like this comes up, SpaceX would take full responsibility. This statement resonates like a false promise considering the narrow and biased scope of an infrastructural project that chooses not to see its transboundary impact, and that remains distant from a neighboring community that is poorly informed about the environmental and societal implications of the SpaceX agenda.

After conducting fieldwork in Playa Bagdad since 2019, I can confirm that neither SpaceX nor any Mexican authority has reached out to open a discussion about a detrimental situation that already has environmental consequences. In several field trips, community members have shared their experience of being exposed to the sound of SpaceX's launches, claiming that since the tests started, it is possible to observe how the wildlife behavior has been affected, primarily birds and terrestrial mammals. Fishermen say that whenever navigating offshore while a launch is being performed, the spacecraft rumbling noise mitigates the sound of the large outboard boat motors, fulfilling the ocean's vastness to create an eerie atmosphere of disorientation. However, the loud presence of SpaceX in the region will surely steer Playa Bagdad —a fishing community dependent on a biosphere that is now endangered—, in direction to reconfigure its economy as a sighting touristic destination from where to witness the frequent lift-offs persuading an industrialized outer space. The former equation draws attention to a historical scenario that underlines the US-Mexico border as a site for systemic experimentation that, with the rise of neoliberal politics, was subjected to a process of industrialization that permeates every aspect of society. Therefore, Playa Bagdad stands as a critical ground to think about the recursive implications of the emergence of an elitist economic zone mediated through geopolitical treaties delimitating abstract frontiers, only reachable for those with the technological means to be part of a space club that is —literally— pushing for an international order of societal stratification.

In *The Art of Noises*, a futurist manifesto written by the Italian composer Luigi Russolo, when speaking about modern warfare, he states that there is no movement or activity that is not revealed by noise, i.e., "noise enables us to discern a marching patrol in deepest darkness, even to judge the number of men that compose it" (Goodman 2010, 40). The former statement perils into falling as a phenomenological tautology. However, it could also operate as a guideline to navigate the intersection of SpaceX's sonic violence with Playa Bagdad's complexities through the politics of sound. This encompasses the frictions between the local against the global, nature against technology, rudimentary improvisation against hi-tech design, and necropolitics against space exploration.

The cultural and economic tensions resulting from the SpaceX-Playa Bagdad axiom spotlight a community that is being politically neglected while also being subjected to a process of dislocation that intends to be neutralized by opaque jurisdictions promoting SpaceX as the main contender in a new space race. A new era distant from the space exploration program *Whole Earth Security* proposed by Arthur C. Clarke and Carl Sagan, which advocates for "civilizational progress through knowledge enlargement, consciousness-raising, and the republican agenda of power restraint in the interest of the many" (Deudney 2020, 227). On the contrary, the industrialization of space is currently being put together over the violent and seductive imperatives of capitalism, on top of hidden layers aiming at constituting telecommunication empires, a profitable asteroid mining industry, and space governance organisms through corporate coalitions protecting the interest of those with technological superiority, such as NewSpace.[4] The shortage of perspective demands to scrutinize history, looking at stimulating a political memory interweaving events where technological hegemony enhanced by international law have paved the way to settle and control what the colonial apparatus conceives as peripheral land ––territories open to be rationally domesticated, planned, and re-engineered.

4. "NewSpace is a global industry of private companies and entrepreneurs who primarily target commercial customers, are backed by risk capital seeking a return, and seek to profit from innovative products or services developed in or for space..." at https://www.newspace.im

Such is the case of the Arianespace launch site at Kourou, in French Guiana. As the world's first commercial space transportation company founded in 1980, hundreds of satellites owned by different nation-states, corporations, and scientific institutions have been taken into orbit through this spaceport. Arianespace is a private enterprise with solid ties to the French government, who, after more than 200 years, still has political control over a South American territory that once was utilized as a penal colony, and now designated as an *overseas department* that, ironically, hosts a crucial space center responding to the economic interest of France and the European Union.

In the ethnographic research *Space in the Tropics: From Convicts to Rockets*, Peter Redfield narrates his way through the city of Kourou and the Arianespace facilities. The investigation revolves around a cultural catharsis derived from the co-existence of a highly advanced launch site within the bounds of a territory that has not been able to obtain its independence, yet still bears the wounds of a society subjugated through "the instituting of a penitentiary system as a strategy in which the action of moral reform could translate into a scheme of colonization" (Redfield 2000, 188). The penitentiary was located in a small piece of land called Devil's Island, right in front of a complex astronautic infrastructure with three different launching platforms corresponding to the Ariane 5, Soyuz, and Vega space vehicles. Forty years later, a similar scenario emerges when SpaceX —a private enterprise working hand-in-hand with an imperialist government looking forward to controlling an economic zone enabled by exclusive technologies— is putting together its operational headquarters in a territory hosting an intricate geopolitical conflict.

Moreover, Russolo frames ancient life mostly as silent, only interrupted occasionally by the intense sounds produced by the exceptional movements of the Earth's crust, hurricanes, storms, avalanches, and waterfalls (Russolo 1913). According to Russolo, it was not until the 19th century that noise came to light, as a consequence of the invention of the machine —a notion he frames as a field of potential and resistance against a nostalgic version of the past. The outspoken Futurist's adoration for modernity, machines, and their affiliation with a nationalist ideology that bloomed into Mussolini's fascist regime, set the basis for undertaking a deconstruction process looking forward to decoding the political function of sound through a typological scheme, in which the binary categories of silence/noise relate to the culture/nature continuum. In this instance:

> silence often connotes a conservative guise founded on devotion for a nostalgic return to a notion of nature liberated of the machinations of technology; whereas noise stands as any form of unorganized sound whatsoever with the capacity of impacting on thought, tradition, and the *status quo* (Goodman 2010, 318).

Following this line of thought, when analyzing the noise produced during lift-offs by launchers with a large payload capacity as Saturn V or Starship/Superheavy, stock recordings show the very same volume intensity than earthquakes and volcanic eruptions. The overtone of this association suggests a factual position in which technology, as we experience it today, has reached the power to represent —at least in the form of sound —as massive scale natural phenomena. The former glimpse of truth demands to take on a process of paradigmatic reconfiguration, looking after the urgency to come up with fresh models of planetarity, anticipating new ways of envisioning technology's relationship with the environment. According to technology philosopher Lukas Likavčan, "planetary imagination is largely shaped by the infrastructure of space exploration" (Likavčan 2019, 10). If so, it is impossible to think of futurities ruled by equity, empathy, and justice when space programs with such political leverage as SpaceX perpetuate questionable power dynamics down here on Earth, where it is possible to scrutinize their activity. Up there, they will be in the dark.

Fig. 7. Starship lift-off at Boca Chica (Texas, US), 2021.

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Preemptive Futures: Entropic and Negentropic Information in Speculative Design

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Preemption is an anticipatory action taken to secure first-options in maximising future gain and/or minimising loss. For instance, in risk management, responses are planned before a crisis takes place; such preemptive decisions are made based on speculations of possible future(s), directed by information feedback and analysis from a variety of sources. A systematic formulation of preemption and its relationship to computation are deeply rooted in the history of WWII; in the big data era, preemption is further augmented by the collaboration of human and machine intelligences, urging a rethink on how information is produced and used. By tracing a timeline of events around the conceptualisation of information, this paper aims at understanding the design and planning implications of preemptive decisions and how it may help us in rethinking speculative design. This paper first revises the idea of 'information' through a historical and theoretical study, and how it had been defined differently through the notion of entropy by Norbert Wiener, Claude Shannon, and Erwin Schrodinger from fields of cybernetics, information, and quantum theories. It discusses entropy from three perspectives: information compression and reconstruction, information entropy and energy entropy, interpolation and extrapolation. Finally, based on entropic and negentropic use of information, this paper rethinks the roles of speculation and preemption in today's design context, especially their applications in the collaborative intelligence of humans and machines within distributed, open source networks.

Keywords preemptive design, speculative design, entropy, negentropy, collaborative intelligence

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1. Introduction

Preemption has various meanings in different disciplinary contexts at different scales. For instance, futures markets, health insurance, and multitask operating systems (OS) are forms of micro-scale preemption that distribute risks and work to a larger community; military strikes, state preemption, and geoengineering are forms of macro-scale preemption that minimises options of the opponents in securing first-rights (Anderson, 2010). Although preemption can take different forms, it generally has speculative and anticipatory qualities, with present actions informed by a multiplicity of possible future(s) (Malik, 2016). The 'preemptive' frames design and planning as sets of iterative processes that feedback between decisions and their physical manifestations; sometimes maximising one's choices rather than generating definitive solutions; in most cases, it is meant to continue an infinite game for the overall survival of a system (Carse, 2013). For instance, HKSAR's (2021) quarantine provisions with Restriction-testing Declaration is a form of preemptive planning, iteratively adjusted based on weekly assessments to prevent wider contamination, which contributed to almost a year of near-zero COVID cases. It is inferred based on sensory data from a network of distributive devices (i.e. a government-developed app *LeaveHomeSafe* stores individual's visit records on local devices), crowdsourcing information on contamination flows between atomic units of the city with the larger transportation system (HKSAR, 2020). The preemptive decisions parameterised pandemic contingencies within a set of socioeconomic constraints developed along a time axis, and the sensory becomes an iterative feedback process that cannot be cognitively separated from our inference and actionistic systems. Together, these systems form one of the preemptives.

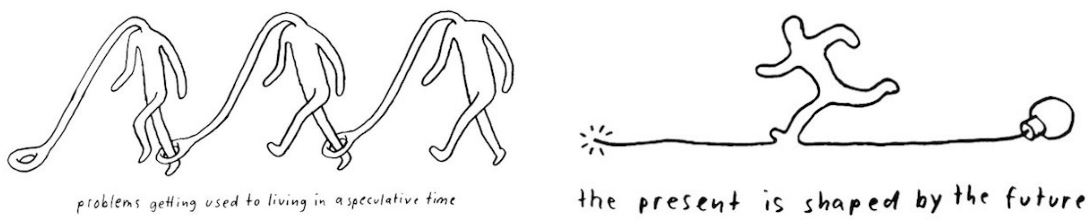


Fig. 1. Time complexity in preemptive actions, such as preemptive policing (Malik, 2016).

The etymology of 'preemption' can be traced back to c. 1600, from *pre-* 'before' and *emption* 'purchase' - '*a purchase by one before an opportunity is offered to others, originally as a right*', rooted in the colonial history of *preemptive land* and *preemptive war* (etymonline, n.d.). The former can be traced back to the US's *Distributive Preemption Acts* of 1830 and 1841, '*giving squatters a right of first refusal to purchase land they had occupied prior to its being opened for sale [...] Congressmen who favoured squatters' rights would also favour moving Indian tribes out of the old southwest*' (Carlson & Roberts, 2006). The latter originated from the *Caroline Affair* of 1837, where British Troops crossed Canadian borders to defeat rebels, and an African-American was shot to death; the British argument of preventive strike established the principles of 'anticipatory self-defence' within international law (Jones, 1976). In view of this history, it is important to keep in mind that preemption is often political - it is used to plan and justify actions based on future(s) that are yet to occur. But rather than suffocating ourselves with the geopolitical rectitudes that would necessitate preemption, this paper wishes to explore its conceptual democratisation in the everyday computational design context. The speculative nature of preemption puts on the design table the worst, best and most mundane kinds of scenarios and the probability distributions of each to maximise design profit.

Anderson (2010) wrote extensively on how anticipatory actions led to the planning of future geographies that are made and lived in the name of preempting threats to liberal-democratic life. Mazereeuw (2015) from the MIT Urban Risk Lab has been looking into participatory risk management - '*in a field that has traditionally been the domain of emergency managers and engineers, we bring preemptive design and community engagement into the risk-reduction equation*'. Bratton's (2019) Terraforming program speculated on planetary-scale preemption as '*a viable plan, but also to the refusal of bad ones if necessary [...] speculative design must focus on what is so deeply functional as to be unlikely; and that, finally, the future becomes something to be prevented as much as achieved*'. IBM (n.d.) worked with preemptive consultants to deliver comprehensive compliance and end-to-end computational solutions, indexing and time-stamping messages for search efficiency, scalability and security across an international network of communication. Gill's (2012) theory on *collaborative intelligence* characterised '*multi-agent, distributed systems where each agent, human or machine, is autonomously contributing to a problem-solving network*'. Within distributed, open source networks, preemptive computing may be used to design system centrality, scheduling of resources and first-option decision-making (Boussinot, 2006). How to translate such principles for design and planning, and what value does it bring to collaborative challenges in computation?

This paper introduces an interdisciplinary study on 1) democratising preemption for design production, giving deep considerations to current, emerging socio-economic and computational ideas; 2) differentiating preemption beyond prediction to anticipatory actions coming from speculations; and 3) entangling 'preemption against less desirable futures' with 'speculation on the multiplicity of futures'. The speculative shares similar traits with its actionary counterpart - the preemptive - in various disciplines, from speculative realism to speculative financing; there is an emphasis on how information is being used to map alternative future(s), identifying or imagining futures from the opponents' perspectives (Higgins & Connell, 2019). Along these lines, a critical rethink on the notion of 'information' cannot be escaped: its value and utility in relation to the tools that operate it, especially in the development and differing understanding of entropy, which built the relationship between information and energy and ways in which we may describe the state of any system using mathematics as a universal language. By mapping a timeline of events around entropy, this paper hopes to prompt discussions on the future role(s) of information, especially in the collaboration and communication within computational design production.

2. A Historiography of Entropy

Information can be used in many different ways in many different contexts; most notably, it can be defined as entropy or negentropy (i.e. negative entropy), and the differing definition affects the ways in which we think about and use information in design and planning (Shannon, 1948; Wiener, 1948). Entropy is the measure of probable surprises and disorder; whereas negentropy is the minimisation of entropy (Schrodinger, 1944). This measure is the foundation to which all digital signal processing and communication technologies operate on - from digital images, video conferencing, big data analytics to machine learning.

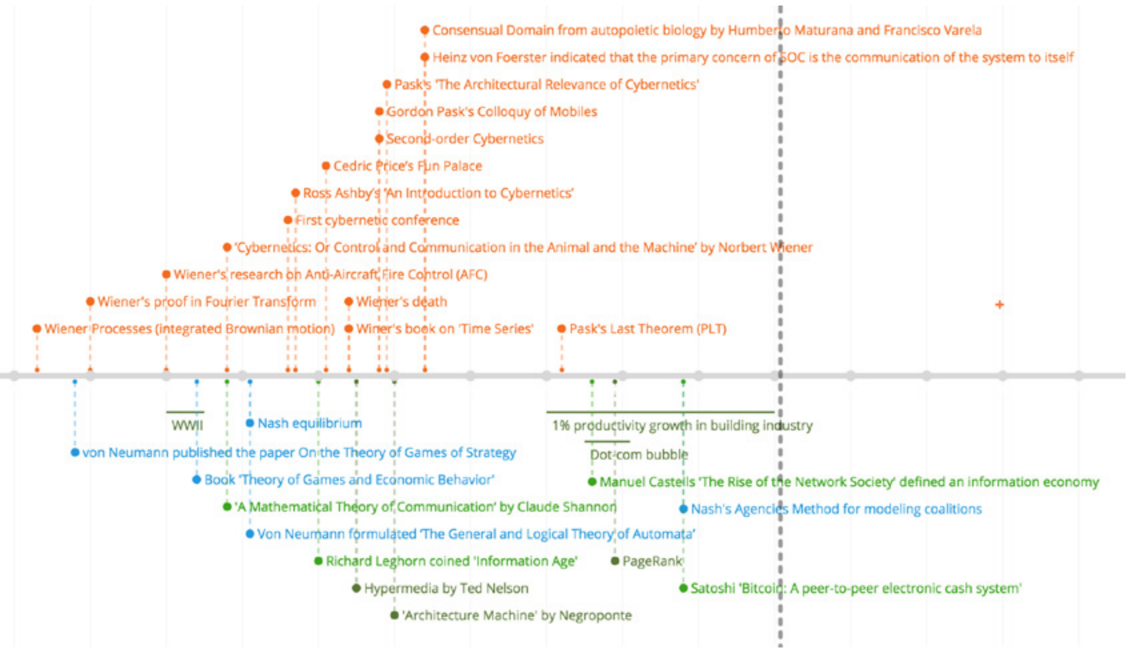


Fig. 2. Tracing a timeline of events around cybernetics and information theories (Ng, 2021).

2.1 Information Compression, Reconstruction, and Intelligence

Two of the greatest science figures in the 20th century related information to entropy differently. Claude Shannon and Norbert Wiener - respectively the father of information and cybernetics theories - were both involved in WWII Anti-aircraft fire control (AFC) research: the art of shooting the opponent's aircrafts down (Galison, 1994). Shannon (1948) was dedicated to the communication of information, whereby the fewer 'bits' you need to use to retrieve a piece of information, the better the wartime communication - Shannon's entropy - the limit to a lossless compression. Whereas Wiener (1942) was working on unifying the engineering disciplines of communication with control, looking into signal processing in a time series - compression in time operations.

Compression exploits the redundancy or the lack of surprises in data to reduce the size in data representation. This caused significant savings in the length of transmission - the better one can compress, the faster one is able to send information back and forth to communicate, but what does ‘better’ in compression mean? The challenge lies not only in the act of compressing, but reconstructing from the compressed. How can the sender compress messages in a way that the targeted receiver can reconstruct the information contained to precision? For instance, if one is on Zoom, can the signals be compressed in a way that the video will be reconstructed on the receiver’s end in real-time, looking almost no difference in quality to the human eye as before the compression? From such examples, one can tell that the problem of compression extends beyond simple technical engineering, to the ‘*control and communication in the animal and the machine*’ (Wiener, 1948). There is a need to understand not just the observed system, but also the observer to the system - human-machine interaction.

According to Shannon (1948), an increase in entropy is an increase in the amount of probable arrangements in a system - an increase in the amount of information, where lossless compression and bandwidth are values. If one can figure out the redundancy in some data (e.g. the repetitive units in data), one can eliminate them to achieve downsizing. Such ‘lossless’ compression is the systemic limit to which Shannon was questioning - a measure of maximum compression, a measure of entropy. This was much inspired, as Shannon (1948) had acknowledged, by Wiener’s (1942) work on extrapolation and interpolation - one of the reasons why Wiener is being named as ‘*one of the founders of the field of artificial intelligence*’ (AI) by MIT (n.d.).

Wiener and Shannon were both hired as research assistants to study one of the most rapidly used computing devices at the time - the differential analyser (Guizzo, 2003). The inventor of this particular analyser is Prof. Vannevar Bush, who was the chairman of National Defence Research Committee (NDRC). During the war, Wiener (1940) sent some of his marvellous ideas to Bush in a memorandum, explaining that the analyser can only do general differential equations, but not partial, meaning that the machine can only work in one dimension, namely time, but not in 2 or more dimensions. Wiener recognized ‘*discretizing the data over a grid and then averaging [...] by a line-by-line scanning of the grid [...] and that the data had to be represented digitally rather than intensively*’; such convolutional thinking is very much present in today’s neural networks (Masani, et al., 1987). On the other hand, Wiener (1948) stated that the machine should do arithmetic by making choices on the basis of previous choices according to a schedule furnished to the machine - a memory based on feedback loop; such formulation of an ideological automated computing machine, a logical machine, much resembles a human. Wiener received a response that his idea was not immediate enough to have been effective in the war (Mindell, et al., 2002). According to the mechanical computing logic of its time, infinite memory is not possible in a finite space; thus, some had held that a universal calculating machine - or a universal Turing (1936) machine - would not be possible given our physical constraints (Borel, 1913). **This highlights the significance of entropy, probability, and compression - the critical measures concerning the limits to synthetic intelligences and constraining the boundary to all signal processing research** - so that no one would spend half their lifetime trying to run an algorithm that simply does not satisfy Shannon's entropy limit. This also set the foundation for Chaitin's (1977; 1994) Algorithmic Information Theory (AIT), one of the founding fields of AI that concerns itself with the shortest computational means to express the largest amount of information - it 'is the result of putting Shannon's information theory and Turing's computability theory into a cocktail shaker and shaking vigorously'.

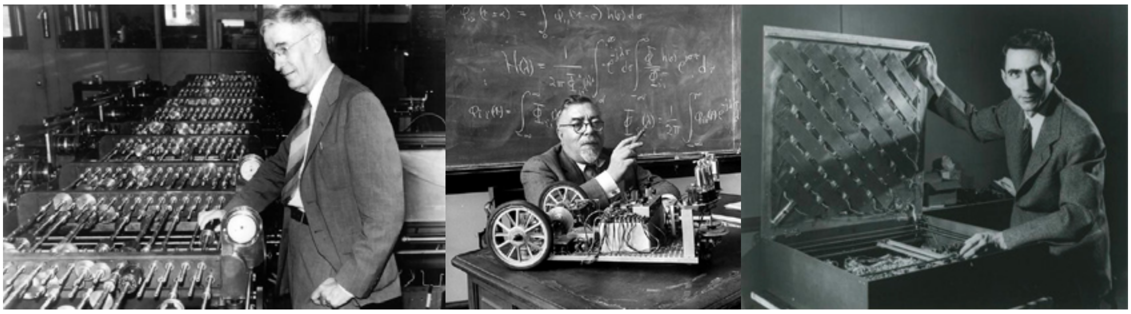


Fig. 3. Vannevar Bush next to a differential analyser in the early 1930s, Norbert Wiener next to his moth robot based on circular feedback in 1949, and Claude Shannon next to his learning machine Theseus in 1952. Image source: Computer History Museum, Cybernetic Zoo, MIT Technology Review.

2.2 Information Entropy, Energy Entropy, and Design as Decision-making

> *'the moment high power circuits are used to transmit patterns or control the temporal behaviour of machines, electrical engineering differs from communications engineering only in the energy levels involved and applicable to such energy levels, but in reality [...]* ***not a separate branch of engineering from communications.'*** - Wiener (1942) Extrapolation, Interpolation and Smoothing of Stationary Time Series

While information entropy measures the limits to synthetic intelligences, a negentropy approach to information relates a system to its larger environment, taking a perspective from outside the system. Wiener (1950) shared a belief with Schrodinger (1944) that within a world which always decays into chaos, living beings always strive to minimise entropy through the creation of information, as exemplified by the incremental thought experiment 'Maxwell's (1871) demon' , correlating information entropy to energy entropy. Meanwhile, Einstein (1905) proved the existence of atoms using Brownian motion, and Schordinger was invested to question why physicists were able to explain a lot of things that happen at the very large scale, like astronomy, but are not able to understand things that happen at the electromagnetic scale, like socio-biology, and to the atomic scale, the quantum mechanics; most importantly, understanding across scales. Schrodinger suggested a 'naive physicist approach'- while not every phenomena can be understood through their causal relationships, instead, they may be understood by their correlations. He stated that '*physical laws rest on atomic statistics and are therefore only approximate, and their precision is based on the large numbers of atoms intervening*'. Thus, our physical laws at the macro-scale are actually just an approximation of what is happening at the micro-scale. This is a formulation for the study of complex systems by their correlation.

Schrodinger (1944) described this as the 'discontinuity of mutations', and he moved on to stating a 'remarkable general conclusion': the collapse of possibilities produces order. But what does order mean? According to the second law of thermodynamics, the level of disorder of any isolated system always increases. If we imagine a system of gas without any external input of energy to hold the molecules together, molecules naturally dissipate and sparse out. The measure of the amount of unavailable energy to do useful work is a measure of entropy. Looking at sociobiological systems like our body, it doesn't simply disintegrate when it's living, Schrodinger concluded that '*[living beings] feeds on "negative entropy" [...] evades the decay to equilibrium [...] organisation [is] maintained by extracting "order" from the environment*' - the export of entropy, the minimisation of disorder or 'free energy'.

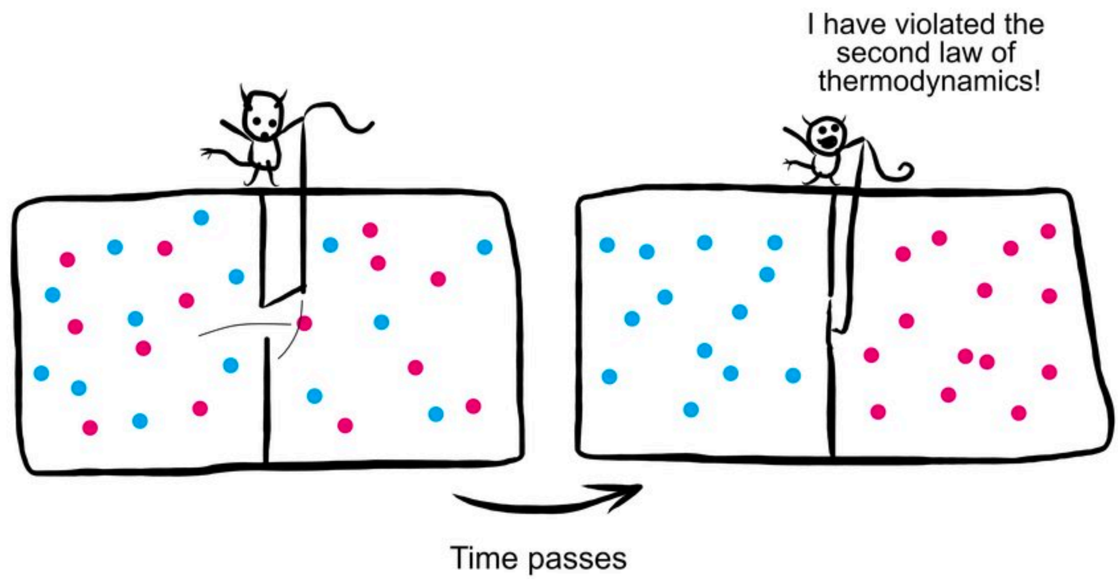


Fig. 4. An illustration of Maxwell's Demon. Image source: Alyssa Adams.

In the context of design, order does not necessarily imply a cartesian grid, but **the extraction of information - a statistical boundary to a system: to first measure the amount of possible arrangements in the state of a system, to first approximate how much isn't being known, to first design a measure of uncertainty.** Schrodinger (1944) put it very poetically '*much more important for* *us here is the bearing on the statistical concept of order and disorder'* - a *'statistical meaning of entropy'*.

$$S = k_b \ln \Omega$$

S = entropy

k_b = Boltzmann constant

$\ln$ = natural logarithm

Ω = number of microscopic configurations

In Schrodinger's (1944) 'entropy = k log D', K is a constant, D is a quantitative measure of the disorder of a system; the logarithm of D increases with D. The left side to the formula is the macroscopic observation of a system; the right side is '*the microscopic view based on the rigorous treatment of a large ensemble of microstates*'. In 5 symbols, the equation provides a descriptive linkage between macro and micro - a means for us to comprehend across scales. Understanding the entropy of a system enables us to derive how much energy we have to input to a system in order to achieve a desirable state; identifying the means of input and describing the evolving state of a system is the act of design as decision-making, providing us a means to correlate information with energy.

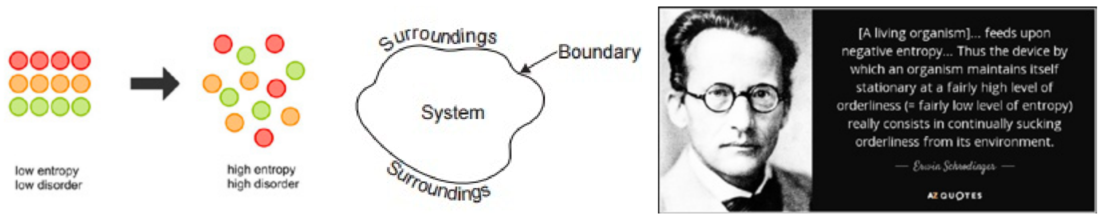


Fig. 5. Schrodinger's (1944) formulation of how living beings, different to other forms of thermodynamic systems, are negentropic. Image source: AZ Quotes, OER Commons, Adobe Stock.

2.3 Interpolation, Extrapolation, and Choices

In the matter of extracting statistical boundaries, Wiener (1950) mapped the extent to decision-making within time series, which are '*sequences, discrete or continuous, of quantitative data assigned to specific moments in time and studied with respect to the statistics of their distribution in time [...t]he closing price of wheat at Chicago, tabulated by days, is a simple time series*'. This forms a feedback loop between the statistical computation of matter and its material manifestations.

> *'The fields of statistical practice in which time series emerge can be broadly divided into two categories: statistics of economic, sociological, and short-term biological data on the one hand; and statistics of astronomical, me-*

teorological, geophysical, and physical data on the other.' - Wiener (1950) Human Use of Human Beings

Wiener categorises time series into short-runs and long-runs. The former '*forbid the drawing of conclusions involving [...variables...] at a distant future time to any high degree of precision*'. The overall system goal is to be able to draw some sort of reasonable expectation for actions to be taken to have an advantage on proximate conditions based on short-run fluctuations, as in speculative financing. The latter is typified by '*long runs of accurate data taken under substantially uniform external conditions*'; in such cases, the question of design lies in taking data collection as a 'rule' rather than an 'exception'.

Discreteness and continuity in a set of data depends upon whether the sampling is a rule or an exception. A discrete time series is when observations are taken only at specific times (e.g. when a user logs in); a continuous time series is when observations are made continuously through time (e.g. Brownian motion as described by the Wiener process) (Li, 2013). The drawing of a simple function based on discrete data points is an interpolation, which can act as a datum to measure disorder or deviations in a system for purposes of entropy. Concurrently, an extended estimation or projections into proximate futures are extrapolations, much used in iterative interior reconstruction of digital imaging, often combined with a priori knowledge acting as datum or an information seed (Ruchala, et al., 2002; McGlamery, 1973). The compression question of whether data points can be approximated as continuous, smooth, or possibly periodic helps to minimise uncertainty of a system by prediction - negentropy.

> *'The message itself is a pattern and organisation. In fact, a set of messages can be thought of as having entropy, just like a set of states in the outside world. Just as entropy is a measure of disorganisation, the information carried by a set of messages is a measure of organisation. In fact, the information carried by a message can be interpreted as the negative of its entropy, and the negative log of its probability.* ***That is, the more likely a message is, the less information it provides*** *[...]* ***This amount of information is a quantity that differs from entropy only by its algebraic notation and a possible numerical factor.'*** - Wiener (1950) Human Use of Human Beings

To Wiener, information is negative entropy; prediction of less probable events yields more information (e.g. floods); whereas Shannon's entropy holds that the prediction of more likely events yields more information (e.g. weather reports). The socioeconomic value of (neg)entropy might be reflected in Shannon's (1948) use of the word 'choice' - '*can we find a measure of how much "choice" is involved in the selection of the event or of how uncertain we* *are of the outcome?'* - information is measured relative to the amount of choices within a stochastic process. Put simply, compression doesn't mean less choice, but through interactions at the horizon of system boundaries, which mediate between an individual and its environment, the amount of choices become more apparent. **To Shannon's entropy, the ability to predict the likeliness or increasing the amount of choices of one's environment - complex systems that are chaotic and dynamic in nature - becomes one's freedom.** Whereas Wiener (1942) gave the example of '*policy questions [which] do not appear so generally [as in the case of long-run geophysical data,] the effect of a change of policy on the statistical character of the time series assume much importance*', like in short-run socioeconomic or biological data; nonetheless, '*the problem of flood control will show [...] the distinction between the two types of statistical work is not perfectly sharp*', especially in our big data epoch. **For Wiener's negentropy, if one can predict and preempt one's opponent's choices better than the opponent, it secures one's freedom, given that one has the capacity to influence decisions.**

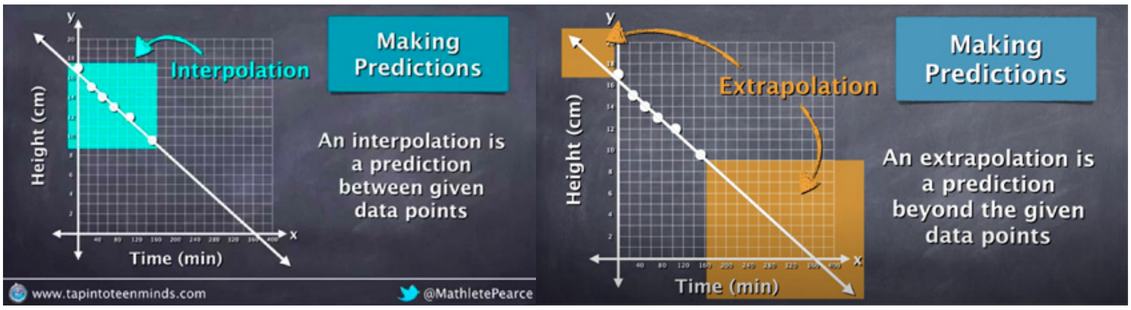


Fig. 6. Prediction with interpolation and extrapolation. Image source: Mathlate Pearce.

The computational history of preemption cannot escape mentioning John Von Neumann - one of the most all-rounded, interdisciplinary scientists and mathematicians of the twentieth century - father of *Game Theory* and *von Neumann Architecture*, and a major contributor to the *Manhattan Project* (1928; 1945; 1945b). Von Neumann was a strong supporter of 'preventive war' - a form of preemption. Amongst which, the Manhattan Project and the invention of the atomic bomb is one of the most significant preemptive games in modern history, where he did '*crucial calculations on the implosion design of the atomic bomb [...his] mathematical models were also used to plan out the path the bombers carrying the bombs would take to minimize their chances of being shot down*' (Standford.edu, n.d.).

Game Theory is the mathematical approach to describing and conceiving dynamics between competing players, largely applied in fields of sociology, economics, politics and warfare (Morgenstern & von Neumann, 1944). Whereas the von Neumann Architecture is the principle model for the modern formulation of Central Processing Units (CPU) and digital computers. These two pieces of scientific discoveries advanced the simulation of interactions amongst rational decision-makers within a game, and were made scalable to geopolitical situations, including the mathematical modelling of the '*Cold War interaction between the U.S. and the USSR, viewing them as two players in a zero-sum game*' (Stanford.edu, n.d.). Together, Game Theory, CPUs, and atomic bombs gave rise to the transcendence of conflicts from hot to cold, from the physical to the mathematical, and threats of mutual destruction from the analogue to digital domains. The race for preemptive design is as much about the advancement of reality and the simulations of those realities. Ever since the Cold War, our computational universe is shown to be one of von Neumann's and Shannon's rather than Wiener's; it is not until today, with advancements of AI and Web2.0, that we once again revisit the wonders of cybernetics.

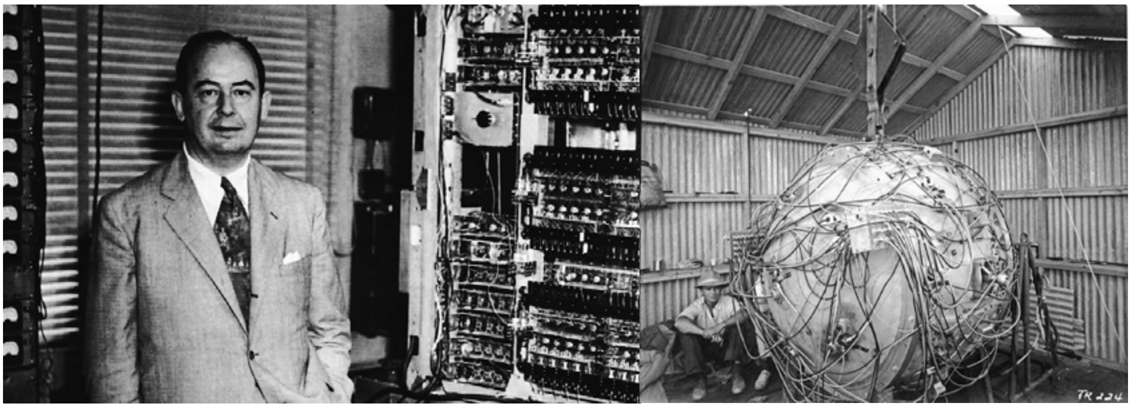


Fig. 7. John von Neumann, who is a strong supporter of 'preventive war', next to an electronic computer in 1945; first nuclear bomb in 1945; Game Theory modelling of Cold War; von Neumann Architecture. Image source: Sothebys, Kapooht, Cornell University, Michigan State University.

3. Preemptive, Speculative, and (Neg)entropy Design

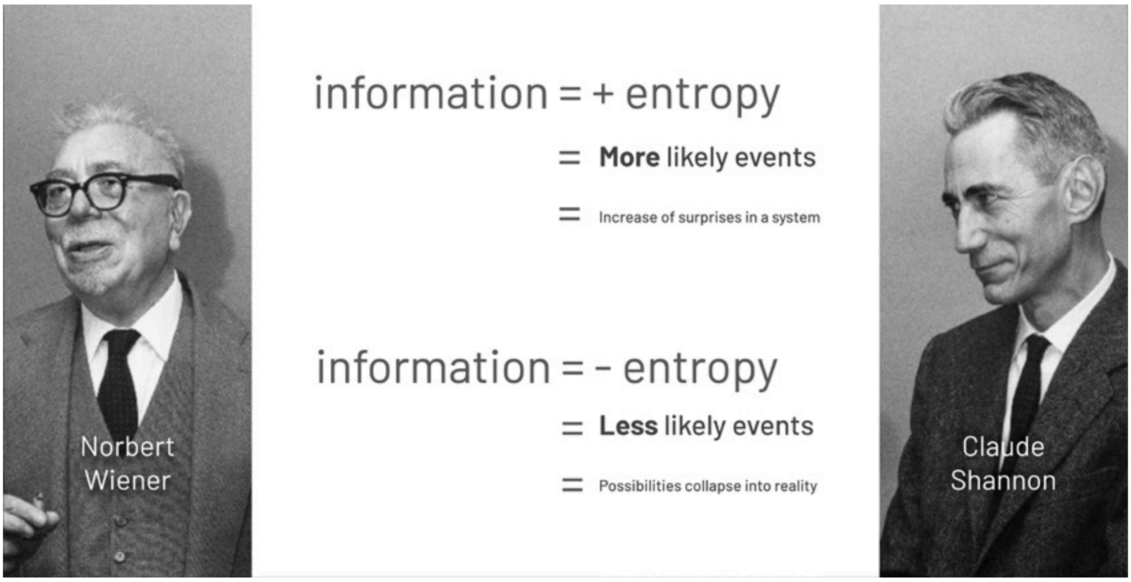
3.1 Neg/entropy Design

Shannon was indeed a former student of Wiener, both of whom based their hypothesis of communication theories on prediction and probability distribution (Mindell, et al., 2002). Wiener (1942) quantified information from another perspective - from the time domain to the frequency domain in a time series, making it easier to zero out insignificant data with simple point calculations, compressing time for prediction. Most notably, Wiener (1933) contributed to Fourier Transform (FT) and Brownian motion, where the time relationships are summarised by the notion of a state that evolves over time according to some probability distribution. Knowing the state and the entropy measure of a system at any point in time not only provides a good description of the system at that time, but it does seem to capture the critical information we need in order to answer questions about the future evolution of the system (Ng, 2021). **This led to Wiener and Shannon's similar worldviews, which differ merely by an algebraic sign - information = +/- entropy.**

The design implications of Wiener's negentropic world view is that our environment contains no information, but information is always the construct of living beings or intelligences. To Wiener, the more information that can be derived from a system, the less surprises there are, the less entropy, the more likely one can predict the opponent's moves to preempt (e.g. hit one's target in the war). Negentropic design can be seen as the extraction of order - drawing reasonable expectations from predictions, and the action taken to minimise entropy in a complex system based on information feedback - preemption. Whereas an entropic approach to design can be seen as maximising and measuring the amount of possible arrangements or choices within a system - speculation. In this sense, speculation and preemption work hand-in-hand to maximise and minimise entropy in an information system. Take Generative Adversarial Networks (GANs) and Wave Function Collapse (WFC) as examples: the former utilises a generative model to output options and and a discriminative model to preempt the options until equilibrium; the latter reduces the initial superposition of several eigenstates to a '*single eigenstate due to interaction with the external world*', where the collapsing of possibilities - negentropy - are brought about through the act of observation (Microsoft, n.d.).

According to Schrodinger (1944) large-scale complex systems increase in entropy globally, while minimising entropy locally. Such can be achieved on the edge of a network, much like reflexes on our body's peripheral nervous system - the system is smart but not necessarily intelligent. **A smart system is a network of sensing, actuation, and control units that is able to react based on raw data. Whereas intelligence is the ability to minimise entropy through the generation of information, and is able to predict, speculate, and preempt.** Maxwell's (1871) demon is a form of self-organising intelligence that illustrates how any complex system, which utilises information to overcome entropy, should be studied not simply as mechanics but as optics. **While intelligence is able to overcome entropy without applying any work (as defined by thermodynamics), smart is its physical counterpart; the feedback between smart and intelligent systems is the bringing together of analogue and digital computation - the union of Wiener and Shannon's worlds.**

Fig. 8. Wiener and Shannon's definition of entropy. Image source: MIT Museum, author.



3.2 Speculative Design

Speculative design is the increase in entropy or the maximisation of surprises in a system. It is the investment of resources into assets (tangible or intangible) with the hope of significant gain in the future from short-run and long-run fluctuations, pertaining to substantial risks for the same reason, just as Speculative Financing. It is to build without formal commitment from any end users, just as Speculative Construction. It is the computing of tasks in advance to achieve real-time performance, even though the task may not always be needed, just as Speculative Computing.

Speculative design can be based on fictional communication in constructing a narrative to illustrate and persuade alternative futures, just as Speculative Realism (Robin, 2007). Alternatively, non-fictional speculation is defined here as a 'naive physicist's approach' - Speculative Reasoning. Having learnt the statistical foundation of one's sciences, social or natural, one begins to think about relevant contributions and the best possible way of asking questions, to humans and computers alike, comparing one's anticipatory theories with contextual facts (Schrodinger, 1944). In this sense, it is counterintuitive to the trial-and-error approach of most machine learning systems nowadays, but one must not '*imitate the iterative methods of the computational tools*' if one can't replicate their speed in induction; as Carpo (2017) advocated: '*each to its trade; let's keep for us what we do best*'. Speculation is a human trade, which can be advanced with the help of machine intelligence.

In this sense, speculative design is a proto-scientific approach that studies the '*normative criteria for the use of experimental technology*', with a genuine willingness to be tested for failures in advancing to becoming real sciences, social or natural - Speculative Engineering (Brakel, 2000; Bunge, 1984). For instance, in the field of transistors, many small and medium design firms have the capacity to speculate on the architecture, but only relatively bigger enterprises can prototype for testing due to the high specifications of fabrication. **This exemplifies the general participatory qualities of the speculative, and highlights the significance of collaborative intelligence across scales.** Speculative design can be achieved through intelligent pipelines, datum construction, and information seeding to bootstrap crowd contribution and enable variational output.

3.3 Preemptive Design

Preemptive design is the decrease in entropy or the maximisation of order in a system through anticipatory actions taken based on speculative design. In the case of distributed computing involving a network of autonomous agents - collaborative intelligence - preemptive design is the interpolation and extrapolation based on long and short run statistics in scheduling time and resources. Interpolation is the compression of high-dimensional data into models that act as datum in measuring deviation; extrapolation can be used for prediction and reconstruction of information.

In a distributed network, system capacity rests in the autonomy of each individual component in how they make decisions - with, without, or partial memory. Depending on 1) the size of the system, 2) the amount of agents, 3) the discreteness and continuity of data, 4) the targeted system centrality and 5) scalability, Markov and martingales properties can be used to model system movements and leverage system memory in a large-scale network. Wiener processes spawned the study of continuous time martingales, it's property '*states that the future expectation of a stochastic process is equal to the current value, given all known information about the prior events*'; as opposed to Markov properties, where the future is independent of the past given the present - the '*stochastic process essentially has "no memory"*' (QuantStart, n.d.). These stochastic logics can be applied to preemption within a time-sharing network - many users sharing the computational resources at the same time, where context-switching is based on a scheduler furnished to the machine (Clark, 1965). As Wiener (1950) stated, '*the structure of the machine or of the organism is an index of the performance that may be **expected** from it*' - prediction can help in estimating the importance of tasks for scheduling, without complete information for scalability in large-scale systems - preemptive computing.

In non-preemptive computing, each agent voluntarily yields control periodically but must cooperate for the scheduling scheme to work; it helps to carry out each task to precision with simpler implementation (Boussinot, 2006). It is often used in memory-constrained embedded systems but rarely deployed in large-scale systems, as each agent has almost complete autonomy, and a 'selfish' agent (e.g. a poorly designed program) may consume all of computing time (PC, n.d.). Whereas in preemptive computing, the scheduler preemptively multitasks without synchronising to all agents all of system memory, but interrupts tasks to resume them at a later stage for purposes of speed, and is much used in real-time computing. Much like the logic of speculative computing that performs tasks, which are not necessarily needed, but may increase overall system efficiency. Take geometry prediction as an example, voxels as discrete data parcels paired with a preemptive scheduler can interrupt the upsampling at any time to distribute computing power amongst several tasks. In such cases, **the system is technically distributed, but not inherently decentralised, where centrality is a matter of design** (Ng, 2021).

4. Conclusion

This paper mapped a timeline of events around cybernetics, information and quantum theories, tying the history of entropy with computation to rethink preemptive and speculative designs. Through theoretical means, this paper aimed to provoke discussion on the role of information in the collaboration between a distributed network of human and machine intelligences - collaborative intelligence. In revisiting Norbert Wiener, Claude Shannon, and Erwin Schrodinger's thinking, this paper first questioned the difference between 'intelligence' and 'smart'. A smart system is a network of sensing, actuation, and control units that is able to react based on raw data, whereas intelligence is the ability to minimise entropy through the generation of information, and is able to predict, speculate, and preempt. Through the notion of algorithmic information theory (AIT) - a combination of Shannon's information theory with Alan Turing's computational theory - entropy is defined as a measure of the computational limits to synthetic intelligence, and negentropy is the minimisation of uncertainty in a system through intelligence.

Wiener defined information as negative entropy (negentropy): the prediction of less likely or anomaly events and the minimisation of uncertainty. Whereas Shannon defined information as positive entropy: the more 'surprises' or disorder, the less repetition, the more information in some messages. Within design, an entropic approach maximises surprises or options in a system - speculative design that seeds ideas, whereas negentropic approach is the design of order through defining statistical boundaries, and when all design possibilities collapse into reality (i.e. implementation or fabrication of design). Wiener and Shannon's differing understanding of information also provokes differing understanding in 1) intelligence, 2) design as decision-making, and 3) choice and freedom within collaborative systems.

Wiener shares a similar worldview with Schrodinger: although energy entropy tends to increase, living beings are the negentropic through the creation of information - intelligence. This shows a means by which designers may describe and capture the immateriality of information and their physical manifestation through our modes of energy exchange, grounding it within the larger socio-economic context. Negentropy is the minimization of uncertainty by prediction, and can take forms of interpolation and extrapolation: the former uses *a priori* knowledge to project into multiple future(s); the latter draws functions through sets of data points to measure expected deviation. While taking into consideration long and short-run statistical works, the overall system increases in entropy on a global scale, while minimising entropy at a local scale. As such, freedom is the prediction of less likely events and the ability in preempting such events.

Shannon's information theory shares a similar worldview with John Von Neumann, who is a major contributor to game theory, the invention of CPUs, and the atomic bomb. Together, these inventions facilitated speculative preemption games within the Cold War, and gave rise to a transcendence of conflict from the physical to the digital domain. As such, freedom is the prediction of the likeliness of an environment, and the maximising of choices and futures in a system - speculative design - and preemption is the lack of reason to change only one's own strategy after predicting the opponent's choices, be it natural or artificial opponents. The value of speculative design is the anticipatory action taken through design preemption, and vice versa - speculative and preemptive designs inform one another.

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AI Art as a Hyperobject-Like Portal to Global Warming

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This paper situates artificial intelligence as a vehicle that can allow human agents to engage with complex issues such as global warming. Drawing on Timothy Morton's conceptualisation of global warming as a 'hyperobject' which, by its very nature, resist knowability on a human scale, I consider the extent to which AI, when it is itself approached as hyperobject-like, can become a useful medium for engaging critically with the issue of global warming. The argument, then, is not that AI can make global warming human-knowable, but that through AI, human agents can access the quasi-unknowability of global warming. I begin by surveying Morton's theory of the hyperobject and its valence in critical discourse on contemporary/digital art, and then explore the positioning of AI as hyperobject-like. This discussion is bookended by analysis of a representative artwork, Tega Brain et al's *Asunder* (2019), which, as I argue, addresses global warming issues by incorporating AI as a hyperobject-like technology.

Keywords Artificial intelligence, digital art, hyperobjects, global warming, anthropocene

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1. Introduction

This paper situates artificial intelligence (AI) as a vehicle that can allow human agents to engage with complex issues such as global warming. Drawing on Timothy Morton's conceptualisation of global warming as a 'hyperobject' which, by its very nature, resist knowability on a human scale, I consider the extent to which AI, when it is itself approached as hyperobject-like, can become a useful medium for engaging critically with the issue of global warming. The argument at the centre of this discussion is not that AI can make global warming human-knowable, but rather that through AI, human agents can access the quasi-unknowability of global warming. I begin by surveying Morton's theory of the hyperobject and its valence in critical discourse on contemporary/digital art, and then explore the positioning of AI as hyperobject-like. This discussion is bookended by analysis of a representative artwork – *Asunder* (2019), created by Tega Brain in collaboration with Julian Oliver and Bengt Sjölén – that addresses global warming issues by incorporating AI as a hyperobject-like technology.

Specifically, I want to suggest that in *Asunder*, AI is marked by a poetics of unknowability that allows the technology to make global warming, which itself resists knowability on a human scale, more easily graspable for human audiences. Both AI technology and global warming are characterised by extreme degrees of complexity; nevertheless, AI outputs (such as AI-generated images) can manifest as relatively accessible and relatable for human audiences, even when the underlying algorithmic events are non-human-computable. In *Asunder*, it is through this twist that the complexity of global warming becomes graspable.

As a conceptual framework for this discussion of AI and global warming in relation to one another, I rely on a close engagement with the philosopher of ecology Timothy Morton's concept of the hyperobject (e.g., Morton 2010, Morton 2013, Morton 2018). Hyperobjects, as Morton defines them, are things that are so massively decentred, distributed, and complex that humans cannot perceive and experience them as discrete objects, but only as diffuse, quasi-unknowable phenomena that are virtually impossible to grasp intellectually, and the workings of which cannot be comprehensively pin-pointed in time and space. In describing hyperobjects, one of Morton's main examples is global warming, which is non-human-computable in its totality even though (or precisely because) it now completely saturates and co-determines all domains of human perception and experience. My discussion builds on the suggestion that, more and more, a similar characterisation can also be applied to AI. On this basis, I want to argue that when an artwork such as *Asunder* conjoins AI and global warming, then the former can help to frame the latter on a human-computable scale. Thus, AI, precisely because it shares in some of the confounding characteristics of hyperobjects that also describe global warming, can help in bringing a knowable shape, depth, and dimensionality to at least some aspects of global warming.

After an in initial introduction of Tega Brain et al's *Asunder*, in Section 2 of this paper I consider how (and how well) Morton's concept of the hyperobject can be mapped onto AI. In Section 3, I return to *Asunder* to discuss in more depth how it draws on AI as a hyperobject-like technology to address global warming issues.

2. Mapping Morton's Hyperobject to AI (Art)

As noted, *Asunder* (2019), created by Tega Brain in collaboration with Julian Oliver and Bengt Sjölén, incorporates AI technologies in order to critically address global warming issues. Presented as a three-channel video installation, the project shows the outputs of a purpose-built AI system, which analyses wide-ranging environmental data sources to suggest terraforming interventions designed to keep Earth inhabitable. As such, the suggestions generated by *Asunder's* AI system respond directly to the catastrophic impact human activity has on the planet. However, the AI-generated suggestions are no less extreme, and include things such as the levelling of mountain ranges, the creation of new islands, or the replacement of entire cities by newly planted forests. These suggestions are so impossible to implement that they may be taken to amount to nonsense. But *Asunder* does not frame AI as unthinking, senseless, or idiotic. Instead, the work invokes the notion of non-human (artificial) intelligence as a vehicle through which human audiences can better connect to problems that might otherwise be too complex, too alien, or simply too diffuse for them to grasp. Since *Asunder's* AI system renders images of how its suggestions would alter existing landscapes, the experience of engaging with this artwork very viscerally renders the unthinkability of global warming as graspable (although terrifying and uncanny).

Taking *Asunder* as a point of reference, this section considers the feasibility of mapping Timothy Morton's concept of the hyperobject to AI in general, and to AI art more specifically. Throughout, I will weave global warming into my discussion, both because it is *Asunderis* main focus, and because Morton uses it as an ideal example for explicating their concept.

Morton first discussed the hyperobject in the conclusion of their 2010 monograph *The Ecological Thought*, and has continued to develop it since then, most prominently in *Hyperobjects: Philosophy and Ecology after the End of the World* (2013). The concept has since then been widely embraced by theorists, for example in the philosophical domains of object-oriented ontology (OOO) and posthumanism, but also in research fields including ecology, sociology, and law, as well as by artists.

Most generally, the term hyperobject describes a thing which, due to its extreme complexity, cannot be grasped or experienced as a totality. Morton connects five core characteristics to hyperobjects: viscosity, nonlocality, temporal undulation, phasing, and interobjectivity. A frequently invoked example that integrates all of these characteristics is that of plutonium radiation: it exists beyond human-computable time-scales (the half-life of the Pu-239 isotope is 24,100 years); it is massively distributed in our environment, to a point where it can reasonably be said that it simultaneously exists everywhere and nowhere at all; it is many-dimensional in its interactions with and impacts on the universe as a whole, without being fully human-addressable; and it manifests in ways (e.g., cancer) that point to the underlying hyperobject without ever entirely representing it. To consider the suitability of these five core characteristics for conceptualising AI as hyperobject-like, I will here offer a brief discussion of each of them in turn.

2.1 Defining the Hyperobject in Relation to Global Warming and AI Viscosity

As the first key characteristics of hyperobjects, Morton lists viscosity. By this, the author means that a hyperobject tends to spread on a massive scale, and in doing so will cling both to materials and to conceptual contexts beyond itself. A hyperobject, in other words, may end up being everywhere at once, and everything will be inextricably entangled with it without necessarily being felt to be so. As Morton writes, “The more I struggle to understand hyperobjects, the more I discover that I am stuck to them. They are all over me. They are me” (2013, 28). Accordingly, global warming expresses itself in highly localised, temporally specific ways (e.g., as a sunburn, or as an out-of-season rainstorm, or as the charred remnants of a tree following a wildfire) that saturate the world so completely that there is no longer any getting away from its symptoms, even though none of them can – individually nor collectively – represent the totality of the underlying hyperobject as such.

In a similar fashion, AI has become so pervasive in contemporary socio-cultural, technological, and political landscapes that it, too, can be understood as having a tendency to attach itself to everything it comes close to. From the perspective of a human agent situated in any networked part of the world, today we are fully surrounded by and saturated with AI, and most everyday actions and interactions enmesh us further with it. AI systems are invading all domains of human activity, from work to play, from psychology to governance. For much-discussed and well-documented examples, we need not look further than the ways in which AI channels, shapes, and directs our social media existences; the ways in which recommendation algorithms can be both based on but also determinative of our consumer behaviours (to say nothing about our political perspectives); the ways in which movement through public space is becoming more and more controlled and prescribed by AI (whether in the form of surveillance regimes, ‘smart city’ technologies, or self-driving vehicles); and so on. In the profusion of news reporting on how technology colonises more and more domains of human (inter-)activity, AI emerges as a runaway phenomenon not so dissimilar to Morton’s viscous hyperobject.

2.1.1 Nonlocality

Nonlocality, the second characteristic in Morton's definition, is borrowed from quantum theory, and refers to the fact that hyperobjects tend towards massive distribution across time and space, to the point where the nonlocal qualities of a hyperobject's entangled existence(s) can outweigh any local manifestations. Regarding global warming, this means, for example, that even though we have developed a vast range of scientific tools and statistical protocols to observe global warming, as hyperobject global warming forever escapes the totalising gaze of the sensorium we have at our disposal, and is, indeed, "not a function of our measuring devices" (Morton 2013, 49). It also means that even though a human agent can have specific experiences in which the effects of climate change 'touch down' in highly specific ways and in a highly localised fashion, one can never quite definitely put one's finger on what it is, where it is, or when it happens in a given ecology.

The simplest way of considering AI in this context is to highlight, again, the pervasiveness and ubiquity of artificially intelligent systems in the diverse landscapes of contemporary networked societies. From the internet of things and cloud computing to interconnected big data analytics protocols spanning across different social media platforms, AI matches the characteristic of nonlocality very well, for example in the way in which it will tend to manifest, from individual agents' points of view, in what Morton calls "subjective impressions" that never represent the hyperobject as a whole. Additionally, quantum computing (especially its tentative implementations in machine learning contexts; e.g., Schuld et al 2015) and advances in ultra-highspeed data transfers (which allow for quasi-simultaneity in data access from different locations) also approximate the nonlocal qualities of quantum coherence on which Morton draws in this context.

2.1.2 Temporal Undulation

Morton's third characteristic is that of temporal undulation, a quality which forces human observers to acknowledge that hyperobjects tend to exist in ways which transcend human-computable time scales, as well as traditional assumption concerning the fixity, continuousness, and linearity of time-space. As Morton writes, hyperobjects such as global warming "are time-stretched to such a vast extent that they become almost impossible to hold in mind" (2013, 58). At the same time, they exist beyond the conception of time as a linear, unidirectional flow, in the sense that they project time in all directions: for example, the presence of carbon compounds in the atmosphere is simultaneously a result of events that occurred over the course of millions of years preceding our individual lives (e.g., the turning of organic matter into oil in the past), an effect of current events (e.g., the burning of fossil fuels), and an irreversible marker of events yet to come (global warming effects will persist for at least the next 500 years). This does not mean that hyperobjects somehow contradict temporality or exist outside of it; they simply represent “very large finitudes” (Morton 2010, 40) so big as to become human-unthinkable.

The complexity of AI technology stands in close relation to Morton’s notion of the temporal undulation of hyperobjects. For example, based on the evaluation of or extrapolation from existing data, AI systems can compute precise predictions of events that lie so far into the past or in the future that they vastly surpass the frame of human-comprehensible timescales. Additionally, the quasi-simultaneous execution of large numbers of calculations of which advanced computational systems are capable also exerts an inversion of what Morton describes as the time-stretchedness of hyperobjects: by simultaneously generating many outputs on the basis of parallel computing methods, AI systems can be said to inhabit time-space in ways that, again, confound the human experience of time.

2.1.3 Phasing

Morton’s fourth characteristic, phasing, refers to the trans-dimensional qualities of hyperobjects, meaning that it is “impossible to see [a hyperobject] as a whole on a regular three-dimensional human-scale basis” (Morton 2013, 70). Hyperobjects, in other words, tend to phase in and out of the human perceptual range; even if they are within range, only isolated and limited aspects of it can be perceived by human agents – the ‘full picture’ remains inaccessible in a higher-dimensional realm. In relation to global warming, Morton here references examples such as the destruction caused by a hurricane or a period of drought, but likewise the feeling of raindrops on one’s head. These examples represent isolated instances where the hyperobject global warming intersects with the human experiential plane.

This characteristic resonates strongly with the many-dimensionality of computational spaces within which some AI operations occur. Many aspects of AI now tend to escape the horizon of human perception and understanding. To revisit a phrase I used above, human agents can certainly experience the workings and effects of AI whenever it touches down in highly specific ways – but none of these experiences will encompass a totality of the functions AI now represents, nor the totality of its material implementations, nor the full extent of its capabilities or the implications thereof. In this sense, AI can also be argued to bear similarities to other hyperobjects such as genetic kinship, weather systems, traditional knowledge, or justice (e.g., Bruncevic 2018).

2.1.4 Interobjectivity

Lastly, Morton characterises hyperobjects as interobjective. This means that a hyperobject connects to a multiplicity of other objects and concepts, and will also connect these to one another, to a point where its existence and significance may reveal itself most powerfully in and through these entanglements. The interobjectivity of the hyperobject global warming is thus expressed in a multi-dimensional system with a myriad elements, including, for example, crops that are (or are not) growing in a very specific locality due to raindrops that are falling in one location (rather than in another) in response to weather systems that are themselves responding to global shifts in ocean currents. On many levels, this conceptualisation also gives rise to rethinking notions such as causality or objecthood across and beyond systems of thought that have arranged themselves around the presumed centrality of human agency.

The characteristic of interobjectivity somewhat integrates the already-mentioned aspects of hyperobjects. In relation to this, about AI it can now be said that its operations and instantiations are so massively enmeshed with diverse technologies, places, functions, and purposes, and its actions ripple so pervasively through the world as human agents experience it, that the shared space in and through which human-perceptible meaning flows has come to include many non-human elements. These entanglements include computer chips, circuit boards, sensors, data transfer infrastructure, all kinds of input and output devices, as well as the vast range of informational artefacts that form the algorithmic underpinnings and the outputs of AI systems. In AI contexts, ongoing philosophical questions about non-human sentience, new kinds of machine personhood, computational creativity, and, most fundamentally, the nature of intelligence as such, also figure into this characteristic.

Overall, this brief survey suggests that AI, understood in the totality of its development trajectories, application areas, underlying concepts, rendered experiences, and computational as well as material instantiations, does, indeed, behave somewhat like a Mortonian hyperobject. This is especially true if one takes into account (as AI art generally does) the public imaginaries informing the ways in which AI figures across the cultural, socio-political, technical, commercial, and regulatory landscapes that it also shapes so powerfully.

2.2 Hyperobject-like AI

From the foregoing discussion, it should be clear that a correlation between AI and Morton's concept of the hyperobject will hold up best with certain – but not all – definitions of artificial intelligence. A very wide range of definitions of AI are now circulating in and beyond domains such as computer science, philosophy, law, media theory, and software studies. Depending on context, these definitions cover a spectrum from the highly specific (e.g., precise technical description of AI systems in terms of underlying algorithmic functions, machine learning models, and data processing protocols) to the highly inclusive (e.g., definitions of AI that draw on philosophical perspectives on cognition, perception, or intentionality). Across this spectrum, it is generally accepted that definitions of AI are context-dependent, dynamic, and subject to frequent shifts and updates, and that there is no coverall definition that can meaningfully apply to all existing and emerging contexts.

Since the present discussion focuses on the expansiveness of AI both as concept and as implemented technology, an inclusive approach is here most useful. Elsewhere, I have defined AI as "any assemblage of technologies, operations, functions, and effects that can be meaningfully perceived as resulting from intelligent (including creative) behavior, or which can be identified in outputs that are the results of such behavior" (Zeilinger 2021a, 38). This definition conveys an open-endedness and inclusivity that may by some be perceived as a shortcoming. I would argue, conversely, that these features help to emphasise both the complexity inherent in discrete AI systems, as well as the emergent diffuseness of the concept of AI in the cultural landscape more generally.

In this view, the complexity and diffuseness of AI derive from interactions between as well as the stacking-up of separate technical elements, ontological planes, and conceptual vectors. In other words, AI here refers both to processes and to outputs that may be impossible to grasp in their totality even when individual elements (e.g., discrete algorithms or computational routines) are relatively straightforward. The complexity of AI thus emerges in a cascading and snowballing fashion from manifold interactions between conceptual and technical constituent elements. For example, it is relatively simple to graps the logic by which a GAN system generates ostensibly 'new' and 'original' outputs based on its access to a dataset of appropriate templates; the same is not true, however, for the many-dimensionality of data compression and data evaluation that occurs in Generative Adversarial Network (GAN) latent space.

There are, certainly, some aspects and characteristics of hyperobjects that do not map perfectly onto AI. For example, as a technology that relies for its functioning on resources whose stability and availability is subject to disruption (i.e., electricity, computer hardware, infrastructure, human operators), AI does not currently correspond well to Morton's description of hyperobjects as the "longest-lasting objects" known to humankind (Morton 2013, 85). However, given the alignments between AI and the characteristics of hyperobjects that I have outlined, in a discussion concerning issues and phenomena that are so vast, of such complexity, and so massively distributed that they generally confound human-knowability, it is nevertheless worth asking what becomes possible when we AI is conceived as hyperobject-like. Several possible answers to this question readily suggest themselves – for example with regard to issues of AI (un-)explainability and AI (un-)knowability.

A common source of criticism levelled against emerging AI technologies focuses on the lack of explainability that often characterises AI operations. The term generally refers to the ability of a computational system to "provide an explanation for a decision it has made" (Berry 2021, 222). Such an explanation, it goes without saying, must be human-computable, i.e., it must make sense to a human observer/interpreter of the operations and outputs of an AI system. Arya et al (2019), accordingly, count among the "stakeholders" in requests for AI expainability "citizens, government regulators, domain experts, or system developers." Without a doubt, requirements for the implementation of explainability methods aimed at human audiences serve important roles in contexts where unexplainability could be an undesirable bug (such as biased decision-making based on problematic datasets or data-labelling practices) or a potentially malicious feature (such as in data-driven surveillance practices and obfuscatory blackboxing of AI functionality). However, requirements for human-explainable AI may fail to account for the fact that to some degree, AI's ability to compute and signify also arises precisely from the fact that it is not human. An approach that regards AI as hyperobject-like can therefore accommodate unexplainability in some contexts, and it then becomes possible to reconsider, beyond the anthropocentric notion of algorithmic accountability, the question of what is at stake when something is (or is not) explainable.

Is an explanation automatically a solution to a problem? With regard to global warming, it can be argued that efforts at fine-grained explanation can serve to distract from the overall gravity of this ongoing, all-encompassing event. The problem of atmospheric carbon dioxide, for example, is a vast yet easy to grasp aspect of global warming more generally. As such, it frequently serves as a placeholder for the underlying hyperobject, with the result that attention shifts from the bigger (potentially unthinkable) issue to graspable pseudo-solutions, such as carbon credit systems or schemes that allow travellers to offset the carbon footprint of their air travel by paying for the planting of trees. (We should note that in this example, the 'solutions' offered also shift the underlying issue from the domain of planetary-scale ecology to that of capitalist economy.) In the process, the hyperobject global warming loses depth, nuance, and urgency, even if aspects of it now appear to have been shifted to a human-computable dimensionality. In a similar way, strictly enforced human-explainability of AI can vastly diminish the potential of the technology. For example, advanced AI systems may now be able to develop proofs for mathematical problems that remain unsolvable for human mathematicians. But, at the intersection of mathematics and philosophy, there is considerable controversy about whether such proofs are acceptable to the research community (e.g., Tymoczko 1979, du Sautoy 2019). This is because the proofs offered by AI systems may well be of such complexity that they are beyond the capacity of human agents to check and verify them. The somewhat odd question this raises is whether a mathematical theorem that is AI-based and non-human-explainable can be considered 'real,' even when it is widely considered as correct within specialist communities.

The notion of unknowability can open itself up to similar recalibrations when AI is considered as hyperobject-like. In relation to AI, unknowability is invoked, for example, in discussions that concern speculations about a becoming-sentient, becoming-creative, or becoming-autonomous of AI (Zeilinger 2021a, 68f.). Both science fiction and AI research is full of debates about such a forking-off of AI from its human origins. Ray Kurzweil (2005), in a typically anthropocentric mode, has famously described this as the "singularity," i.e., the moment when technological advances enter a runaway mode, and ultimately becoming unknowable, with unpredictable consequences for humanity. But the term also figures in less dramatic visions for AI. For example, Bringsjord et al (2001), writing about the possibility of non-human creativity, suggest that an element of unknowability is a key requirement if we were ever to recognise AI as truly creative. Oliver Bown has similarly suggested that AI systems may, at some point, no longer function "in particularly human-like ways" (2015, 18).

Morton describes such developments as the "future future" of objects, in which they have entered a "radical unknowability" (e.g., 2013, 67). To accept global warming as hyperobject means that its quality of unknowability cannot be denied. In fact, in many ways it is precisely this unknowability that determines everything we can know about global warming. I would argue that something similar can apply to AI in the contemporary cultural landscape: when AI art projects suggest that computational systems are 'hallucinating,' 'dreaming,' or 'fantasising,' often this is done precisely in order to invoke the unknowable and uncanny, and to apply it to the complex computational systems responsible for producing the artistic outputs under consideration. I have elsewhere (Zeilinger 2021a, 2021b) commented very critically on AI art that operates in this mode. But, against the background of my foregoing discussion, I would concede that a poetics of unknowability conveyed through AI helps to make graspable the hyperobject global warming. Here, to deny AI unknowability would mean to drastically diminish the audience's ability to appreciate the immensity of the hyperobject global warming with which the artwork interfaces.

3. Asunder as a Hyperobject-Like Portal to Global Warming

Over the course of roughly the past decade, Morton's concept of the hyperobject has been embraced not only by researchers and theorists, but also by artists. Thanks to popular proponents such as the curator Hans Ulrich Obrist (see Obrist and Morton 2014), but also in the wake of exhibition projects such as 'Hyperobjects' (2018) at Marfa Ballroom, Morton's philosophical writing and conceptual framework are embraced by artists who invoke the idea of the hyperobject as a modality for creative expression, as a subject of their artmaking, or as an interpretive framework (e.g., Morton et al. 2018; Morton 2021; see also Part 2 of Bruncevic 2018).

Tega Brain created *Asunder* in collaboration with Julian Oliver and Bengt Sjölén as a commission for the Museum for Applied Arts (MAK) in Vienna, Austria. Premiered as part of the Biennale for Change, the three-channel video installation has been exhibited extensively since then. It presents itself as an AI-driven "environmental manager" that generates recommendations for terraforming interventions on the basis of its evaluation of a wide range of "satellite, climate, topography, geology, biodiversity, population and social media data" (Debatty 2019) gathered in real time. As noted above, many of these recommendations appear surreal or absurd, and many of them are impossible to implement. The system might recommend, for example, to relocate entire cities and replace them with newly planted forests; to redraw coastal lines in aid of flood prevention; or to relocate rare earth mines to high tech factory hubs. In exhibition settings, these recommendations are then rendered visually as AI-generated aerial views of the altered regions.

Because of the magnitude of the suggested changes and the impossibility of implementing them by human means, it can be tempting to consider the AI recommendations as nonsensical. Indeed, it is easy to rationalise the absurdity/impossibility of the AI suggestions by foregrounding AI's non-human-ness as an insurmountable obstacle that prevents the system from recommending meaningful changes. But what is inevitably lost in such a rationalisation is an appreciation of the seemingly beyond-human enormity of the changes that are in fact now required to counteract global warming. In other words, to interpret the artwork's AI system as incompetent or nonsensical from a human, anthropocentric perspective obstructs one's view of the vast, almost unthinkable scale on which human activity now impacts the planet.

At a 2020 Ars Electronica discussion panel specifically devoted to the topic of AI and ecology, Brain suggested that the use of AI systems in artworks dealing with climate change can represent an opportunity for learning to acknowledge non-human agencies with which we co-exist in the ecosystem that we are trying to understand and control, and which we are now trying to keep survivable (Ars Electronica 2020). Put differently: using AI and paying attention to its functioning and limitations can be a way of addressing humanity's involvement in and with the hyperobject of global warming, which may work best if AI itself is situated as hyperobject-like.

In an essay published a year before the release of *Asunder*, Tega Brain elaborated ideas that help clarify the conceptualisation of the project. Invoking the thinking of Katherine Hayles and Jennifer Gabrys, in this text Brain reminds us that computational models are not just ways of analysing, interpreting, and representing data, but also have a "powerful world-making capacity" (Brain 2018, 153). As such, they are capable of much more than merely expediting the kinds of calculations that end up perpetuating and amplifying anthropocentric knowledge systems. If that were the case, then AI-driven solutions modelled on simplifying, anthropocentric systems thinking, when applied to ecology, may achieve little more than what Donna Haraway has called an “informatics of domination” (cit. in Brain 154). Yet, as the title of Brain’s essay notes, “the environment is not a system,” and systems thinking may be missing the point when it comes to using AI to explore the realities of and solutions to ecological crises (see Walsh et al 2020 for an approach that may be straddling this line).

As in my example of atmospheric carbon dioxide, where pseudo-solutions such as the carbon credit system flatten the severity of the underlying issue, so the ‘smartness’ of AI that applies reductive systems thinking to ecology produces “a kind of myopia” (Brain 159). It is then impossible to account for the co-determinative qualities of extremely complex symptoms, causes, and effects of global warming, for the complexity of the “species entanglements” (153) that characterise life under global warming, or also for any insights that could be derived from acknowledging the connections (rather than separation) of humans and environment. What is ignored, in other words, in an anthropocentric, system-oriented AI-driven informatics of domination is the many-dimensionality of global warming, or, to put it with Morton, the hyperobject global warming as such.

The way in which *Asunder* incorporates AI resists such simplification and anthropocentric rationalisation. Through the deceptively simple visuals of impossible terraforming interventions, the work reminds us that the most sophisticated calculations may be worthless when they are conducted in an un-thinking fashion, but also that there are paradigms of the thinkable that go beyond the human-comprehensible. When AI is considered as hyperobject-like, the experience of *Asunder* changes: now, the proposed solutions of the artwork’s AI system appear no longer as absurd or nonsensical, but begin to resonate with the unthinkable immensity of the global warming issues addressed in the project.

Asunder makes no attempt to explain global warming, nor to pull it into a realm of knowability or offer viable solutions. Instead, it foregrounds AI outputs that emphasise the technology’s hyperobject-like qualities. As I’ve suggested, this is done not in order to mystify AI, but, rather, so that audience members can more easily grasp, through the quasi-unexplainability of complex AI ‘solutions’ that are impossible to implement, the hyperobject global warming itself. A question to end on is which other contexts could benefit of a reframing of AI as hyperobject-like, so that AI may open up new and different ways of thinking with and through other hyperobject-like scenarios. Specifically, what Tega Brain and her collaborators have achieved in *Asunder* with regard to global warming could perhaps also open new directions in richly debated areas of AI discourse regarding non-human legal personhood, or questions regarding AI creativity.

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E-embroidery: Soft Circuits Aesthetics applied to Traditional Craft

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As the tradition of Portuguese embroidery faces a struggle for preservation and valorization, artistic research can reinvigorate its status in the cultural system, through an encounter between tradition and modernity. Emerging digital art practice embodies code as a medium for artistic expression and promotes a re-casting of both the artisan's and the designer's work, pushing them to discover new domains of artistic creation and to adopt new materials and materialities.

This paper presents a practical enquiry on the application of *Soft Circuits* as raw material, tool and content in the process of transforming traditional Portuguese embroidery into digital interactive artifacts, converging Art and Science, enhancing artisan skills, and dealing with issues of ethics, participation/collaboration, social innovation and, ultimately, cultural sustainability.

Keywords Traditional Embroidery, Contemporary Aesthetics, Soft Circuits, Cultural Sustainability

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1. Introduction

The symbiosis between art and technology, the reality of Portuguese traditional embroidery and its effort to preserve and enhance it, the reinvention of an imaginary and the appreciation of artisan skills, ethical issues and cultural sustainability, as well as the paradigm of contemporary aesthetics that, through interaction, lead us to the endogenous experience and reality, compose the axis of this research. It arises as a reflection on the contribution of electronic materials, soft circuits specifically, when applied as raw material, tool or content in the sustainability of traditional embroidery from Portugal, redesigned as an interactive digital artifact in contemporary imaginary.

In this article we analyze the use of soft circuits in digital artifacts, considering soft circuits both as a resource for e-embroidery and also as an expressive element of the project in the scope of cultural sustainability. We illustrate with the presentation of Filozell-e, an interactive digital artifact we produced and exhibited as part of our practice based research. We discuss the aesthetics of soft circuits focusing on electronic components specifically designed for wearables and e-textiles - *Lilypad (Arduino)*[1] and *Flora (Adafruit)*[2] - applied to traditional embroidery. We conclude with a vision for aesthetics in e-embroidery, perceived from processes of reinvention, renewal and innovation in the context of cultural sustainability.

1. https://create.arduino.cc/projecthub/products/arduino-lilypad-main-board

2. https://www.adafruit.com/category/92

2. Soft circuits applied in Embroidery: State of the Art

"Open-source programmers and crafters may seem like they come from different worlds. Still, the two communities have much in common", as the *Open-Source Embroidery* founder and curator of the namesake exhibition Ele Carpenter states. This British movement brings together knitters, embroiderers and quilters "who see parallels between the way they create their crafts and how open-source software creators share their ideas" (Priya 2009).

Recent developments in physical computing are exposing us to new forms of use of electronic materials, which reveal a shared philosophy and methods between craft and technology in its growing applicability in artistic and cultural contexts.

2.1 Case Studies: Artists working with Soft Circuits embedded in Embroidery

An emerging community creatively explores and shares instructional tutorials to create flexible circuits or interactive textiles, involving artists and programmers such as Leah Buechley and Hannah Perner-Wilson (Buechley et al. 2010; Perner-Wilson 2014).

In this context, the *High Low Tech* research group at the MIT Media Lab (2009 to 2014) led by Leah Buechley and involving artist researchers like Hannah

Perner-Wilson, among others, explored the intersection of physical computing, electronic materials, manufacturing processes, traditional crafts and design (Fig. 1). With the aim of placing computing in new cultural and material contexts and developing tools that democratized electronic materials, the main objective was to involve different audiences in the design and implementation of their own technologies.

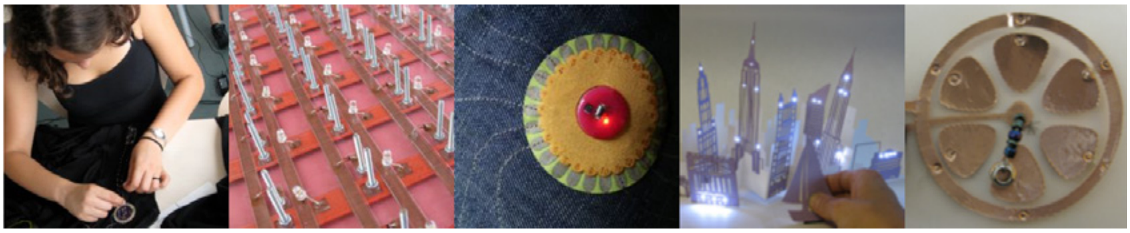


Fig. 1. Examples of projects of the work developed in the High Low Tech research group. Source: https://highlowtech.org

The aesthetics of the e-textiles microcontrollers are progressively making part of the visible interface, assuming a hybrid aesthetics that combines embroidery using traditional materials and techniques mixed with interactive electronics with outputs – lights and sounds, for example – generated by the onboard software. Becky Stern's open-source work (Fig. 2) embedding the *Lilypad* microcontroller and sensors in customized embroidery (Stern 2014) is an output at the crossroads of this hybridization.

Fig. 2. LilyPad embroidery A Tribute to Leah Buechley, created by Becky Stern. Source: https://beckystern.com/2008/04/21/lilypad-embroidery/

Teresa Almeida explores the possibilities of soft circuits as socially engaged participative activities, thus developing a conceptual framework for a woman-centered approach through a design methodology that embraces practical interdisciplinary design research, such as working with e-textiles (Almeida 2019). Group activities become workshops. The objective is to explore electronic circuits, using technologies for creative expression and demystifying knowledge of electronics, as can be seen in *Geek Art: Needlework*, which brought together programmers and artisans. Founded in 2005, the *Open-Source Embroidery*[3] movement is made up largely of knitters, embroiderers and programmers. This social development project grew to support and facilitate the practice of artists

3. https://research.gold.ac.uk/id/eprint/3111/1/osembroidery.htm

who have investigated the relationship of handcrafted embroidery with open-source programming.

Victoria Bradbury is also a contemporary artist that makes use of electronic materials applied to textiles to conceptualize her artistic expressions. With a vast work of participatory and experimental artifacts that stage common objects, the artist highlights them as tools to explore historical, social or political systems. An example is the *Witch Pricker* installation where she reinvents the witch persecution that took place in 1649 in Newcastle, UK. Victoria explores a new vision of the limits of the traditional with works conceived in the scope of *Maker Culture* and combines tradition and technology in new artistic practices for the 2ist century and its coexistence with established traditional practices (Bradbury 2013).

The variety of kits available nowadays – where it is even possible to create the exact kit with the components needed for each project (Martinez 2019; Perner-Wilson 2014) – offer alternative opportunities for reinventing and renewing traditional materials. The modernization in the way of communicating *Living Wall* (Buechley 2010), storytelling through playful interactions using conductive ink[4] or the most sophisticated technological fashion projects, such as the work of Hussein Chalayan[5] or the project *Caress of the Gaze* designed by Behnaz Farahi (2015).

4. https://vimeo.com/121878247

5. Design Museum (2014) Hussein Chalayan – profile. https://designmuseum.org/designers/hussein-chalayan

Electronic materials with applicability to textiles through needlework open up infinite possibilities for the design and implementation of digital artifacts, which, when designed under the artisanal aegis, allow the rediscovery of craft techniques, deconstructing their initial logic, reinventing and introducing them. In the contemporary imagination, as an example of the digital artifact Filozell-e described in 3.1. These digital artifacts created from the exploration of soft circuits work with the surfaces of the objects themselves, in the construction of interfaces that will acquire meaning from the relationship with the public in space. Sometimes, the system behind the interface is able to react to received stimuli, changing its own state and adapting it to the response (Neto 2020). It should be noted that works created with soft circuits differ from common technical interfaces because they have aesthetic or even conceptual concerns related to the poetic project of a craftsman/artist.

Today, with computing through the use of sensors and other programmed interfaces with algorithms and associated with the artistic object, issues related to reality, representation, illusion, landscape, space, shape, color, texture, movement, composition and content that permeated pictorial production and sculpture for centuries can continue to be approached in different ways in the work of art. The use of technology and soft circuits thus work as inducers of aesthetic possibilities through their ability to articulate space, time or ideas in the development of functional conceptual interfaces or aesthetic enjoyment that characterize contemporary art.

2.2 Traditional Embroidery: the Portuguese Case

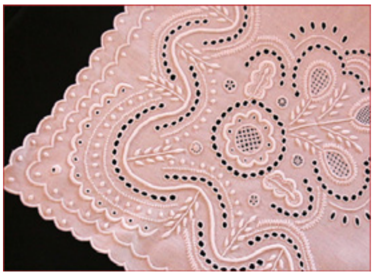
Over the centuries, the traditional embroideries of Portugal were considered symbols of wealth, power and a reference of social class. As a textile art, they have always represented a considerable weight in the economic activities of the environment in which they operate, even if they are conditioned by the types of raw material available. In Portugal, each region has its own embroidery style, which incorporates the culture, environment and images of its history and tradition (Pires 2009). The technique and imagination of the raw material and the narrative are transferred from generation to generation. The embroiderers receive this legacy from their childhood family, finding the feminine world in their embroideries. These first assume themselves as artisans and only later, in rare cases, as artists or creators. The surrounding space, that internal image that is so present in your memory, is transferred to paper, then to fabric and takes shape with the needle and thread. It arrives at this stage, loaded with symbolism and narrative.

Currently, the following embroideries are registered in Portugal: Embroidery of Arraiolos, of Nisa or Alinhavos of Nisa, of Castelo Branco (Pinto et al. 1992), of Caldas da Rainha (Carvalho 2019; Tavares 1999) or of D. Leonor, of Airães, of *Filé*, of Tibaldinho (Pereira 2017; Teixeira 1998), of Guimarães, of Viana do Castelo, of Madeira and of the Azores. Although traditional embroideries have a conceptual basis inspired by the cultural and traditional ambience of the area where they are located, the traditional embroideries of Nisa, Guimarães, Airães, Tibaldinho and S. Miguel (Azores) exceptionally display themes that are mostly vegetal. This focus on floral elements was particularly inspiring for the creation of the artistic project that will be described later on (see 3.1). The traditional embroidery of the island of Faial stands out, using straw collected from the environment as raw material (Silva 2006).

The predominant base in traditional embroidery is linen and cotton; the exception is the Arraiolos embroideries (produced on “jute”) and the *Filé* embroideries (produced on net constructed using knots and fixed in wooden frames). As for the stitches used, these are repeated in the different embroideries, standing out as predominant: the full stitch, the sieve, the cord, the open hem, and the flower stitch (Magalhães 1995).

Table 1. Certified embroidery in Portugal: summary of the main types and its characteristics.

Embroidery style	Allusive image	Most evident features
Embroidery of Arraiolos	 https://goo.gl/JNvpxp	With an ancestral history, Arraiolos embroideries were grouped into three epochs, the current one being characterized by simplification of motifs, geometrization of shapes, creation of patterns, monochromatic and low-contrast polychromatic combinations. The base is a natural fiber and the wools are colored, have a larger gauge and a special twist in order to be resistant to use.
Embroidery of Nisa	 https://goo.gl/i6Ded3	The Nisa embroidery are embroidered in white on linen cloth or sieve-embroidered cotton, which gives them great resistance. The theme is mostly vegetal, with floral and natural motifs.
Embroidery of Castelo Branco	 https://goo.gl/udwbv2	The Castelo Branco embroidery involves a very specific symbolism: the two-headed bird represents two souls in a body, the trees represent life, the carnations allegorize the man, the roses the woman, among others. It is made with the linen stretched in a circular or rectangular frame. The most common stitch is the loose stitch or wide stitch.

Embroidery of Caldas da Rainha	 https://goo.gl/3hzJ8u	Initially with linen threads, dyed by cooking in teas of different plants and flowers of *carqueja*, which gave them the uncertainty of the color and the tint. Currently, the three-tone cotton thread is embroidered on fine-textured linen fabric. It takes the form of an arc, spiral, angles, repetitions, hearts, respecting the symmetry in all imagery.
Embroidery of Airães	 https://goo.gl/QqmiVv	Shape of sieves and open hems. The fabric to be embroidered is usually linen or chambray. Cotton yarn is the most used regarding the velvet stitch of this typology. The motifs are related to the fauna and flora of the region, namely the grape bunches, cob, floral compositions, butterflies, fish and bows.
Embroidery of Filé	 https://goo.gl/4adw6E	*Filé* embroidery makes use of a net as a work base, and is made from raw or white yarn. This net features small squares that vary in size according to the intended work. Solid stitches, cross stitches and the finishing stitch are used.
Embroidery of Tibaldinho	 https://goo.gl/FuVDnC	*Tibaldinho* embroideries are harmonious and predominantly white, on linen. They use open and solid stitches, such as the cord stitch, cutout stitch and sieves. Decorative motifs choose the arch in terms of the cutout and borders of each theme that form circles, spirals, loops, stars and sieve in geometric shapes.

Embroidery of Guimarães	 https://goo.gl/mY3gZb	With industrial linen as a support, the composition focuses on the local fauna and flora, birds, flowers, stars, borders and bows. The compositions are embroidered with DMC cotton thread and in monochrome in red, blue, beige, white, gray and black.
Embroidery of Viana do Castelo	 https://goo.gl/oM1kh8	The base is handmade linen and DMC cotton lines, in white, red and blue, are the most used. Other materials are wool and golden thread cord to outline the designs giving them more emphasis. Recently, the golden thread has been replaced by a white thread, linking the main designs together by branches, curls, brambles and angles.
Embroidery of Madeira	 https://goo.gl/gfxyXH	Madeira embroidery is crafted on linen, silk, cotton or organdy, and the most used stitches are buttonhole, richelieu, flower foot, among others. The official stitch is the “cord stitch” used in the contours of cutout motifs, on light textured fabrics.
Embroidery of the Azores	 https://goo.gl/JR2ZBi  https://goo.gl/YPHwhm	Specificity is characterized according to the tradition of each island where they are produced. The Island of São Miguel recreates, in hues, asymmetrical floral elements such as clovers, ferns, branches and some birds, inspired by the decoration of Chinese tableware. It uses two shades of blue, cotton thread on linen, cotton or white chambray fabric.

2.3 Electronics applied to Soft Circuits

In *e-embroidery*, physical computing takes place through hardware and software specific to its design, requiring code design with experimental flexibility, with its subjective dimension of creativity directly impacting the type of aesthetic object produced and the response provoked by and in the participant. Regarding the soft circuits as potentiators of new contemporary aesthetics, we highlight the characteristics of the *LilyPad* and *Flora* microcontrollers. This type of hardware consists of prototyping platforms based on the principle of inputs and outputs. Inputs can be used in the form of a button, switch or sensor. Data from sound, movement, temperature and light can be processed by the microcontroller, in the same way that it allows connecting a large number of inputs and simultaneously controlling a large series of production outputs – light and movement or more complex outputs, such as sending short SMS messages. Both brands offer various electronic components and conductive wires, which can be used as soft circuits, combined in traditional craft processes (sewing, fashion design and textile design) with electronic engineering, computer science and hardware skills. Interactive embroidery uses these e-materials as a resource, insofar as they articulate with the environment, communicate through interactive multipurpose languages, establish conceptual dialogues, acquire new functionalities, prove to be challenging in the tracing of the creative imagination and indicate a shift towards the artistic system of interactive or responsive interfaces to the medium, part of a digital culture oriented towards the visual, sensorial and nonlinear, where the user is the context of the work of art.

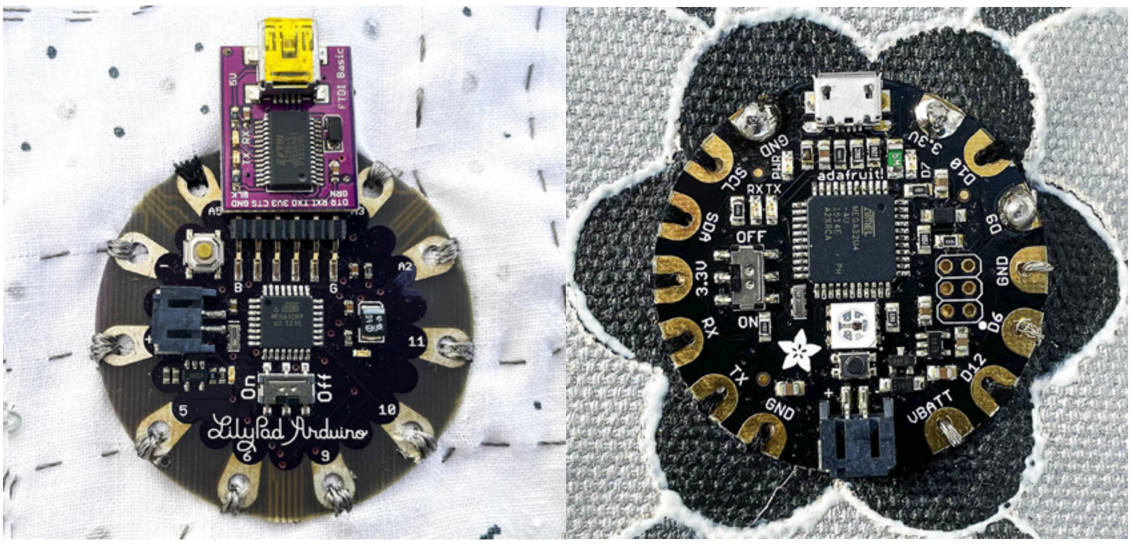


Fig. 3. Microcontrollers and other series electronic components applied to e-embroidery: *Lilypad Arduino* and LEDs, RGB LED, buzzer and vibe board (left); *Flora Adafruit* and LEDs (right). Source: paper authors.

The software used to program the e-embroidery interactive subsystems is the Arduino IDE. For the schematic design of the circuits and systems and to simulate the functionalities it is possible to use tools freely available online, such as *Fritzing*[6] or *TinkerCad*[7]. *Fritzing* is an open-source software, specific for the

6. https://fritzing.org
7. https://www.tinkercad.com/things?type=circuits

design of electronic circuits in an accessible and creative way, presenting them in schematic or breadboard form. Both applications contain several icon libraries alluding to different components from different brands and the possibility of processing diverse Arduino board versions. By building creative interaction systems and enabling users to previously test, these tools allow users to document their prototypes, share them with others, teach electronics in the classroom and test the system layouts they build.

3. Artistic Practices combining Portuguese Embroidery and Soft Circuits

When we combine electronic materials with craftsmanship, we explore electronic components, using abstract schemes with applicability to traditional or common materials. Thus, Turkle and Papert (1990) "interactive crafts suggest alternative physical, intellectual and cultural paths for electronic materials". According to these authors, supporting different styles of approach is important not only for cognitive but also emotional reasons. Our research with young students (graduates in Basic Education), illustrate how they derive pleasure from the way of working with handicrafts, reinventing it in terms of exploring new technological materials, using different textures, innovating in the aesthetic, expressive and functional aspects, recording the importance of preserving knowledge and the mental challenge that the application of electronics requires.

As for e-embroidery, we mean textiles embroidered with conductive thread, conductive fabrics, conductive fibers and/or the integration of technological materials in non-conductive fabrics (Bost . and Crosetto 2014). Embroidery using soft circuits with applicability in textiles should consider the indications illustrated in figure 4: (1) start by threading a needle with the conductive thread that currently appears as a stainless-steel thread wrapped in cotton. Pull the thread through the eye of the needle to a length of 30 cm. Tie a knot at the end of the thread. (2) Thread the needle through the back of the fabric, adjusting the knot securely. Push the needle through the fabric again, approximately 5 mm away. This time, the needle moves from the front to the back of the fabric. (3) At the finishing knot, bring the needle to the back side of the fabric through your last stitch. Finish with a small loop of yarn on the fabric surface. Seal with a little glue or nail varnish to prevent the lead wire from stretching and altering the conduction. (4) In the textile article, the embroidery is constructed on a design from the back of the work, preferably on a self-adhesive non-textile fabric, making the certification of the connections between the assembly of each component, individually and progressively. Our experimentation led us to the conclusion that traditional embroidery must be performed on the front of the fabric, in a stage prior to the assembly of the electronic system. Figure 4 shows the technique used in sewing soft circuits to the textile.

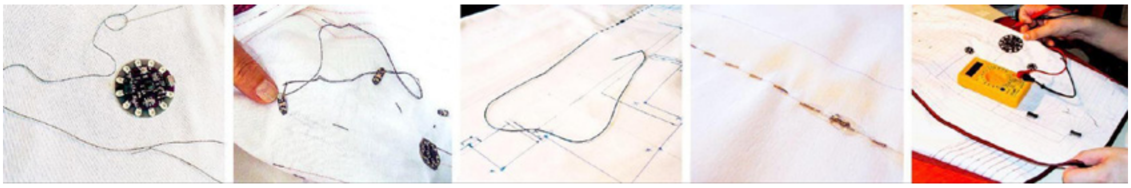


Fig. 4. Technique of Sewing electronic materials to textile: 1. Preparation of materials; 2. Base design and basting; 3. Sew of an LED; 4. Node sealing; 5. Current control after each turn on. Source: paper authors.

3.1 The Filozell-e Interactive Artifact

The interactive digital artifact Filozell-e is presented in the form of an embroidered and painted linen tapestry. It supports two microcontrollers and a number of actuators that, as programmed, respond to two sensors – proximity and ambient sound. The conceptualization of the project is based on three realities: symbiosis between design and technology, which results in original artistic expressions within the scope of creativity and aesthetics; interaction between humans and machines through interactive communication, seeking to explore the improvement of communication between them; and the reality of traditional embroidery that fight for its preservation and valorization, in this case applied to the culture of Santa Catarina da Fonte do Bispo, Tavira, Portugal. These themes are the foundations for the research that served as the basis for the design of the project, which studies how the new aesthetics of Digital Art can contribute to reactivate the interest and enrich the Traditional Embroidery of Portugal, deconstructing its logic, thus reintroducing embroidery into the contemporary imaginary.

Concept design included sketches and varied designs, which allowed us to envision different possible embodiments for the starting idea, in the sense of establishing an initial attempt that would be part of a more complex final composition.

The first step to materialize the abstraction of the concept in a tangible structure in perspective was a photographic documentation of the autochthonous species of local flora at Santa Catarina da Fonte do Bispo, Tavira, Portugal, followed by graphic sketches, the simplification by leveling the design of the species and color studies (Fig. 5).

The design of the experiment took into account important aspects of human nature in terms of stimuli and attention, considering knowledge and skills in areas such as perceptual psychology, science of cognition, environmental design, haptics, informational content design, interaction design, heuristic computing and design thinking.

Fig. 5. Photo to document autochthonous species of flora in the region of Santa Catarina da Fonte do Bispo, Tavira, Portugal, (the Cardo, Cynara Cardunculus) and its simplified graphic sketch. Resulting design was simplified by leveling the species design and color study, distinguishing the different shades that were applied in the final work (dimensions 1000 mm x 1500 mm). Source: paper authors.

The design of the concept, narrative and experience outline was followed by the development of the artifact, culminating in the realization of the final physical artifact. This phase included the design of the matrix, the transition from the matrix to the fabric, the outline of the design on the textile, the painting of the textile, outline of details, hand embroidery, system design, code programming and physical prototype tests and the production of the artifact exploring functional and aesthetic considerations, oriented to the realization of the concept.

Fig. 6. Sequence of the pattern design on the fabric (left) and hand embroidery applying the *Pé de Flor* stitch (right). Source: paper authors.

Fig. 7. Implementation of Arduino electronic circuits (left), testing the response of the actuators to the data sent to the microcontroller by the ambient sound sensor. Details of technology integration: application of *Neopixel Flora* and interaction with a motion sensor that activates the LED light by human proximity (right). Source: paper authors.

Fig. 8. Visitor interacting with the final version of the artifact Filozell-e, publicly displayed at ARTeFACTO 2018, *1st International Conference on Transdisciplinary Studies in Arts, Technology and Society* (right). Source: https://bit.ly/3LSzOmn

Regarding the implementation of the artifact, technology was then integrated (figure 7), followed by use and validation of the system and debug tests, planning of the display of the artifact Filozell-e (figure 8) and finally the deployment of the artifact as finished work as it was presented in public exhibitions.

3.2 Streamlining Embroidery and Building Community Workshops

Soft circuits applied to traditional embroidery propose to conceptualize new poetics, new functionalities and contribute to new forms of dissemination and promotion of local populations. The progress of the research is currently focused on the design of a set of guidelines and its implementation towards a new embroidery operationalized in participatory environments and work with the community.

Seeking to return and expand artistic practices to the communities of embroiderers and digital artists, we planned and promoted a workshop on the theme "Soft Circuits in Traditional Embroidery: Reinvention of an Imaginary for Sustainability". In an initial phase, the activity was planned to stimulate a group of students in the last year of the Degree in Basic Education. The concept was presented, and students' suggestions were considered, so adjustments were made in order to optimize the learning curve with a public that is usually unfamiliar with physical computing. From this experience, the workshop will be optimized in order to expand to local communities where traditional embroidery is practiced, seeking to attract multidisciplinary audiences and bring together different generations - usually older participants hold traditional knowledge and the younger ones contribute by learning the technologies that are needed to implement the desired interactive prototypes.

The implementation of the laboratory work, which resulted in a set of samples that served as motivation for the workshop, was based on sustainability at the cultural level (to the extent that we meet the past, we rely on existing visual metaphors resulting from traditional knowledge), environmental (we make art inspired by the surrounding environment and with zero waste, collecting traditional embroidery, with the possibility of reusing the materials in artistic works) and economic (in a well-implemented system, it could be a source of income for embroiderers/digital artists).

As main objectives, the production of sustainable art stands out in this context, combining traditional materials and techniques with electronic components, reinventing embroidery in a sustainable way by proposing its reintroduction into the contemporary imaginary.

With this laboratory activity, we intend to address the potential of soft circuits applied to textiles, in terms of their innovation and reinvention of an imaginary. We proposed to study the articulation between electronic materials and traditional embroidery, the innovation of emerging proposals, their importance in contemporary art and the conceptual and constructive aspects linked to sustainability. The embroideries that served as the basis for exploration during the workshop were selected according to the following parameters:

× Hand-embroidered proposals;

× Embroidered pieces with ancestral essence in terms of design or fabric (preferred options were cotton or linen);

× The preference for embroidered pieces in which there was an emotional or conceptual involvement.

Fig. 9. Exploration of technological materials and sewing microcontrollers in embroidery. Source: paper authors.

Fig. 10. Exercise development 8: *Lilypad*, temperature sensor and *Lilypad* leds that light up when temperature decreases. Source: paper authors.

All participants showed interest and taste for learning about this topic, and a lot of motivation for a future application, suggesting hypotheses for application and exploration during their professional activity as basic education teachers. The sustainability of interactive embroidery was also a matter of interest for future study and experimentation. In order to minimize the biggest problem experienced in this workshop, specifically the lack of knowledge of the sewing technique and stitches used in embroidery, it was suggested by the participants that in future workshops, invitations should be addressed to embroiderers in the area or family members of the participants.

Participation would then become a means for the exchange of knowledge between traditional embroidery and new technologies, as the technique, imagination, raw material and the narrative have always been passed on from generation to generation. Traditional Embroidery is a legacy inherited from the childhood family, so narratives are loaded with symbolism created by ancestral generations, internal images resulting from experiences passed on to paper, then to fabric and finally take shape with the needle and thread. These intergenerational bonds are an area to nurture in future iterations of our research.

4. E-Aesthetics towards Cultural Sustainability

By nature, traditional crafts integrate references to their environment and communicate cultural values and social realities. The creative exploration of these culturally rooted practices with the possibilities of soft circuits has given way to intergenerational exchange, thus leading to the preservation of memories and revitalization of traditional crafts.

In this scope, a digital artifact – Filozell-e - was created and implemented using soft circuits applied to textiles. It can be conceptualized as an invitation to interactive experiences with the realities of the surrounding environment.

Complementarily, the workshops on interactive embroidery have been exploratory activities that contribute to validate the research in terms of cultural sustainability, insofar as we meet the past, and for the recognition of the other, their experiences and choices, collecting and choosing the objects that serve as a basis for the creation of visual metaphors from the reinvention and renovation of existing embroideries. This social extension also proposes to contribute to the guidelines for the development of populations and rural spaces, associated with principles of economic sustainability in terms of the circular economy and creative industries.

Based on the feedback from embroiderers, students and users, ideas have been confronted, from which we conclude that the works of art that make use of the combination of technological materials with embroidery, are artistic explorations focused on the exploration of innovation platforms, technology, new construction processes, new approaches and new readings for embroidered objects that are considered traditional. By reinventing themselves, these artworks are presented as a medium for artistic interfaces that suggest physical, intellectual, and cultural paths supporting different styles of cognitive and emotional approach. The resulting artworks create dialogic relationships with the user and the environment, suggesting an active participation through touch, approach, response to light or sound. They remind us of the importance of preserving popular knowledge through creative and conceptual challenges of creating an artistic nature.

The shift of the artistic object into the cultural system gives purpose to the sustainable reconversion of societies and brings awareness to the work of artisans as artists. It is then pertinent to carry out new e-aesthetic explorations that combine traditional and electronic arts, establishing connections where signs of a collective consciousness become part of our cultural sustainability.

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Rematerialising Digital Technologies Through Critical Making

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This article examines artistic practices that engage with digital technologies through a critical making methodology. Critical making is described as a hands-on practice that aims to merge critical thinking with making. This is a practice that focuses on the process of making and combines material experimentation with critical thinking about the effects of digital technologies. Critically-made artifacts in the artistic context have the potential to disrupt pre-established notions of art engaged with digital technologies as well as to challenge screen essentialism in artistic production and everyday life. In this paper, it is proposed that critically-made artifacts are a form of post-digital art based on hybridisation of digital and non-digital technologies. This turn in artistic practices engaged with digital technologies is seen as a way to rematerialise digital technologies unfolded in physical space as well as a critical reaction to the post-digital condition, where all aspects of daily life are circumscribed around digital technologies in computational societies.

Keywords Critical Making, Installation, Audiovisual Art, Pedagogy, Post-digital, Aesthetics, New Materialism, Media Arts

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1. The nature of critical making

Recent artistic practices engage with digital technologies critically and combine them with physical materials through hands-on making. These modes of artistic production can be described as critical making, as "a general descriptor for kinds of conceptual-material" (Ratto and Hertz 2019, 19) practices engaged with critique, digital technologies and non-digital materials. The key research questions of this paper are: (1) What is the nature of critical making as an artistic practice? (2) How is critical making distinguished from other forms of hands-on making? (3) How does critical making as an artistic practice relate to a form of post-digital art?

This paper aims to answer these questions by starting with an overview of the term critical making coined by scholar Matt Ratto (2011) who considers it an educational and pedagogical hands-on workshop. Further on, it analyses the perspective of scholar and artist Garnet Hertz (2016) in which critical making is taken beyond the scholarly domain, oriented toward makers and technology-oriented artists as a way to introduce critique to hands-on material practices of physical engagement with digital technologies. Following from this, critical making is distinguished from the maker movement and attempts to introduce a critical stance towards it. Critical making is further analysed in the context of the arts as hands-on material-conceptual experimentation with technologies that often result in hybrid installations that assemble non-digital and digital technologies. This potential of critically-made artifacts in the arts is examined in the art installation *Entanglements* (2021) by the collective ANNEX.

To conclude, the paper argues that critically-made artifacts in the context of the arts introduce a bifurcation from previous art engaged with digital technologies that focus solely on the technical possibilities of new media. As an alternative to new media art practices, critical making approaches digital technologies through a hands-on material engagement that attempts to convey both awareness of their technical operations and sociocultural consequences through a rematerialisation of digital technologies in physical space.

1.1 A brief introduction to critical making

The term critical making was introduced by the scholar Matt Ratto in 2008 to describe the "combination of critical thinking with hands-on making" (Hertz 2016). It intended to merge both "critical social reflection and making" as a pedagogical hands-on practice and "material engagements with technologies" (Hertz 2016). Initially, it was intended as a practice for scholars and students who work primarily in the realm of critical theory and abstraction, ideas, criticism, text, linguistics and individualism (Ratto and Hockema 2009). Making belongs to the physical and material domain, as embodied and hands-on practices often community-oriented through the sharing of tools, spaces, knowledge and collaboration. Ratto and Garnet Hertz associate critical thinking with the Frankfurt School of Critical Theory and describe being critical as reflexive and hermeneutic or linked to the "goal 'to liberate human beings from the circumstances that enslave them'" (Horkheimer 1982, 244: Quoted in Ratto and Hertz 2019, 21). Following this latter definition of criticality, critical making aims "to reconnect our lived experiences with technologies to social and conceptual critique" (Ratto 2011, 253). As an attempt to combine both areas, critical making aims to merge the domains of critical theory and making as an effort to bridge the disconnect "between conceptual understandings of technological objects and our material experiences with them" (ibid.).

Consequently, the conception of critical making, as an academic and pedagogical workshop that merges criticality and making, is composed of three stages that do not have a fixed order.[1] One stage is dedicated to the literature review and the compilation of relevant concepts. Another stage engages in material prototypes through digital fabrication. In this stage, the development of prototyping "is used to extend knowledge and skills in relevant technical areas as well as to provide the means for conceptual exploration" (ibid.). And, finally, a recursive stage that requires a process of reconfiguration and reflection over the created artifacts to discover "alternative possibilities, and using them to express, critique, and extend relevant concepts, theories, and models" (ibid.). However, the focus of critical making is not merely on the resulting artifact, but rather on the sharing of "results and an ongoing critical analysis of materials, designs, constraints, and outcomes" (ibid.). In the words of Ratto, the goal of critical making is to make tangible the abstract realm of concepts and bring them closer to the body and not only to the brain, as a way "to make new connections between the lived space of the body and the conceptual space of scholarly knowledge" (Ratto 2011, 254).

1. See more about the pedagogy of critical making in Ratto (2011) and Ratto and Hertz (2019).

1.2 Critical making as a process-oriented practice

Following Ratto's conception of critical making, it is also distinguished from critical design. Hertz explains that critical making is a "constructive process of making" instead of merely "building an artifact" (Hertz 2016). Hertz points out that regular methods for design "often produce systems that lack cultural richness, emotion, and human-oriented values," and similarly, engineering "often overemphasizes principles like efficiency and productivity that contributes to a consumer-oriented culture that overworks, overproduces, and overconsumes" (ibid.). While critical design is oriented to "building refined objects to generate critique of traditional industrial design" (ibid.), critical making is a "process-oriented and scholarship-oriented" workshop in which the final prototypes are considered traces of the making process (ibid.).

In short, critical making highlights a hands-on process-oriented practice that emphasises critical thinking about technical devices and digital technologies. This is achieved through the process of making as collaborative, constructive and reflective action. To make a precise and defined object is not the ultimate goal. Instead of being oriented towards a fixed object-based practice, critical making is a process-oriented practice with an "emphasis on critique and expression rather than technical sophistication and function" (Ratto 2011, 253).

2. Re-politicising makers and technology-oriented artists

Extending Ratto's conception of critical making as part of the academic fields of social sciences and humanities, Hertz understands it as reaching beyond the scholarly domain. For him, the potential of critical making stems from the "perspective of hands-on technology development and studio practice—in *makers* becoming more critically engaged with their medium" (Hertz 2016). Critical making is directly aimed at the "builders of technology—whether hackers, engineers, industrial designers, or technology-oriented artists" (ibid.). From this point of view, the practice of critical making challenges makers to adopt a critical stance through tinkering and DIY practices engaged with physical computing, materials, digital technologies and other technical objects.

2.1 The maker movement

Following Hertz's perspective, critical making is a practice aimed at those who are immersed in building new technologies to take a "step back and reevaluate the assumptions and values being embedded into their technological designs" (Hertz 2016). This perspective on critical making has the potential to introduce to the maker movement a constructive critical engagement with technologies through the process of making, eventually prompting alternative technological imaginaries. Therefore, critical making challenges the maker movement, often perceived as a non-critical and leisure time practice popularised by Make magazine[2] through "subtracting critical engagement from the [making] process" (Ratto and Hertz 2019, 23). Dale Dougherty, the founder of Make magazine, "describes makers as enthusiasts who want to explore the possibilities of both new and old technology (Dougherty, 2012b: Quoted in Dufva 2018, 88). This view of the maker is seen from the European and North American context, which forked from hacker culture. This converted making into a popular de-politicised practice merged with traditional crafts and DIY practices accessible to any person with enough free time. In contrast to making as a leisure activity, seen from the European and North American contexts, in different contexts "making is driven by environmental and economic conditions of necessity, rather than leisure or profit-driven innovation" (Foote and Verhoeven 2019, 77),[3] similar to repair and other DIY cultures.

2. Make magazine popularised the term maker to "rebrand and sanitize the term 'hacker' to be more acceptable to the public, schools, and potential sponsors" (Ratto and Hertz 2019, 22).

Making as promoted by Make magazine is criticised by the scholar Tomi Dufva as a "continuation of the neoliberal agenda" (Dufva 2018, 89). Without a critical perspective, making is merely another hobby and a "new commercial trend" (ibid., 90) for-profit driven where making takes a commercial path into building consumer commodities of handmade items within the creative industries and start-up culture. Therefore, critical making attempts to challenge this and introduce a "sense of criticality back into post-2010 maker culture: to un-sanitize, un-smooth and re-politicize it" (Hertz 2016).

Critical making and the maker movement explore and propel new forms of engagement with hardware and material expression together with FLOSS[4] and creative coding practices.[5] The choice of a tool or a medium for the creative process can be considered political expression. But, as Hertz rightly asks "after learning to use a 3D printer, making an LED blink or using an Arduino, then what?" (Hertz 2012). The next important step for critical digital making is to ask "questions about the design, purpose, and cultural value of created things [...] [in] the process of making" (Ratto and Hertz 2019, 23).

Dufva argues for another perspective of the maker as "a societal and political movement, closely tied to hacker culture and open software & hardware movement" (Dufva 2018, 90). It has proliferated through makerspaces, hackerspaces and FabLabs, as community-oriented places where tools and knowledge are shared (ibid., 89). Adding to this, as scholar Christina Dunbar-Hester writes, these spaces are not places for job market preparation but rather for community participation to "experience making as both politicized and distinct from capitalist production" (Dunbar-Hester 2020, 143).[6]

However, digital making is only made possible due to raw material extraction, labour and manufacturing of "cheap hardware from China [that] is costing someone else their health and soil" (Bogers and Chiappini 2019, 8). In other words, digital making and its affordable digital tools are only made possible in a globalised economy with established power relations, one that relies on the exploitation of workers and the environment. Critical making takes into consideration the previous aspects to introduce a more diversified critique of hacking and making which attempts to include not only class and labour critique but, too, the "transnational political economy of the material conditions that support Global north" (Dunbar-Hester 2020, 5). By challenging these material aspects, critical making differentiates from the pre-established maker movement as it aims to challenge the sociocultural consequences of digital technologies. In short, critical making attempts to re-introduce critique to makers as a form to engage with "sociocultural histories and futures, as well as the environmental and economical implications of digital machines" (Bogers and Chiappini 2019, 8).

3. For example, "Gambiarra" is a Brazilian expression related to improvised methods of making and solutions to solve a problem with any available material. Similarly, "Jugaad" derived from India "is described as a type of frugal innovation or a 'hack'" as a response "to problems with a creative solution, fix, or workaround" (Foote and Verhoeven 2019, 77).

4. Free/Libre Open-source Software (FLOSS) stands for "a set of practices for the distributed, collaborative creation of code that is made openly available through a reinterpretation of copyright law; it is also an ideologically charged mode of production and authorship that seeks to reorient power in light of participants' understanding of the moral and technical possibilities presented by the internet." (Dunbar-Hester 2020, 6).

5. Dufva defines creative coding not "only as an artistic medium or as a method to learn computer programming, but as a process through which one can comprehend and critique the surrounding digitalised world more clearly" (Dufva 2018, 12). It enables "experiential connection with the digital processes, providing [...] hands-on experiences and theoretical frameworks" (Dufva 2021, 272). Similarly, the scholar David M. Berry rejects the notion of "software immateriality" and argues for code "as a medium materialised into particular code-based devices" (Berry 2011, 10).

2.2 Making as embodiment through hands-on approach

Making includes a direct engagement with a different range of technologies, from affordable "new digital tools, such as 3D-printers or laser cutters or even biotechnology" and, too, an engagement with traditional handcraft practices (Dufva 2018, 89). Making is then understood not as a break with older forms of hands-on material practices for the sake of the new, as promoted by new media art or digital art practices, but an engagement with both "new" and "old" media through physical engagement and material experimentation that might include materials such as paper, textile, clay, wood, metal, glass, stone and even mass-produced objects or the repurposing of older media technologies.

Making and hacking, as hands-on approaches, "consists of the opening of both physical (machines) and abstract (software) products, by which a maker gets to know how the products or tools operate by way of doing by hand." (ibid., 94-95). In this sense, Dufva quotes the scholar Seija Kojonkoski-Rännäli who "relates making by hand to Heidegger's concept of making (bauen)" in which "making is not only an act of creating an artifact but that it also includes aspects of caretaking and belonging to the world the maker creates" (Kojonkoski-Rännäli, 1995: Quoted in Dufva 2018, 91). Therefore, making by hand is a form of "grasping of the world [...] a core function of being" (ibid.).[7] Similarly, the philosopher Bernard Stiegler describes the relation between "to make" and "to act" meaning "to *take* one's dreams with *enough force* for them to *become real*" (Stiegler 2016, 93). Stiegler relates crafting not only to "what makes or fabricates" but "to exteriorize something" which requires action and initiates "one or more new circuits of transindividuation"[8] (ibid.). Thus, making by hand is a way of caring, belonging and "personality transformation: by working materials, the maker remakes herself" (Nijenhuis 2019, 138). Making can thus be considered a "form of knowledge creation [that] predates intellectual comprehension" (Dufva 2018, 91). Critical making attempts then to add a sort of reflection and critique through the iterate process of hands-on making.

In sum, making is understood as a form of embodiment through a direct intervention that approaches digital technologies from a material perspective. This can be seen as a way to grasp the disorienting environments of the post-digital condition, as "the messy state of media, arts and design *after* their digitisation" (Cramer 2014, 17). In other words, critical making entails a rematerialisation of digital technologies as an embodied experience accessible through a hands-on approach in physical space. Thus, critical making is a form of being in the world that engages through an iterative process with the materiality of digital technologies and critique that allows a deconstruction of the hidden values and mechanisms embedded in our everyday technical devices to expose their pervasivenes.

6. Dunbar-Hester writes that maker and hacker spaces are seen as sites of "[v]oluntaristic technology communities [and] are important sites because they are utopian spaces where people play and tinker not only with technical artifacts but with social reality, imagining social relations through participation in a third space outside work and home, though they are in dialogue and tension with labor market and domestic economies." (Dunbar-Hester 2020, 240)

7. The scholar Seija Kojonkoski-Rännäli "uses the Greek term techne (tekhniké) [...] understood as a making by hand [...] it can also be interpreted as understanding and knowing [...] techne fuses knowing and doing into one: problem-solving and molding of the material, thinking and motor skills are closely combined" (Dufva 2018, 91).

8. The concept of "transindividuation" is for Stieglers "the process of co-individuation within a preindividuated milieu and in which both the "I" and the "We" are transformed through one another. Transindividuation, then, is the basis for all social transformation and is therefore a way of addressing what happens within education" (Stiegler and Rogoff 2010).

3. Critical making and post-digital art

The curator Nora O. Murchú describes the critical maker as one who "engages with the material layer of digital technologies through prototyping to interpret and to intervene in the values embedded within them" (Murchú 2020, 168). Following this view of the critical maker, Dufva writes that by offering "a critical understanding of our everyday digital products, making can empower the user in the digital world" (Dufva 2018, 89). The artist engaged in critical making differs from merely technical-oriented artists. The critical maker probes technical objects with a critical and political attitude instead of merely relying on learning how to handle digital tools or computer programming to create artifacts. The critical maker is here understood not as a regular user who uses tools as intended, but rather, as a user who not only learns "how the tool works, but also to hack and reprogram the instrument" (ibid., 95). In this sense, through critical processes of hacking and making, makers manage to glimpse "inside the black box and make it their own" (ibid.).[9] These critical practices attempt to change power relations and enable artists to take control of their tools of production. On the one hand, this allows the artist to reconfigure and reinvent digital and non-digital tools and devices to fit their artistic purposes, instead of handling a product from its original design instrumentality. On the other hand, the artist becomes an empowered user "with an enhanced ability to parse the complexity of our sociotechnical world" (Ratto and Hertz 2019, 25). However, this empowerment is far from creating a direct and large sociocultural impact and is better viewed as micro-politics that consist in taking small steps towards questioning and disrupting the power relations imposed by Big Tech.

To this end, the critical maker questions the sociotechnical world from an ethical, critical and collective perspective that attempts to step away from capitalist exploitation of proprietary software and consumer-oriented digital tool or interfaces. A perspective that moves in-between digital and non-digital technologies and materials as well as online and offline modes of production. As such, the critical maker creates a kind of post-digital art that deviates from pre-established configurations of artistic production mediated through digital technologies.

3.1 Critically-made art

The maker acknowledges non-human agency in matter and in doing so the production of art engaged with digital technologies is taken from an embodied and collaborative perspective of human and non-human agents. In this way, critically-made art can be understood as based on new materialism philosophy,[10] openness,[11] diversity,[12] and hybridisation[13] of technologies. Critically-made objects introduce critique and re-evaluation of the impacts of digital technologies and might result in artifacts such as prototypes, case studies, hybrid installations

9. The abstraction layers of software and its inner logic and structures brought a "world [that] is difficult to grasp or understand when the user cannot see how the program is constructed [...] [proprietary] software [becomes] a black box without any access" (Dufva 2018, 94).

10. New materialism is in general seen here as a reaction to the decrease involvement "of matter in the dominant Euro-Western tradition as a passive substance intrinsically devoid of meaning. [...] new materialists routinely emphasize how matter is "alive," "lively," "vibrant," "dynamic," "agentive," and thus active" (Gamble et al. 2019, 111).

11. For a detailed analysis on openness and the maker movement see Saari et al. (2021).

and other non-installation formats.[14] The critically-made artifact unveils traces of hands-on material experimentation engaged with technologies and critique by debunking their infrastructures as well as challenges how digital technologies are perceived in everyday life. Critically-made art introduces new perceptions that unfold digital and non-digital materials through space as a form to grasp the sociocultural impacts brought by digitisation.

In the context of the arts, critical making bifurcates from established forms of new media art that focus solely on the virtual, simulation and abstract layers of code as a medium, or the zeros and ones. Critically-made art distances itself from the modernist paradigm of aesthetics pursued by new media arts, one that focuses solely on the technical possibilities and specificities of a medium. Instead of propagating the tradition of medium-based arts, critically-made art creates perceptions and affections that result in a sort of impure aesthetics, one that mixes and combines critique, hands-on material experimentation of non-digital and digital technologies. Consequently, this combination of technologies and different materials can be understood as hybridisation.

3.2 Post-digital hybridisation

Critically-made artifacts as hybridisation shift art from "an object with a fixed arrangement of meanings, material and aesthetic composition to one that is open and subject to continuous flux" (Murchú 2020, 166). As such, it has the potential to "alter everyday situations, objects and rules to build provocations that encourage a re-evaluation of technology in culture" (ibid.). This is here understood as a post-digital hybridisation, a form of post-digital art that critically combines non-digital and digital technologies, as entanglements of material assemblages that are reconfigurable and open-ended installations. This emerges in the artistic context engaged with digital technologies as a rejection of new media art and as a reaction to the post-digital condition where everyday life is pervaded by digital technologies that have become banal technical gadgets. Critically-made artifacts are then a form of post-digital art engaged in hybridisation across different materials as a tactic that unfolds and rematerialises digital media technologies through physical space. As a result, these artifacts challenge the dominance of screen-based art practices to approach digital technologies beyond screen essentialism.[15] By doing so, they expose both "the inner-workings and external influences to these systems, and their increasing authority in society" (Murchú 2020, 171). As Hertz puts it, critically-made artifacts instantly "hit like an emotional sledgehammer if thoughtfully implemented" (Hertz 2016). These artifacts trigger reflection of digital technologies' effects and render "a provocative, speculative, and rich vision of our technological future that avoids the clichés of consumerist-oriented industrial design." (ibid.). The perceptions generated by critically-made artifacts engage with post-digital hybridisation through material

12. See more on diversity and inclusion issues of open technology cultures in Dunbar-Hester (2020).

13. On neo-analogue hybrids and the repurposing of older media technologies see Ferreira and Ribas (2021).

14. Critically-made objects can be "documented online, exhibited in public art galleries, or published as case studies in academic papers—and can work to expose the hidden assumptions within the designed objects around us and be embedded in technological systems to a wide audience" (Hertz 2016).

15. Screen essentialism means to stay at the surface level of the screen and its image output where information is "disembedded from its material carrier" (Berry 2011, 36).

assemblages that have a vibrant potential[16] to be affective where non-human forces transform human perceptions, affections and emotions through an art form that not only critiques or comments on digital technologies but presents a re-imagination of other possible material conditions and technological futures.

4. Entanglements

As an example of a critically-made artifact in the arts, it is now examined the art installation *Entanglements* (2021) created by the collective ANNEX,[17] recently presented at the festival Transmediale 2022 in Berlin, Germany. This artwork is chosen to illustrate the previous analysis of critically-made artifacts as post-digital hybridisation. The work is here analysed from the aesthetic experience perspective of an audience.[18] The installation *Entanglements* is considered as a critically-made audiovisual sculpture that creates a hybrid environment and radiates traces of its making and critique through the assemblage of several layers of physical materials. In the process of making, different materials related to information and communication technologies have been assembled, including digital and non-digital materials as well as sound and video in order to unmask the materiality of the cloud[19] and critique of their environmental impacts. In general, the work aims to "re-evaluate the utopian fantasy of digital communication and to reflect on how we live together through data infrastructure, today and into the future" (ANNEX 2021).

4.1 Grasping the cloud

Entanglements is a large-scale audiovisual sculpture (Fig. 1 and 2) that allows the audience to enter and experience it from within its circular formation relating to the campfire[20] and data infrastructures. The artwork assembles different materials, such as network burnt server-racks (Fig. 3), a web of ethernet cables, coals, fans and media, such as speakers, lights, live cameras and several vertical screens. This form of hybridisation combines the burnt server-racks stacked up high, entangled with cables linked to the servers to form a messy web, symbolic of the internet. Through a tactile and direct material engagement, the cloud infrastructure is deconstructed to grasp its materiality as well as to disclose its local and planetary ecological consequences.

Various screens are vertically displayed and show text generated by machine learning[21] over satellite thermal pictures and videos as well as real-time thermal video from the installation space. The aerial pictures show data centres in Ireland,[22] it is forecasted that by 2027 data centres in Ireland will consume 31% of the total electricity demand (ANNEX 2021). The viewer is reminded of the environmental consequences of data centres not only through the burnt server-racks but, too, by generated text on screens such as:

16. The philosopher Jane Bennet claims that there is a vitality in materiality, things have a force of their own, she calls it "thing-power." She writes that "Thing-power may thus be a good starting point for thinking beyond the life-matter binary, the dominant organizational principle of adult experience. The term's disadvantage, however, is that it also tends to overstate the thinginess or fixed stability of materiality, whereas my goal is to theorize a materiality that is as much force as entity, as much energy as matter, as much intensity as extension." (Bennet 2010, 20).

17. The collective ANNEX works within the fields of architecture, art, media theory, computer science and gaming, it is composed of Sven Anderson, Alan Butler, David Capener, Donal Lally, Clare Lyster and Fiona McDermott.

18. Further analysis of the artwork with a methodology other than the aesthetic experience would enable further understanding of the critical theory explored, collaborative aspects of the artists and hands-on processes of making as well as their social participation and engagement with the wider community.

19. Cloud computing is the dominant business model and infrastructure of information technologies on the internet.

20. As ANNEX writes, the campfire is seen here as a "primitive architectural space where early human civilizations formed alliances, built social networks, and eventually developed complex societies" (ANNEX 2021).

21. The screens display text that was generated by a "machine learning algorithm that has been trained on over 10 million words relating to the field of data infrastructure" (ANNEX 2021).

22. Ireland hosts "corporate headquarters of gigantic tech companies, from Amazon to Facebook and Google to Microsoft, [...] Dublin overtook London as the data center hub of Europe and now hosts 25 percent of all available European server space." (ANNEX 2021)

> This intersection of human, technical, and social aspects of global systems of production, consumption, and waste treatment is, in important ways, one of the most dynamic and significant drivers of climate change, and it has been inextricably with the rise of another facet of capitalist production. (ANNEX 2021)

The installation is interconnected and controlled through software to generate the media playback and the composition which lasts about 20 minutes. It triggers sounds, lights, fans, screens and real-time video. It is embedded within a powerful soundscape of mechanical sounds as well as the sounds of birds, water and the sea. These sounds are from a grotto where the first transatlantic telegraph was placed in 1857 on Irish Valentina Island. The soundscape emanates from two large subwoofers, felt through the body, together with speakers located around the structure. It appears as though the sound triggers white LED lights that illuminate coals (Fig. 4). On the bottom of the structure and around it are fans that produce wind when triggered.

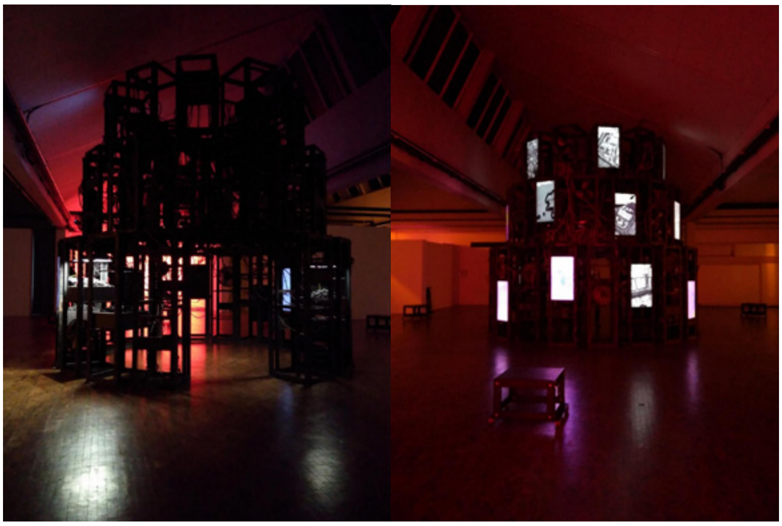

Fig. 1 and 2. *Entanglements* (2021). Art installation at Transmediale 2022, Akademie der Künste, Berlin, Germany.

Fig. 3 and 4. *Entanglements* (2021), close-ups. Art installation at Transmediale 2022, Akademie der Künste, Berlin, Germany.

The artwork explores hybridisation of materials in physical space as a critical tactic to express concerns about the environmental impacts of information technologies and their ecological footprint with a focus on its drastic amount of energy consumption and heat generation in maintaining the networked world. The scholar Sean Cubitt writes that the production of the digital culture and the logistics of "digital equipment now uses at least as much energy as the airline industry" (Cubitt 2016, 102). And according to Greenpeace, information technology companies rely heavily on non-renewable energy sources, such as coal, to power cloud computing (Cook 2012). All this reminds one that to send an email, scroll on Facebook or reproduce a video on YouTube or "a virtual fire, such as Netflix's *Fireplace For Your Home*, creates real heat in its production" (ANNEX 2021) that adds to the carbon footprint of the online world.

The installation *Entanglements* unmasks the materiality of data infrastructures to deconstruct the data centre, the infrastructures dedicated to store, distribute and handle data as the basis of the networked society. The materiality of the cloud is emphasised through hybridisation as a tactic that assemblages technical objects that compose data centres to critique their energy consumption and residual heat associating the data centres with the production and distribution of energy infrastructures. As such, the work is here considered as a critically-made artifact that rematerialises the cloud and unfolds it physically and spatially through digital and non-digital materials. To conclude, the work affectively points out the growth of global data and its environmental impacts by unmasking the materiality of the cloud. This critique through material hybridisation challenges the popular imagination and marketisation of an immaterial digital culture that is marketed as "independent of material substrate, transportable on the vague and indeterminate channel of 'the Internet'" (Parikka 2013).

5. Conclusion

In this paper, the nature of critical making was analysed as a practice that emphasises critical thinking about technical devices through the making process. Inherent to critical making is a pedagogical component that aims to strengthen technical skill, incorporate critical theory about our sociotechnical world and promote awareness of STEAM[23] in education. Critical making can be distinguished from other forms of hands-on making as it re-politicises makers and has the potential to critically reconfigure the maker movement. This form of making differs from uncritical-making, leisure-making or forms of entrepreneurial-making. Thus, the critical maker is an artist engaged with technologies through critique and materials who deconstructs the inner mechanisms embedded in our everyday devices. Critical makers are politically and ethically engaged through hands-on making which creates community-oriented practices with the sharing of technical knowledge and a sense of social participation and belonging. These values and modes of artistic production are distinct from capitalist modes of production such as labour division, individualism, competition, disaffection and consumer-oriented commodities of artistic production.

23. Science, Technology, Engineering, Arts and Mathematics (STEAM).

The art installation *Entanglements* (2021) was examined to illustrate a practical example of a critically-made artifact in the context of the arts. The installation suggests hybridisation of digital and non-digital materials together with critique of the ecological footprint generated by data centres and their sustainability. These negative consequences of environmental pollution brought about by computational societies are part of a constellation of digital media materiality, which includes not only electricity production and consumption, but, too, mining, unfair labour conditions, planned obsolescence, e-waste and other residual effects from digital technologies.

It was argued that critical making rejects the new media art paradigm and is instead associated with a post-digital art practice critical about the consequences brought on by digital technologies. As a form of post-digital art, critical making engages both "new" and "old" media through physical engagement by hand and material experimentation. Thus, critical making provides a rematerialisation of digital technologies in physical space as embodied technical devices accessible to the hand. This artistic practice is accessible to a wider range of people than just experts in the field or a niche of new media artists.

Critically-made artifacts are a kind of politicised art that aim to disrupt the "relationship between the visible, the sayable, and the thinkable without having to use the terms of a message as a vehicle" (Rancière 2006, 63). These artifacts introduce new perceptions and affections that "transmit meanings in the form of a rupture with the very logic of meaningful situations" (ibid.). As a result of a new materialist perspective, critically-made artifacts create an impure aesthetics based on openness, influx and hybridisation. As hybrids, critically-made artifacts result from an interplay with matter, digital and non-digital materials that blur human and non-human agencies to include the incalculable, or what is outside the realm of computation.

To conclude, critically-made artifacts reject the rhetoric of immateriality affiliated with digital technologies and is better understood based on hybridisation, a critical tactic that unfolds the digital spatially. These artifacts have the potential to influence and transform our affections and perceptions of everyday life pervaded with digital technologies as well as to unmask the sociocultural consequences, political, economic and environmental impacts brought about by digital technologies in computational capitalism.

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Constructive Interpretation and Text Transformation

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This paper considers the project of active transformation of texts through the substitution of words, for instance by the 'N+7' method of the Oulipans, which replaces each noun in a text by the seventh subsequent noun in a particular (print) dictionary. This method is conservative in that it only allows for intracategorial substitutions; the present paper aims to extend existing semantic interpretative mechanisms in order to handle intercategorial substitution. A type shifting system is proposed for this purpose, and applied to an example, followed by discussion of implications and extensions of the system.

Keywords experimental literature, formal semantics type theory, constructive interpretation

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1. Project

Texts can be viewed as settled, concrete objects. Most literary work is meant to be a closed and inviolable whole, which is constructed by the author and which cannot be modified by the reader. This is a fundamentally passive notion of 'reading' which removes a great deal of agency from the reader, who is not free to alter the text, rephrase it, or interject their own words or ideas, except at the level of interpretation. Even there, the understanding of the reader is often called into question as a misinterpretation, as inconsistent with the source text, as out of alignment with the intentions of the author. But this way of thinking seems excessively limiting: reading of course can be a passive activity, but it should, potentially, also be an active one.

What constitutes active reading in the sense meant here? There are many ways to actively engage with a text by manipulating it or interpolating new elements with it, as discussed by Goldsmith (2011). One could for instance insert any kind of content: words, sentences, paragraphs; one could lop off large chunks of the original text, from modifiers up to whole chapters; one could rearrange things wildly and make an entirely new story, or introduce a completely novel and unfamiliar worldview. But these acts are ultimately perhaps not so different from simply writing entirely new texts. It seems much more productive and interesting to constrain the process in some way.

With this notion of constraint, I take my inspiration from the Oulipo, a mostly French collective of writers who imposed constraints on their writing and on their texts (Becker 2012; Elkin and Esposito 2013; see also Schiavetta 2000 for more on the general notion of constraint employed here). Perhaps the most famous example of an Oulipan text is Georges Perec's *La Disparition*, a novel in which the letter e never appears, though there are many others, such as Anne Garréta's *Sphinx*, a love story in which the gender of the lovers is never indicated, a much more difficult task in the French in which the book was written than in English. A constraint of another type is the so-called 'Transposition N+7' invented by Jean Lescure (Lescure, 2018), in which each noun is replaced by the noun falling seven nouns after it in the dictionary; this last is closest to what I have in mind here.

The constraints above are interesting and, at least in some cases, have led to work of substantial artistic and literary interest. But they aren't really suitable for active reading: eliminating every *e* from a text, for instance, would yield either a large number of truncated words or require extremely extensive rephrasing, both of which seem outside the genuine scope of *reading* as normally construed. What, though, about Transposition N+7? This constraint seems to have similarities to what has been discussed so far in the present work: transposing and substituting words. The difference is only that the substitution is sourced externally to the original text, to the dictionary, so it is in some sense more transformational than a notion of reading should perhaps be. I conclude from all this that an interesting constraint to apply to a notion of active *reading* is that all substitutions and changes should stem from the source text, which is to say that all material drawn upon should be text-internal. Of course, this is only one possible constraint, but it is the one that will inform the text transformations carried out in the remainder of this paper, and the semantic system that supports them.

There is a fundamental conservatism in the N+7 constraint: it allows only substitutions of nouns. A slightly more liberal system 'W+7' enables substitutions within any lexical category: verbs, adverbs, and so on. But now consider a more radical system of active rewriting of texts where any term can be (universally) substituted for any other. Such a system is likely to produce much more radically different texts, and texts of radically new types; but there are obvious difficulties. In some cases, such substitutions will not cause problems for semantic interpretation: for instance, if a nominal like *tree* is universally substituted for an adjective like *blue*, the set of interpretable semantic parsetrees will remain constant, for (on many theories of adjectives, at least) the two both have the same semantic type, namely *<e, t>*.[1] But many other substitutions will lead directly to problems in interpretation. How is one to interpret a noun or adjective when it is substituted for a determiner such as every, which are standardly given the type of generalized quantifiers (i.e. *<<e, t>, <<e, t>, t>>*), or vice versa? In fact, it is not so obvious how to interpret strings like *Tree every light or Mayonnaise some blue*, a situation which only gets more extreme as complexity increases (*Parquet blue each some and opposition tree or sweet if at*).

But if one wants to push the project of text transformation to its limit one is faced with a difficult choice. One must either give up on producing interpretable texts, which removes much of the interest of the project (and, arguably, of its artistic merit, for an uninterpretable literary text is of relatively limited interest compared to interpretable ones), or one must find a way to interpret strings like those above. Doing so is the goal of the present work and is carried out in §3, after a brief explication of the background theory and method in §2. This opens the Oulipan tradition to a new domain: previous work has applied constraints to text construction, but only within the bounds of normative interpretations of natural language. The project reported on here opens the door to a new kind of practice which functions on an interpretative level.

This goal is of independent interest: what would a language of infinite flexibility look like? What happens when certain constraints on language construction and structure are eliminated, for instance that only determiners can have denotations of generalized quantifier type? These constraints are often considered to be empirical in nature, and, construing this term as referring to existing (linguistic) systems, perhaps they are indeed empirical; but there is in principle no reason other kinds of languages could not exist, and an exploration of the space of potential systems is interesting in its own right. Further, the construction of

1. The discussion from here involves the system of type-theoretic combinatorics standard in formal semantics: see Heim and Kratzer (1998) for an accessible introduction and Montague (1974) for the foundational text.

linguistic and mathematical systems is (to my knowledge) almost unknown as an artistic practice, possibly for reasons of complexity or the required expertise. This lacuna in the space of artistic expression is one that should be filled, and, from this perspective, projects of the kind comprising this work is one that should be pursued for itself, not merely as a vehicle for enabling other sorts of artistic practice (here: text rewriting and 'active reading').

The work described here can therefore be viewed as a first exploration into a larger domain of abstract and conceptual art taking as its toolkit linguistic and mathematical systems. But this exploration is, in the present context, mostly at the service of text transformation, a detailed example of which within the proposed system is provided in §4; the reader who is uninterested in mathematics is free to skip the previous technical part in favor of the larger project.

2. Background theory and methodology

The system I propose for interpreting texts where unlimited tranformation is allowed is set within a formal semantic system for analyzing linguistic meaning. There are two main aspects of such systems relevant to the present discussion: the kinds of things meanings are taken to be, and the way in which they are derived.

Formal semantics has its roots in analytic philosophy, in particular philosophy of language; philosophy of language in turn has its roots in logic. In standard logics, the notion of truth is fundamental: sentences are taken to denote truth-values, true and false in the most basic systems, which is then extended to various other kinds of values in other systems. Propositional logics concern themselves only with sentence-level phenomena, but first-order logics also make reference to predications and other things which operate at the subsentential level; still, the fundamental notion involves truth, so subsentential objects are understood in terms of how they contribute to the truth of sentences. Thus, the basic first-order analysis of the sentence *A badger sleeps* can be written $\exists x[\mathit{badger}(x) \wedge \mathit{sleeps}(x)]$ in modern notation, where *badger* and *sleeps* are understood as sets of individuals which are true of the variable x if whatever object is selected by the variable can be found in the relevant set: the quantifier $\exists x$ then allows modulation of the object the variable selects (via manipulation of an assignment function), and the whole is true just in case there is some individual which satisfies both predicates (see e.g. Gamut 1991 for an accessible introduction geared toward those interested in natural language).

Within linguistics, this background logical framework has been extensively applied in theories of the semantics of natural language which aim at providing meanings for the infinitude of possible sentences. These theories are commonly used together with views of syntactic structure in which sentences are modeled using tree structures, which themselves aim at giving structural analyses of all possible sentences (see Chomsky 1957 for an early exemplar of such a syntax). The aim is to give a system in which, when two words appear adjacent together in the hierarchical structure derived from a set of phrase structure rules (or similar method), the meanings of the two can combine into a new meaning reflecting both.

In such theories, natural language expressions are associated with mathematical objects, their *denotations*. These objects consist of two elements and have the form $\varphi : \gamma$. Here, the first element φ consists of expressions of the λ-calculus, a mathematical system for representing functions and their arguments (Barendregt, 1981). The leading idea is that when two expressions combine into a larger one, one of them must be a function which takes the other as argument, yielding a new expression: for instance, in the maximally simple sentence *Elin smokes*, 'smokes' is understood as a function taking an individual as input and yielding a truth-value as output, ie. 'true' if Elin is in the set of smokers, and false otherwise; 'Elin' is taken to denote an individual.

The second element, γ, expresses the semantic *type* of the object φ and can be viewed as a way of representing the kind of function that it is, which in turn is understood in terms of the sorts of arguments that it takes. Type theory is used for this purpose. Here, the type of a function is determined by its input and output, and in the simplest case are constructed recursively from the elements *e* ('individuals') and *t* ('truth-values') and functions from one to the other (written '$<\alpha, \beta>$' for a function from α-typed objects to β-typed objects). The denotation of 'smokes', written [[*smokes*]], for instance, is a function from individuals to truth-values, and so written $<e, t>$; 'Elin' is an individual and so [[*Elin*]] is of type *e*. A fuller set of types can be found in Figure 1.

1. [[*Elin*]] = *elin* : *e*
2. [[*smokes*]] = λx[*smokes*(x)] : $<e, t>$

Note that, for any function, the argument it takes must correspond for its input type for function application to take place; for natural language, that means that when two words combine, one must be the right type to be input to the other, or a meaning for the complex expression will fail to be obtained.

With this background, we can start to see the problem that arises with universal transformations: in many cases, text transformation will result in strings of words that fail to denote expressions that can combine, because the expressions will fail to have the right types. Consider, for example, the sentence *Elin smokes and drinks*, and suppose that 'and' requires both expressions adjacent to it to have the identical type (here: $<e, t>$). But now suppose we substitute 'Elin' for 'drinks', yielding *Drinks smokes and Elin*: 'Elin' is of type *e*, and so the requirement of 'and' is not satisfied, and the semantic derivation will fail. The problem of universal text transformation is, in a nutshell, the problem of finding a way to assign types to lexical items in transformed texts that makes them interpretable in the semantic system. As we will see shortly, the way in which we do so has the potential for many unexpected and interesting results, and the further potential to produce a new space for literary (and other artistic) exploration.

Fig. 1. Attested types in natural language.

Type	Category	Examples
e	N	Tabitha, Elis
t	S	‘I like hazelnuts’, ‘You never shut up’
$<e, t>$	N, Adj, V (intransitive)	wheatgrass, puzzling, masturbate
$<e, <e, t>>$	V (transitive), P	harvest, towards
$<e, <e, <e, t>>>$	V (ditransitive)	introduce, give
$<<e, t>, <e, t>>$	Adv	frenziedly, sadly
$<t, <t, t>>$	Conj	and, or
$<<e, t>, <<e, t>, t>>$	*D*	every, some

3. System

The most obvious way to universalize interpretation is to allow expressions to have their standard denotations and to define mappings from them to expressions of other types. Assuming the set of possible types used in natural language is finite, we then will have a procedure for interpreting any term in any position. This simple strategy extends standard work on type-shifting in linguistics (e.g. Hendriks 1993; Winter 2002), with the difference that, instead of using type-shifters to ‘normalize’ semantic parsetrees by mapping nonconforming elements of them in a way that yields the expected denotation, we are instead starting with nonstandard syntactic configurations (or, at least, configurations in which unexpected elements comprise the leaves of a syntactic tree derived by familiar grammars) and transforming them in such a way that they yield an interpretation which might be unexpected or even incomprehensible (though semantically or logically coherent).

Concretizing this method requires starting with a set of semantic types and providing a system for transforming each of them into all the others. Since our interest here is text transformations, we need only consider the set of types attested in natural languages. Figure 1 lists the types that will be addressed in the work described here.[2]

For the project, it will suffice to have rules which can transform each element into elements of one other type. We need not write rules transmuting each type into all other types, as chains of type-shifting can be introduced. Some of the necessary rules already can be found in published work, and we will make free use of these here. The others – those not needed for practical linguistic applications, and so not addressed in that literature – must be defined separately.

The strategy of this section will be to use interpretations close to some familiar ones found in natural language, and to use the simplest possible methods:

2. This list is not completely exhaustive: it ignores several factors, for instance the complexity of the adverbial system (which admits several other types, e.g. sentential adverbs) and the existence of not-at-issue types such as those used for expressive content. Extensions to these domains are, however, straightforwardly available.

heavy use of identity functions and indexical substitutions. The last section of this work will explore more ambitious and wilder possibilities. Let us start with the simplest types, *e* and *t*. (3) is a rule which maps type *e* objects – proper names – to the sets of individuals named by that term. The existing literature includes many rules useful for going back and forth from different interpretations of nominals, which are necessary for the semantic parsing of certain linguistic phenomena; (4) is one such rule, mapping The strategy of this section will be to use interpretations close to some familiar ones found in natural language, and to use the simplest possible methods: heavy use of identity functions and indexical substitutions. The last section of this work will explore more ambitious and wilder possibilities. Let us start with the simplest types, *e* and *t*. (3) is a rule which maps type e objects – proper names – to the sets of individuals named by that term. The existing literature includes many rules useful for going back and forth from different interpretations of nominals, which are necessary for the semantic parsing of certain linguistic phenomena; (4) is one such rule, mapping properties to their associated definite descriptions.[3]

3. The below is only an exemplar selected from the domain of possible rules for each case: for the current project, it is enough to be able to derive interpretations, as opposed to explicitly making available all possible interpretations. Again, other rules can be selected from the provided sources if desired, or other kinds of interpretations, for instance nominalizations of verbs or adjectives (*littering, blueness*) instead of the ι rule (Chierchia and Turner, 1988; Chierchia, 1998). See the last section for more discussion and alternatives.

3. $[[name]]=\lambda x\lambda y[named(x, y)]$: <*e*, <*e*, *t*>>
   Example: $[[name]]([[Tabitha]])=\lambda x[\lambda y.named(x, y)](t) = \lambda y[named(Tabitha, y)]$
4. $[[\iota]]=\lambda P[\iota x[P(x)]]$: <<*e*, *t*>, *e*> (Partee, 1987)
   Example: $[[\iota]]([[mongoose]])=\lambda P[\iota x[P(x)]](\lambda x[mongoose(x)]) = \iota x[mongoose(x)]$

The strategy in (3) will not work (or not straightforwardly) for adding arguments to existing types in general. Here we will make use of indexical elements instead: the standard indexicals tied to the context of utterance familiar from the work of Kaplan (1989). Adding arguments will amount to the insertion of variables or, in some cases, indexical elements; removing arguments will amount to the insertion of indexical terms which saturate the argument positions in question. (5) shifts one-place (intransitive) predicates to two-place (transitive) ones by introducing an additional argument place associated with a causation. (6) shifts two-place predicates to three-place ones by adding an argument place for the time at which the predication holds.

5. $[[cause]]=\lambda P\lambda y\lambda x[cause(x, P(y))]$: <<*e*, *t*>, <*e*, <*e*, *t*>>>
   Example: $[[cause]]([[sleep]])= \lambda P\lambda y\lambda x[cause(x, P(y))](\lambda z[sleep(z)]) = \lambda y\lambda x[cause(x, (sleep(y))]$
6. $[[at]]=\lambda R\lambda z\lambda y\lambda x.R(y)(x))$ at z : <<*e*, <*e*, *t*>>, <*e*, <*e*, <*e*, *t*>>>>
   Example: $[[at]]([[kiss]])= \lambda R\lambda z\lambda y\lambda x[R(y(x)$ at $z](\lambda y'\lambda x'[kiss(x', y')]) = \lambda z\lambda y\lambda x[kiss(x, y)$ at $z]$

For the lowering side of these, we simply saturate existing positions with indexical elements. (7) maps three-place predicates to two-place ones; (8) saturates an argument position of a two-place predicate. Both of these mappings are managed via the insertion of an indexical element *this*, the value of which is selected from available contextual elements as usual with what amounts to a free variable. Further discussion of the role of pragmatic reasoning in systems like this will be deferred to the final section.

7. $[[trans]] = \lambda R\lambda y\lambda x[R(this)(y)(x)]$: <<e, <e, <e, t>>>, <e, <e, t>>>
   Example: $[[trans]]([[give]]) = \lambda R\lambda y\lambda x[R(this)(y)(x)](\lambda z'\lambda y'\lambda x'[give(x', y', z')]) = \lambda y\lambda x[give(x, y, this)])$
8. $[[intrans]] = \lambda R\lambda x[R(this)(x)]$: <<e, <e, t>>, <e, t>>
   Example: $[[intrans]]([[kiss]]) = \lambda R\lambda x[R(this)(x)](\lambda y'\lambda x'[kiss(x', y')]) = \lambda x[kiss(x, this)$

Now we come to rules which have little use in empirical linguistics. The first rules introduced above are relatively commonly used; the second set can in principle be useful for things like causative alternations; the third set, while nonstandard, correspond to cases where an argument is present but unstated. The rules which follow are needed to ensure the interpretability of all strings, but result in meanings which don't really correspond to phenomena found in ordinary language. This is as desired: we are not especially interested here in 'sensible' semantics, but rather in the possibilities stemming from universal interpretation.

(9) maps adverbial denotations to one-place predicates. Here we could make use of a simple identity function, but for the project of textual substitutions and transformations, it is more interesting to allow the mapping to pick up something else from the text which is then modified by the adverbial meaning. This amounts to property anaphora, which is something frequently found in natural language (Asher, 1993); we could make use of dynamic tools, but here instead we simply allow the type-shifter to pick up a predicate from the discourse context.[4] The corresponding 'lift' is given in (10).

4. In the example in (9), the predicate is 'dynamic', which is in the discourse context because of its presence in the sentence to which this footnote is appended.

9. $[[existadv]]$=, where $Q \in C$, $\lambda P\lambda x[P(Q)(x)]$: <<<e, t>, <e, t>>, <e, t>>
   Example: $[[existadv]]([[slowly]]) = \lambda P\lambda x[P(\lambda y[dynamic(y)])(x)](\lambda P\lambda y(slowly(P(y)))) = \lambda x[slowly(\lambda y[dynamic(y)])(x)]$
10. $[[inadv]] = \lambda P\lambda Q[Q(P)]$: <<e, t>, <<e, t>, <e, t>>>
   Example: $[[inadv]]([[bitter]]) = \lambda P\lambda Q[Q(P)](\lambda y[bitter(y)]) = \lambda Q[Q(\lambda x[bitter(x)]]$

We now need rules which allow the two simplest types to alternate with each other. (11) takes type *t* objects – sentence denotations – into predicates, which can then be lowered to type *e*;[5] (12) takes individuals into their corresponding statements of self-identity.

11. $[[tet]] = \lambda p \lambda x[p] : \langle t, \langle e, t\rangle\rangle$
    Example: $[[tet]]([[\textit{the chips are old}]]) = \lambda p \lambda x[p](old(chips)) = \lambda x[old(chips))]$
12. $[[et]] = \lambda x[x = x] : \langle e, t\rangle$
    Example: $[[et]]([[tabitha]]) = \lambda x[x = x](t) = (t = t)$

The final two sets of rules needed are where things get downright strange, from the perspective of ordinary natural language interpretation. Here, we need to map conjunctions to other kinds of semantic objects, and produce and eliminate determiner meanings. This sort of operation is very much not a thing in the standard semantics of natural language: after all, what would it even mean for *blue* to have a quantificational meaning like *every*, or for *and* to predicate something of *Idis*, much less for *almond* to have a meaning which conjoins propositions? One set of possible answers to these questions follow, starting with the conjunctive case.

In the case of mappings involving conjunction, the 'lowering' direction is simple: we simply map the conjunction to a proposition, which can then in turn be fed back into the rule system to yield whatever type is required. The needed rule is given in (13). There we again make use of the discourse context in order to maintain the aesthetic of substitution/transformation. Consequently the mapping picks up the truth value of the previous discourse segment. To do this, an auxiliary definition is required: let the meaning of the text have the form $S_1, \ldots, S_n$ for discourse segments $1, \ldots, n$, and let the value of the sentence currently under interpretation be *i*, so its semantic value is S_i. We then map the conjunction to S_{i-1}, the value of the previous sentence. For mappings from predicates into conjunctions, it is of course possible to simply choose a conjunction – *and, if, or,* etc. – and map all predicates into it; here, however, we have chosen to incorporate all of the above and simultaneously use elements from each of the conjunctions mentioned. In (14), the predicate *PC* maps predicates *P* to conjunctive meanings, yielding the easily satisfied *or* if something in the discourse context satisfies *P*, but the more stringent conditions imposed by *and* otherwise. This definition has the additional advantage of retaining aspects of the meaning of the original, lifted predicate.

13. $[[ctop]] = \lambda C[S_{i-1}] : \langle\langle t, \langle t, t\rangle\rangle, t\rangle$
    Example: $[[ctop]]([[or]]) = \lambda C[S_{i-q}](\lambda p \lambda q[p + q \geq 1]) = S_{i-1}$
14. $[[predcon]] =$
    $\lambda P[PC(P)] : \langle\langle e, t\rangle, \langle t, \langle t, t\rangle\rangle\rangle$, where $PC(P) =_{def} \begin{cases} \lambda p \lambda q[p + q \geq 1] \text{ if } \exists x \in C[P(x)] \\ \lambda p \lambda q[p = q = 1] \text{ else} \end{cases}$
    Example: $[[predcon]]([[vitamin]]) = \lambda P[PC(P)](\lambda x[vitamin(x)]) = PC(\lambda x[vitamin(x)])$

5. This transformation is by way of a proof of concept. A more contentful version might relativize the proposition to a source or to a judge parameter.

Now only the quantifier case remains. For the 'raising' case, the question is what quantificational force should be assigned. We define two distinct mappings here and allow them to be selected by context: this strategy is similar to the use of indexicals above. Other interpretations are of course possible. The 'lowering' case (16) picks out sets in which the quantifier properly applies to that set and some additional predicate, where both are available in the discourse context: this condition is not difficult to satisfy and thus is often also a place where pragmatic uncertainty enters the picture.

15. Predicate to quantifier.
    1. $[[predall]] = \lambda P'\lambda P\lambda Q[\forall x[P(x) \wedge P'(x) \rightarrow Q(x)] : \langle\langle e, t\rangle, \langle\langle e, t\rangle,\langle\langle e, t\rangle, t\rangle\rangle\rangle$
       Example: $[[predall]]([[blue]])= \lambda P'\lambda P\lambda Q[\forall x[P(x)\wedge P'(x) \rightarrow Q(x)](\lambda x[blue(x)]) = \lambda P\lambda Q[\forall x[P(x) \wedge blue(x) \rightarrow Q(x)]$
    2. $[[predsome]] = \lambda P'\lambda P\lambda Q[\exists x[P(x) \wedge P'(x) \wedge Q(x)] : \langle\langle e, t\rangle, \langle\langle e, t\rangle, \langle\langle e, t\rangle, t\rangle\rangle\rangle$
       Example: $[[predsome]]([[blue]])= \lambda P'\lambda P\lambda Q[\exists x[P(x)\wedge P'(x)\wedge Q(x)](\lambda x[blue(x)]) = \lambda P\lambda Q[\exists x[P(x) \wedge blue(x) \wedge Q(x)]$
16. $[[quantpred]]= \lambda Q\lambda x[P(x)]$ s.t. $\exists Q \in CQ(P)(Q)] \wedge P \in C : \langle\langle\langle e, t\rangle, \langle\langle e, t\rangle, t\rangle\rangle, \langle e, t\rangle\rangle$
    Example: $[[quantpred]]([[every]])= \lambda Q\lambda x[P(x)](\lambda P\lambda Q\forall x[P(x) \rightarrow Q(x)] = \lambda x[P(x)]$ for P s.t. $\forall y[P(y) \rightarrow Q(y)]$

With this, a system is in place to interpret any substitution of textual elements. Its overall form is shown in Figure 2. As is clear from the diagram, the type $\langle e, t\rangle$ is central to the system, but there is a path from any available type to every other, though it is sometimes circuitous.

The next sections show how it applies to the systematic replacement of terms in a particular text and situate the system in a larger artistic project involving notions of translation and constraint.

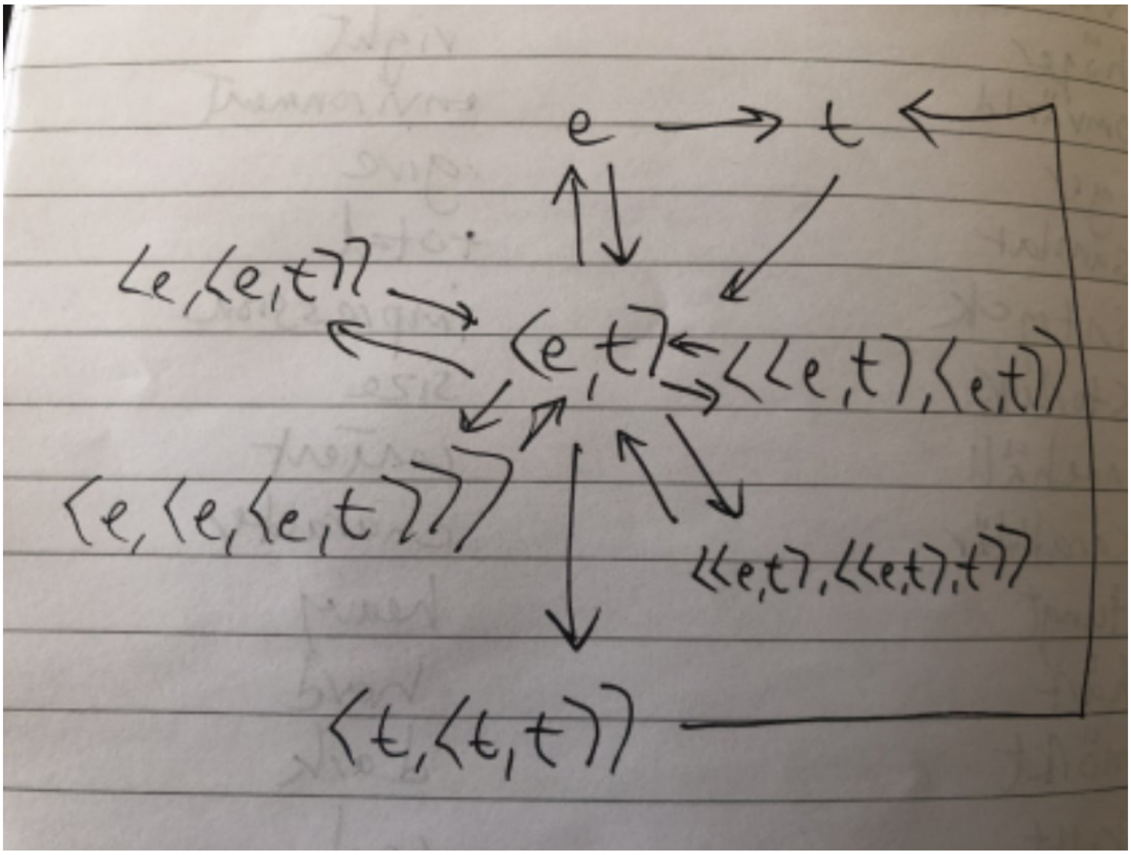


Fig. 2. Overall form of the type-shifting system for universal interpretation.

4. Realization

Let us now see how this system applies to a particular text. §3.1 indicates the text to be transformed, and the following two subsections show how the transformations work and their results. Along the way we also see the way in which the system produces choice points in the production of a semantic representation which give the reader agency in the interpretative process.

4.1 Source

The active reading method proposed here, consisting of textual substitutions and interpositioning, will be carried out twice on the following source text.[6] The method will first be applied in such a way that only items of similar type are substituted for one another. In the second iteration, the substitutions will be freer, yielding a wilder new text. In the final case, logical representations of some sentences of the text will be provided: no such representations are given for the other texts, since only in the third text will the need to introduce methods to interpret text completely freely arise. As we will see, this results in meanings as wild as the form of the new text itself.

6. This text was taken from https://en.wikipedia.org/wiki/Sailing_stones (April 20, 2020).

The first documented account of the sliding rock phenomenon dates to 1915, when a prospector named Joseph Crook from Fallon, Nevada, visited the Racetrack Playa site. In the following years, the Racetrack sparked interest from geologists Jim McAllister and Allen Agnew, who mapped the bedrock of the area in 1948 and published the earliest report about the sliding rocks in a Geologic Society of America Bulletin. Their publication gave a brief description of the playa furrows and scrapers, stating that no exact measurements had been taken and suggesting that furrows were the remnants of scrapers propelled by strong gusts of wind – such as the variable winds that produce dust-devils – over a muddy playa floor. Controversy over the origin of the furrows prompted the search for the occurrence of similar phenomena at other locations. Such a location was found at Little Bonnie Claire Playa in Nye County, Nevada, and the phenomenon was studied there, as well.

4.2 Transformation

A first transformation of the text is reproduced in this section. We have here applied three operations in limited number: these are listed below. We restrict the use of these transformations to ones which do not affect the syntactic or semantic structure of the text substantially, which in essence amounts to substitutions within similar syntactic categories. As we will see, this drastically limits the sort of substitutions that can be carried out, and the degree to which changes in the text are possible.

1. Intersubstitution of words within the text (limit: 5 substitutions). Two points: when substitution requires changes in grammar – pluralization, agreement, etc. – the needed changes are also made; substitution can apply to multiple forms of the same root (e.g. *published, publication*).
2. Deletion of words (limit: 2 deletions). Again, grammatical changes are allowed.
3. Systematic and deliberate mis-resolution of ambiguous words together with restatement into unambiguous forms.

The specific alterations made here are as follows; in the text itself, substitutions and deletions made are indicated with boldface.

1. Substitutions:
   (a) phenomenon ⟷ wind
   (b) crook ⟷ prospector
   (c) area ⟷ origin

(d) play ⟷ slide
(e) America ⟷ Fallon

2. Deletions:
(a) Nevada
(b) rock

3. Misinterpretations:
(a) playa: The intended meaning is the Spanish *playa* 'beach', but we reinterpret as the English term and spell it out as 'player'.

The first documented account of the **playing**___ **wind** dates to 1915, when a **crook** named Joseph **Prospector** from **America** visited the Racetrack **Slider** site. In the following years, the Racetrack sparked interest from geologists Jim McAllister and Allen Agnew, who mapped the bed___ of the **origin** in 1948 and published the earliest report about the **playing**___ in a Geologic Society of **Fallon** Bulletin. Their publication gave a brief description of the **slider** furrows and scrapers, stating that no exact measurements had been taken and suggesting that furrows were the remnants of scrapers propelled by strong gusts of **phenomena** – such as the variable **phenomena** that produce dust-devils – over a muddy **slider** floor. Controversy over the **area** of the furrows prompted the search for the occurrence of similar **winds** at other locations. Such a location was found at Little Bonnie Claire **Slider** in Nye County and the **wind** was studied there, as well.

The sense of the text has changed substantially, not just in that it is no longer about sailing stones but rather about some sort of wind, but also in location: the setting is no longer the USA, but somewhere else. It is a bit harder to make sense of than the original and some of it looks silly, but the changes are not extremely substantial. This is to be expected given the limitations imposed above, namely that we required ourselves to respect the normal syntax and semantics of English; and, indeed, the sentences comprising the resulting text can easily be interpreted using standard compositional methods (Heim and Kratzer, 1998) augmented with mechanisms for parenthetical expressions (e.g. Potts 2005). The entire text itself is also easily modeled in a dynamic setting for text interpretation (Groenendijk and Stokhof, 1991; Muskens et al., 1997). Thus, for this less ambitious version of a substitutional project, the sort of rules introduced in section 2 aren't required; but the result is not as deep or interesting as one might hope for given the possibility of universal substitution. We thus see that this simple style of substitution is open to the same critique I leveled against the N+7 transformation above: excessive conservatism.

4.3 Retransformation

We now take the already altered text from the previous section and apply further transformations to it. The types of transformations and the number which we are allowed to apply remain constant, but this time we impose no constraint on respecting standard syntactic or semantic structures, or type identity of the substituted elements. Again, some grammatical smoothing will be carried out when tweaking the text makes the morphology odd, e.g. for pluralization and agreement; but, given the setting, we will not make alterations in category. The result will be a text that is much wilder than the first transformed version. The specific alterations made are as follows; in the text, they are italicized (the boldface from the previous transformations also remains).

1. Substitutions:
   (a) 1915 $\longleftrightarrow$ geologic
   (b) muddy $\longleftrightarrow$ no
   (c) a $\longleftrightarrow$ variable
   (d) Allen $\longleftrightarrow$ taken
   (e) and $\longleftrightarrow$ furrow

2. Deletions:
   (a) exact
   (b) measurements

3. Misinterpretations:
   (a) variable: in the original text, the intended sense is *varying/ changeable*, but we will interpret it as in *mathematical variable*, and so as a nominal of type <*e, t*>.

The first documented account of the **playing** ___ **wind** dates to *geologic*, when *variable* **crook** named Joseph **Prospector** from **America** visited the Racetrack **Slider** site. In the following years, the Racetrack sparked interest from geologists Jim McAllister *furrow taken* Agnew, who mapped the bed___ of the origin in 1948 *furrow* published the earliest report about the **playing**___ in *variable 1915* Society of **Fallon** Bulletin. Their publication gave variable brief description of the **slider** ands *furrow* scrapers, stating that *muddy* ___ ___ had been *Allen furrow* suggesting that *ands* were the remnants of scrapers propelled by strong gusts of **phenomena** – such as the *a* **phenomena** that produce dust-devils – over *variable* no **slider** floor. Controversy over the **area** of the *ands* prompted the search for the occurrence of similar **winds** at other locations. Such *variable* location was found at Little Bonnie Claire **Slider** in Nye County *furrow* the wind was studied there, as well.

This text is very different from the original, and it is quite hard to interpret. But, with the machinery of section 2, an interpretation can be assigned, even to those cases where the structure is very messy. We show this by providing logical forms for several sentences (or clauses) in this variation of the source text. For composition, we assume the following: (i) composition of elements occurs via either functional application or the predicate modification of Heim and Kratzer (1998); (ii) when substituting terms, the sense is substituted but (crucially) the type of the leaf of the tree remains constant, so composition requires shifting each lexical term into the semantic type appropriate for the position (meaning, for instance, that because *variable* was substituted for *a*, the semantic type of *variable* in all positions where it now appears is that of a generalized quantifier); (iii) only in cases of deletion can syntactic reanalysis occur, meaning that only there do we end up with new trees and thus possibly unchanged semantic types for the elements to be composed. All of these decisions are of course changeable, and are made here mainly for the purpose of illustrating the aesthetic of the formal system. In practice, as with other kinds of reading (active and passive), the reader will be free to choose their own interpretation.

To illustrate how things go, we will give interpretations for two (simplified) sentences from the new text. The main point of this is to show how the system is able to derive meanings for expressions that are misplaced from a type-theoretic perspective – particularly expressions which move strongly across categories, like the shift from nominal to determiner – and how reanalysis resulting from deletion can yield new interpretations. The sentences have been chosen to this end.

The first sentence is (17), one of the simpler sentences in the text but one that exhibits several of the phenomena of interest to us here. The substitution of *variable* for *a* means that *variable* must be given a generalized quantifier type, and the substitution of *furrow* for and means that *furrow* here must be interpreted as a (logical) connective. Applying the rules for these operations – (15) in the first case, and (14) in the second – gives the meanings in (18) and (19) for these terms. Each of these cases has a special feature: in the case of $[[\mathit{variable}_{gq}]]$, universal and existential meanings were both available, but we have allowed context to select the existential meaning, and for $[[\mathit{furrow}_{con}]]$, a strong conjunction was chosen because the discourse context failed to make available any object satisfying *furrow* in its literal sense. The meaning of (17) is then given in (20); this is of course absurd and impossible to satisfy in any model which closely corresponds to the structure of our world, since no location is also a mathematical variable here.

17. Variable location was found at Little Bonnie Claire Slider furrow the wind was studied. (S5)
18. $[[\mathit{variable}_{gq}]] = \lambda P \lambda Q[\exists x[P(x) \wedge \mathit{variable}(x) \wedge Q(x)]$
19. $[[\mathit{furrow}_{con}]] = \lambda p \lambda q[p = q = 1]$

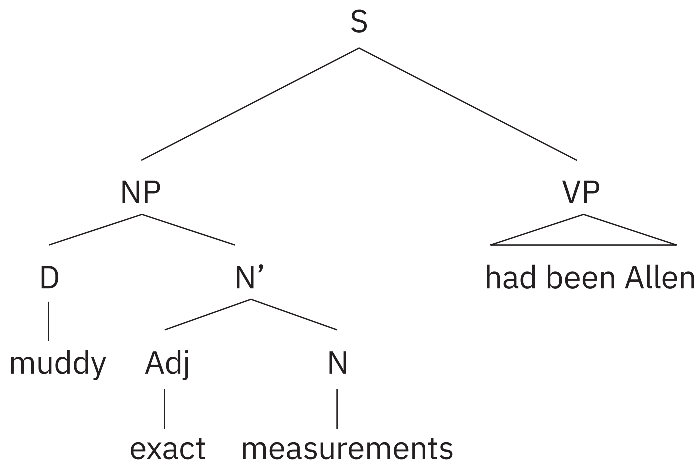
20. $\exists x[location(x) \wedge variable(x) \wedge found\_at(x, lbcs) \wedge \iota x[wind(y) \wedge studied(y)]]$
'There is a location which is a mathematical variable and is found at Little Bonnie Claire Slider and the wind was studied.'

Turning to (21), several new and interesting issues arise: the nominal interpretation of *and*, the predicative interpretations of *Allen* and of *no*, and, most interestingly perhaps, what to do with *muddy*, which has been left in a mysterious situation, lying in a determiner position but which fails to form a constituent with any other lexical terms due to the deletion of the words following it. The first three issues are easily addressed in the same way as just seen for (17), with the sole caveat that interpreting *and* as a nominal requires chaining of two rules: first (13), which alters the connective meaning to a simple truth-value 0 which can then be shifted to an <*e, t*> type by (11). We arrive at truth-value 0 because (13) instructs us to take the truth-value for the previous sentence, but, just as we saw immediately above, the use of *furrow* as a connective means that the connective has the semantics of *and*, which means that if any of the conjoined sentences is false, the whole sentence is, and the use of generalized quantifier *variable* in the place of publication – *variable 1915 Society of Fallon Bulletin* – means falsehood for this sentence, for nothing is both a bulletin and a mathematical variable, just as in the previous example. For the case of *no*, we require two predicates from the discourse context such that there is no overlap in their denotations: many such are available, but selecting [[*wind*]] and [[*geologist*]] works, and causes $[[no_{pred}]]= [[wind]]$ (or [[*geologist*]], but we have selected [[*wind*]] here). The results of all this are given in (22), (23), and (24).

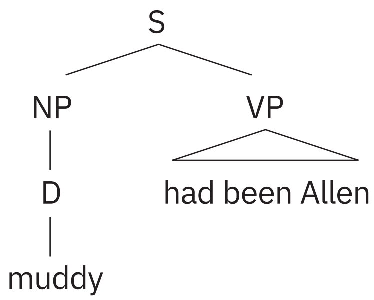
21. Their publication gave variable brief description of the slider ands furrow scrapers, stating that muddy had been Allen furrow ands were the remnants of scrapers propelled over variable no slider floor. (S3)
22. $[[and_{nom}]]= \lambda x[0]$
23. $[[allen_{pred}]]= \lambda x[named(allen, x)]$
24. $[[no_{pred}]]= \lambda x[wind(x)]$

The situation with *muddy* is more complicated and requires having a look at the syntax. The clause we must consider is the complement of *stating*, namely *muddy had been Allen*, which before deletion of 'exact measurements' had the following structure:[7]

7. This syntax is primitive, and syntacticians might find it shocking (especially how labeling works after deletion takes place), but we need not be too concerned about it because our aim here is only to characterize how semantic composition takes place in this kind of example.



After deletion takes place, the structure is as follows, assuming that categories remain constant and no covert elements are present (consonant with true deletion):



So in this situation, *muddy* should be given the type of a generalized quantifier as it is in a D position. This is straightforward using (15), yielding (25), in which the quantifier is given a universal interpretation.

25. $[[muddy_{gq}]] = \lambda P \lambda Q[\forall x[P(x) \wedge muddy(x) \rightarrow Q(x)]$

But this won’t give a proper denotation for the sentential complement, as its own complement is of type <*e, t*>: the output of composition will be type <<*e, t*>, *t*>, which will fail to be sensible. Here, then, we need to do a more standard kind of linguistic type-shifting, and massage the type of $[[muddy_{gq}]]$ into something suitable for composition with its complement in such a way that it yields a type *t* object. Fortunately, such an operation is already available. We need only map the generalized quantifier into a predicate and further lower that to something of type *e*. This mapping is carried out in two steps according to (16) and (4). In the first step, (16) applies to (25), which is a universal quantifier which qualifies its first argument with the predication *muddy*; since nothing in the discourse context is both (known to be) muddy and anything else, the antecedent is trivially satisfied and we can pick any predicate from the discourse context for the output. We choose [[*crook*]]; this is then mapped to an individual by (4), ultimately yielding (26).

26. $[[\mathit{muddy}_e]] = \iota x[\mathit{crook}(x)]$

With all this in hand, (21) can be given the semantic interpretation in (27). This interpretation is one that the reader would likely not arrive at without the aid of the semantic framework, and the unexpected ways in which the rules interact, as seen for instance with *muddy*, which would never have been interpreted as the property [[*crook*]] without the interaction of the rules which derived it: (25), (16) and (4).

27. $\exists x \exists y[\mathit{publication}(x) \wedge \mathit{made}(y, x) \wedge \exists z[\mathit{brie\ f}(z) \wedge \mathit{part}(z, x)$
$\wedge\ \mathit{desc}(z, \iota x' \forall y'[y' \subseteq x' \rightarrow \lambda y[0](x') \wedge \mathit{slider}(y) \vee \mathit{scraper}(y')])$
$\wedge \mathit{variable}(z) \wedge \mathit{state}(z, \iota z'[\mathit{crook}(z') \wedge \mathit{named}(\mathit{allen}, z')] \wedge \iota x''[\lambda z[0]$
$(x'') \wedge \mathit{scraper\ remnant}(x'') \wedge \exists y''[\mathit{variable}(y'') \wedge \mathit{wind}(y'')$
$\wedge \mathit{slider}(y'') \wedge \mathit{floor}(y'') \wedge \mathit{propelled\_over}(x'', y'')]])]]$
'There is a publication they made which contains a description of something all parts of which are either false or sliders or scrapers, and which is a mathematical variable; it also states that there is a crook named Allen and the existence of other things which are false and also scraper remnants which are propelled over a floor which is a slider and wind and a mathematical variable.'

This is very odd; but it is also a kind of poetry, with a kind of beauty. This meaning itself can be restated in other ways, for instance in free verse as in Figure 3. This text is entirely unexpected from the perspective of the original. This is one way to realize the aesthetic of textual substitution, and one way to use mathematical tools and constraints to make the process simultaneously transparent and opaque.

5. Variation

The goal of this work was to set out a system for the universal interpretation of textual transformations and substitutions irrespective of syntactic/semantic category. A sample system was provided in §2. The examples in the last section showed the power of the system: it can result in unexpected and strange changes in textual meaning, and ones that may bring out the meaning of the kinds of texts that result from cross-categorial substitutions in a more interesting way than simply trying to make sense of then 'manually' as the type-shifters interact in potentially unanticipated ways. The project of text transformation/substitution is part of a larger practice of constructing translations/mappings between media: texts, mathematical structures, spacetime, concepts, physical objects (McCready, 2020). The present work shows one way this practice can be carried out, and one way formalization can contribute to it. It is also a first example of artistic work in which mathematics is the medium rather than merely a technique or a place to draw inspiration, in the sense that the system itself is to be understood as the object of artistic practice (though in this case the full interest of the practice arises in conjunction with texts and substitution).

Fig. 3. Free verse translation of (27).

words on a page
available
to all
describe a thing:
complex, multifaceted
all of it false
or a tool for
sliding or scraping and
jointly
a variable
x or y or z

these words
claim more, claim
a presence:
dishonest Allen
and more presences
false things
remnants
vestiges of scrapers
moved
by exterior force
across a complex plane
a floor a variable a slider
wind

The results of the substitutions can be made more wild by further modifying the type-shifters themselves. In this initial version, we have mostly just used the discourse context, pragmatics, and a kind of reader-based choice function (ie.: the interpreter can pick whatever predicate strikes them as appropriate, as we did with [[$muddy_e$]]) above), but more randomized options are available too. One could assign each word in the text a position in a table of numbers in the way we already did for discourse segments and truth values, and then randomly generate numbers which induce substitutions, using dice or computational means. This kind of randomization can be built into the type-shifters, which will produce quite different sorts of transformed texts than the ones above. We expect that further experimentation will produce highly different results. More broadly, the current system suggests a new palette for experimentation on texts via mathematical methods which has the potential to open up interesting new domains for artistic practice.

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Autolume-Live: Turning GANs into a Live VJing tool

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Creative Artificial Intelligence is increasingly used to generate static and animated visuals. While there are a host of systems to generate images, videos and music videos, there is a lack of real time video synthesizers for live music performances. To address this gap, we propose *Autolume-Live*, the first GAN-based live VJing-system for controllable video generation. By analysing the needs of VJs and current Deep Learning-based audio-visual systems, we developed a live video synthesiser that extracts musical features, such as the amplitude, pitch and onset strength, and allows mapping these to generate trajectories in the frame latent space. These frames can further be manipulated through a MIDI Interface which allows the user to improvise, manipulate the Neural Network and adjust the output to accompany live music performances in a co-creative way.

Keywords Creative AI, GAN, Video Generation, Interactive System, Audio-Visual, VJ

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1. Introduction

With an increasing amount of generative models in AI and Deep Learning (DL), artists are finding ways to use these systems for their creative expression. This is extensively seen in musical and visual practices. Creative agents can be used to co-create live coding musical performances (Wilson et al. 2021). Using Generative Adversarial Networks (GANs) (Goodfellow et al. 2014; Karras, Laine, and Aila 2018; Karras et al. 2020), both curated installations (Obvious 2018) and visual live installations (Klingemann 2019) have been created. With the rise of Creative AI, new ways to create experiences and channel creativity are emerging. One domain that is not influenced by Deep Learning so far is live audio-visual performances. For live musical performances, it is common to have a VJ use pre-recorded clips to create a responsive visual experience. We are interested in a way to combine VJing with GANs. We choose to use GANs over other generative models, such as Diffusion models, due to their high-fidelity, comparatively fast inference time and because they already have a large following of artists.

While there are audio-visual installations using GANs, they are bound to offline creation. Artists have used Style-transfer, Deep Dream and other frameworks to create music videos by manipulating pre-recorded videos (Hardcore-analhydrogen 2018). There are artistic works extracting music features from a track and mapping it to the latent space of a GAN (Siegelman 2019; Klingemann 2018; Jonathan 2021.; Alafriz 2021; Steenbrugge 2020). But all these systems either lack documentation or a user interface, which makes the systems inaccessible for new users. Furthermore, none of these systems tackle live video generation. To bridge the gap from automated offline systems to a realtime VJing Software we propose *Autolume-Live*, to our knowledge the first live Music Visualiser and VJing software based on GANs (Goodfellow et al. 2014; Karras, Laine, and Aila 2018; Karras et al. 2020). The program explores the latent space of trained models and drives the image generation through music. The algorithm uses audio features, such as amplitude, onset timing and pitches to influence the images generated by the model. Additionally, we incorporate a MIDI-controller as an interactive tool to allow artists to edit and manipulate the generation process using Network Bending (Broad, Leymarie, and Grierson 2021) and GANSpace (Härkönen et al. 2020). We show that with modern graphic cards and developments in generative models, interpretable AI and compression techniques, it is possible to create an interface that allows artists to accompany their live music performances with adjustable visuals.

We first discuss different types of visual systems and showcase offline approaches using Deep Learning in Section 2. We focus on offline approaches, as there has been no research in the domain of Deep Learning based live audio-driven visual generation. We present *Autolume-Live* in Section 3, describing its different modules and the VJing interface that we implemented while focussing on the characteristic of VJing tools introduced by Hook et al. (Hook et al. 2011). In addition to the system, we have also created two installations using *Autolume-Live*. We briefly outline the process behind these pieces in section 4. Lastly, we discuss the possible changes and iterations that could be made on our system to improve the usability and the expressiveness of the tool (Section 5).

2. Background

2.1 Audio-reactive Visual Systems

Before discussing our framework, we first have to understand the different types of real time audio-driven visual software. First, there are *Music Visualisers*, which map musical feature data to parameters of a visual system. While Taylor et al. synthesise a complex scene with virtual characters and spaces that respond to audio features (2006), commonly music is visualised by showing the live spectrogram in different formats. Secondly, *Video Synthesisers* relate to the mapping of any signal to control visual generation. Most *Music Visualisers* and *Video Synthesisers* can be used offline and online. A specific application of these systems for live performance is *VJing software*. These generally combine the audio-reactive components of *Music Visualisers* and *Video Synthesisers* and add an interactive component that allows an artist to manipulate media live. By applying visual transformations or adjusting mappings, every performance can become a unique experience based on the performer, aka Visual Jockey (VJ). In their study, Hook et al. explore the ways VJs adapt and appropriate technology to create visual performances through dialogue and the creation of a documentary film (2011). They focussed on multiple artists and performances and extracted the essence of the medium for those artists. When it comes to VJing tools, there is a need for a physical, tangible, interface that responds with immediacy, and allows the user to accompany music live and improvise. The tool should allow the artist to control a variety of parameters, while keeping usability in mind. The benefit of a physical interface, such as a VJ controller, is that it can be seen as another instrument that can be incorporated into a performance.. Lastly, the visuals should be responsive to its context and surrounding, e.g. the music, and every performance should have the possibility to be unique.

TouchDesigner and Resolume are popular VJing software (Resolume 2022; Derivative 2022). By looking at current VJing practices, we see a trend to use video loops, shaders and generative algorithms. These softwares incorporate multiple levels of music analysis. Both low level features such as amplitude, onset strength, timbre etc., and high level features, for example affective features computed through sentiment analysis, can be used to modify parameters, such as colour, shape and position. When it comes to VJing, response time is important. Hence, TouchDesigner and Resolume focus on systems that are efficient and can process information with little latency. For that reason these VJs have not used GANs and other DL based generative models, and to our knowledge, these approaches have not seen any use in any live performances.

2.2 Offline Audio-Reactive Systems

Our goal is to implement a Deep Learning based VJing tool. When it comes to creating music videos using AI it is either possible to do frame synthesis, i.e. generating every frame from scratch, or create collages, stitching together videos to fit the music (Fan et al. 2016). Our system is based on frame-by-frame (FBF) generation, hence we will be focussing on these music-driven video models.

By moving away from live visualisation, FBF approaches can do further audio feature extraction and can use more complex generative algorithms. For example, it is possible to use GANs to generate the visuals and use the audio features to manipulate the image output, without worrying about the runtime. The current literature comprises three different ways to generate audio-reactive videos using GANs: *Latent Space Traversal, Latent Space Interpolation, Chroma-Based Interpolation* (Brouwer 2020; Siegelman 2019; Alafriz 2021). Additionally, these offline frameworks describe further manipulations that can be performed on the video feed.

GANs use vectors sampled from a latent space to generate images. Vectors that are close together in said space are mapped to visually similar images. By moving around in the latent space it is possible to generate smooth videos interpolating between different key-frames. Researchers and artists have used this quality of GANs to create videos showcasing images morphing from one into another. The three mentioned offline audio-reactive systems use the topology of the latent space in different ways.

Fig. 1. Example generated with *Deep Music Visualiser* (Siegelman 2022). (https://www.youtube.com/watch?v=L7R-yBZ5QYc).

One way of mapping audio to video through movement in the latent space is based on a random walk. We call this approach *Latent Space Traversal* (Fig. 1) and a version of it was used in Deep Music Visualiser (DMV) (Siegelman 2022). In this case, the amplitude of the spectrogram and the shift in amplitudes between time steps are used to vary the step size of the random walk. This approach of audio-reactive image generation has the benefit that it can respond to music without any harmonic, percussive separation, but it is unable to capture repetition which is a common quality of music. As the model moves into random directions at every timestep it is unable to return previous points based on the audio. Furthermore, this approach lacks a variety of parameters, since only the audio features and a multiplier to the step-size are used.

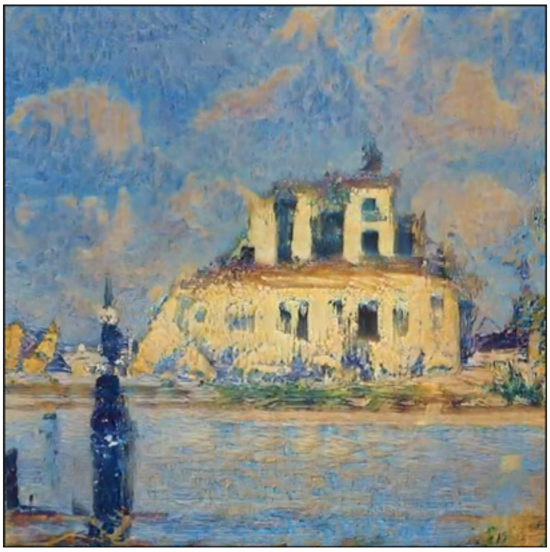

Fig. 2. Example generated with *Lucid Sonic Dreams* (Alafriz 2022). (https://www.youtube.com/watch?v=l-nGC-ve7sI).

Another way of navigating the latent space is Latent Space Interpolation, i.e. interpolating between preset positions in the latent space. While the previous *Latent Space Traversal* was unable to capture repetition, *Latent Space Interpolations* allow creating loops. Lucid Sonic Dream (LSD) (Alafriz 2022) is a system that uses this approach, similar to DMV the amplitude and shift in amplitudes are mapped to the speed of the interpolation. While looping is one of the strengths of *Latent Space Interpolations* this does create a repetitive experience. To circumvent this problem, LSD uses a combination of both *Latent Space Interpolations* and random walks. The harmonic and percussive tracks are separated. While the harmonic track is used to modulate the speed of the loops, the percussive track is used to introduce a momentary "pulse". This "pulse" is created by performing a random step as seen in the Deep Music Visualiser for one time step and then returning to interpolating to the next latent vector. An example of a video generated by LSD is shown in Figure 2.

Fig. 3. Example *Chroma-Based Interpolation* as implemented by Brouwer (Brouwer 2020). (https://wavefunk.xyz/assets/audio-reactive-stylegan/rhodes.mp4).

Lastly, there is *Chroma-Based Interpolation*, showcased in Figure 3. Instead of using the amplitude of the audio signal, the pitches are calculated through a chromagram and mapped to the visuals. A chromagram is computed by clustering a spectrogram into frequency bins for every pitch (Ezzaidi et al. 2012; Ellis 2007). In western music theory, normally 12 bins are used. In LSD and DMV, conditional GANs can be used, where a class vector is appended to the input to define the content of the synthesised image (Oeldorf and Spanakis 2019; Mirza and Osindero 2014). It is then possible to use a chromagram to influence the content of the video, i.e. every pitch is linked to a different content class. A different approach to incorporate pitch is to map every pitch to a key-frame (Brouwer 2020). The resulting video consists of interpolations between keyframes based on the pitches present in the music. For example, if the note C is mapped to a blue frame and the note D to a red frame. At every point in the music where the letter C is played on its own the video would show the blue frame, but if multiple notes are played the two keyframes are interpolated, i.e. if we play C and D together a purple frame will be shown. The mixing ratio between keyframes is the amplitude of the responding pitches. While this approach implicitly captures repetition through the pitch, it is not able to represent atonal or monotonous musical. Without any pitch changes, the mapping will create a static video.

In addition to using short-term features, amplitude and pitch, Brouwer incorporates long-term musical features to visualise long-term musical structures in the music. By applying Laplacian-Segmentation (McFee and Ellis 2014) on the audio track, the song is clustered into sections and different sets of latent vectors are used for the distinct parts in the music (Brouwer 2020).

3. Autolume-Live

We are interested in creating a live visual engine that can be controlled by discrete triggers and continuous controls. In particular, we focus on creating a VJing-tool that uses both audio and a controller as its input. As shown in Figure 4, our system uses an Audio Module to extract onset strength, amplitude and pitch and maps these either to the latent space W or the noise term that is added to every layer. The Controller Module processes the interactions with the MIDI-Controller, applying affine transformations to the Synthesis Modules layers or manipulating the latent space (Fig. 4.). Our system runs live to make it possible for the user to immediately see the results of their interaction. This opens the door to live improvisations and a feedback loop where the output of *Autolume-Live* impacts the user's creative vision.

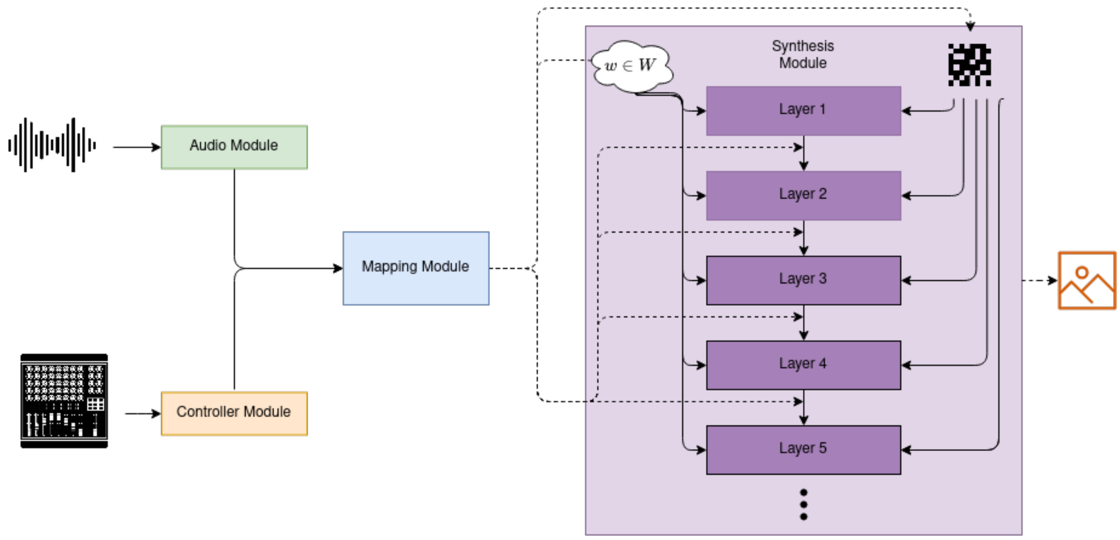

Fig. 4. *Autolume-Lives* framework showing how we mapped audio and controller signals into manipulations for the Synthesis Module.

3.1 Frame Synthesis Module

3.1.1 StyleGAN2-ada

Autolume-Live is using StyleGAN2(-ada) to generate an image at every timestep (Karras et al. 2020). StyleGan2 is an adaptation of GAN which uses a Discriminator to train a generative model by learning a boundary between real and generated samples. The training of these two models results in a two-player mini-max game. The Generator is trying to minimise the likelihood of the Discriminator correctly classifying its output as generatd. The Discriminator tries to maximise the probability of it correctly classifying a sample as real or generated.

We choose to use NVIDIA's StyleGAN2 framework for its high quality generative power. In particular we use StyleGAN2-ada to train our model. The generator stays the same, but to reduce the amount of necessary data further augmentations are introduced in the Discriminator training process. The dataset size is important in the context of VJing, because our objective is to create a system that is usable by artists, who do not have access to large datasets or want to use their creations as training data. Furthermore, StyleGAN2(-ada) is already widely used by artists meaning they could plug in their already trained models and also use services, such as Runway ML (Runway 2022) to train their models without ever having to touch any code. Nevertheless, other generative image models could be used instead and in our framework, the model architecture is a module that can be exchanged in future iterations according to newer research.

StyleGAN2(-ada)'s Generator model can be divided into a *Mapping Network* and a *Synthesis Network*. The Mapping Network disentangles the latent space. It maps a normally distributed latent Vector z to an intermediate latent space W. By introducing an intermediate *Mapping Network*, the latent space is disentangled, this means that moving around in that space returns more predictable outcomes and smoother transitions. The *Synthesis Network* uses the mapped latent vector $w \in W$ to generate an image. It incorporates an additional noise term at every resolution level. The latent vector dictates the content of the generated image, while the noise term adds variation to the output. Furthermore, the lower levels of the Synthesis Network generate the coarse structure of the image while the higher levels add fine details and textures. When generating videos with StyleGAN2, we realised that sampling noise at every time step creates jittering between frames. Because of the jitter, there is constant change in the visuals, which sometimes distracts from the audio-reactive nature of the algorithm. Hence, we decide to sample a single noise term on startup and reuse it throughout the video.

3.1.2 Content-Aware GAN Compression to Reach Real Time Generation

Immediacy and responsiveness are important factors of any VJing-system. VJing-Softwares recommend a delay below 50-milliseconds that is reaction within a frame at 20 FPS or optimally for the delay to be unperceivable by the human eye under 20-milliseconds which corresponds to 60FPS. Since our audio and visual modules are linked together, it is important that the combination of audio feature extraction and image generation stays below this threshold. In our tests, using the standard styleGAN2 architecture on an NVIDIA QUADRO 5000 with 16GB of VRAM the highest resolution we can generate, while keeping a framerate around 60FPS is 128128. Generating images in a higher resolution makes the framerate drop drastically, e.g. with a resolution of 256x256 we reach a framerate of 40FPS and with 512x512 the framerate drops to 24FPS. One way to increase the inference speed of a model is to compress it as a preprocessing step of system.

The process of network compression focuses on (1) reducing the number of parameters by pruning the model (Blalock et al. 2020; Huang et al. 2018; Han et al.

2015), and (2) distillation (Hinton, Vinyals, and Dean 2015), using the original model as a teacher for a smaller model. Where these ideas work well for classification tasks, they do not work on GANs. But, by introducing content-aware pruning and distillation Y. Liu et al. have shown that it is possible to compress StyleGAN2(-ada) and reduce the complexity of the network counted in the number of floating point operations (FLOPS) by a factor of 11 (Y. Liu et al. 2021). The idea of content-aware compression is that a content-parsing network is trained to find the features in the model which have the biggest impact on the visuals. During the pruning and distillation process this model masks the generated image of both the pruned and teacher model. Then the distillation loss is applied on the masked image generated by the teacher and the pruned model. This enforces that the salient objects in an image are distilled into the pruned model.

3.2 Audio Module

We expand the offline techniques described in section 2 to run live. To do so, we use a monophonic audio stream with a chunk size of 1024, a sampling rate of 44100 and compute the mel-spectrogram, chromagram (Ellis 2007), onset detection and strength locally. For both the spectrogram and the chromagram, we use a FFT window size of 2048. We compute the mel-spectrogram instead of a normal spectrogram, as it better represents the perceived amplitude of the different frequencies by human ears. For efficiency we detect onsets and compute their strengths by approximating a threshold to track onsets with a moving Root Mean Square over the last second.

We originally computed the harmonic percussive decomposition (Driedger, Müller, and Disch 01 2014), but due to the small active window size and efficiency of the algorithm the quality of the decomposition did not justify the drop in framerate. As *Autolume-Live* takes a live signal as its input, the analysis is noisier than the previous offline approaches, which leads to flickering in the images. To reduce the noisiness and make the visuals respond smoother we compute the moving average over the last 3 steps of the audio signal before extracting audio features.

3.3 Controller Module

Autolume-Live is meant as an expressive interactive tool to accompany live audio performances. Jonathan Hook et al. explore the needs of VJs through an in depth qualitative study (Hook et al. 2011). They show the need for a physical interface that can be used for performances, i.e. an interactive system that is visible to the audience and a tool that gives haptic feedback. This is why we chose to integrate a MIDI-Controller, which is a common tool for VJing, into our system. Through its buttons the controller allows the user to toggle binary interactions, while its faders are a useful tool for continuous manipulations. For our working system we use the Behringer BCF2000 controller which has eight faders, 16 buttons and 8 infinite knobs. An additional benefit of using a physical controller in comparison to a digital interface is the possibility of parallel interaction using multiple hands and fingers. This allows the user to adjust multiple parameters at the same time where a mouse would limit the intractability.

3.4 Mapping Module

We use the features we extract from the live audio feed and the input from the controller to drive the image generation. In the following, we describe the mappings we have implemented so far, but due to the modality of the system artists are able to use their own mappings for both the audio-reactive images and the interactions with the controller.

3.4.1 Audio Mapping

Autolume-Live is implementing *Chroma-Based Interpolations* (Fig. 5), *Latent Space Traversal* and *Latent Space Interpolation* (Fig. 6), which can be switched between on the fly. But, the system is written to be modular, where future iterations could allow the user to reconfigure the mappings to their liking. Additionally, we use the strength of the onset, i.e. the amplitude of the spectrogram when an onset was detected as a multiplier to the standard deviation of the noise that is injected in StyleGAN2(-ada). This creates a perceivable change in the image.

Fig. 5. Example of *Chroma-Based Interpolation* given a digital piano input to our system. (https://vimeo.com/670850243).

For both the chroma-agnostic *Latent Space Traversal* and *Interpolation* (Section 2.2.) approaches, we use the same audio mapping, only adjusting the directional vector to either be random or pointing to a specific seed. We normalise the directional vector, so that the step size before applying audio mappings is 1. The vector is then multiplied by both the average amplitude of the spectrogram at the current time step and the difference between the current average amplitude and the previous. This leads to bigger steps when the amplitude is high or the amplitude shifts drastically, hence the biggest step would occur when a high amplitude, loud sound, follows a low amplitude, e.g. silence.

Fig. 6. (left) Example *Latent Space Traversal* using *Autolume-Live* (https://vimeo.com/670850199). (right) Example of a *Latent Space Interpolation* using *Autolume* (https://vimeo.com/670858023).

3.4.2 Frame Manipulation

By understanding the generation process, it is also possible to manipulate it. By going astray from the linear generation process and playing with the network's activations, noise and latent vector injections, it is possible to edit images increasing how much the media is manipulable, also called Network Bending (Broad, Leymarie, and Grierson 2021; Bau et al. 2018). The most basic version of this consists in applying affine transformations to the models activation. By doing so, we can translate, rotate, and zoom in on the image. In addition to applying transformations to layers 'activations, it is also possible to fuse features of two images by injecting the latent vector resulting in one image for the first resolution levels and the latent vector for the other in the rest of the layers. This creates a fusion of both images, where the vector used for the lower levels decides the structure of the image and the second the colours and textures (Brouwer 2020). Lastly, StyleGAN2-ada has a truncation value, which decides the sampling space from the latent space. A low truncation value reduces the diversity of the visual content, while a truncation value greater than 1 results in more abstract, expanded visual space. We use all these techniques to give the artist the potential for affecting and controlling the performance (Hook et al. 2011) and adjust the visuals to better suit the audio performances.

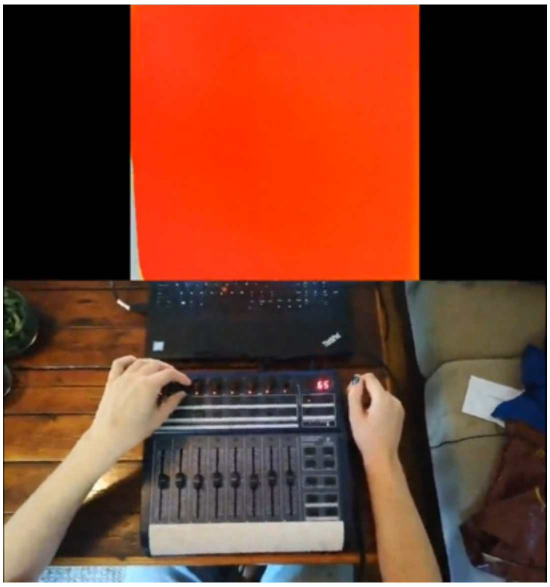

Fig. 7. Using the 8 knobs at the top of the MIDI-controller it is possible to apply Network Bending on the visuals generated by *Autolume-Live* (https://vimeo.com/670849859).

3.4.3 GANSpace

In addition to generating frames automatically, we want the user to be able to directly manipulate not just the rotation and positioning of the image, but the entire content . Although StyleGAN2(-ada) already disentangles the latent space, moving into random directions will not correspond to any semantics. We believe that this could interfere with how well the user can understand the interface. By finding semantically meaningful manipulations we improve the manipulability of the images, as the user can understand what the different directional manipulations mean. One way of finding directional vectors in the latent space that have interpretable meaning is *GANSpace (Härkönen et al. 2020).*

GANSpace identifies interpretable directions in the latent space using PCA. This method is lightweight and does not need any supervision (Shen et al. 2019). It finds the basis of the latent space in which the generated images have a high variance. We decided to use GANSpace as a preprocessing step instead of other approaches, because it has a low overhead, where other approaches introduce additional computational expenses during inference (Shen et al. 2019; Roich et al. 2021). GANSpace returns a list of vectors that can be plugged into a pretrained model without increasing inference time. Furthermore, this algorithm is model invariant, meaning that in future iterations the GAN architecture can be replaced and GANSpace could still be used to find interpretable manipulations on the images. In Figure 7 we showcase an example where the user can manipulate abstract images using the sliders of the VJ controller.

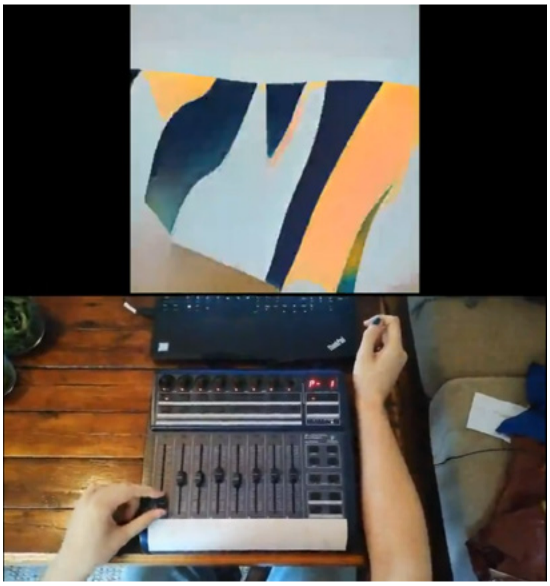

Fig. 8. Moving through the latent space using the faders of the MIDI-Controller. Every fader's values range between -1 and 1 weighting the first 8 directions found by GANSpace (https://vimeo.com/670850116).

3.4.4 Presets

It is normal for VJs to pre-record and save visuals that they want to use one or more times in a performance. Although we do not allow users to pre-record and save video clips, we allow the user to preset certain parameters of *Autolume-Live*. First of all, it is possible to predefine a set of latent vectors that are used by the *Latent Space Interpolation* and can be accessed during performances (Fig. 9). Then, it is also possible to predefine the content that can be generated. As *Autolume-Live* uses a StyleGAN2(-ada) Generator, the visuals that are generated are dependent on the data the model was trained on. Mostly these Generators synthesise images with only a few varying contents. Hence, to increase the visual variety, a set of models can be given to the software, all with their own predefined set of key-frames.

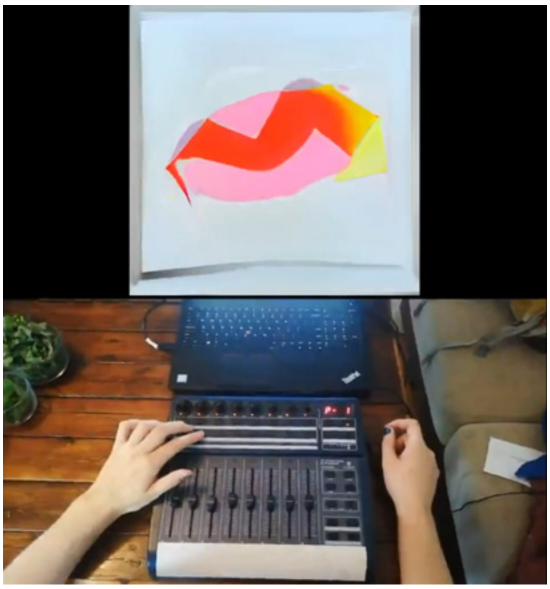

Fig. 9. Accessing key-frames using the Midi-Controller (https://vimeo.com/670850154).

3.4.5 VJ-Controller

We decide to link all these manipulations to a MIDI-Controller as this gives the user a visual representation of the current states and tangible feedback, which are both important interface features for VJs (Hook et al. 2011). The user can edit the current image according to salient directions, using the eight directional vectors we extracted with *GANSpace* to ever fader, where moving the fader up or down will set the coefficient for the weighted sum off all directional vectors that are added to the current latent vector. The knobs toggle further manipulations, i.e. rotation, translation, zoom and truncation value changes. By pressing the knobs the transformation is applied and the intensity can then be adjusted by turning the knob. Multiple transformations can be applied at the same time. We also linked the different audio-visual mappings to the controller. It is possible to switch between mappings pressing on one of the knobs. For both *Latent Space Interpolation* and *Latent Space Traversal* the same knob allows the user to add an additional multiplier to the step size, i.e. allows them to manipulate the sensitivity of the visuals reactions to the audio.

To access the different key-frames we use the array of buttons on the controller. On startup, every button is linked to a latent vector that can be predefined by the user or overwritten during the performance. These latent vectors are the positions the *Chroma-Based Interpolation* passes through. By pressing a button a position is loaded and the visualisation process proceeds from that key-frame. Furthermore, when multiple buttons are pressed at a time the average of all these seeds is used to create the visuals. Lastly, it is possible to iterate through the list of models by clicking the space bar of the computer that is running *Autolume-Live*.

4. Examples of Artworks made with Autolume-Live

Due to the 2020-2022 situation surrounding COVID-19, we were unable to use our system to accompany live performances. We have used different iterations of *Autolume-Live* to create two installations. We recorded some curated sessions and displayed them at the *Distopya sound art festival* in Istanbul 2021 (Dystopia Sound and Art Festival 2021) and *Light-Up Kelowna* 2022 (ARTSCO 2022). In both iterations, we let the audio mapping automatically generate the video without using any of the additional image manipulations. These installations show that the system on its own is already able to generate interesting and responsive visuals for a musical piece.

For the installation at the *Distopya sound art festival* we trained a StyleGAN2(-ada) model on abstract paintings and rendered a video using the described *Latent Space Traversal* mapping. For this particular piece we ran a super-resolution model on the final video as the original video output was in

512x512 and the wanted resolution was 4k. For our piece at *Light-Up Kelowna* we ran *Autolume-Live* with the *Latent Space Interpolation* mapping. The display included three urban screens, which allowed us to showcase three renders at the same time. We composed a video triptych using a dataset of figure drawings, a dataset of medical sketches and to tie the two videos together a model trained on a mixture of both datasets.

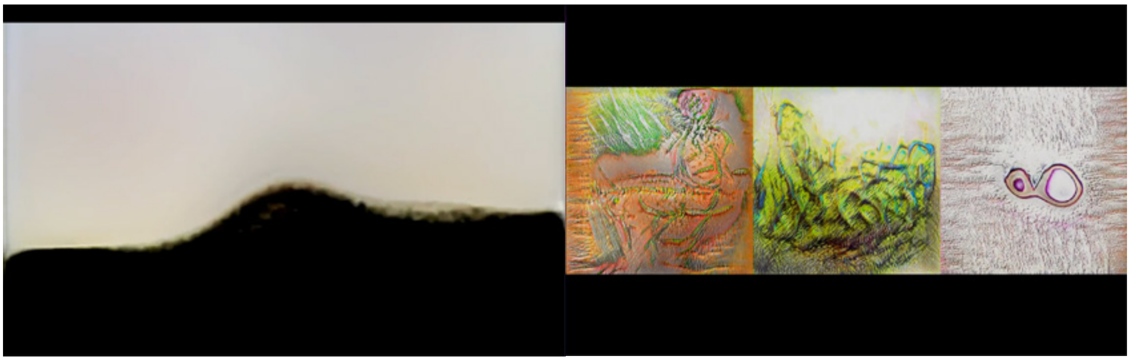

Fig. 10. Installations exhibited at *Distopya sound art festival* (left: https://vimeo.com/527564204) and *Light-Up Kelowna* (right: https://vault.sfu.ca/index.php/s/VBu760eFjNne1I6).

5. Future Work

Autolume-live is a prototype VJing tool using GANs. We are only using fundamental signal processing to extract audio features for the visualisation. This has already resulted in responsive visuals, but we hope that in the future these can be expanded on. Our Audio Module, we have coded in fundamental audio feature extractions and mapped them to features of the Synthesis Module. By replacing the Audio Module with a Neural Network it might be possible to connect its latent space to the GAN's latent spaces which could result in improving the expressiveness of the visuals. More high-level characteristics of the music could be extracted, such as the emotions and themes, which could then influence the content of the video. Especially text-to-image (Marinos Koutsomichalis 2021; Ramesh et al. 2021) and text-to-video (Wu et al. 2021) approaches could improve our framework. Text-to-image models could be used to more easily find latent vectors that the user wants to use in their performance. Instead of moving around the latent space using the sliders or doing prior work to find an image with certain features using CLIP based optimization, the user could simply describe the preset images they want to generate instead of using faders to move around the latent space (SOMNAI 2022; Murdock 2022).

In addition to richer audio-visual mappings, there are still improvements to be made to the system as a VJing tool through its Controller Module. An important aspect for VJs is the *interface reconfigurability*. Currently our system has a variety of transformations and editing possibilities linked to the MIDI-controller, but all these interactions are hard coded. In the future, we would want the user to be able to rearrange the MIDI-controller and also define their own transformations. Furthermore, the user should be able to freely define their own audio-visual mappings, creating a completely modular interface. For that it might be interesting to incorporate our system into a preexisting VJing software to build on their preexisting audio feature extraction and visual manipulation algorithms.

When it comes to generative models trained on data it is always important to discuss what was used to train the model. The datasets allow the user to define the content of the visual performance. At the moment there are three options to aggregating images with varying advantages and disadvantages. The first and easiest way is to use datasets that have already been curated. While this approach is the least time consuming it opens up questions of copyright and also takes away from the novelty of the resulting pieces. Secondly, it is possible to collate images from artists under open licenses. This process takes longer, as the dataset has to be manually selected, but it allows for more control on the content and the data can be unique for the installation without the need to create every image. Lastly, the most time consuming approach is to create every image for the dataset. This removes the problems of copyright and allows for complete control over the data used to train the model. In our installations we followed the second approach, collecting images and editing them to create a cohesive dataset. We believe that in the future exploring the data as an additional tool for creative expression allows for new collaborations. For our upcoming pieces, we are collaborating with artists to create never seen before corpora to create completely novel experiences.

Lastly, we have only been able to use the system for private rehearsals and curated exhibitions due to the lack of live music performances during the COVID-19 pandemic. Once live events are more common we plan on using *Autolume-Live* to accompany live music performances at festivals. We also plan on inviting VJs to use our tool for further additions and changes to the tool to better suit live performances.

6. Conclusion

We sought out to create a live system for audio-reactive image generation and composed a tool for live visual synthesiser. *Autolume-Live* fulfills the requirements posed in a previous qualitative study on the expressive interactions VJs look for in their interfaces. Where previous GAN based music visualisers can only be deployed offline, our system can accompany live performances following three different audio mapping styles. In addition to automated video generation, we expanded our system as a VJing tool, to better encompass live performances. We allow the user to improvise and manipulate the medium live using a MIDI-controller. By deploying *Network Bending* and *GANSpace* the user has control over the visual performance in a responsive and understandable manner. Furthermore the user can store and call upon checkpoints and switch between generative models on the fly allowing them to practice before performances and finetune the visual content to fit the current musical content.

While our system is able to accompany musical performances without user intervention, we believe that incorporating a MIDI-controller makes the system ascent in its usability. Increasing the intractability lets an artist collaborate and fine-tune the visual performance. With further advancements in making GANs more efficient and developments in explainable AI we believe that we will find new ways of manipulating the generation process, increasing the variety in the content that can be generated. By improving the inference time of GANs or incorporating different synthesis models, the tool will become more accessible to a wider range of users as currently a high performing GPU is needed to run the system in real time.

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On the Possibility of a Non-Anthropocentric Visuality

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This paper aims to understand if it is possible to speak of a non-anthropocentric visuality. The progressive and continuous increase of information production at a global level has led us to witness a specific set of visual information that, we argue, can be considered to be decentered from anthropocentric ocular optics. If we are in fact able to speak of a non-anthropocentric visuality, as this paper strongly suggests, this means that such concept is distinct from a non-human visuality, and that this scopic regime allows for other forms of sensing that extend beyond human sensory capacities. If we subscribe to this perspective, important consequences arise, specifically concerning the relation between visual information and governance. This analysis reinforces the need to further examine and carefully look at visual information produced outside of ocularcentrism, and its implications for the knowledge that supports itself on it.

Keywords Non-anthropocentric, visuality, non-ocularcentric, image, visual epistemology

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1. Introduction

Visual information structures are not only a subjective visual perception, but also a set of more complex networks, which stem and are organized according to the latter, in order to create information, systems of knowledge, and to actively manage human and natural resources.

However, a set of technological developments and processes of mediation related to the transmission of visual information raises several relevant questions. Taking into account the various actants who actively participate in the production of visual information today, are we able to speak of non-anthropocentric visuality? If so when? How can we define a non-anthropocentric visuality? Why is the concept of a non-anthropocentric visuality relevant and does this change our conception of visual information?

In order to answer these questions, this paper will adopt the following structure. In section 2 we will present our working concept of non-anthropocentric visuality. This section will contextualize the concept of non-anthropocentric, and the concept of visuality, relying directly on Nicholas Mirzoeff's work, which will set up the definition advanced by this paper. Section 3 will focus on the mediation processes underlying a possible non-anthropocentric visuality, and will seek to distinguish between the concepts of anthropocentric, non-anthropocentric and non-human visuality. In section 4 we try to identify in which cases we can refer to a non-anthropocentric visuality. In section 5 we answer the questions that were presented at the beginning of this paper and section 6 presents our conclusions.

The subject of this paper is quite wide in its scope, which we acknowledge. However, we believe that the issues raised here are crucial and contribute to a better understanding of future technological and visual developments, particularly if we take into consideration how visual regimes are fundamental in the constitution of governance policies, social and material organization, and in the production of knowledge. It is also important to mention that this paper follows the fundamental contributions made by the work of Nicholas Mirzoeff (2011) regarding the development of the concept of visuality and Benjamin Bratton (2016) regarding the conception of a global technological-computational network. These are the two aspects this paper will most fundamentally support itself on and try to work through.

Methodologically, this paper follows a qualitative approach and suggests that a non-anthropocentric visuality should motivate a critical consideration regarding the production of visual information, and that such a visuality can come to influence the way we deal with and interact with said information. This paper also suggests that a non-anthropocentric visuality should motivate critical consideration regarding the production of visual information, and that such a visuality can come to influence the way we deal with and interact with said information.

2. Defining a Non-Anthropocentric Visuality

The concept of non-anthropocentric has been extensively debated in the theoretical field over the last decade (Haraway 2016b; Iovino 2010; Latour 2005; Pschera 2016; Svoboda and Haqq-Misra 2018). Often framed within the field of environmental ethics and animal studies, interest in the concept of non-anthropocentric has, however, been expanding beyond these domains (cf. Braidotti 2019; Grusin 2015). Non-anthropocentrism, as well as the non-human, arises in many cases informed by the concept of Anthropocene which has defined the most recent developments within critical theory. Its ecological, political and social contours have often been discussed under the subcategorization of 'non-human turn' (Grusin 2015; Hoły-Łuczaj 2018).

The non-anthropocentric is often characterized as that which opposes an anthropocentric perspective and seeks to move away from a strictly human-focused framing. Non-anthropocentric thinking has underlined an inter- and intra-species link, deriving knowledge from multi-species communities, and bringing into focus how meaningful experiences and relevant information can be constructed from our experience "as sentient beings among a diverse array of other sentient beings" (Frie 2021, 35), while refusing the premise that human beings hold sovereignty over the rest of the world (Braidotti 2019; Hoły-Łuczaj 2018, 170). Throughout this paper the concept of non-anthropocentric will acknowledge this theoretical framework but will not be limited to it. Our use of non-anthropocentric will contemplate non-human agents (living and non-living), technological apparatus and computational processes.

Considering that the perspective advanced here regarding the concept of non-anthropocentric visuality is going to be distinct from the concept of anthropocentric visuality, we will first clarify what is our understanding of the latter. An anthropocentric visuality focuses on the human and is inherently associated with the ocular globe and with an ocularcentric visual domain. An anthropocentric visuality reproduces ocular conditions and is always dependent on a human positioning, scale and perspective (cf. Campos 2011, 18). It can be argued that the anthropocentric domain contributes to a particular optical phenomenology, through this optical preference, and through the devices and technologies that prolong and amplify the human eye (Branco 2013, 298-299). The human eye and the subsequent "omnipresence of optics" became "a source of discursive attraction" (Medeiros 2012, 24, 107), which started to associate vision and the ocular globe with reason and objectivity (Branco 2013; Id. 2022). This way, the mediation of the visual and its representation justified a connection with the idea of truthfulness, fundamental for the knowledge that was constructed out of visual information. As we will see below, there is, on the other hand, visual information that is not focused on the human and that does not seek to reproduce ocular conditions.

As Mirzoeff (2011) refers, visuality is a 19th century term that was first implemented by Thomas Carlyle that does not refer to the totality of images and visual devices, but to the visualization of history (3, 124). For the author, visuality is directly related with authority and harks back to the battlefield and the ability to visualize and strategize from it. By representing a visualization of history, this visuality imposes an authority and sovereignty of its own. Visualized power becomes an "epistemic apparatus" and generates a discourse that, more than vision, is about historical, social and cultural power (Ibid., 132). This visuality is characterized by a social and historical control that requires mastery over the visual, social, economic and topographical fields (Ibid., 295).

The framework from which Mirzoeff conceptualizes visuality and countervisuality is inherently postcolonial and decolonial. This theoretical perspective is fundamental for the systematization of an epistemological framework that contextualizes and systematizes the links of proximity between visuality, authority, law and sovereignty. Informed by Foucauldian thought, this framework defines visuality as "a technique for waging war appropriated as a means to justify authority as the imagining history" (Ibid., 277), and always has as its purpose the enforcement of violence and surveillance. From the plantation complex to the era of "visualized information war", visuality is always a condition of cultural domination, and socio-hierarchical division (Ibid., 57, 62, 295)

Mirzoeff's conceptualization of visuality is correlated with the "sovereign eye of the genius" (Ibid, 124). In this sense, this concept of visuality is always anthropocentric and ocularcentric, since all the devices that reinforce this visuality, like photography or surveillance cameras, reproduce human ocular conditions. But what happens when we consider the process of visualization of history beyond an anthropocentric perspective, integrating in this process the influence of agents which contribute, influence and condition the process of historical constitution and, therefore, epistemic production? If we consider visuality as the process of visualization of history, then history is also about the systems, artifacts and agents that allow for that same visualization and that reinterpret and re-signify it.

In this paper, non-anthropocentric visuality will be understood as a historical visualization that is both *decentered* from an *anthropocentric* position, scale and perspective, and from anthropocentric ocular optics. A non-anthropocentric visuality, in its genesis, does not seek to reproduce ocular conditions and does not focus exclusively on the human. A non-anthropocentric visuality moves out of a human perspective, allowing for a historical visualization structured by non-human actants. It is also important to note, as we will clarify below, that a non-anthropocentric visuality is distinct from a non-human visuality.

This paper does not argue in favor of a substitution or superimposition of a non-anthropocentric visuality to the detriment of an anthropocentric visuality, or in relation to an ocularcentrism. It simply identifies and systematizes a set of developments, which could constitute what could be considered a parallel visuality – sometimes even convergent – with the dominant ocularcentrism. These considerations aim to clarify how this visuality manifests itself and spell out possible implications in relation to how we implement, organize and report visual information. Likewise, this paper does not intend to make any assertion or axiological consideration regarding the possibilities of a non-anthropocentric visuality.

3. Apparatuses and Mediation

The domain of visual information, which is itself subsumed under processes of transmission of information, is subject to the influence of information technologies that, consequently, shape visualities. The field of visual information is currently conditioned by a set of technologies and devices that precede, shape and organize that same field of information. This means that in all information processing processes there is a fundamental correlation between *techne* and *episteme* (Flyverbom, Madsen and Rasche, 2017; Manovich 2020, 131-132).

Reiterating this same aspect Vial (2019) argues that nothing happens in life without a phenomeno-technological mediation (133). The specific technological system of a specific era defines the phenomenal aspect of the world we experience. Each technological system, assisted by the artifacts and tools that materialize it, creates 'ontophanic' conditions that are always material conditions of a unique and particular phenomenological manifestation (Ibid., 137, 138). That is, each "historico-technological era" creates objectively singular circumstances. The subjective perception of the phenomenological experiencing of the world is always "a technoperceptual birthing before the presence of things. To learn to feel this technopereptual aspect of presence means accessing ontophanic feeling." (Ibid., 139).

The existential quality of our world also depends on our ties with artifacts, which are more than mere passive recipients (Ibid., 127). The apparatus, which is always mediation, therefore occupies a fundamental place in the debate concerning visual information. Apparatuses "as techno-transcendental structures make the world be (factitivity of make-be), as much as they condition the possible experience that we can make of it (factitivity of make-make)." (Ibid., 115). This means that the apparatus is not neutral, but an object that has its own history and integrates the complex process of producing "objective knowledge" (Wark 2016, 160). The apparatus, especially the scientific apparatus, acts upon the world and in the search for objectivity cuts the world "over and over again ... getting comparable results. But the results are always the product of a particular apparatus, which makes the cut in the world in a particular way. What is measured is not the world, it is rather the phenomenally produced in this particular apparatus." (Ibid, 157). Underlining the link between *episteme* and *techne* and how dependent the production of knowledge, or transmission of information, is on the objects and mechanisms that actually produce it, McKenzie Wark states that "The real is a phenomena that the apparatus produces. An apparatus is not an idea; it is techne, a media." (Ibid., 159). There is an intrinsic relationship between the phenomenological perception of the world, and the information and the devices that materialize it. "It is the apparatus that produces the phenomena ..." (Ibid., 161).

For some authors, this mediation becomes particularly evident in the case of the visual production of science or in what Don Ihde calls "science's visualism". Scientific objects and apparatus, as well as all imaging technologies "transform perceptibility" while maintaining "the obvious analog qualities of ordinary vision" (Ihde 2002, 44).

Even though lensing apparatuses transform a phenomenological perception, the mediations of imaging technologies, as Don Ihde refers, are always grounded in an "embodied vision". Even though the technological or scientific apparatus might displace ocular vision with what Ihde calls a "second sight" it remains perpetually bound to the "anthropomorphic invariant". No matter how complex the technological mediation might be, it is always perceived by a bodily perceiver.

This "invariant" seems to suggest that it might be difficult to speak of a non-human visuality, at least within the framework presented here. If one understands non-human visuality to be a (historical) visualization that takes place outside human visual perception and human scientific apparatus where one only considers the conditions of information production by non-human agents and actants, this would imply that it would be possible to perceive these visualizations without any sort of human mediation, apparatuses or methodologies, that would distort, through this translation, that same visual information. The concept of non-human visuality assumes that we could perceive visualizations outside the human cognitive experience, through mediation processes, that do not alter them. At the moment, it seems difficult to conceive of this possibility. In other words, it would be necessary not only to produce "non-human information", but also a "non-human representation" of this information.

This paper will therefore consider the idea of a non-anthropocentric visuality, which will be distinct from a non-human visuality. The difference resides in the fact that the first one manifests itself from visual information produced displaced from human ocularcentric perception, even though the order of what is measured and the experience of measuring is always invariably human. Even if it is produced outside the human ocular capability, it is almost always organized towards human use. In short, non-anthropocentric visuality conceives a historical visualization beyond an ocularcentrism, but for human knowledge. A non-human visuality, on the other hand, presupposes a visualization of an experience which seems to be impossible to be perceived outside anthropologically conditioned apparatuses. It would only be possible to speak of non-human visuality if the processes of representation of certain visual information were also non-human. Since all our visual information is always represented through anthropological apparatus and methodologies, presently it only seems possible to speak of a non-anthropocentric visuality.

The next section will demonstrate that the emergence of the accidental computational megastructure to which Bratton (2016) refers to and which begins to structure our visual domain, introduces dynamics of visual information production that do not reproduce ocular conditions. Besides going beyond human visual capability, these dynamics allow for extra-ocular historical visualization and other forms of sensing. Following the question if it is possible to speak of a non-anthropocentric visuality, the next section seeks to identify cases of visual information production that are decentered from the dominant ocularcentrism.

4. Non-Anthropocentric Visuality

As it was mentioned, the non-anthropocentric perspective is commonly inserted in a biotic, animal and ecological framework (Brina et al. 2021; Frie 2021; Grusin 2015; Iovino 2010). The non-human turn and questions regarding the development of fields of knowledge interested in considering a comprehensive concept of ecology, suggest a tendency to incorporate data and information from distinctly non-anthropocentric perspectives.

When we speak of a non-anthropocentric visuality that does not reproduce ocular conditions and does not focus on the human we speak, first of all, of a visualization that takes place outside human positioning. That is, visual information that is produced by non-human biotic agents, synthetic elements, ecosystems and various sets of "bodies, machines and other chemistries signaling to itself about itself" (Bratton 2016, 340).

As Mirzoeff underlined, the aggregate of visual information by which a visuality emerges, does not have to refer strictly to images (2011, 295). Chips, sensors, lasers and non-human actants are fundamental elements of these processes, through which a relational dynamic is established. One of the most recent examples of an expanding network of sensory and informational sharing is the case of the Internet of Animals. In this network, the ocularcentric position is displaced to other non-human species. The broad concept of the Internet of Animals, and more specifically the ICARUS project by Matin Wikelski, resort to the use of bio-logging technological devices in order to capture and sense physiological information, geolocation, topographical information and acoustic tracking. Through this information are generated maps patterns of migratory movements, maps that make visible the reasons why certain species behave as they do, and maps that aggregate biologically relevant data and try to understand the relations of causality and interactivity between species and the environments they occupy (Curry 2018; Wild et al. 2021).

Maps and information systems such as those generated by the *ICARUS* project, or the Internet of Animals more generally, move away from notions of “embodied vision” (Ihde 2002, 46) or “emplaced vision” (Brantner 2018, 24) that are always inherently linked to a terrestrial, human positioning. These two cases refer to a displaced or decentered (shared) vision, which is now materialized from positions outside our own through various actants, whether non-human species or electronic apparatuses and devices (cf. Latour 2005).

The ocular decentering of which non-anthropocentric visuality can be symptomatic of is not only related to the integration of other non-human positions, but also to the incorporation of scales inaccessible from an individual human experience. The visualization made possible by the *ICARUS* project is conceivable not only thanks to the incorporation of positions outside the human, but also because there is a large computational structure that allows for the aggregation and connection of several sensors, physiological data, geographic data and acoustic tracking into a coherent system.

This large structure is conceptualized through what Benjamin Bratton calls The Stack, defined as a “global technical system” and “geopolitical geography” (Bratton 2016, 19). This multi-layered “accidental megastructure” (Ibid., 8) is one of the most complete and influential theories of the global technological-computational network. Leading theoretical contributions that focus on the influence of electronic computational devices within the anthropological realm, often do so according to an anthropological scale (Brantner, 2018; cf. Floridi 2015). Benjamin Bratton’s The Stack conceptualizes beyond these scales and frameworks. As an aggregate of a global technological network, The Stack moves away and decentralizes itself, first and foremost, from a strictly human positioning and scale. On the other hand, as an architecture composed by layers, the model of a global technical system is characterized by an interoperable dynamic.

At this scale the processes of mediation and the information aggregation logistics are illegible and incomprehensible, which means the territory of the visible and the image are fundamental when it comes to consider information produced by this network. One of the main functions required of visual devices is therefore the coalescence, reconversion, description and aggregation of information, into legible and intelligible visual schemes. The language of this specific production of visual information is characteristically diagrammatic, schematic and descriptive (Bratton 2016, 231). Given that what is intended to be described and schematized is, or may be, invisible (obstructed, for example, by underground layers, adverse weather conditions, private ownership) this visual information is made legible, in the very processes of interoperability, translation and mediation of information.

Even though all this information is represented, analyzed and measured according to human methods, apparatuses and agents, the fact that we are able to witness a visual domain being constituted according to assemblages that go beyond the human ocular apparatus and that, in the way it gathers information, does not seek to reproduce these optical conditions, may be relevant. According to the author, this network is a medium of composition that through actions of measurement, association, location, identification and connection, produces “new creations in their own right” (Bratton 2016, 200). Unlike processes of “digital mapping” (Brantner 2018, 25) or “locative media” (Hjorth and Pink 2013), this network’s mode of organization makes it possible to conceive visual information that exceeds human ocular competences, or put differently, enables other forms of seeing and sensing (Bratton 2016, 153).

This mechanism can therefore be understood as part of a knowledge infrastructure dedicated to a “reproduction of the world” (Wark 2016, 167), beyond any ocularcentric capability or simulation. What is particularly important is the fact that this reproduction of the world, which involves more than images, facilitates the assimilation of a set of different technologies that enable a collective “self-understanding”, through which both we, as a collective social body, and the world can sense themselves, and thus render and construct our own conditions (Bratton 2016, 153; 2021, 46). The augmented capacity to sense is expanded largely through non-human actants. Since the status of user is open to any living and non-living being or object, it becomes evident that there is a relationship between the ability to sense and visualize the world, and all the agents and elements that are not human. We therefore argue that the possibility to sense the social, geological, topographical, atmospheric and ecological conditions of the world through means other than human physical and sensory capacities seems to be a feature of a non-anthropocentric visuality.

It may be relevant to underline, as Bratton understood, that the global computation network is, for the most part, a set of non-visual systems that nonetheless manage to describe themselves as an image (Ibid., 341). This clarifies its mechanical interoperability and its departure from an ocular logic, its ability to produce and represent visual information, and the attention that must be devoted to this network in order not to assume that the information produced by it is invariably true, in particular, with regard to what concerns governance practices.

Both the last two aspects mentioned referring to a decentering of human position and scale are based on the paradigm of classical computation. Would there be relevant consequences for the topic of a non-anthropocentric visuality, if we developed another type of computation that subjugated or made classical computation nonessential? In this last segment we will try to briefly consider this question, since there is currently another type of computation being developed that could become relevant for the production of visual information: quantum computation.

Quantum computation, as many researchers recognize, is at an early stage of development (Su et al. 2020; Cai et al. 2018), which means that inferences made from the information gathered, will be limited. We can at least refer to the subdiscipline of quantum imaging that aims to develop new techniques that allow for “optical imaging and parallel information processing at the quantum level" (Gatti et al. 2008, 253), through the exploration of quantum-mechanical phenomena (Yao et al. 2017). As opposed to current computational apparatuses that store their information in bits, quantum computers store information in quantum bits, or qubits, which have distinct properties (entanglement, superposition of quantum states and quantum coherence) and provide this type of computation with superior performance in terms of "information storage and parallel computation" (Su et al. 2020, 214521).

Vision is and will continue to be one of the most important processes of mediation concerning the acquisition of information (Yao et al. 2017) and the complex process of cognition. If quantum computing were to have widespread practical application as classical computing has today, it could have an impact on the way we relate to visual information.

As it happened at the dawn of the internet – which was fundamental for the development of visual theory, and visual information more broadly – the application of information stemming from quantum computing occurs mainly in the scientific and military fields. Quantum image processing algorithms are applied to visualize experimental results related to medical imaging, pattern recognition and quantum radar (Su et al. 2020; Wang et al. 2021). The processes of quantum imaging processing and quantum computing also prove to be useful in terms of how information is transmitted. Researchers have often mentioned the underlying possibilities regarding cryptography, stenography, watermarking and processes of encryption. (Yan et al. 2017; Yao et al. 2017). It is also important to mention that within the scientific community there are already proposed frameworks to represent "films" in quantum computers (Yan et al. 2017), even though we do not yet know how "film" would behave or be represented through a quantum medium. Quantum imaging therefore seems to suggest a change in the current parameters of visuality, specifically in the way information is aggregated and constructed.

Since there is a focus on the encryption process, and since processes such as watermarking are possible, if the information produced by quantum computing becomes viable and disseminated, we might witness a dynamic that favors attitudes of decoding and revelation in relation to visual information, as opposed to contemplation or interpretation. Interaction instead of description.

Operating at a quantum scale and framework, this is possibly the field that most deviates from the conception of visual information, understood in a traditional sense. In any case, we reiterate that the possible inferences to be made are quite limited, and even if all these developments come to fruition, all these processes and information, however complex they may be in relation to classical computing, will continue to depend on human mediation and representations made by human apparatus.

5. Discussion

The conception of a non-anthropocentric visuality suggests the possibility of a historical visualization that is not only human but also contemplates ecological, technological, organic, biotic and synthetic realities.

So, can we speak of a non-anthropocentric visuality? As mentioned earlier, the concept of non-anthropocentric visuality is characterized by a decentering from ocularcentrism through the production of visual information by non-human agents. According to this perspective, a non-anthropocentric visuality is distinct from a "non-human visuality" and an "anthropocentric visuality". In the domain of a non-anthropocentric visuality, we witness visual information that is produced by non-human agents, and that is subsequently translated and mediated by human apparatuses and human cognition.

As science studies, the 'non-human turn' and several studies related to climate science and the Anthropocene demonstrate, the sovereignty of human knowledge and experience over the rest of our planetary reality, has been continuously questioned. A historical visualization is no longer exclusively anthropocentric. Henceforth this visualization is also technological, geological, climatic and pandemic. Although it is difficult to speak of a non-human visuality – which would somehow manage to capture, measure and record information through neutral apparatuses and neutral "bodily perceivers" (Idhe 2022, 48) – we can assert that we observe the capture of data and visual information produced by non-human agents and apparatuses, decentered from a non-anthropocentric position, scale and perspective.

Taking into account that the apparatus is not only an extension of the human but also a "User-subject of and for" other systems, objects, machines and animals, often without human interference, it is also this new cluster of participatory agents (whether they are machines, animals, apparatus, etc) that enables a "decentering of human perspective in describing the potential plurality of deep address haecceities, invoking potential Users across an abyssal spectrum of scalar abstraction and physicalization" (Bratton 2016, 273), or what Rosi Braidotti calls a "multi-scalar relationality" (Braidotti 2019, 46). If the apparatus can be both used as a prosthetic, and as a user that "prosthet-icizes the human" (Bratton 2016, 273) it is maybe this agency that allows us to consider the idea of a dominion in which the autonomy of a visualization (historical, technological, ...) does not depend exclusively on human power, as we frequently assume.

Although there is always an observation, mediation and representation that is invariably human and inscribes these processes of visualization in an inherently anthropological regime, and which in turn seems to hinder the conceptualization of an objectively non-human visuality, the gradual extension and complexity of these processes through an increasingly diverse network of agents, human, non-human, biotic and non-biotic, suggest the possibility of visualizing a set of historical processes extrapolated and *decentered* from an ocularcentric reality, outside of an exclusively anthropocentric framework.

If Mirzoeff conceptualized a visuality as a colonial, authoritarian and coercive visual regime – always based on an ocularcentric framework –, the conceptualization that we propose through the concept of "non-anthropocentric visuality" is also an attempt to reformulate and rethink a regime that, through the integration of a planetary reality, can be post-colonial, non-authoritarian and non-coercive. No longer in the hands of the Hero, but constituted outside the dominion of human hegemony, constructed and visualized away from an anthropological epicenter. Beyond a critique of "weak anthropocentrism" (Frigo and Ifanger 2021), the conception of a non-anthropocentric visuality seeks to clarify which conditions, agents and protocols affect the contexts that produce certain information, in order to assess which agents allow and catalyze practices of knowledge and the transmission of visual information.

We therefore argue that the visualization and representation of realities and historical processes outside an ocularcentric perspective, seem to justify the concept of a non-anthropocentric visuality, or at least, of an extra-ocular visual domain.

So, why is the concept of non-anthropocentric visuality relevant and how does it expand our conception of visual information? Visuality is not just about images, but above all about the conditions that allow for or obstruct certain images or visualizations. If the apparatuses and devices of a planetary technological-computational network allow for a collective social body to mediate itself through connections of information, energy and matter, then through these same apparatuses there is a capacity for the world to "sense itself" (Bratton 2021, 41.44, 46). As the present pandemic has shown, measures aimed at public health, social organization, border regulation or external policy are implemented and actively based on a non-anthropocentric planetary-scale visuality, and its subsequent "sensing" capacity, that is only made possible because of this global network. Sensing is here understood as a perceptive capacity that is amplified beyond the scale of what is only optically and ocularly perceptible.

As other authors have mentioned, sensing relates not only to a human capability, but also to a competence of matter, ecosystems and complex technical assemblages (Fuller and Weizman 2021, 28). The construction of new sensors and sensing capabilities through chains of technologies and organisms constitutes new figurations and visualizations of reality (Ibid., 62). The "post-photographic" condition calls attention to these new visualizations, and therefore new realities, which come to constitute a dynamic in which the value of visual information derives not from individual images but from the relationship between them, and the assemblages that these create among themselves (Ibid., 77). Just as recent investigations try to think and act beyond the traditional conception of what aesthetics are or present themselves to be (Ibid.), this paper also seeks to contribute and add to the question of what processes of historical visualization can be, who can contribute to them, what they can look like, and what kind of criteria should be cultivated within these visual regimes. Mirzoeff identified the relationship that visuality (within an authoritarian and coercive framework) established with modes of governance (Mirzoeff 2011, 125). The sensing capacity we are referring to (Bratton 2021) is, on the other hand, conceptualized towards "positive biopolitics" which aim to animate sensing, reason, care and a concern for how life can be repaired, sustained and preserved through the legitimacy and competence of "(non-policing) social governance" (120-132). Therefore, it seems that in this sensing there is a capacity to understand a human and non-human corporeal materiality, in an integrated way.

On the other hand, the assimilation of physiological information, geolocation, reproduction of satellite images, sensors and computational devices according to scientific mediations and practices, carries with it the notion of precision and truthfulness, of which we must remain aware. The visual information of non-anthropocentric visuality, through the visibilities or invisibilities it produces, through the agents it incorporates or excludes, through the calibration it implements, influences governance practices that are based on (visual) information, which is not always unquestionably objective, true or legitimate. While the framework of a non-anthropocentric visuality could be used to condition specific interpretations, the information it produces, and more importantly the information it represents, should not always be considered inherently true. To consider the idea of a non-anthropocentric visuality also means one should remain attentive as to how such visual information is used to justify or legitimize practices of governance. Visual information assembled through planetary-scale computation is today a constituent element in decision-making regarding the accuracy of geographic boundaries (seen, for example, with the 2010 border dispute between Nicaragua and Costa Rica in relation to the mapping made by Google), enabling or constricting migratory flows (Transborder Immigrant Tool App), domestic and foreign policies (seen with Strava's Global Heatmap that revealed the location of previously unknown American military bases in 2018), or control of natural resources (Bratton 2016, 119, 120, 173).

Lastly, certain aspects of non-anthropocentric visuality may give rise to different attitudes from the ones that prevail today, in relation to how and what we consider visual information. The processes outlined in section 4 suggest active dynamics of decoding and detection of underlying or implicit information that, in case they become viable, will have a clear influence on the processes of visual production and consumption.

Succinctly, this paper conceptualizes a non-anthropocentric visuality as the possibility to visualize a set of historical processes and developments outside a necropolitical framework (Mirzoeff 2011, 300) and outside the sovereignty of anthropocentric ocularcentrism. We argue that a non-anthropocentric visuality stands as an opportunity to reconfigure and finally set aside the colonial and imperialist legacy of visuality and make use of the visualization of history through positive integrative policies (cf. Lowerre-Barbieri et al. 2019; Bratton 2021, 145) that refrain from restraining, controlling or surveilling. Through a collective approach and an ethical standing, ocularcentric history now holds the possibility to extend and build a more complex visual domain and expand the conception of images and anthropocentric vision.

We conclude with an outline of questions that can and should be considered in the future. First, can the non-anthropocentric visual dominion be considered a development of an anthropocentric visuality? If we assume that a historical visualization has to be a visualization beyond human physical limitations that contemplates synthetic and ecological technological realities, does it make sense to make a distinction between an anthropocentric and a non-anthropocentric visuality? On the other hand, if we assume that a non-anthropocentric visuality manifests a reproduction of planetary conditions, can we speak of a maintenance of such a visuality? Is it possible to say that humans have ceased to be the main agent of its maintenance? And should there be a concern with the maintenance of this visuality and the reproduction of planetary conditions?

6. Conclusion

In short, a non-anthropocentric visuality is the aggregate of visual information produced outside ocularcentric hegemony that promotes other forms of sensing that go beyond the human sensory capability. The global technological-computational system facilitates and enables the perception of this visuality and allows us to perceive that in it there is no reproduction or simulation of ocular conditions, but only subsequent conversions and translations of information into readable formats.

While XIX century visuality was based on the sovereign eye of the Hero which reified the maintenance of authoritarian, colonial and state power, a non-anthropocentric visuality relies on the non-human agents and apparatuses themselves that allow for a biocentric historical visualization and reproduction of the world, including sensing beyond human physicality. If we accept that a historical visualization is no longer merely anthropocentric (and climate science and the Internet of Animals make very strong cases in this regard), it makes sense that we may observe other types of non-anthropocentric visualities and *epistemes* that reflect this shift.

Lastly, as stated before, this paper does not seek to make axiological considerations. But if we can, indeed, speak of a non-anthropocentric visuality, moving forward it will be important to consider in depth the ethical and moral implications of this visuality, and attempt to understand in detail its influence in the fields of biology, political theory, visual theory and data science. Even if future developments qualify the concept of a non-anthropocentric visuality as flawed or deficient, it will be nonetheless important to thoroughly study and examine the array of visual information that is produced outside of an ocular-centric dominion.

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Data Visualization as Portraiture: An analysis of the use of personal data in the visual representation of identity

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This paper analyses aesthetic and design artefacts that represent the identity of an individual through the visualization of personal data, focusing on their reflexive, documental, and biographical potential. To this end, it analyses the concepts, data types, design methodologies, and visualization techniques, as well as the experiential characteristics of these artefacts. This analysis is part of an ongoing research that explores data visualization techniques for the representation of personal identity, highlighting the potential of using personal data as a raw material for portraiture. The research is motivated by the current context of technological ubiquity, wherein virtually all human activities inevitably leave a digital trace. It explores the potential of these records of personal data to convey characteristics of identity that are relevant in private and social spheres. As such, it also points to a reconceptualization of portraiture driven by computational media, as the representation of personal identity through the use of personal data.

Keywords Personal data, data portrait, data visualization, identity, portraiture, computational media

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1. Introduction

Our current daily activities are constantly mediated by a growing number of technological devices capable of quantifying and recording various aspects of human life in the form of digital data. These records can include vast sets of highly personal information about actions, habits and preferences, social and intimate interactions, as well as bodily functions. These data refer to specific individuals who can be identified through them (Wolf 2010). Drawing on the notion that "new media offer new opportunities for self-definition" (Bolter and Grusin 2000, 231) this research explores how the visualization of personal data can efficiently convey characteristics of one's identity.

In doing so, it also seeks to highlight the wider uses and implications of personal data, by addressing issues related to one's agency and control over personal data (Kennedy et al. 2015; Mun et al 2010). In this sense, authors such as Stepanchuk (2017) point to a growing hegemony of entities that facilitate the development of technology that enables the collection and archiving of personal data. In this context, they highlight how the construction of identity becomes conditioned by the affordances of technology, as a result of technological determinism (Poletti and Rak 2014). They point to the implications and, not yet fully predictable effects, that digital technologies have on human ontologies (Hernández-Ramirez 2017; Floridi 2014), as they structure an individual's relationship with themselves and with others.

Authors like Zuboff (2019) and Harary (2015) highlight issues of commercial exploitation and social manipulation through the collection and analysis of personal data. But despite the current context of surveillance capitalism highlighted by these authors, there are alternative views and creative approaches to the use data produced by and about individuals. Designers like Lupi (2017) explore data from a humanist perspective, through the creation of visualizations that support decision-making processes (Ciuccarelli et al. 2014). These approaches also seek to facilitate social interactions between users in digital environments (Donath 2017) or seek to provide the individuals with mechanisms of self-knowledge that allow them to act upon themselves (Foucault 1998; Floridi 2011). Motivated by these ideas, this paper is part of an ongoing research that explores the concept of "data portrait" as coined by Xiong and Donath to describe "representations of people made by visualizing data by and about them" (Donath 2017, 187).

2. Data Portraits

The first notable experiences around the concept of data portrait emerged in the late 1990s, to represent participants in online forums. In this context, visualizations were created by mapping each user's activity to help group members "to make sense of each other" (Donath 2017, 198).[1] A data portrait can then be defined as a graphic representation of personal identity achieved through the visualization of personal data. It is the result of a multidisciplinary practice that essentially applies data visualization techniques to the realm of portraiture. This approach to portraiture is reminiscent to forms of artistic production that appropriate techniques from scientific disciplines, such as the exhaustive observation of daily life, data collection, analysis, and inventory, as an ethnographic basis to produce aesthetic artefacts (Morley 2007).[2]

Addressing the notion of data portrait implies debating the relationship between *portraiture, data* and *visualization* (Sampaio et al. 2019). Commonly, a *portrait* seeks to evoke an individual by visually conveying characteristics of their identity (West 2004). This can be done by depicting similarities related to their physical appearance. It can also be accomplished by resorting to contextual elements, such as certain poses, clothing, and everyday objects that illustrate their habits and interests, and thus convey the identity of the person they represent (West 2004). For Xiong and Donath (1999), the online equivalent of these contextual elements is behavioural data. *Data* are "abstract in nature and in themselves are meaningless. Only when organized and contextualized do they produce information" (Lee 2014, 19). Thus, data can be considered raw material from which information emerges, through cognitive processes and visual perception (Meirelles 2013). Accordingly, *visualization* can be understood, on the one hand, as the formation of ideas resulting from the human ability to reason, that is, to the creation of a mental image. On the other hand, it refers to the materialization of an image that allows to represent something visually, that is, the conversion of concepts into images or visible forms (Almeida 2017). In the field of information design, visualization is a representation technique that comprises the mapping of abstract data into a graphic system to produce meaning (Manovich 2002).

As we have discussed elsewhere (Sampaio et al. 2019), the visualizations of personal data addressed in this paper can be understood as 'portraits' because they visually communicate personal identity by fulfilling biographical and documentary functions. Nevertheless, they differ from most traditional forms of portraiture because, rather than conveying identity through physical appearance (conveying gender, age, or race), they do so by highlighting behavioural traits and patterns related to one's lived experience, habits and interests. In this sense, data portraits do not describe one's *appearance* but evoke one's *experience.*

3. Functions of data portraits

Data portraits take advantage of the potential of personal data as the product of one's daily experiences to convey identity traits. However, rather than merely assuming an analytic stance, data portraits also value the subjective expression

1. The *PeopleGarden* (1999) project was one of the first data portraits created at MIT Media Lab by Rebecca Xiong and Judith Donath. It used the "simplicity and intuitiveness" of the garden metaphor to "convey how user's behaviour changed over time" (Xiong and Donath 1999).

2. For example, *Portrait of Deb from 1988-199?* (2012-2013) by L. J. Roberts, results from a series of embroidered emblems collected by Deb, as the outcome of an autoethnographic practice. The work is based on the notion that material objects express meaning and employs enumeration techniques and personal inventory as a form of portraiture (Goodyer and al. 2016, 240). Another example would be *Everyone I Have Ever Slept With 1963-1995* (1995), by Tracey Emin, which is an art installation composed of a tent with the appliquéd names of, literally, everyone she had ever slept with, including family, friends, lovers and even two numbered foetuses (West 2004, 211).

of what is commonly understood as objective, numerical data as an index of reality.[3] In this sense, they resort to "techniques from the universe of statistical analysis, but their purpose is artistic" (Donath 2017, 209).[4]

As designed artefacts, data portraits also fulfil specific expressive and communicative functions that are similar to their traditional counterparts, as an "artistic" endeavour with a "biographical" or "documental" function, as a "proxy", or even, as a "political tool" (West 2004, 43-69).[5] In this sense, data portraits can act as a *proxy, double or substitute* for users in virtual environments (Donath et al. 2014). They can also work as a *mirror or a self-reflection* that allows the observation of behavioural patterns (Sampaio and Ribas 2021). Additionally, they can be a *critical discourse* and promote awareness of the wider implications of our digital footprint and our loss of control of the data produced by and about us (Donath et al. 2014).

3. This type of work is conducted to enable the same exploration of identity that characterizes traditional portraiture, but they employ different techniques, such as enumeration and personal inventory. Thus, these works "shift the attention from the portrait's iconic qualities to its indexical ones" (West 2004, 212). As Whitelaw (2008) observes "Data here is first of all indexical of reality. (...) These works gather existing data from the network, drawing together thousands of elements that are already, unproblematically, 'out there'. This reinforces the sense of collapsed indexicality; these data points have causes (authors) of their own that in some sense guarantee their connection to reality, or at least defer the question of that connection. Data's creation — in the sense of making a measurement, framing and abstracting something from the flux of the real — is left out."

4. As *aesthetic artefacts*, data portraits try to trigger "subjective experiences such as introspection, surprise or aesthetic fruition" (Almeida 2017, 100).

3.1. The data portrait as double

To establish interpersonal relationships in virtual environments we need interfaces that allow for self-representation, because personal identity is not embodied. In this context, the *selfie* has become the preferred way of "bringing the face to the interface" (Donath 2001). However, despite being a mimetic representation, its use is more advantageous in social networks where users know each other in real life, because, without this reference, the *selfie* loses its contextual value and can become ambiguous or even misleading (Donath 2001). Consequently, alternative modes of self-representation based on quantifying behavioural data, such as data portraits, can be less prone to be elusive or misinterpreted (Rettberg 2014).

Xiong and Donath (1999) identified several advantages in representing individuals in online communities through their behavioural data. One of them is that this kind of representation offers context, comprising a history of past interactions within the community. Also, user status can be updated according to their most recent interactions. As such, these visualizations can evolve and change over time, sometimes in real-time. Being based on objective and non-anonymized data these portraits can be considered reliable. At the same time, they also provide some degree of privacy, as they produce meaning only within the context of the platform on which they are generated (Donath et al. al. 2014). Finally, as they do not rely on mimetic attributes, they ideally eliminate stereotypes since assumptions about the subject/user are based on their real actions and not on potentially biased characteristics such as sex or race (Donath 2001).

3.2 The data portrait as a mirror

In addition to conveying socially relevant aspects of identity, and due to their biographical and documental nature, data portraits can also fulfil a reflexive function by expressing traits of identity that are most significant within the personal sphere. In this case, the data portrait is designed to act as a "data mirror" reflecting one's behavioral patterns (Donath et al. 2014).

Much in the same way several artists have used the self-portrait as an exploration of their identity throughout history (West 2004), modern self-tracking technologies also facilitate this type of biographic record through data collection and visualization. When coupled with self-tracking techniques, the data portrait can materialize as an interface between the user and their data. Like a traditional self-portrait, it can be a means for self-knowledge and exploration. In this sense, data portraits can be framed as "technologies of the Self" (Foucault 1998). As Foucault argues, these technologies allow individuals to "establish a closer and truer relationship with themselves" (1998, 18). They belong to a set of specific techniques that human beings use to produce knowledge about themselves and to implement changes on their own lives in order to optimize them (Lupton 2014).

According to Donath et al. (2014), in the private sphere, data portraits function as "data mirrors, portraits designed to be seen only by the subject, as a tool for self-understanding". This reflexive function results from the affective relationship that the user creates with data when visualized (Pink et al. 2018). According to studies carried out by Lupton (2016)[6] and Pink et al. (2018), personal data, when visually represented, acquires a symbolic value and generates feelings of belonging, which are associated with memories and a notion of continuity. As with photographs displayed in an album, data portraits thus acquire a sentimental value due to their biographical and documental qualities.

5. West (2004, 43-69) summarizes the functions of traditional portraiture as "the portrait as a work of art", "the portrait as biography", "the portrait as document", "the portrait as proxy or gift", "the portrait as commemoration or memorial" and, finally, "the portrait as political tool". As proposed by West, portraiture is traditionally understood as serving "functions that other works of art have not (...) in a way that is unique to its genre" (West 2004, 220) given that portraits "are representations, but also material objects" (West 2004, 43).

6. Lupton expands on the idea that the materialization of personal data through its visual representation connects data with users on her book Quantified Self (2016).

3.3 The data portrait as critical discourse

In most of our daily activities, in addition to the information we intentionally create and give away, vast records of data are generated without our full awareness, resulting in a digital footprint that is also accessible to other parties, such as government agencies, commercial companies, and data brokers (Rettberg 2014). However, we have little or no access to those data or the representations made of us, even though they are the product of our actions and interactions (Harary 2015).

Feeding on our "behavioural surplus" (Zuboff 2019)[7] algorithms are constantly analysing our identity, by translating our actions, preferences, and interests into behavioural data. This process of data extraction began online, resorting to metadata as "device/software generated data" that is "necessary for every activity on the internet" (Joler et al. 2015a), but is continually being driven towards

7. Behavioural surplus is described by Zuboff (2019) as data that goes beyond online product and service use.

new sources in the real world. Metadata is indispensable for communication on the internet as we know it today, but it is also extraordinarily intrusive. As stated by Edward Snowden in a conference call in 2014, "Metadata absolutely tells you everything about somebody's life. If you have enough metadata, you don't really need content" (Joler et al. 2015b). According to Zuboff, in the context of "surveillance capitalism", the use of these data goes far beyond online product and service improvement, as it is now being primarily claimed "as free raw material for hidden commercial practices of extraction, prediction, and sales" (Zuboff 2019, 8).

In this context, data portraits may provide a better balance between the intentional ways we convey our identity and the unintentional traits of identity we provide to third parties. By making our digital footprint visible and accessible, data portraits can be a means to attain some degree of agency over personal data making it "accessible, understandable, and actionable for our everyday tasks" and, as such, connect "people with timely and meaningful insights" (Bonde 2013).

Data portraits can also build a critical discourse on the established power relations around personal data, evoking current debates on data protection and privacy, and the common disregard of big data companies of user's rights and control over private information. As such, data portraits also fulfil a political function when devised as critical statements on current data commodification practices and data policies. According to this view, data portraits become not only an expression and manifestation of an individual's presence in the world but also "a point of view on that world and a way of potentially recreating or restoring it", considering that, as stated by Medeiros (2000, 36), "to represent is always to revolutionize".

4. Analyses of data portraits

In order to further understand the expressive and communicative functions of data portraits, as a double, self-reflection and according to their critical stance, we analysed a set of artifacts concerning their different creative approaches to the visual representations of identity based on personal data. The current analysis updates and expands a previous one (Sampaio and Ribas 2020) by delimiting the scope to artefacts that use computational means for collecting, processing, and visually representing data, to highlight the mediation of identity by technologies of everyday use.[8]

8. As sources of information on the projects, we resort to direct observation, authors' documentation, and bibliographic references to the analysed works, as in the previous study (Sampaio and Ribas 2020).

4.1 Scope

The current selection of aesthetic and design artefacts corresponds to works that 1) aim at the visual representation of personal identity, 2) resort to the visualization of personal data, 3) are based on computational media and 4) are not visually mimetic. This selection seeks to comprise a diversity of projects, ranging from the emergence of the concept of data portrait, as established by Xiong and Donath in 1999, to the present day:

1. *PeopleGarden*, Rebecca Xiong & Judith Donath, 1999
2. *Authorlines*, Fernanda Viégas & Marc Smith, 2004
3. *A Week in the Life,* Andreas Fischer, 2005
4. *The Dumpster*, Golan Levin, Kamal Nigam and Jonathan Feinberg, 2006
5. *Themail*, Fernanda Viégas, Scott Golder and Judith Donath, 2006
6. *Fitbit*, Gadi Amit et al., 2007 – ongoing
7. *Personas*, Aaron Zinman and Judith Donath, 2008
8. *Spigot (Babbling Self-Portrait)*, Jason Salavon, 2010
9. *Atlas of the Habitual*, Tim Clark, 2010-2011
10. *TimeMachine*, CADA, 2012
11. *Nike Hyperfeel Experiment,* Aramique, 2013
12. *Heart Bot*, Aramique, 2014
13. *Data as Object*, Brendan Dawes, 2014
14. *The Art of the Thrill*, Soso Limited, 2014
15. *Porsche BlackBox*, OnFormative, 2015
16. *Good Night SMS*, Paul Heinicker, 2015
17. *The Sixth Sense*, Clever Franke, 2016
18. *Poisonous Antidote*, Mark Farid, 2016
19. *Floating Map (Life Location Project)*, Stephan Cartwright, 2016
20. *Heart of Travel*, Joshua Davis, 2017
21. *Data Selfie*, Data X, 2017
22. *Halo*, Peter Crnokrak – ORA, 2017
23. *The Art of Feeling*, Random Quark, 2017
24. *Building Hopes*, Accurate, 2018
25. *OnePlus 7 Live wallpaper*, OnFormative, 2019
26. *Made to Measure*, Studio NAND, 2020

4.2 Aim and focus

Considering the main communicative and expressive functions of data portraits, the framework for analysis focuses on 1) the work's *concept*, i.e., its motivations, objectives, and approaches to personal data, 2) on the work's *mechanics*, i.e., data collection and analysis processes in order to analyse how the work's intent is actually implemented, and 3) on the elements of their *experience*, i.e., the outputs, interfaces and behaviour of the work, addressing the main characteristics of the visual representation and the kind of perception of the source data these portraits allow.[9]

9. The analysis framework was adapted and expanded from a previous study (Sampaio and Ribas 2020) and based on a model proposed by Ribas (2014) for the analysis of digital computational systems. It is also based on the model that describes the process of deriving information from data through its visualization described by Fry (2008), which in turn systematizes the "informational-digital praxis" proposed by Renaud (2003).

In particular, we consider how the choice of personal data defines the *theme* and *content* of the data portrait concerning their functions. We then observe the *data collection* and *data analysis* processes, which are implemented at the level of their mechanics, as specific means to accomplish the work's intent. Finally, we observe the elements of the *experience* of each work, or what is accessible for the user/audience to experience, in terms of *surface* (outputs and interfaces) and *dynamics* (behaviour), which define the perception and experience these visualizations promote (Table 1).

Considering these specific points of view on the works analysed, we now describe the categories of the framework, as informed by parameters referenced below and as resulting from a comparative analysis of the works selected.

Concerning the works' *concept* and theme or subject matter, the focal point of the current analysis is the portrait's intent as tied to the main functions of the data portraits: as a *double* (a proxy of the user in online communities), or as a data *mirror* (a mechanism of self-observation through self-tracking), or as a *critical discourse* (by re-appropriating personal data). Consequently, we find it useful to specify different *types of portraits: self-portraits, individual portraits, and collective portraits.* We also examine the *motivation* behind the creation of the portrait, as an *internal* motivation tied to a personal discourse or artistic reflection, or whether it results from an *external* motivation, such as with the development of a product or service.

Within the conceptual dimension, we also consider the works' *content*, as tied to its function and relating to the *data sources* used, whether collected from a *virtual environment* or the *real world*. The *typology* of data is described in terms of *behavioural data, biometric data, data related to the surrounding environment.* A relevant aspect to this analysis is the *ethnographic value* of the data used in the visualization that, according to Whitehead (2005), can express a wide array of information about the individual portrayed, namely their *physical characteristics, psychological traits, social relationships, behavioural patterns, or their physical environment.*

Table 1. Analysis framework.

1. CONCEPTS	THEME	**Portrait's intent**	Data double; Data mirror; Critical discourse
		Type of portrait	Self-portrait; Individual portrait; Collective portrait
		Motivation	Internal; External
	CONTENT	**Data source**	Virtual environment; Real world
		Typology	Behavioural data; Biometric data; Surrounding environment data
		Ethnographic value	Physical characteristics; Psychological traits; Social relationships; Behavioural patterns; Physical environment
2. MECHANICS	DATA COLLECTION	**Data collection**	Service providers; Devices; Web 2.0
		Level of control	Deliberate; Non-deliberate
		Recording format	Textual; Numerical; Other
	ANALYSIS	**Data analysis**	Statistical; None; Not possible to observe
3. EXPERIENCE	SURFACE	**Informational structure**	Hierarchical; Relational; Temporal; Spatial; Spatio-temporal; Textual
		Representational stance	Analytical; Expressive
		Modes of expression	Visual; Audiovisual; Material
		Output format	Static image; Physical object; Moving image; Digital interface
	DYNAMICS	**Behaviour of the output**	Contemplative; Interactive
		Nature of the output	Static; Transient; Variable

Moving on to the *mechanics* of the work, or the specific implementation of its conceptual aim, we examine how the *data collection* is done. Namely, through *service providers* using digital network services (big data), *devices* with built-in sensors (IoT), or provided by the user in *social networks* and other similar platforms (web 2.0). A relevant aspect to the current analysis is observing the *level of control* that the subject/user has over data collection processes. Based on Selke (2016), we distinguish between a *deliberate* way of collecting data (i.e., using self-tracking tools) and a *non-deliberate way* (when data collection is automated without the active intervention of the user). The data *recording format* is also considered, if it is *textual, numerical,* or *other* (i.e., image, sound), as well as the processes of *data analysis* implied, to highlight if *statistical analysis* or other methods are applied to personal data.

Finally, considering the *experience* of the data portrait, we focus on the sensory expression and observable behaviour of the work, to understand the kind of perception and aesthetic experience it promotes. We observe the type of *informational structure* employed in the visualization according to the categories defined by Meirelles (2013), which can be *hierarchical, relational, temporal, spatial, spatio-temporal,* or *textual*. Additionally, the representational *stance* of the visualization can be *analytical* (if the visualization favours legibility) or *expressive*, when it favours a subjective experience of the data, or an aesthetic experience promoting reflection and inciting emotional response. The *modes of expression* of the output can either be *visual, audio-visual,* or *material*, and the *output format* of the visualization system can be a *static image*, a *physical object*, a *moving image*, or a *digital interface*. Additionally, the nature of the *output* can be either *static, transient* (time-based) or *variable* (real-time). Finally, regarding the *dynamics* of the data portrait, the overall *behaviour* of its *output* can be merely *contemplative* or devised as an interface allowing *interactive* exploration.

5. Tying concept, implementation, and experience

The results of this analysis point to the interdependency between conceptual intent, relating to the functions of data portraits, and the types of data and visualization strategies used, within a diversity of modes of expression and formal aspects of data portraits.

5.1 Approach to personal data

We observed that these artefacts often articulate several expressive functions, with a predominance of the reflexive one. Their theme is always shaped by the personal data that visualizations use as content, which also relates to their typology (Table 2). Data portraits of the late 1990s and early 2000s were predominantly aimed at representing users in online communities and were, at the same time, individual and collective portraits (e.g., *PeopleGarden, Authorlines, Themail*) whose goal was to act as a double or proxy for the subject/user, communicating their identity to others. Subsequent data portraits are more diversified thematically, also articulating various expressive functions.

Table 2. Analysis results — concepts.

Portrait's intent	Type of portrait	Motivation	Data source	Typology	Ethnographic value
Data double	Self-portrait Collective portrait	External	Virtual environment	Behavioural data	Social relationships Behavioural patterns
Data mirror	Self-portrait	Internal	Virtual environment Real world	Behavioural data Biometric data Surrounding environment data	Physical characteristics Psychological traits Behavioural patterns Physical environment
Critical discourse	Self-portrait Individual portrait	Internal External	Virtual environment	Behavioural data	Physical characteristics Psychological traits Social relationships Behavioural patterns Physical environment

Many of the projects analysed aim to represent individuals before themselves, as self-portraits or self-observation tools through self-tracking (e.g., *Fitbit, TimeMachine, Halo*). Some data portraits depart from this function to then construct a critical discourse (e.g., *Spigot, Data as Object, Poisonous Antidote*). These portraits fulfill a political role, based on the aggregation and re-appropriation of personal data that is scattered on different networks and platforms. Such as the case of *Spigot (Babbling Self-Portrait)* or *Poisonous Antidote*, which highlight aspects related to lack of privacy and security in the online world, raising questions about who owns these data. Projects with this type of critical stance tend to explore issues related to the individual's agency over their data and are usually moved by the internal motivation of their creators. In turn, projects that primarily aim at conveying personal identity, fulfilling the function of data double, often stem from external motivations and therefore have a more applied nature.

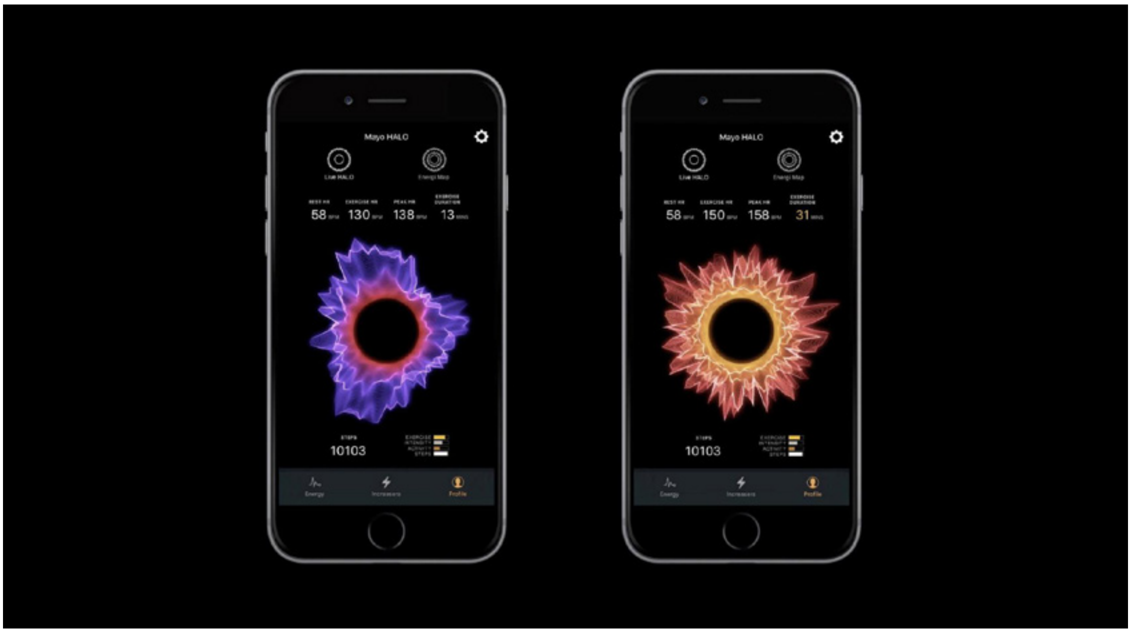


Fig. 1. *Halo*, Peter Crnokrak – ORA, 2017.

Regarding the data sources related to the portraits' intent, we observed that when the data portrait fulfils the role of a *double*, or a proxy communicating the subject's identity to others, it tends to be based on behavioural data retrieved from user activities within a platform. Such is the case of *PeopleGarden* and *Authorlines* that resort to the visualization of these types of data to hinder the deceitful self-representation of users in these online communities (Donath 2017). On the other hand, when the portrait is self-directed and fulfils a *reflexive* role, it usually resorts to biometric data, sometimes correlated to data of the individual's surrounding environment, as data extracted from the real world.

Most data portraits allow us to infer patterns of behaviour, and sometimes couple these with psychological traits, social relationships, or the environment of the individual portrayed. When biometric data is correlated to data of the surrounding physical environment, it allows us to infer the psychological traits of the subject. Such is the case of *The Art of Feeling*, which uses EEG signals to detect positive or negative emotions, and The *Art of the Thrill* that visualizes the excitement one feels when driving a sports car by measuring one's heart rate, breathing, perspiration and body temperature. Finally, the more types of personal data are correlated in the visualization system, the more information it is possible to infer about the person portrayed, and the more ethnographically relevant the portrait becomes (e.g., *The Sixth Sense*).

5.2 Data collection and analysis processes

The different data portraits analysed involve diverse means of data collection and ways of processing data in the preliminary stages of their development, which determine their final outputs (Table 3). Biometric data and data on the surrounding environment are always captured by sensors embedded in self-tracking devices. If the portrait resorts to behavioural data it tends to use software (like web 2.0 services or platforms) or hardware, like sensors integrated IoT devices (e.g., smartphones or wearables like smartwatches, pedometers, and heart rate monitors).

Table 3. Analysis results — mechanics.

Portrait's intent	Data collection	Level of control	Recording format	Data analysis
Data double	Service providers Web 2.0	Non-deliberate	Textual Numerical	Statistical
Data mirror	Service providers Devices	Deliberate	Textual Numerical	Statistical None
Critical discourse	Service providers Devices Web 2.0	Deliberate Non-deliberate	Textual Numerical Other	Statistical None

Consequently, when the data portrait is intended to act as a *double* or a proxy for the subject/user, the behavioural data are usually captured in a passive and non-deliberate way, meaning that the user does not have to actively interfere with the data collection process (e.g., *PeopleGarden*). On the other hand, when the portrait aims to fulfil *reflexive* functions and is self-directed, the user has some degree of agency in the process of data collection, using self-tracking devices and applications (e.g., *Fitbit*).

When the visualization assumes a critical stance, it tends to combine deliberate and non-deliberate methods of data collection (e.g., *Poisonous Antidote*). In this case, personal data is often reappropriated from web 2.0 platforms (e.g., *Data as Object*) and used as a means of understanding what these platforms actually 'know' about us (e.g., *Data Selfie*). Such is the case of *Spigot (Babbling Self-Portrait)* that uses data from Jason Salavon's browser search history, which Google keeps in file and uses to build consumer profiles. In most cases, personal data is handled by the visualization system, mostly, in numeric format, as a quantification of human experience or the real world.[10]

10. After being extracted from the human experience or the real world it is converted to a scale of pre-established numerical values. This quantification process aims to simplify the treatment of data by the computational media. Nevertheless, some of the projects also use data in textual format as a complement.

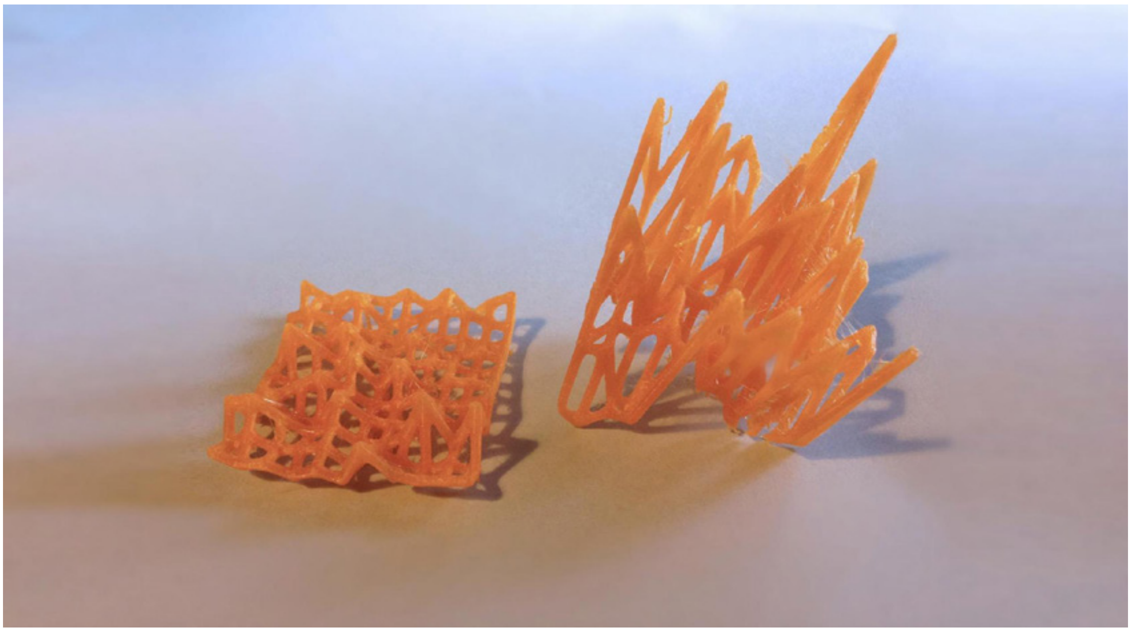


Fig. 2. *Data as Object*, Brendan Dawes, 2014.

Consequently, and concerning the methods of data analysis, in addition to correlating various types of data to create ethnographically relevant data portraits, most projects also resort to the statistical analysis of data. They rely on quantified data to generate knowledge about the self, thus measuring various aspects of the individuals' daily experiences, and employing arithmetic operations to reveal behavioural patterns. This happens predominantly with portraits directed towards self-observation that resort to self-tracking (e.g., *Halo*), or in projects that seek to assess what information can be inferred by third parties from the data we dissipate on daily basis, even without our total awareness (e.g., *Data Selfie*). However, statistical analysis is not always involved, and projects like *Floating Map (Life Location Project)*, which translates geolocation data into geometric plexiglass sculptures, use personal data as raw material for creating expressive visualizations, emphasizing the creative possibility of mapping abstract data into any tangible form.[11]

11. These projects explore the visual representation of personal identity by employing the concept of transmutability of digital data that states that any kind of digital data can be translated into image or sound (Levin 2010, 273).

5.3 Visualization and expression of data

The diversity of modes of expression and formal aspects of data portraits reflect specific approaches to personal data, which can also be related to the portrait's function (Table 4). In this sense, most of the projects analysed use hierarchical, temporal, or spatio-temporal informational structures. Thus, the temporal dimension is often highlighted to express the variable nature of human experience over time and to favour the perception of patterns that emerge from data.

Table 4. Analysis results — experience.

Portrait's intent	Informational structure	Representational stance	Modes of expression	Output format	Behaviour	Nature
Data double	Hierarchical Relational Temporal Textual	Analytical Expressive	Visual	Digital interface	Interactive	Variable
Data mirror	Relational Temporal Spatial Spatio-temporal	Analytical Expressive	Visual Audiovisual Material	Static image Physical object Moving image Digital interface	Contemplative Interactive	Static Transient Variable
Critical discourse	Hierarchical Relational Spatio-temporal	Analytical Expressive	Visual Audiovisual Material	Static image Physical object Moving image Digital interface	Contemplative Interactive	Static Transient Variable

However, despite using common information structures for data visualization, the representational stance often privileges expressiveness over legibility or analytical features (e.g., *Halo*). In contrast to visualizations of an analytical nature, data portraits value the subjective expression of data because, even if "the goal of visualization is often accuracy", the data portrait is also "an artistic production, shaped by tension among the often-conflicting goals of the subject, artist and audience" (Donath 2017, 187).

Given that the focus of the analysis is on visualizations (rather than sonification) the modes of expression are predominantly visual, be it moving images (e.g., *Porsche BlackBox*) or, sometimes, graphic interfaces (e.g., *Heart of Travel*). Complementary outputs, like prints (e.g., *The Sixth Sense*) or physical objects are also explored, in installation or performance settings (e.g., *Poisonous Antidote*), emphasizing the plasticity of digital data.

Fig. 3. *Building Hopes*, Accurate, 2018.

According to these mostly static and transient outputs, data portraits are mainly contemplative, even though recent data portraits increasingly tend to have interactive properties, allowing users to explore the visualization at will (e.g., *Building Hopes*) or to manipulate its parameters (e.g., *Heart of Travel*). Thus, variable outputs are present across all kinds of data portraits, but they are still less frequent due to technical constraints since they require the system to respond in real-time to variations in the data flow.

6. Discussion

This analysis reveals how data portraits fulfil the same biographical, documentary, and reflexive functions inherent to traditional forms of portraiture. Although distanced from a mimetic stance based on physical appearance, they evoke the expressive and communicational functions of their classic counterparts as essentially tied to the representation of the subject before the other and/or before himself.

Data portraits that act as a *data double* or proxy of an individual in social contexts tend to have very clear and legible content and visualization strategies (Fig. 4). In this sense, the role of data double can be considered the most pragmatic function of data portraits, as applied to a specific context, which also helps to delimit the data they rely on, the data analysis, and the visualization strategies applied. Accordingly, it relies on behavioural data that is prone to reveal behavioural patterns, often collected through service providers and Web 2.0 platforms, in automated non-deliberate ways. Resorting to different types of informational structures used, their representational stance can nevertheless vary between analytical and expressive, and being applied to an online environment, the modes of expression are mostly visual, as interactive digital interfaces. The data portrait, as a double, aims at effectively communicating identity traits that are relevant to the social dynamics between users in virtual environments. As such, it is also a contextual portrait, both an individual and a collective portrait that emerges from the need of interfacing social interactions within online communities.

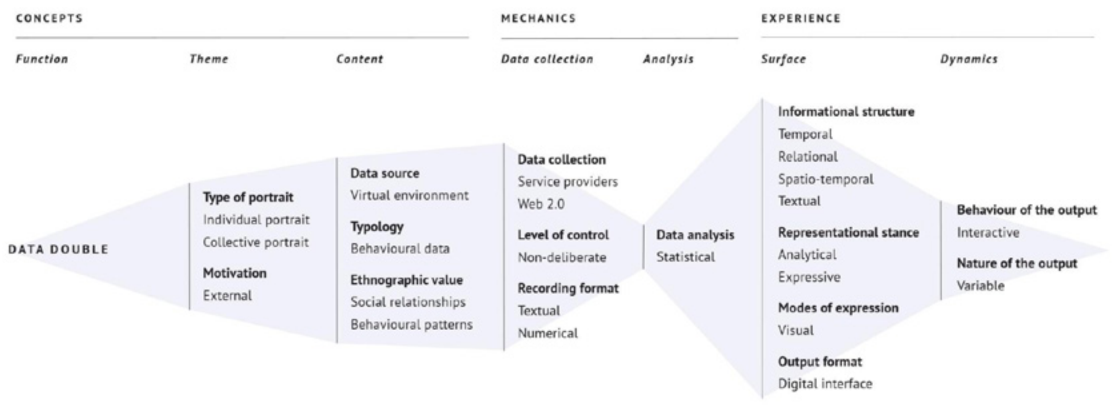
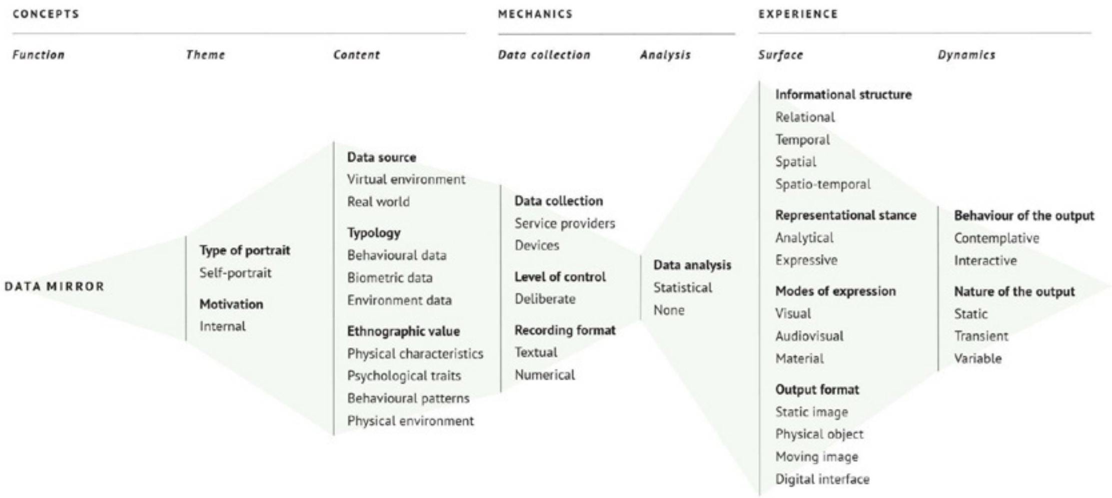


Fig. 4. Characteristics of the data portrait as data double.

When acting as reflexive *data mirrors*, directed towards self-observation, data portraits convey relevant characteristics of identity that are valued mostly within the individual's private sphere (Fig. 5). As such, their themes are well circumscribed, as self-portraits that emerge from internal motivations. But the data that they resort to can be broader in scope in relation to the other functions of data portraits, comprising the virtual environment, and the real world, as behavioural, biometric, or environment data. The ethnographic value of the portrait is also broader since these portraits can convey physical characteristics, psychological traits, behavioral patterns and information about the physical environment of the subject/user. Therefore, contrary to what happens with portraits that fulfil the function of data doubles, data portraits that act as data mirrors are based on the deliberate collection of personal data, made through service providers and personal devices. Often using statistical analysis of data, data mirrors present more diversified visualization strategies, oscillating between objectivity and subjective expression. This diversity is also reflected in the output formats, sometimes explored as complementary expressions of the same data portrait. For example, a static image can evoke aspects of traditional portraiture, such as the crystallization of a moment in time, materialized for future contemplation. In contrast, dynamic visualizations are evolving self-portraits that unfold in real-time, seeking to highlight the changing nature of human experience and identity over time.

Fig. 5. Characteristics of the data portrait as a data mirror.



Finally, when devised as *critical discourse* on the quantification of all aspects of human experience as digital data, data portraits often point towards the various political implications of the current uses of personal data (Fig. 6). Consequently, they source their data from virtual environments taking advantage of the behavioural surplus, and commenting on its commodification, by extracting as much information on the individual as possible. Hence the broad ethnographic scope and diversity of data collection processes, also tackling possible ways of reappropriating data traces from service providers, devices of everyday use, and web 2.0 infrastructures. Similar to the reflexive functions of data portraits that act as data mirrors, these critical artifacts also explore diverse visualization strategies to reappropriate personal data and use it to the user's advantage, as a tool for self-knowledge. Consequently, this kind of critical stance can be internally or externally motivated, having both applied or artistic purposes, and combining a critical discourse with the role of a self- or individual portrait.

Fig. 6. Characteristics of the data portrait as critical discourse.

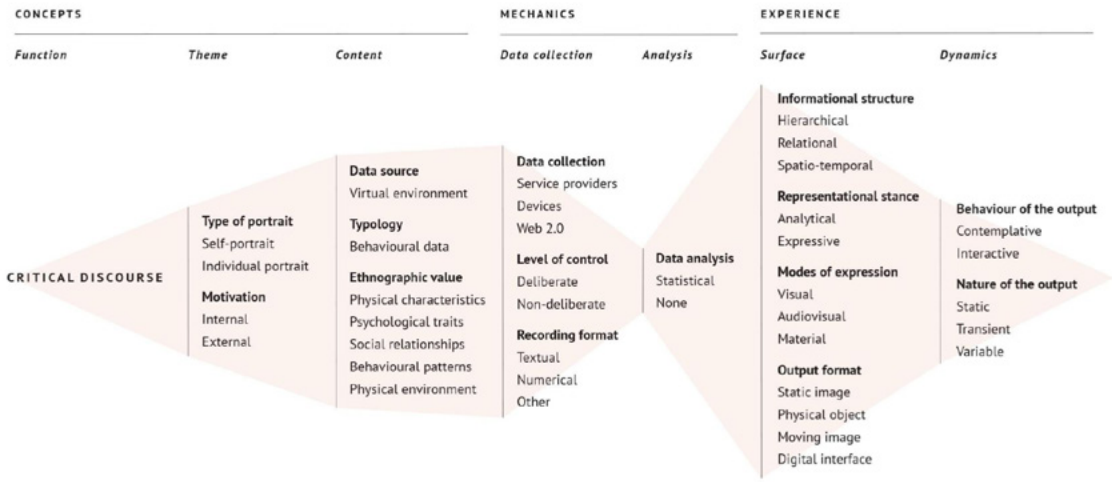


Fig. 7. Variations in the scope of concepts, mechanics, and experience of the three functions.

One of the aspects differentiating these functions are the sources and typology of data, as well as their ethnographic value as expressed by the visualizations (Fig. 7). Even if these functions of data portraits are better accomplished when more data sources and typologies of data are articulated, as ethnographically relevant data for conveying identity, relevance is also relative to the context in which the data portrait is produced and circulates.

7. Conclusion

This analysis sought to point out the design strategies and methods that become relevant to the communicative and expressive functions of data portraits, as designed artifacts that take advantage of the potential of using personal data as a raw material to represent and convey identity, as well as to critique and raise awareness of the implications of our digital footprint, and how it reveals identity traits.

To fulfil these communicative and expressive functions, data portraits can use the same sources of data but diverge in their visualization strategies. When the data portrait is designed according to a *reflexive* or a *proxy* function, it usually resorts to relational and spatio-temporal informational structures, since it favours the perception of data variability over time. In addition, it also makes clear the human provenance of the input data, as in *Halo* (2017), by Peter Crnokrak. However, when the data portrait aims at establishing a critical discourse on the appropriation of personal data by service providers or questions the lack of user agency over their data, the visualizations tend to be devised as metaphors of the big data universe which, according to Ge, et al. (2018), is characterized by its volume of data, variety, and veracity. In this case, the visualizations usually favour a contemplative experience, through a cumulative representation of the different types of data that are generated and collected about individuals, as with *Poisonous Antidote* (2016), by Mark Farid.

In sum, these visualizations of personal data are designed to convey relevant identity traits, both for the represented individual and within their social sphere. At the same time, they also question the dematerialization and technological mediation of social interactions, by dwelling on the dissociation between our physical and our digital selves.

Consequently, data portraits also point to a reconceptualization of portraiture, informed by the creative potential of computational media, and reflecting changes in the way we create and experience this representational genre. In this sense, we can evoke how, thirty years ago, in the conclusion of his essay on *Portraiture* (1990), Brilliant wrote that maybe portraiture as a distinctive genre would disappear when "instead of an artist's profile portrait the future will preserve only complete actuarial files, stored in some omniscient computer, ready to spew forth a different kind of personal profile, beginning with one's Social Security number" (Brilliant 1990, 174). On one hand, this statement evokes the extension of current practices of data extraction for profiling individuals, which we can observe in the context of surveillance capitalism. On another hand, it also suggests how the creative practices addressed in this paper can take advantage of the potential of personal data to convey personal identity in ways that more directly correspond to one's lived experience than what mere appearance can convey.

Therefore, data portraits can be seen as a counterpart to Brilliant's idea, by taking advantage of personal data as a raw material for portraiture, distanced from an analytical stance and favouring subjective expression. As a means of visualizing subjectivity, and as visualizations of a subjective nature, data portraits point towards an expansion of portraiture, rather than its disappearance. They suggest how portraiture evolves as "numbers are infiltrating the last redoubts of the personal" (Wolf 2010) and this representation genre expands becoming more attuned to our current mode of living immersed in data.

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A virus called Ika-tako and other (digital) cute aggressions

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This article investigates the relationship of computer viruses with the concept of "cute aggression" and its tentacular ramifications, taking as a springboard the Ika-tako virus: a malware created in 2010 by a Japanese NEET called Masato Nakatsuji, which replaced data files with amateurish drawings of cartoony octopuses and squids. Dividing the analysis into three sections that address issues of its production, content, and reception, and connecting the Ika-taku virus to a set of further transgeographical and transhistorical examples, I seek to demonstrate how these instances of cute aggression push the boundaries of playfulness, spontaneity, and naivety, threading into a territory where cuteness, race, sexuality, and cybercrime conflate.

Keywords cuteness, cybercrime, Japan, *kawaii*, malware, otaku, ransomware, *yuru-kyara*

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1. Introduction

In August of 2010, media all over the world, from online technology news websites like *PC World* and *The Wired* to television shows like *The Colbert Report*,[1] covered the news of a Japanese computer virus that replaced data files with cartoony octopuses, squids, and sea urchins. The Ika-tako virus (イカタコウイルス), translating to English as “Squid-octopus” (in Japanese, *ika*, イカ, means “squid” and tako, タコ, means“octopus”), was uploaded to the Internet by an unemployed 27-year-old man called Masato Nakatsuji, infecting somewhere between 20000 and 50000 computers worldwide. The malware, disguised as a music file, lurked in the depths of Winny, a Japanese P2P file-sharing program for Windows. When executed, it worked through the affected hard disks, sending their files to a central server set up by Nakatsuji and replacing them with homemade drawings of marine invertebrates. [Figure 1] Eventually, Nakatsuji was arrested and sentenced by the Tokyo District Court to two years and six months in prison on charges of property destruction.

1. *The Colbert Report* was an American talk and news satire television show hosted by Stephen Colbert, with a large cultural impact on American society and culture.

Fig. 1. Screengrab of a computer infected with the Ika-tako virus.

Nakatsuji’s drawings resembled the “loose” aesthetics of Japanese *yuru-kyara* (“relaxed characters”). *Yuru-kyara* are unsophisticated mascots whose wobbly, awkward looks make them all the more lovable (Occhi 2012, 113; Suter 2016, 777). [Figure 2] Icons of Japanese *kawaii* (“cute”) culture, such as Hello Kitty, are meant to have an enjoyable, even healing effect on observers (Occhi 2012, 111, 113); but unlike Hello Kitty and other polished corporate commodities, the *yuru-kyara*’s primary function is to “convey a strong message of love for one’s hometown” (Suter 2016, 777), promoting tourism to increase a region’s revenue. Even though they are driven by economic goals, to general audiences, *yuru-kyara* come off as noncommercial characters, more earnest and flawed than the slick products of well-oiled profit machines like Sanrio (Hello Kitty’s motherhouse). The unassuming quality of Nakatsuji’s amateurish drawings, too, is *yurui*, meaning “loose,” “wobbly,” “slack,” or “relaxed.” The most circulated Ika-tako virus mascot in the media was a bubble-shaped orange octopus with chubby tentacles and a round mouth. This character appeared in several variations: giving a friendly wave, comically angry, or wearing an afro. Other figures by Nakatsuji included a spirited white squid, a lazy-looking whelk, a sleeping sea urchin, a drooling jellyfish, and a bowtie- wearing starfish. Also, surprisingly, a mole, the only mammal in the group—an animal that lurks underground instead of underwater, but a lurker nonetheless. [Figure 3] The dissonance at play here is that, although Nakatsuji's characters look *yurui*, they are destructive rather than healing, like any form of digital pollution, prompting the Ika-tako virus to vacillate between cuteness and aggression, friendliness and antagonism.

Fig. 2. Funassyi is a popular *yuru-kyara*. It represents the city of Funabashi, in Chiba.

Fig. 3. Ika-tako virus characters by Nakatsuji Masato.

This article takes the Ika-tako virus as an aesthetic and poetic launching pad for a wider discussion on the relationship of computer viruses with the concept of "cute aggression" and its tentacular ramifications. Cute aggression, here, is understood not only in its stricter sense as "aggressive impulses caused by an excess of cute affect" (Dale 2016, 40) but, more broadly, as the simultaneous combination of lovability and aggression in a single entity. Typical examples of cute aggression are expressions of affection such as "it's so cute I could crush it" (Stavropoulos and Alba 2018) or "it's so cute I want to die" (Dale 2016, 40), used when faced with, for example, a baby or a puppy; these phrases eloquently illustrate the point that, as Cute Studies scholar Joshua Dale notes, an "encounter with cuteness seems fraught with the possibility of violence" (Dale 2016, 40). Therefore, though one could argue that cuteness and aggression are intrinsically linked at their core, cute aggression has also become a recurrent trope in pop-cultural artefacts, with well-known examples in the West such as the animated web series *Happy Tree Friends*, but especially in connection with Japanese manga, anime, and *kawaii* cultures. The popularity of styles like *yami-kawaii* ("sick-cute"), *buso-kawaii* ("ugly-cute") or *guro-kawaii* ("gore-cute"), that inspired internationally acclaimed music idols like Kyary Pamyu Pamyu, is one of the most visible manifestations of this phenomenon. [Figures 4 & 5] At the same time, and given how ubiquitous cuteness has become in Internet culture over the past couple of decades, it's relevant to understand how the various facets of digital society have been shaped by this growth, specifically, when things get a little chaotic, like with trolls or malware, both of which can be considered as forms of digital pollution. I will leave the former—e.g., right-wing trolls with Twitter icons showing cute anime girls—for a future occasion. For now, the Ika-tako virus can serve as an interesting starting point for thinking about the latter.

Fig. 4. A popular character from the *yami-kawaii* manga series *Wrist-Cut Transformation Subculture a Menhera* (more commonly known as Menhera-chan) by Ezaki Bisuko.

Fig. 5. Examples of yami and *guro-kawaii* visuals by Japanese musical idol Kyary Pamyu Pamyu.

Two aspects of the Ika-tako virus stand out in this context. To begin with, it speaks of the real damage that cute objects and subjects *can inflict upon us*, since Nakatsuji's *yurui* characters are active participants in their creator's cybercrime, and their actions are what bring them into the realm of aggression (by themselves, the cartoony sea animals are "just" cute). As a result, it is different from looking at an illustration drawn in a *yami-kawaii* style, that may depict cute aggressions but does not *do* anything harmful to the viewer. In addition, since the literal reference to octopuses and squids is embedded within one's experience of the Ika-tako virus, it is ideally suited for a *tentacular* analysis of the imaginative universes that unfold from it—a mode of thought reminiscent of philosopher Donna Haraway's "tentacular thinking"(Haraway 2016), with all its twists, turns, detours, and knots. In fact, as I have argued elsewhere, as "a dumb aesthetic" (Legge 2016, 142), "cuteness resists, even repels, the seriousness expected from art and the academia" and "No matter how much thought one puts into analysing cute things, there remains an impression of an academic hoax" (Sousa 2020, 48), approaching it from the point of view of aesthetics invites us into more speculative and entangled territory so as to accommodate it. The Ika-tako virus, therefore, serves both as a case study of cute aggression in and of itself and a magnet for the connections one can establish with several other pieces of media, past and present, whose aesthetic and poetic valences touch on similar themes, like tentacles reaching out in different directions.

In the following sections, I will address issues related to, firstly, the contents and reception of the Ika- tako virus, especially concerning the link between tentacles and cute aggression in pop culture, Japanese animation, and comics, and how this often carries sexualized and racialized undertones. Secondly, how these cute aggressions find resonances in the association between the idea of the "naughty child" and the behaviors and social condition of its creator, Masato Nakatsuji, as representative of a type of man linked to otaku and NEET cultures and encapsulating ideas of disruptive immaturity in the context of Japanese society. And thirdly, I will discuss how the connection of the "naughty child" and their cute aggressions to malware, far from being fortuitous, has roots in the latter's very genesis, such as in the historical Cookie Monster virus, and the relationship of the Ika-tako virus to others that evoke a certain "age of innocence" of playful computer viruses, like the more recent Rensenware.

2. Ika-tako and beyond

2.1 Tentacular (cute) aggressions

The media responses to the Ika-tako virus demonstrate the ease with which these slip into negative and racialized realms beyond the scope of a simple piece of malware. For instance, in *The Colbert Report*,[1] the popular American host Steven Colbert remarked that the Ika-tako virus was surprising because "believe it or not, these Japanese squid drawings are not pornographic" (Hoskinson 2010). Another blogger proclaimed that "Cthulhu attacks Japan's file-sharers," stating that the "Ikatako virus… replaces files with pictures of the great squid-god, Cthulhu" and labelling it a "Tentacle Attack" ("Cthulhu Attacks Japan's File-Sharers" 2010). The fact that, in the western collective imagination, mentions of "squid" and "Japanese" evoke extravagant tentacle erotica and Lovecraftian monstrosity is also observable in an (in)famous short sketch of the American adult animated sitcom, *Family Guy*.[2] [Figure 6] After Stewie corrects Brian that *tai chi* is originally from China, not Japan, he adds that "the Japanese have a whole other thing going on." In typical *Family Guy* fashion, the scene cuts abruptly to a Tokyo street where two Japanese men stand talking to each other. The following scene takes place:

> Japanese guy 1: Hey, you wanna see a movie?
>
> Japanese guy 2: Nah we're Japanese, let's go watch a schoolgirl bang an octopus! Both: [While high fiving] Yeah!
> [An anime octopus slides onto the screen]
>
> Octopus: Oide dakishimete ageruyo, suction cup feel goooood!
>
> [An anime schoolgirl slides onto the screen while the octopus goes after her] Schoolgirl: [high-pitched] Hiiiiiiiii!
> Octopus: Hmmmm Ha ha haayy…"

2. *Family Guy* is an American animated sitcom created by Seth MacFarlane for the Fox television network. It has been the target of copious criticism and controversy due to its dark humor, sexual themes, and racial jokes.

Fig. 6. *Family Guy*'s Japanese octopus sketch (https://youtu.be/2pYfUtBfS6c).

This sketch exploits the racial stereotype of Japanese men as sexual deviants with bizarre fetishes. Nevertheless, the fact that the production team chose to shift its usual animation and art style in order to accommodate the anime octopus and schoolgirl is highly suggestive. While the octopus talks and moves around, his body is still with the exception of the jerky movements of his mouth and tentacles. In turn, the schoolgirl, a generic female character that is reminiscent of Sailor Moon, is entirely static, sliding across the screen rather than walking. The perversion of this scene is emphasized by the octopus's appearance as a gigantic, energetic purple cephalopod with plump tentacles, large sparkling eyes, and a coy :3-shaped smiley face, closer to a friendly Superflat mascot than to Hokusai's famous *shunga*[3] octopus (although this one, as is typical of this style of Japanese print, also reflects a playful and humorous approach to sexuality). In this way, the sketch parodies what is perceived as markers of "Japaneseness" in anime: on the one hand, its limited animation (Lamarre 2009, 316), i.e., the technique of "moving drawings" instead of "drawing movements" (Lamarre 2002), that often characterizes anime on a formal level; and, on the other, its perverted cuteness, in which the aesthetics of *kawaii* function as an ambivalent symbol of innocence and deviancy. Indeed, the general leniency of Japanese comics and animation towards sexually suggestive contents has raised many eyebrows, both internationally and domestically, sometimes derived from clashes between the different media environments in which these works circulate (McCurry 2014). For instance, in Japan, the popular kids' TV show *Crayon Shin-chan* actually ran in comics magazines targeted at a "young adult" demographic, before being adapted into an animated series aimed at children and broadcast at the same time slot as other more innocuous (or, at least, more canonically family-friendly and free from eruptions of scatology and sexual innuendo) shows, like *Doraemon* (da_chicken 2021). As such, *Shin-chan* "has delighted Japanese children, and infuriated their parents, for more than two decades" (McCurry 2014; Pera 2017) and continues to raise complaints and restrictions in countries like Portugal and Indonesia—despite the heavy glocalization that the series is subject to in the West, that significantly softens its "unpalatable" contents (da_chicken 2021).

3. *Shunga* is a form of erotic art from Japan. Most *shunga* were color woodblock prints (*ukiyo-e*) featuring nudity and explicit sexual content. Hokusai's *The Dream of the Fisherman's Wife* (1814) is one of the most famous *shunga* (Stanska 2017).

The connection between monstrous tentacles and cuteness is not limited to stereotypical Western views on anime, as one also finds it in Japanese shows, usually played for comedic effect. An example of this is the popular manga series *Shinryaku! Ika Musume* ("Invade! Squid Girl") by Anbe Masahiro, whose protagonist is an adorable anthropomorphized girl with hair shaped like blue tentacles. [Figure 7] Although *Ika Musume* is a slice of life comedy with an environmental message—the Squid Girl seeks revenge on humankind for polluting the ocean—the series is no stranger to tentacle rape (in Japanese, *shokushu goukan*) allusions, both in the show and in the works of fans. For instance, the entry for "Squid Girl" in the satirical website *Encyclopedia Dramatica* features various pornographic illustrations of Squid Girl assaulting other female characters with her tentacles. [Figure 8] The fear that octopuses and squids, no matter how cute they appear on the surface, will turn sexually aggressive, speaks to a lineage of tentacle erotica in *ero-manga* and anime pornography (commonly known as "*hentai*" in the West) arguably initiated in 1814 by Hokusai Katsushika's famous erotic woodblock print *Tako to Ama* ("Octopuses and shell diver," known as *The Dream of the Fisherman's Wife*). [Figure 9]

Fig. 7. Manga series *Shinryaku! Ika Musume.*

Fig. 8. Image macro parody of Shinryaku! Ika Musume cute heroine threatening to sexually assault the victim with her tentacles.

Fig. 9. Hokusai Katsushika, *The Dream of the Fisherman's Wife (Tako to ama)*, 1814.

As scholar Laura Ettenfield points out, in the West, octopus-like monsters also have a history of association with unrestrained, primitive female sexuality, as is the case of Victor Hugo's novel *Les Travailleurs de la Mer* (*Toilers of the Sea*, 1866) (Ettenfield 2018, 78). Nevertheless, because of how pervasive tentacle erotica is in Japanese comics and animation, the Ika-tako virus would be a completely different and arguably less interesting object had Nakatsuji used photographs or realistic drawings of tentacled creatures. Of course, it would still align with the broader oceanic terror, or thalassophobia, widespread in literary and popular culture—which has its most well-known representatives in Jules Verne's giant octopuses in *Vingt mille lieues sous les mers* (*Twenty Thousand Leagues Under the Sea*, 1870) and H. P. Lovecraft's tentacled abomination, Cthulhu—but the perverse connotations to Japanese animation would be lost. The same applies to the *Family Guy* sketch, whose pervertedness would be decreased had the show's standard art and animation been used to depict a "real" octopus and woman. The characters' cuteness is thus at the heart of the heightened sense of violation at play, whether it is sexual, in the case of *Family Guy*, or otherwise invasive, in the case of the Ika-tako virus, that penetrates computers to destroy data.

2.2 Naughty children

In the case of the Ika-tako virus, the cute mascots are goofy and relaxed, giving off an impression of blissful innocence, as if unaware of the nefarious consequences of their actions. They are like naughty children, whose behavior, however disruptive, is, or should be, according to common perceptions about the naughtiness of children, fundamentally benevolent. Indeed, Nakatsuji, the creator of the Ika-tako virus, channels this "naughty child" image himself. A graduate student from the Osaka Electro-Communication University, many news reports stressed that Nakatsuji was an unemployed techie in his late twenties, like the stereotypical otaku[4] or NEET (the acronym for Not in Education, Employment, or Training) "parasite

4. Otaku is the Japanese subculture roughly equivalent to the Western "geek" or "nerd" and is now a word included in most English language dictionaries, as it has entered the common vocabulary, particularly on the Internet, to mean an obsessive fan of Japanese comics, animation and video games.

singles,”[5] perceived to be socially or intellectually immature by Japanese society at large. Indeed, despite Cool Japan campaigns to rehabilitate the image of the otaku in the eyes of the general public,[6] they remain to this day the epitome of Japan’s postmodern afflictions (Vincent 2010), as “failed men” (Galbraith 2015, 27) who embody the breakdown of discipline, work ethic, and other heteropatriarchal principles. Moreover, in the collective memory of the Japanese, the otaku are linked to horrific events like Miyazaki Tsutomu’s brutal child killings in the late 1980s—he was dubbed the “otaku murderer” by the media for being a fan of anime, manga, and slasher horror movies—or the more recent Kyoto Animation arson attack in 2019, that represent the darker consequences of alienation through fantasy.[7] Like artist Murakami Takashi’s “little boy” (Murakami 2005) theory, the otaku as a lost/infantilized man symbolizes the “displacement of progressive social and political ideals and involvement, and withdrawal into the selfish and conformist middle-class domesticity and material comfort of privatized family life” (Yoda 2006, 246). As Nakatsuji’s actions seem to demonstrate, this regressive movement breeds its own streak of pent-up resentment and frustration, eventually manifesting in antisocial behaviors and destructive actions against the social and technological structures of post-industrial society.

Significantly, the Ika-tako virus incident was not the first time Nakatsuji was arrested for a cybercrime. In 2008, he had been detained in relation to coding and distributing the Harada virus, then one of Japan’s “Big Three” viruses (Kageyama 2008), named after an acquaintance of Nakatsuji’s called Harada (“Japanese Police Arrest Inventor of Computer Virus” 2008). [Figure 10] Nakatsuji also distributed a Harada subspecies that replaced data with stills from the cult anime series *Clannad*, showing the heroine walking amidst falling cherry blossoms (Geere 2010). [Figure 11] Other subspecies of the Harada virus used *moé*[8] characters from shows like *Haruhi Suzumiya*, *Lucky Star*, and *Kanon*. In addition, the pictures were captioned with digitally superimposed phrases admonishing the users of Winny for their illegal file-sharing activities (“Kyou Is a Virus …” 2010). [Figure 12] Such a controversy was brewing in Japan at the time, as Winny’s developer Kaneko Isamu was fined and arrested in 2004 for encouraging users to copy and distribute movies, games, and other contents illegally (although the Osaka High Court overturned the decision and acquitted him in 2009) (*The Japan Times Online* 2013). During his own trial, Nakatsuji argued that “If movies and animated films are illegally downloaded, TV networks will stop showing these programs in the future.” And added: “My hobby is to watch recorded TV programs, so I was trying to stop that” (“Japanese P2P Virus Writer Convicted, Escapes Jail” 2008). Ironically, because back when Nakatsuji was detained, Japan lacked laws against malware creation and distribution, he was sentenced to two years in prison and a three-year suspended sentence for the copyright infringement of *Clannad*, as well as for defaming a fellow student (presumably, Harada) (Loo 2008).

5. A “parasite single” is an adult who chooses to stay at their parents’ house indefinitely and typically live at their expense, without marrying or making any other attempts to become independent. It is a phenomenon that has become particularly evident in developed countries in America, Europe, and Japan.

6. “Cool Japan” is the name of a series of government-sponsored policies and advertising campaigns, started in the early 2000s in Japan, that aim to increase the country’s “soft power” by exploiting the popularity of domestic pop culture among foreign youth, in particular, manga, anime, video games, music, and *kawaii* culture.

7. As Japanese popular culture becomes an increasingly global phenomenon, the moral panics triggered by such events are also more likely to spread. Take, for instance, a recent incident involving a young student planning an attack on a Portuguese university, who was flagged and prevented in time by the police from carrying it out (Henriques, Oliveira, and Silva 2020). In the sensationalist media, detailed reconstructions of the student’s room were shown featuring anime figurines, collages with manga panels, and plushies from popular series like *Pokémon*, stating that he was a fan of cartoons from Japan, and with psychologists on TV claiming that the memorabilia and the plushies were markers of immaturity.

8. *Moé* is a slang word originating from the otaku subculture that has a complex and polyphonic meaning. In terms of character design trends in Japanese comics, animation, and video games, the aesthetic of *moé* is characterized by a preference for cute, round characters evoking the image of a “little sister”.

Fig. 10. Screengrab of the Harada Virus.

Fig. 11. Example of a picture used in the Clannad Virus, featuring the main heroine Furukawa Nagisa.

感染経路 1 : Propagates via network shares

特 徴:

This worm arrives on a system as a file dropped by other malware. It can also be downloaded unknowingly by a user when visiting malicious Web sites.

It can also arrive via network shares.

Upon execution, it drops several copies of itself on a hardcoded path.

This worm propagates by searching for files in all accessible network shares. If it fin files inside the shared folders, it replaces said files with copies of itself.

In addition, this worm displays an immovable window on the affected user's screen with the following image:

Furthermore, this worm searches for folders inside the *C:\Program Files* folder for fil bearing an .EXE file name extension. If it finds .EXE files in the said folders, it replac

Fig. 12. Notice regarding another form of Harada virus, featuring the character Hiiragi Kagami from the anime and manga series *Lucky Star.*

Nakatsuji's justifications for his actions, namely, his statement that he was trying to save the Japanese culture industry from piracy by creating and distributing a computer virus, grant him the aura of a "naughty child" with his heart in the right place but questionable means. In the same vein, Nakatsuji told the police that he did not think that he would be arrested for the Ika-tako virus, as he had created the squid and octopus drawings himself (Geere 2010) and, as such, had not violated any copyrights, as opposed to what had happened upon his first arrest. When questioned about the Ika-tako virus, Nakatsuji also claimed that "I wanted to see how much my computer programming skills had improved since the last time I was arrested" (Geere 2010). These declarations align Nakatsuji with what Sharon Kinsella calls the "little rebellion" (Kinsella 1996, 243) of Japanese cuteness instead of the more conscious and aggressive stances that often characterize Western countercultures. Although

Nakatsuji's words are not openly confrontational, they make a mockery out of petty copyright laws and the absurd fact that he had been arrested for violating intellectual property instead of his actual cybercrime. Indeed, Japan's bill against cybercrime was only approved and revised in 2011, one year after Nakatsuji was sentenced, this time around, for property damage caused by the Ika-tako virus— another workaround used by the Japanese authorities to punish malware developers in the absence of specific laws (Someya 2011). Likewise, Nakatsuji's drive to do his best in malware creation jabs at Japan's culture of *ganbaru* ("perseverance," "doing one's best"), whose ubiquitousness rivals that of the *kawaii*, and that many Japanese consider oppressive (Jones 2015).

2.3 Playful malware

All in all, the Ika-tako virus could be said to have a nostalgic quality, resembling "the cute computer viruses of the past" (McCormick 2016). As Rich McCormick puts it in an article for *The Verge*, there was an earlier, more earnest period in computer history when flashy malware set out to destroy a computer, pure and simple, instead of mining for credit card information and other exploitable data (McCormick 2016). The Malware Museum, for instance, offers an online archive of these computer viruses from the 1980s and 1990s that operated in MS-DOS; the viruses have been neutralized, removing their harmful code and leaving only the colorful, playful visuals that can be downloaded by the Museum's visitors. Some of these old viruses, like "Mars Land," appeal to the poetic beauty of the medium, showing a digital landscape of red dunes with the tagline "coding a virus can be creative." [Figure 13] Others take a more straightforward approach, like "one piece of nefarious code that simply displays the word 'ha!' in flickering ASCII characters" (McCormick 2016). [Figure 14] The Ika-tako virus may be less spiteful in tone, but its mixture of destructiveness and playfulness is certainly not inferior to these older viruses—quite the contrary.

Fig. 13. GIF animation of the malware "Mars Landscape 2by Spanska, from the Malware Museum.

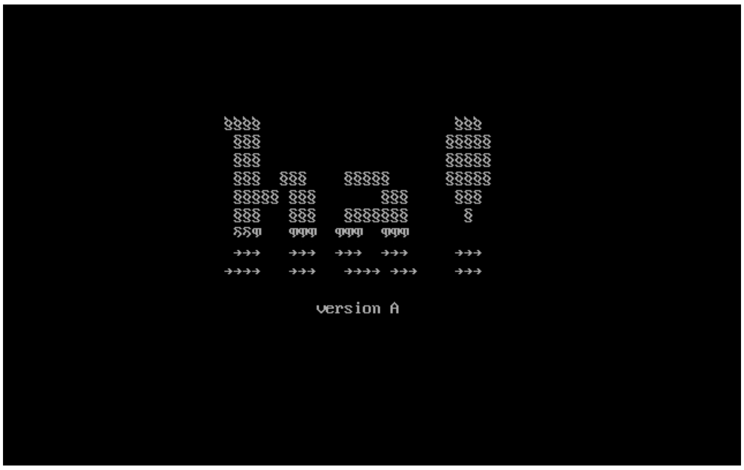

Fig. 14. "Ha" malware, from the Malware Museum.

While computer viruses and cuteness may seem like an odd pairing, their history interlocks from their onset. The Cookie Monster program from MIT Multics, often credited as the world's first computer virus, "was named after a recurring "Cookie Bear" sketch on the American variety TV series *The Andy Williams Show*, in which a guy in a comical bear costume tries all sorts of mischievous and amusing tricks to get a cookie from the show's protagonist (who would yell at the bear "No cookies! Not now, not EVER!!!" and slam the door in frustration), serving as an inspiration for the annoying behavior of the program (Tavares 1995). The original program was a harmless prank codded by an IBM computer operator at Brown University in the late 1960s, who manually activated it to tease unsuspecting students (Tavares 1995). In 1970, an MIT freshman, Seth Stein, created an automated version of the Cookie Monster that "spread from its birthplace... to practically every Multics site in the world" (Tavares 1995), including the Pentagon— even though, unlike later viruses, the Cookie Monster did not replicate itself, thus having to be transferred manually from site to site via magnetic tape (Tavares 1995). The Cookie Monster ran in the background, occasionally blocking the computer to display a message requesting a cookie. After a few minutes, if no action took place, it flashed the message "I didn't want a cookie anyway" and disappeared (Fitzpatrick 2008).

If users typed in the word “cookie,” the Cookie Monster flashed “thank you” and went to sleep, unblocking the computer (Fitzpatrick 2008). [Figure 15] Rumors have it that writing the word “Oreo” would remove the virus entirely (Posey 2000). In popular culture, the program came to be associated with the Cookie Monster from *Sesame Street* (who only debuted in 1969, after the creation of the virus), mostly because of the 1995 film *Hackers*, which included a fictitious rendition of the Cookie Monster virus featuring the famous muppet. [Figure 16]

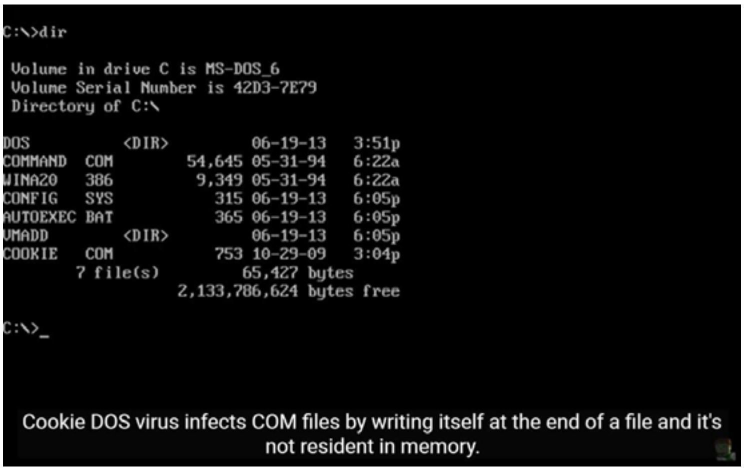

Fig. 15. Demonstration of Cookie Monster-like virus on YouTube (https://youtu.be/8PoU-mT-EBs).

Fig. 16. Cookie Monster scene from the film *Hackers*, directed by Iain Softley (Hollywood, CA: United Artists), 1995 (https://youtu.be/UkGhuXTasQc).

The playful nature of the Cookie Monster virus highlights how cuteness’s phenomeno-poetics are tied to the idea that, as historian Gary Cross puts it, “the cute can steal cookies from the cookie jar but do it without real malice or greed” (Cross 2004, 44). Ironically, this naughty but innocuous child, the Cookie Monster, opened Pandora’s box of malware, as similar programs began to be used to steal passwords from computer users (Wentworth 1996). More recently, a malware called Rensenware took the “cuteness” of Cookie Monster-like viruses to new, sadistic extents. Instead of asking for bitcoins like ransomware usually does,[9] Rensenware demanded that victims play *Touhou Seirensen~ Undefined Fantastic Object* (2009), the twelfth instalment of the cult series of Japanese “bullet hell”[10] shooter videogames, *Touhou Project*. *Touhou Project* (東方 Project) is a *dōjin* (self-published) game by the one-

9. “Ransomware,” a portmanteau of “ramson” and “malware,” is malicious software “used to mount extortion- based attacks that cause loss of access to information, loss of confidentiality, and information leakage” (Young and Moti Yung 1996, 159).

10. Bullet hell” is a subgenre of vertically-scrolling shoot’ em up videogames from the early 1990s, where players must dodge an overwhelming number (hundreds or thousands) of bullet-like projectiles, arranged in intricate patterns (“Bullet Hell” 2018).

person Japanese game developer Ōta Jun'ya, under the pseudonym ZUN, whose first instalment, *Highly Responsive to Prayers*, was released in 1996 for NEC's PC-9801. The series, featuring cute graphics and music in anime style, revolves around a shrine maiden who fights *yōkai* (a Japanese folkloric monster) while dodging waves of projectiles covering the entire screen. When Rensenware is activated, a pop- up window appears showing a picture of the character Murasa Minamitsu—a boss from *Undefined Fantastic Object* who is a female spirit in a sailor suit—requiring that victims not only beat the game but do so in maximum difficulty ("Lunatic") and reaching 200 million points. [Figure 17] The task is virtually impossible, as even the perfect playthroughs available online, displaying incredible levels of gaming skill, fail to get the 200 million mark. [Figure 18] Thus, while, at first glance, Rensenware was kind enough to grant its victims a chance to regain control over their computers, they were in for an incredibly frustrating ride. Gone are the days when "cookies" and "Oreos" were enough to appease an annoying but mostly harmless program.

Fig. 17. Rensenware malware pop-up window featuring the character Murasa Minamitsu from the videogame *Touhou Project.*

Video 18. Perfect playthrough of level 6 of *Touhou Seirensen~ Undefined Fantastic Object* (2009) in Lunatic difficulty (https://youtu.be/-A6w_cqPGow).

Rensenware, as it turned out, was also the work of a prankster. According to *Kotaku*, its creator was a Korean undergraduate student who wrote Rensenware as a joke because he was bored (D'Anastasio 2017). He fell asleep after uploading Rensenware to GitHub (an online software development platform for computer code), realizing the following day that it had spread. After that, he uploaded an "antidote" software accompanied by an apology to those affected by the virus (D'Anastasio 2017). "I made it for [a] joke," he wrote. "And just laughing with people who like Tōhō Project Series" (D'Anastasio 2017). Like the Cookie Monster, the cuteness of the Ika-tako and Rensenware viruses, resulting in both cases from their use of manga and anime visuals, reflects the nature of their creators as "naughty children" who wreak havoc out of boredom or earnest, if misplaced, intentions.

3. Closing remarks

This article finds itself at the intersection of the "emerging field" (Dale 2016a) of Cute Studies and the study of digital culture, examining the relationship between computer viruses and "cute aggression" and its ramifications. Cute aggression is a phenomenon in which cuteness and related categories, like the feminine, the infantile, and the playful, combine with the aesthetics or poetics of aggression to create a particular type of experience. In order to address the latter, I used the Ika-tako computer virus, developed by a Japanese man named Masato Nakatsuji, as a springboard for a tentacular analysis within which I draw upon other media objects that have meaningful relationships with it, both in terms of content and form. As I have argued, the Ika-tako is particularly suited to serve as such a catalyst, for several reasons. First, it is a piece of malware that incorporates the aesthetic of Japanese "relaxed mascots" (*yuru-kyara*) into its design, but also hints at a certain tradition of mistrust for tentacled creatures present in both literature and popular culture. Second, it offers a poetic connection to tentacularity through its direct reference to octopuses and squids. "Tentacular thinking" (Haraway 2016) has all to do with cute aesthetics and evading linear thought by taking a messier approach, achieved, here, through a patchwork of transhistorical and transgeographic examples that move away from and towards the "central" case study in centrifugal and centripetal movements.

Each of the three sections in this article—"Tentacular (cute) aggressions", "Naughty children," and "Playful malware"—contributes to a deeper understanding of how seemingly small objects and microphenomena, like a computer virus featuring cute drawings of octopuses and squids, can push the boundaries of playfulness, spontaneity, and naivety. The examples discussed range from Hokusai's *Tako to Ama* to the historical computer virus Cookie Monster, from the American cartoon series *Family Guy* to the intricacies of the slice-of-life universes of Japanese *kawaii* and *moé* cultures. A recurring theme in all of these sections is the idea of the prank or, one might say, "acting cute" as a form of subversion, whether openly antagonistic or not. The first section highlighted its more sexual undertones, while in sections 2 and 3, I have demonstrated that such "cuteness" may not be as unimportant for malware in general as one might expect. On the contrary, not only is the historical emergence of computer viruses rooted in a cute prank (the Cookie Monsters virus), but the creators of viruses such as Ika-tako and Rensenware, which are explicitly associated with the aesthetics of *kawaii* and anime, seem to evoke a childlike attitude. In Nakatsuji's case, one could describe it as the impertinence of a man infantilized by society (a NEET and an otaku), who "acts cute" in the face of piracy, copyright laws, and the Japanese national culture of "doing one's best."

In general, we can draw another conclusion from this discussion. The computer viruses that display cute aggression, such as the Cookie Monster, Ika-tako, and Rensenware viruses, are more than just curiosities; they provide valuable insights into the "weird materialities" (Parikka 2012, 96) of today's cute-obsessed culture. Leading figures in critical theory and aesthetics, such as Sianne Ngai, have asserted that cuteness has become an index of the "surprisingly wide spectrum of feelings, ranging from tenderness to aggression, that we harbour towards ostensibly subordinate and unthreatening commodities" (Ngai 2012, 1). Moreover, the fact that this traditionally undervalued aesthetic category has risen to a position of massive influence owes much to the Internet, which has led to the cute becoming a "dominant aesthetic category in digital culture" (Wittkower 2012), rivalling the popularity of pornography and fake news. Even though the Ika-tako virus and other examples cited in this article are quite limited in time and space, the use of tentacular thinking to approach them indicates that their scope is much broader, threading into a territory where cuteness, race, sexuality, and cybercrime conflate. These entanglements may be counterintuitive, but they are surprisingly widespread, affecting how humans relate to technological artifacts and navigate the digital landscape of the 21st century.

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No noise, no party! On Shannon, Aesthetics and one reason for the love of random in digital art practices

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The notion of communication system as presented in many humanities scholarly works is rooted in engineering and the seminal work of Claude E. Shannon titled "A Mathematical Theory of Communication" - published in 1948. In all, the narrowness of a mathematical understanding of communication, as presented by Shannon, presents severe limitations but also, as it will be shown, possible openings, directions or bridges towards the non-mathematical. In particular, the analysis presented here depicts any notion of communication as being inseparable from any noise. In fact, moving at or beyond the clearly defined mathematical limits that are explicit in Shannon's theory means to invalidate the very possibility of a communication system at all. It is by looking at these limits, it is argued, that a discourse between a theory of communication and aesthetic theories of digital arts is energised. This is not least because in that dialogue might be found a plausible explanation for the ever-growing love of random functions and statistical modelling by many digital art practitioners..

Keywords noise, Claude Shannon, communication theory, Aesthetics, random, statistical modelling, order, digital art practices

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1. Introduction

"A Mathematical Theory of Communication", published in the Bell Systems Technical Journal in 1948 (Shannon 1948), is the seminal work of Claude E. Shannon with which, building on the work of Nyquist and Hartley, the domain of information theory is often told to be born. Following its publication, the influence of Shannon's work was soon felt outside the engineering domain and reached the arts and humanities disciplines.[1]

1. As a notable example in the arts, we mention Bense and Moles' Information Aesthetic theories. For an introduction and critical appraisal of these theories, see Nake (2011).

In media theory and media arts studies, Shannon's work is often introduced to authoritatively sketch out the basic elements of a communication system. In non-mathematical terms, Shannon's schematics of a communication system are simple to comprehend. The system includes a sender - a person, a lighthouse, a computer or anything else able to "send" something - who wishes to convey a message to a receiver - another person, a sailor, another computer or anything else able to "receive" something. In order to do so, the message needs a carrier, a channel or more generally a medium. This entails that noise can affect the system. From these basic premises, a wealth of discourse has been generated. It has concerned itself with the interfering power of the medium, the meaning of the message, the interpretative capacity of the receiver and, not least of all, the hierarchical structure that defines the relationship between technological media and society, where the question is which one controls the other.

Truth to be told, the fact that Shannon's theory is first and foremost a *mathematical* theory is a fact that much of the humanities discourse has, perhaps, underplayed a bit. One notable exception to this "overlook" is certainly a recent work by Cécile Malaspina, titled "An Epistemology of Noise" Malaspina 2018). There she offers an eminent example of how an appreciation of some of the tensions and nuances emerging from Shannon's mathematical model can help broaden its scope to a philosophical questioning of the ideas of information, entropy and noise. In particular, such an analysis brings to the fore an idea of communication as one defined by uncertainty and entropy. In order to take that idea seriously, moving beyond and yet departing from a mathematical understanding of Shannon's theory helps to evade "the Manichean opposition between information and noise, echoing that between order and disorder, life and death" (p.18).

Along the lines of such a methodological approach, this paper presents some considerations relating to the aesthetic of digital art practices on the basis of a preliminary analysis of the strictly mathematical meaning of Shannon's theory.

2. There is no meaning

A close read of Shannon's famous paper is in order. The second paragraph describes succinctly the problem at hand. Here is the excerpt:

> The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. (Shannon 1948, p. 379)

In this sentence we can find the now classical understanding of communication as information or data travelling from a sender to a receiver. Such simplicity of the enunciation is achieved at the expense of insight into the complexity intrinsic to all kinds of communication, for instance as highlighted by pragmatic theories of the early and mid-20th century. This is to say that the problem of communication thus proposed was limited in its scope as an engineering problem and nothing more. On the other hand, Shannon was very clear with regards to the remit of his work. Any use of his theories outside that remit has to confront the narrowness of its original scope:

> Frequently the messages have meaning; that is, they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one selected from a set of possible messages. (p. 379)

This is important. Shannon's theory of communication is not concerned with meaning or semantics but only with the probabilities involved in the successful conveyance and interpretation of data parsed from one point to another through a medium.

Communication is to be understood as a mere parsing of data via a medium. This is something that seems to have pleased many, even when what is at stake is our relational stance with the medium. McLuhan's motto "the medium is the message" (McLuhan 1994), for example, states that the medium is what really counts in communication. Any message conveyed through a medium by a conscious subject, and any meaning extricable from a conscious individual at the receiving end, is inexorably altered by the overpowering presence of the medium itself. In this sense, the importance of senders and receivers is minimised in relation to the organising power of the medium, for instance in the way the presence of electrical light organises visual data within a room. Kittler, as another notable example, also pushes for a view highlighting this dominating aspect of technology over human affairs. At the same time, he also defends a position in which meaning should not be thought of as something given a priori, as McLuhan does, but rather as something emerging from our relationship with the materiality of the medium. Meaning, if one wishes to be concerned with it, is only the result of the reading of a system, or network, parsing information (Gane 2005).

3. There are only variables

The elegant graphical conceptualisation of the process of communication offered in Shannon's paper has offered much food for thought to humanities scholars. Figure 1 shows such a graphical map (with original caption included).

Fig. 1. Original schematics of communication system as depicted in (Shannon 1948, p. 381).

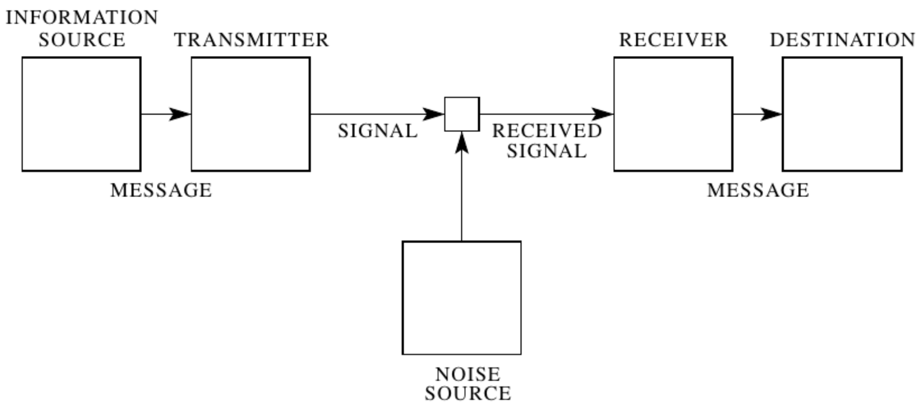

Fig. 1—Schematic diagram of a general communication system.

Shannon describes the figure as made up of five parts: 1) an information source e.g. a teletype sentence, TV/Radio signal etc. 2) a transmitter - essentially a coder 3) a channel enabling the transmission of the coded signal 4) a receiver - i.e. a decoding device 5) "the person (or thing) for whom the message is intended".

The reason why Shannon's theory can do away with meaning and semantics is because an information source can be anything (a person, a computer etc.). In fact, because the sender, as information source, is identified with the message itself, for Shannon it hardly matters who or what sends it. What concerns Shannon is then not the meaning or intentions behind what is communicated, but its form. For example, a sentence is only a group of words and letters put together according to the rules of the system to which they belong (i.e. a syntax and morphology). The fact that Shannon considers the destination as being either a person or a thing is only a veiled, unexplored and possibly naive gesture towards the possibilities of cybernetics.

4. Channel as mathematical uncertainty

There is a curious discrepancy in Shannon's text and it concerns noise. Noise appears in the picture as an element/player in itself but, curiously, in the text is presented as disturbance under what appears listed as "channel". Here is the full definition:

> The channel is merely the medium used to transmit the signal from transmitter to receiver. It may be a pair of wires, a coaxial cable, a band of radio frequencies, a beam of light, etc. During transmission, or at one of the

terminals, the signal may be perturbed by noise. This is indicated schematically in Fig. 1 by the noise source acting on the transmitted signal to produce the received signal. (Shannon 1948, p. 381)

Noise, it seems, *acts on* the medium (the wires, the cables etc.). While not necessarily precise as a definition, we now know what noise does - i.e. it disturbs - but not what it is or where it comes from. Noise disturbs the transmission of a message between a transmitter and a receiver. A sort of trick of God who decided to throw a spanner in the works. A definition though comes at page 19. It states:

> The noise is considered to be a chance variable just as the message was above. (Shannon 1948, p. 406)

For Shannon, noise is nothing more than a mathematical variable, just as a variable is the information source in his analysis. The narrowness of his scope requires such a synthesis. His words are, once again, direct in their purpose:

> We wish to consider certain general problems involving communication systems. To do this it is first necessary to represent the various elements involved as mathematical entities, suitably idealized from their physical counterparts. (p. 381)

Perhaps this sentence epitomises what Husserl famously described – in relation to modern physics – as the "mathematisation of nature" (Husserl 1984, p. 23) ...[2]

Beyond this last remark and at the risk of sounding ridiculous, it is obvious that a theory of communication grounded on statistical analysis cannot accept certainty. Theorem 2 states exactly that:

$$H = -k \sum_{i=1}^{n} p_i \log p_i$$

H is the "measure of how much "choice" is involved in the selection of an event or of how uncertain we are of the outcome". In other words, *H* is the probability with which we can tell what the sent message is and the rate with which information is produced. *H* is the measure for the information source in probability terms. That is, it is the measure of the choice and uncertainty between possible messages without considering any medium of transfer. The interesting part is that *H* must always be positive - i.e. there must be some uncertainty. This also means that in the limit case of $H = 0$ we would have certainty and with certainty we nullify the need for any channel - i.e. no uncertainty means no channel or medium. For example:

> If a source can produce only one particular message its entropy is zero, and no channel is required. (Shannon 1948, p. 404)

2. In the Crisis (§ 9), Husserl devotes some important pages to the impossibility, in modern physics, of a "direct mathematisation" and formalization of sensible qualities (plena). Husserl's distinction – in Ideas I (Husserl 1980), § § 72-75 – between, on the one hand, "exact" and "ideal" sciences (operating through formalisation and idealisation, at the basis of "defined multiplicities"), and on the other, "morphological" and "inexact" sciences (which includes botany, as well as his phenomenological philosophy), enriches the conceptual framework which could be used in a philosophical approach to noise. However, we must leave open the question of whether and how Husserl's theory can illuminate the kind of mathematization carried out by information theory (e.g. the way in which noise is reduced to a mathematical variable, and the limits of such operation), but also the way in which noise is dealt with in contemporary digital practices. It should be considered whether ours 'computers' are 'calculators' in the same way as the minds of the physicists and how differences might require a different conceptual framework.Cristopher Durt (2020) emphasizes the analogy between the process of mathematization of the nature described by Husserl in the Crisis and the digitalization of world. He remarks: "Husserl did not speak of a 'digital' world, but since the 'mathematical world' of modern science is made of data, it is a digital world. The mathematization of nature is a digitization and digitalization of nature. Husserl's insights on the relation between

intuitive experience and the mathematical world thus also apply to the relation between intuitive experience and the digital world. Husserl's account of mathematization explains why it is easy to overlook the fact that the mathematical or digital world is fundamentally different from the lifeworld".

Following from the previous formula, H is 0 "if and only if all the p_i but one are zero, this one having the value unity. Thus only when we are certain of the outcome does$H$ vanish. Otherwise H is positive."

Interestingly, all this is explained in a chapter that Shannon titles as "Discrete Noiseless Systems". In fact, in this preliminary part of his analysis Shannon is only concerned with information source and destination while discarding the channel. And yet we need uncertainty to be able to talk about communication and channels. In doing so, what he is implicitly telling us is that **"noiseless" is another word for "channel-less"**. In other words, noise is neither a dispensable element of a system of communication nor a medium, nor something whose presence we have to begrudgingly live with. Rather, it is a necessary and intrinsic element of communication for at least two reasons: 1) statistical methods are useful as long as noise is present (i.e. $H < 0$) and 2) there can be no channel without uncertainty/noise.

Hence, can there be mediation (as in the act of negotiating and parsing data) without noise? No, because "there would be nothing to mediate". Ultimately, can there be communication without noise? No, because there would be nothing to share or say.

All of the above, of course, is only valid within the clear constraints of another limit case, namely, the one in which any degrees of certainty is forbidden. This is the case presented in Theorem 2,

$H =- k \sum_{i=1}^{n} p_i log p_i$, where all instances of $p_{i1,i2 \ldots in}$ would equal 0. In such circumstances, H becomes undefined[3], meaning that H is only an ever-approaching but never-reaching mathematical idealisation of *pure* noise/uncertainty/chaos - where *pure* means "beyond any possible mathematisation of the phenomenon".

3. log0 is undefined.

In between the boundaries of certitude and irreparable uncertainty lies our channel. Perhaps, and in light of what has been presented so far, the following will suffice as a definition for channel: **a channel is a mathematically described conduit of noise, while the uncountable totality of all noise transcends/ exceeds any possible channelisation . A message, on its part, is that identifiable pattern that survives the passage of the conduit.**

5. Noise as mathematical variable

The second part of Shannon's essay is concerned with discrete channels of communications in the presence of noise. In this part of the essay Shannon includes noise as a mathematical variable (rather than being a necessary and implicit element of the system as I cared to argue previously). By including noise as mathematical variable, the received message E at the receiving end is described as a function of two variables: the sent message S and the channel's noise N.

$E = f(S,N)$

The probabilities intrinsic to the communication channel are described as the combination of the entropy of both the information source and the receiving end. In short, we are applying H across all the elements described in Fig.1. The formula is:

$$H(x, y) = H(x) + H_x(y) = H(y) + H_y(x)$$

where:

- $H(x)$ is the entropy (i.e. noisiness) of the information source;
- $H(y)$ is the entropy (i.e. noisiness) of the receiving end;
- $H_x(y)$ is the entropy of the output when the input is known;
- $H_y(x)$ is the entropy of the input when the output is known and it is also called "equivocation" - the average ambiguity of the received signal.

In this instance, noise characterises the whole communication chain. Noise is present at the input, output and in the channel bridging input and output. Shannon's theory, faithful to the title of his paper, is a *mathematical* theory that aims to establish within what probabilities we can successfully establish a communication between two parties.

Following from the previous formula, Shannon introduces Theorem 10 where he states that:

> If the correction channel has a capacity equal to $H_y(x)$ it is possible to so encode the correction data as to send it over this channel and correct all but an arbitrarily small fraction of the errors. This is not possible if the channel capacity is less than $H_y(x)$. (Shannon 1948, p. 408)

This means that in order to enhance the probability of reconstructing correctly the message sent we need to ensure that the capacity of the channel is greater than the entropy of the input when the output is known. As Shannon then states, "$H_y(x)$ is the amount of additional information that must be supplied per second at the receiving point to correct the received message."

From another perspective, if we are ready to consider this additional information as **pseudo-noise** (i.e. man-made/controlled/correlatable noise), it would seem that we have yet discovered another reason for **the unavoidable necessity of noise in communication. Communication just seems to be a pattern-searching process within a field of noise.**

6. Nature's wants money back

Towards the end of the first part of the paper, **Shannon defines the capacity** *C* **of a noisy channel as the maximum rate of transmission achievable** and defines it as:

$$C = Max(H(x) - H_y(x))$$

where, to be sure:

- $H(x)$ is the entropy of the information source alone; and
- $H_y(x)$, also called the equivocation, is the average ambiguity of the received signal.

Two things should be born in mind here: the relationship between the entropies and the rate of transmission. From this perspective, the capacity C is both the statistical value determining the probability for a variable to be in one state rather than another and the rate with which that value can change.

The relationship between $H(x)$ and $H_y(x)$ is explained by Shannon via the figure presented below:

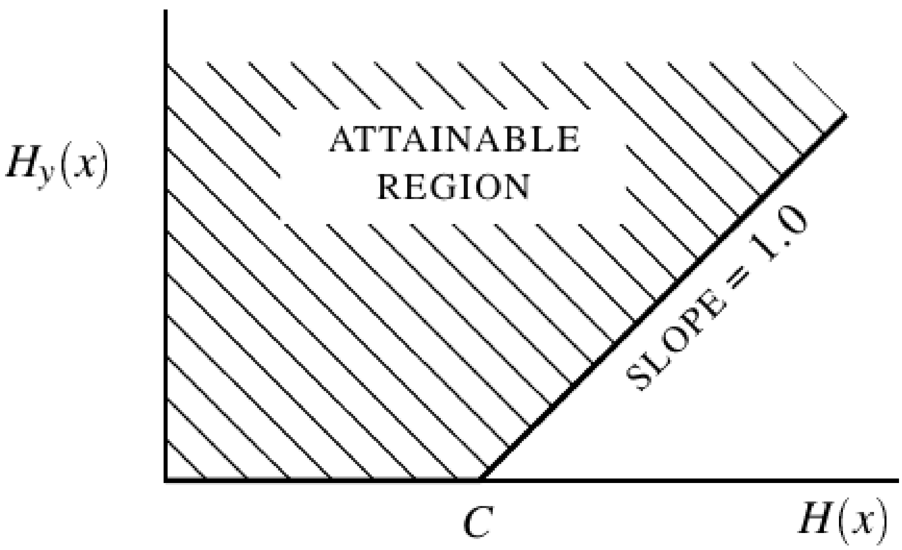

Fig. 2. The equivocation possible for a given input entropy to a channel. (original caption).

Perhaps more clearly than in the formula, this picture tells us that the **rate of information produced by a source** - $H(x)$ - **is always greater than the rate (and certainty) with which the receiver will be able to interpret it** - $H_y(x)$ **or equivocation.** This is in line with what has been stated so far. Indeed, in order to maximise the capacity C we need to have $H_y(x)$ approaching (but never reaching) 0 so that the rate of successful (certitude of correctness) transmission approaches $H(x)$

- the original source. In other words, we increase pseudo-noise with redundancy while attempting to minimise (but never eliminate completely) uncertainty or statistical noise. The limit case of $H_y(x) = 0$ would again be a case of a noiseless (and hence channel-less) system.

It is at this point that Shannon states something exceptional:

> Actually the capacity *C* defined above has a very definite significance. It is possible to send information at the rate *C* through the channel with as small a frequency of errors or equivocation as desired by proper encoding. This statement is not true for any rate greater than C. If an attempt is made to transmit at a higher rate than *C*, say $C+R_1$, then there will necessarily be an equivocation equal to or greater than the excess R_1. Nature takes payment by requiring just that much uncertainty, so that we are not actually getting any more than *C* through correctly. (Shannon 1948, p. 410, emphasis added)

In what highlighted in red lies a very important acknowledgment by Shannon: there is noise outside mathematical noise that cannot be claimed by or accounted for by humans, nor by their technology, logos or culture.

7. The many ways (yet not all) in which noise can be said

The second part of Shannon's essay extends the discussion to continuous channels of transmission (as opposed to the discrete channel discussed so far). While this section is also important, no new interpretations of the idea of noise, nor of communication, are introduced. Hence, this brings to a stop this analysis of Shannon's essay in order to pause the discussion for a quick recapitulation.

We have seen how the idea of channel, of medium and, more generally, of communication systems is inseparable from an idea of noise. Many and diverse uses of the word "noise" have been mentioned by Shannon up to this point. It might be useful to divide these definitions in three macro groups - one for which noise is a mathematical concept ( ), one for which it is not ( ) and one for which ( ) a clear attribution may require at least further questioning - as follows:

× ( ) Noise as disturbance.

× ( ) Noise as unavoidable and necessary feature of a channel.

× ( ) Noise as mathematical variable.

× ( ) Noise as chance variable.

× Noise as entropy of an information source.

× Noise as entropy at a channel's receiving end - aka equivocation.

× Noise as error.

× Noise as redundancy.

× Noise as uncertainty.

Noise is a mathematical variable and as such it is described in terms of the entropy of a system or the many parts thereof. Noise is a stochastic variable concerned either with the probability of a given outcome or, conversely, with its uncertainty. In broad terms, entropy is the measurement of uncertainty in a given system. For that, entropy connects to the randomness with which something might occur (or not). Under this light, any definition of noise blurs across multiple terms such as entropy, randomness, uncertainty, chaos and more generally disorder. All these terms have different and precise meanings. These are not matters of literary caprice. Mathematics requires the narrowness of its definitions for the consistency of its reasoning. For Shannon, noise is primarily a mathematical idealisation of communication. For him, noise is experiential in so far as it is measurable. Noise enters his phenomenal sphere if, and only if, it can be computed. Hence, it does not matter what the real source of that noise is, as long as "what it is" is measurable or countable in statistical terms. Shannon deals exclusively with a calculable world where communication has been mathematicised.

And yet Shannon also hints at noise as something else, something extra, something disturbing and interfering with an otherwise "clean" process. Figure 1 depicts this by placing noise outside the linear left-to-right flow of information. There is no concern for the origin of noise. Shannon is simply concerned with visualising what happens, namely "something" that at once pervades, affects and defines a communication system. Noise, it seems, is everywhere so that perhaps a more faithful drawing would see communication as the mere leftover, or discoverable pattern, or negative image, within a nois-e/y field. Noise would then not be an extra-partes affecting the communication process but something intrinsic and necessary to it - as indeed Shannon's formulas highlight too (i.e. no noise means no [need for a] channel or medium).

Repetitia juvant: can there be mediation without noise? No, because "there would be nothing to mediate". Ultimately, can there be communication without noise? No, because there would be nothing to share.

Furthermore, a communication system can exist only within two boundaries that define noise: certitude and irreparable uncertainty.

Certitude, meaning "lack of noise", makes sender and receiver coalesce into one entity (or subject, if one wishes). No channel at this point is required nor, as Shannon's theorems prove, does it have any reason to exist. Noiseless becomes synonym for channel-less and communication-less. Communication, if taken to mean "making something common", would not without noise be able to accomplish its mission; there would be no sharing possible in the first place.

On the other hand, if we increase the rate of transmission to or beyond the maximum capacity of the channel, message and noise coalesce into an absolute chaos. A chaos from which it becomes impossible to recuperate any meaningful difference between message and noise. To be sure, such an irreparable uncertainty does not lead us to uncover a presumably chaotic structure of reality - or what Meillassoux calls Hyper-Chaos. If *Hyper-Chaos*[4] existed, as Meillassoux acutely observes, it would invalidate any attempt to ground any sort of scientific discourse. Similarly, hyper-chaos would invalidate any effort to ground a theory of communication (and perhaps any attempt to communicate too). The irreparable uncertainty introduced here, rather than implying a "menacing power", refers instead, and solely, to the limits within which it is possible to logically construct a mathematical theory of communication based on a differentiation between message and noise.

In all, noise is something that needs to be carefully handled within a communication system. Too much noise brings greater uncertainty; too little brings us redundancy.[5]

8. For the love of noise

In light of the analysis offered to this point, it is clear that the implications of Shannon' theory of communication for aesthetic discourse must take into account a study of noise. This expanded analysis, bringing to the fore the inalienability of noise in communication systems and media, may prove particularly useful for understanding certain peculiarities in those art practices characterised by the overpowering presence of technological media and digital media in particular.

By bridging the outcomes of our analysis of Shannon's work with the necessary contingencies of an aesthetic discourse, the balancing act of noise becomes both increasingly difficult and ever more fascinating.[6]

If communication is taken – not uncontroversially – as a model for aesthetic discourse and practice, this should certainly not be explored, as in Shannon's paper, in terms of the possibility of "reproducing at one point either exactly or approximately a message selected at another point". One important reason for this divergence from Shannon is that artists are not concerned with stating something in unequivocal or approximate terms ....[7]. Instead, artists wish to share, to gift someone despite knowing in advance that the way their gift will be received cannot be identical to the way in which they intended it in the first

4. "...what we see there is a rather menacing power - something insensible, and capable of destroying both things and worlds, of bringing forth monstrous absurdities, yet also of never doing anything, of realizing every dream, but also every nightmare, of engendering random and frenetic transformations, or conversely, of producing a universe that remains motionless down to its ultimate recess, like a cloud bearing the fiercest storms, then the eeriest bright spells, if only for an interval of disquieting calm." (Meillassoux 2009, p. 64).

5. As discussed previously a noiseless system (or one that aims to be so) can be achieved by either lowering the complexity of the system (e.g. sending only the letter "a" rather than the entire alphabet) or by adding correlated noise to the signale or by sending multiple copies of the same signal – aka pseudo noise). Any message is conveyable only within this careful balancing act.

6. Once again, we do that at our own risk while acknowledging that Shannon's concerns were exclusively mathematical. In fact, if we were to consider the meaning/s of a given message conveyed through a communication system, we would then have to consider also subjects and intentions; in all, something at the heart of all art practices and foreign to Shannon's discourse.

7. To put it with Adorno, "stating" is for science, art asserts (Adorno 1986, p. 168).

place. The implication here is that, in contrast with the nature of communication systems depicted thus far, uncertainty can energise rather than threaten or extinguish aesthetic discourse. This uncertainty, or ambiguity, of the message and the whole system is the "salt" of any social interaction involving arts *in primis.*

Furthermore, from the perspective of an individual's private practice, the same uncertainty is what provides the opportunity for a life-long exploration of one's own artistic practice with and through the body or an instrument. All artists know that the learning and exploratory journey that defines their own practice is unbounded. Only death can put an end to that path. From this perspective, an art practice is defined by an endless exploratory process in, through and in relation with, an overwhelmingly complex and noise-pregnant reality. For that, art practices can be conceived as a wish to command the non-command-able, to tame the untamable, to bring order to chaos.

Yet within this picture there is perhaps one crucial exception, namely the one provided by those art practices defined by an engagement with digital technology. To be sure, the exception here is not given by the blatantly obvious presence of the medium (i.e. the digital); every art practice has their own medium: the body, the guitar, the synth, the brush, the chisel etc. Rather, this exception is provided by the mode of existence of the digital - a mode that is rooted in the most abstract mode of existence of any entity subject, namely, as something countable or calculable. Put concisely, "digital" means "to discretise a flow of electrons in time so as to count things one wants to give a number to" (Torre, 2021, p. 23). This number-game, however, is played in a manner that aims to reduce noise - in fact, erase it[8]. The digital, in the way it is thought today, is entrapped in an ideology of efficiency and performative excellence that wants noise to be minimised to its closest point of disappearance. As Shannon's theorems show, this can be achieved (if one wishes) by either minimising the entropy of the system (e.g. reducing the possible numbers of conveyable messages) or by increasing the redundancy of the system (e.g. creating pseudo-noise). This choice or course of action would move us towards the boundaries of Shannon's channel. Boundaries in which any message, discourse or communicative intent risk becoming mere tautology; no-noise means no channel and, in turn, no communication.

What would the meaning of any art practice be in such circumstances defined by an explicit antagonism towards noise by digital technologies? Little to none, is the argument. Digital art practices, contrary to any other form of art practice and in order to retain an ability to communicate, must then move in the opposite direction, namely, from order to chaos. Here is then the reason for the abundant love that many digital art practitioners share for random routines and statistical modeling techniques. These methods appear to re-introduce noise in an effort to move away from the "dangerous" boundaries/case-limits of the system. After all, it seems to be the only way to hide the unrewarding precision of execution of a mere sequence of commands given to a digital machine.[9] Random

8. For integrity, it may be worth mentioning that there are examples of computer science research that attempt to move in the opposite direction of an efficient and redundant digital realm. Perhaps one of the most famous research is the "best effort" architecture devised by Prof. Akley https://www.cs.unm.edu/~ackley/.

9. Our interaction with the digital is nothing but mere sequences of instructions given under the form of "execute!"

functions and statistical models are the only way, or hope, to strive away from those tautologies visible at the horizon of one's own practice.

In the name of this necessary love for noise which digital tools deny, digital art practices are increasingly defined by a wish to un-command the command-able, to un-tame the tameable, to bring chaos to order.

Still, in all that, it remains to be seen whether such a love for random routines and statistical models are sufficient to re-inject meaning – via an 'injection' of noise - into digital art discourse and practices. After all, digitally constructed randomness is, like any list resulting from any statistical model, correlated noise; noise that remains (or at least wishfully appearing to be) "sealed off from" the noise as uncertainty claimed by Nature.[10] It is noise in a vacuum, then, and entrapped in a solely numerical existence; an existence distant from the necessary uniqueness of self, the subject, the artist. But this is a question for another time.

10. Bar the cases of unpredictable glitches and power outages.

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Artworks

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PAC-MOM: A Game about Gender, Work, and Food Insecurity

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PAC-MOM is a parody of the popular arcade game *PAC-MAN* (1980) by Toru Iwatani. Game scholars classify *PAC-MAN* as an eating game. *PAC-MOM* is a game about gender and food insecurity. *PAC-MOM* is based on data on hunger as a gender issue. This includes the gender pay gap. It takes place in a situation where accessing food requires *PAC-MOM* to work a disproportionate amount more than *PAC-MAN* for the same number of pellets. In addition to having to work more, *PAC-MOM* must avoid powerful ghost-enemies including patriarchy, misogyny, racism, ableism, and many more. *PAC-MOM* is programmed for the web in JavaScript/HTML5 and can be played online in most browsers as a single-player game. The game consists of a training level, a character customization screen, and a main level. The training level conveys background information. The information gained in the training level is applied in the character customization screen and the main level.

Keywords technofeminism, game, data, narrative

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PAC-MOM (Rüst, 2021) is a parody of the popular 1980s arcade game *PAC-MAN* by Toru Iwatani (Bandai Namco Entertainment Inc., 1980). *PAC-MAN* is canonized and classified by game scholars as an "eating game" (Mäyrä, 2008). I created *PAC-MOM* as a parody of *PAC-MAN* (Fig 1). *PAC-MOM* is a game about gender and food insecurity. *PAC-MOM* takes place in a situation where accessing food requires *PAC-MOM* to work more than *PAC-MAN* for the same number of food dots. In addition to having to work more, *PAC-MOM* must avoid a set of powerful ghost-enemies including patriarchy, misogyny, racism, ableism, and many more. *PAC-MOM* consists of a training level a character customization screen, and a main level. The training level conveys background information. The information gained in the training level is applied in the character customization screen and in the main level.

The training level consists of several screens that introduce themes and statistics that the player will revisit in the main level. The game is called *PAC-MOM* and not *PAC-WOMAN* because this is a game about food insecurity and gender and moms are more likely than fathers to be food insecure – specifically single moms. Single moms in the United States are more likely to live below the poverty line and more likely to be food insecure (Freely). In the first screen of the training level, the player sees narrative text and instructions to advance *PAC-MOM* from left to right to eat food dots. The dots begin to disappear as the player moves *PAC-MOM* and more statistics about single moms and food insecurity appear in the narrative text.

The second data set that I am introducing in the training level is the gender pay gap. Although the gender pay gap exists worldwide, I chose data from the United States because it clearly illustrates that the gender pay gap is an intersectional issue: African American, Native American, and Latina women make considerably less than Asian and white women (Association of American University Women, 2021). However, all still make less than white, non-Hispanic men. Because of the gender wage gap, women are required to work more hours to cover basic needs. The player therefore has to press/touch the arrow key far more often depending on the size of the gender gap that is shown in the narrative text. In the game, the player is required to press more intensely to advance *PAC-MOM* as the gender pay gap becomes larger.

The last two screens in the training level introduce the perils that *PAC-MOM* faces: The narration text explains that "food insecure household are on average more vulnerable to poor nutrition and health challenges". It shows two ghosts. One is labelled "Health Care Discrimination" and the other "Body Shaming". The screen serves to illustrate that the perils that food insecure people face are often compounding: Poor nutrition and health challenges are outcomes of being food insecure. However, poor people can often not access healthcare to address health challenges in the same way that rich people can. People with poor nutrition and weight-based health challenges are then often body shamed. Food insecure women therefore face perils such as sexism (the pay gap), racism (racial disparities in the pay gap), healthcare discrimination, and body shaming. In the game, these perils are part of a larger compounding set of dangers that *PAC-MOM* faces in the main level.

The character customization screen of the main contains a slider where the player can adjust how much more their *PAC-MOM* must work as compared to *PAC-MAN*. This part is based on the data previously introduced in the training level. Then, the player can select specific perils (ghosts) that *PAC-MOM* will confront in the main game. If the player does not select any perils, all perils will appear. A ghost labelled “Patriarchy” is always the first ghost to appear.

There are very few players who win the game and I will not spoil this “ending”. Most players will inevitably lose all three lives. When a player has lost, the screen prompt reads: “Sorry *PAC-MOM*, you worked so hard but you lost anyway! Maybe you should have been more confident?”. The player can then click on a button labelled “More Useless Advice” to receive more patronizing self-help advice or go back to the start screen.

PAC-MOM is a playable data narrative. The foundation of the game mechanic and level design is data, but I am extrapolating the data into the game space of *PAC-MAN*, telling the story of *PAC-MOM*, a more complex character. Ostensibly, her world is the same as *PAC-MAN*’s but navigating it requires her to work more to avoid peril and be able to eat.

Rethinking the “Classic” Video Game

PAC-MOM is a practical rethinking of a “classic” game to challenge and rethink a canon of games that are uncritically revered by game enthusiasts and often recreated with minor modification by individuals and organizations (Google, 2010). In her book *Coin-operated Americans* Carly A. Kocurek describes how video game arcades became a space claimed by boys and young men in the US in the 1980s (Kocurek, 2015). A game common to 1980s video gaming spaces was *PAC-MAN*. Every discipline has its canon of “important” works. The longer a canon exists, the more immutable it becomes. Instead of a calcified collection of works, I am proposing a continuous refiguring of works in a canon to encourage continued questioning of a discipline’s history. Instead of worshipping on the altar of the “classics”, we should be creating alternative views of works seen as “historic”. My impetus for this work is to create a subjective view on *PAC-MAN* but also to appropriate *PAC-MAN*, a man-centric narrative, and give it a new life as a feminist data narrative.

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With Love. From an Invader.: An Exploration of Landscape and Identity

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With Love. From An Invader. is a multi-screen audio-visual installation created during the COVID-19 lockdown in 2020-2021 documenting the landscape and soundscape around Sheddon Clough in the north of England using the invasive *rhododendron ponticum* as a symbol not only of the pervasiveness of COVID-19 but also as a means of exploring the political and xenophobic backlash surrounding it. The work explores notions of invasiveness, identity, landscape and recombinant ecologies. The installation deconstructs documentary methods in photography and sound recording to present a novel recombinant experience of place (Iosofat 2009) integrating disparate theories of place, landscape and habitat (Mabey 1973, Maris 2011, and Rotherham 2017).

Keywords soundscape, photography, audio-visual, COVID-19, invasive species

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Introduction

With Love. From an Invader. is the start of a long-term project investigating the complex connections between landscape representation, identity, migration and the environment. For this piece, Yan Wang Preston walked every other day to the same love-heart-shaped rhododendron bush at Sheddon Clough, Burnley, Lancashire, UK (see Figure 1), from 17th March 2020 to the 16th March 2021. A photograph of the rhododendron was taken every two days, in an identical manner, always at half an hour before sunset.

Fig. 1. Rhododendron bush at Sheddon Clough. ©Yan Wang Preston.

The rhododendron has been selected for the project for many reasons. Introduced to the UK by colonial botanists in the late 19th century as an ornamental plant, it is now often seen as a non-native and invasive species by ecologists. It is the particular species, *rhododendron ponticum*, that is invasive. Many of the rhododendron species currently grown in Britain are originally from China, Preston's motherland. Living as a foreigner in a country going through Brexit, Preston feels a strong personal connection with such foreign plants. They remind her of her homeland as well as the complex perceptions around nature, national identities, landscapes and migration.

The area, Shedden Clough on the outskirts of Burnley, was an open-cast limestone mine 400 years ago. Nearly 200 years ago the local landowners planted rhododendron and beech in an effort to change it to a hunting estate. Now it is an 'ecological wasteland', colonised by these non-native plants and by sheep-grazing farms. Hidden in the heartland of the South Pennines, the local landscape is simultaneously post-industrial and post-colonial. Yet the ecology can also be said to be cosmopolitan. The particular rhododendron bush photographed for the installation film happens to have the natural shape of a love heart. An alien species sending out love—it is a rich metaphor to anchor the investigation towards the installation's issues around landscape and identity.

Vision and Contested Landscapes

Fig. 2. *With Love. From an Invader.* Walk No. 130. 04 December 2020. ©Yan Wang Preston.

The photographic vision and modern science share much in common. Both emphasise a human-centric and linear perspective. Both share a naturalised yet mythic authority in being detached, rational, and objective. The long-established notion of the photograph as a document implies to us that to see is to witness and to photograph is to provide evidence. Meanwhile, just like the privilege and power enjoyed by scientific knowledge over other forms of knowledge and knowing, the visual has been given the absolute priority over other senses, such as hearing, smell, and touch. The latter are typically relegated to the 'tribal', the 'feminine', and the 'less intellectual' (Howes 2004). Such emphasis on the vision, the view, as well as the scientific knowledge has largely influenced our ways to perceive, construct and manage the physical landscapes.

With Love. From an Invader. takes the mythic objectivity of the vision and the photograph into consideration, utilising their contestable function as a document to investigate the possible disputes behind an ecological (therefore scientific and authoritative) term: the 'non-native and invasive species'. The project began by taking notice of the changing attitudes towards certain plants and animals in the UK, for example, the rhododendron, which began to be introduced to the country from the late 18th century onwards. In 1849, Joseph Hooker, the soon-to-be Director of the Royal Botanic Garden Kew and President of the Royal Society, stated that "[p]erhaps with the exception of the Rose, the queen of flowers, no plants have excited more interest throughout Europe than the several species of the genus rhododendron" (Hooker, 1849). Yet in the early 21st century, rhododendrons have become a significant issue in British national forests and other areas of uncultivated land. In The Guardian newspaper, rhododendrons have been portrayed as "a spectacular thug out of control" (Simons, 2017). Forest and Land Scotland state on their website that:

> In 2010, we set out our vision to remove rhododendron from Scotland's national forests and land [...] Since then, we've been using chainsaws, herbicides, heavy machinery and considerable human muscle power in the battle against this unwelcome alien. (Forest and Land Scotland, 2022)

Such public dislike towards the foreign species can be echoed within a social-political context, such as the xenophobic backlash surrounding Brexit, and the worsening racism towards east-Asian people during the COVID-19 pandemic. Given that the development of botany and then ecology as scientific disciplines has been intimately intertwined with Western colonialism, one questions whether the same politics are in place in scientific claims and social attitudes. For example, how has the sense of British national identity changed since its heydays of colonial expansion in the 18th and 19th century? Are there parallels to be found between the national opinions towards residential foreign species and foreign people? Finally, how can we explore these questions by investigating Britain's physical landscape and its pictorial representation?

To answer these questions, *With Love. From an Invader.* fixes its obsessive photographic and sonic attention onto a contested land called Shedden Clough—a one-square-mile post-industrial wasteland transformed by lime-mining and then 'infested' by the notoriously 'invasive' rhododendron *ponticum*. For a year, the project set out to discover and collect first-hand information about the rhododendrons and the ecology around them. For Preston, working almost as an amateur naturalist, the primary method was to look, discover, and document with various cameras. The project had an anchor—a large rhododendron bush that happens to have the shape of a love heart icon. The symbolic meaning of this shape and the ecological disputes about the species provided the title of the piece. The project also had a timeline and an itinerary—the photographer was to walk to the bush every other day for an entire year and to photograph it in an identical manner each time, always at half an hour before sunset (see Figure 2). Each trip involved a one-hour walk through this wasteland at the spine of the South Pennines, whatever the weather. Such pre-conceived planning therefore framed the project as embodied research through a complete cycle of the four seasons.

The duration of an entire year had the potential to expand the momentary photographic exposure to the contemplation of a deep time, therefore, connecting the life of one plant to a celestial history. Visually, this sense of deep time is suggested by the extremely slow pace and the stillness of the time-lapse with 182 images. Each picture is presented for 12 seconds—a long time to stare at one still image. The transition between two pictures has a gradual dissolving effect spanning five seconds, resulting in an extremely gradual and subtle merging of the days. The photographs themselves are edited so that they do not completely align—small mismatches happen here and there in a quasi-random manner, making visible the presence of the artist while steering the work away from a strict scientific time-lapse study.

Fig. 3. A fox filmed by the infrared camera in between two rhododendron bushes, 17 November 2020.

Imaging technology, from the microscope to the telescope, has greatly expanded the capacity of human vision while helping to advance scientific research. It has also helped the artist to see other elements of the land beyond a conventional vision. Two infrared and motion-sensitive cameras were placed inside and around the rhododendron bushes in the area, which then captured movements in front of them when triggered. What they revealed was what a rich community of animals thrive in the area including badgers, foxes, deer, rabbits, hares, mice, pheasants, magpies, woodcocks, curlews, and herons (see Figure 3 and Figure 4). Such insights into the wildlife of the area transformed the photographer's perception towards the site's landscape and its ecology. Instead of a wasteland, it is in fact a land full of life and opportunities. The presence of the animals also helped to decentre the photographer's (and by extension, humans') position within the land. We share it with the animals and the plants. We do not own it, neither should we have the sole voice over it.

Fig. 4. The animal footage displayed as a grid. ©Yan Wang Preston.

The badger that digs in the same rhododendron bush each night and the fox who patrols between two rhododendron bushes everyday help to challenge the claim that the rhododendrons are non-native and invasive with negative values for British ecology. On the contrary, the questions to ask are: Who defines a 'good' ecology? What is meant by 'good'? For whose benefit is a particular ecology considered 'good'? The 'discovery' of such a 'rhododendron habitat' agrees with the concept of a recombinant ecology in which species from all over the world form a recombined habitat offering novel ecological values (Mabey 1973; Maris 2011; Rotherham 2017; and Gandy 2020). Such ideas also challenge the prevailing environmental concerns within contemporary landscape photography that frames its criticism on the damage of a pristine and native wilderness (Preston 2020).

If the 182 still photographs of the love-heart-shaped bush serve as a visual meditation of the cycle of life, then the thousands of animal footages collected during the year firmly provide evidence to support the rhododendron's positive value as a valid part of a British ecology. Staying consistent to an editing without 'hierarchy', all of the video clips were included in the final edit. With a grid of 16 small sections on a single screen (see Figure 4), the videos reference to surveillance cameras and our desire to watch and control nature. The appearance and disappearance of the individual pieces of footage has no overall structure to orders them—much like the sudden appearance of the animals themselves on screen having triggered the cameras. This multi-sectional video screen provides a stark contrast to the time-lapse and its strict rhythm, providing a subtle aesthetic experience between stillness and movement for the installation viewers.

Responding to the increasing level of disembodiment within contemporary landscape photography, this project specifically sought novel ways to symbolically and literally place the photographer *within* her subject. One macro lens was attached to a film camera, which was focused on one single rhododendron flower for 10 minutes. The view, approximately one square centimetres in size, is projected onto a wall that is several meters wide, revealing the details of a flower beyond the capacity of human vision at a disorienting scale. The observer is almost like a bee or insect inside the flower. In this way, the flower is disturbingly autonomous from the human world with its intact structure and intense beauty. Yet it is painfully venerable, trembling with each tiniest vibration of the air. Such hyper-real vision is exploited to bring the rhododendrons closer to our physical bodies, to encourage a sympathetic emotional response towards these plants that are so much more than 'non-native and invasive'.

One way actually to embody oneself within the rhododendrons is simply to become a child again and to play inside the bushes. Many people in Britain and other countries have such fond memories with these foreign plants as they grow up. To contrast with the imagined embodiment within a single flower, Preston embarked on a small 'expedition'—to crawl through a large rhododendron area from one side to the other. It took ten minutes and the 'crawler's vision' was recorded with a GoPro camera, which was fixed on Preston's helmet. The result is a highly unstable footage with no fixed viewpoints or direction of orientation. One is simply lost in the world formed by the rhododendrons.

Fig. 5. *With Love. From an Invader.* Installation view at Jeddah Photo 2022. Image courtesy of Jeddah Photo 2022.

The four ways of looking described above are all anchored within the documentation function of photography. They all make use of contemporary imaging technology, from high-resolution digital cameras to low-budget infrared and motion-sensitive cameras, to 1:1 ratio macro-filming camera, and to the

APP-controlled action cameras. Yet each camera's human-centric and linear views form a multi-angled vision that helps to dislodge the observer from the central stage. Instead, they provide an intimate experience in which the viewer is firmly placed inside the rhododendron bushes. Meanwhile, the content of the images and films serve as visual data and evidence, presenting a thriving ecology and habitat rich in fauna and flora.

Resisting the temptation to quantify such information, the work aims to provide a sense of knowing instead of concrete knowledge. The presentation of these visual components, ideally as a four-panel projection, provides an aesthetic experience beyond 'data reading'. This is achieved by the careful choreography of contrasting scales, rhythms, and colours. Designed to form a physical and immersive space, the installation aims to decentre the human body and its viewpoint. One key artistic element that unify the diverse material is time—the year-long observation helps to place the project into a season sense of time. Meanwhile, the 182 ritualistic walks add a strong sense of performativity and intentionality to the work, while aligning the work more towards land art and beyond conventional photographic documentation.

Sound and Constructed Landscape

Another key artistic element in the work is the soundscape, with each walk becoming a heightened experience of not only looking or touching, but also listening. The sound of the land is drastically different from its visual appearance, often with richer textures. Different weather conditions and surface qualities create different sounds with indefinite changes. Invisible elements, such as hidden water channels as part of the industrial heritage, can be heard rather than seen. Tactile experiences can generate different sounds, and similar to the infrared camera footage of the animals, sound recordings of birds, sheep and bees give further evidence of a land rich in life. In traditional Chinese philosophy, the sound of the land, particularly wind, is given the most significance as the physical manifestation of the energy flow between the external world and the internal human body. The land is appreciated not from a visual point of view, but also sonically. That is why so many Chinese landscape paintings feature a human figure 'listening to the wind'. This flow of energy can be understood by the aliveness of the land, 'wasteland' included, which is highlighted more effectively in the soundscape of *With Love. From an Invader.* Meanwhile, different from the visual, the soundscape can be literally felt by the visitors' bodies within the installation space, providing a further sense of embodiment.

Fig. 6. Monty Adkins recording the sound of touching rhododendron leaves. Photograph by Yan Wang Preston.

The sonic element of *With Love. From an Invader.* is constructed from field recordings at Sheddon Clough combined with synthetic sine tones. The recordings were collected throughout the year-long project and comprise environmental sound samples in the areas surrounding the *rhododendron ponticum* bush as well as from within it, and include wind, rain, snow, autumnal dry leaves, rubbing the bark on trees, ice cracking, pheasants, owls, sheep, robins, blackbirds, curlews, cuckoos, geese, magpies, and bees. The studio construction of these sonic elements to create a recombinant representation of a sensorially experienced landscape was heightened by the unnerving anthropogenic silence of the COVID-19 pandemic as for many of us "the pandemic [...] offered us a unique opportunity to listen to our surroundings in novel and unprecedented ways" (Louro et al. 2021, 3).

The sonic element of the installation uses a similar technique of temporal concentration as Luc Ferrari used in *Presque rien no. 1, le lever du jour au bord de la mer* (1967–1970). Just as Ferrari's piece uses sounds recorded across a whole day edited into a 21-minute form, in *With Love. From an Invader.* the sounds were recorded across all four seasons of a year. In the work there is a deliberate fragmentation of the practice of field recording into its constituent elements in terms of the sound recordist as bodily-present in the recordings themselves (the manipulation of 'objects' in situ – such as the ice recordings), location or spatiality (expressed through recording techniques and microphone placement to create either intimacy and expansiveness), time (the editing of recording taken across a year into a 38-minute installation), and representation and contextual signification (expressed through the transformation of environmental materials and the use of sine tones as 'other' – a signifier of the rhododendron as an invasive species).

The environmental recordings are not simply re-presented as field recordings but are isolated from their original context by using noise-reduction techniques, significantly edited, processed, and then recombined to form a simulated 'natural' space. The resultant 'environmental recordings' presented in the installation comprise multiple versions of soundscapes recorded at different times but are often deliberately long, of many minutes in length, to give the impression of a documentary field recording rather than highlight compositional intervention. The work creates a reconstruction of space through layering of materials rather than a documentary recording of the locale. The recombinant approach to create a sonic landscape and the transformations of each layer independently that this allows is reflective of both the ways in which an invasive species affects other wildlife and fauna in an ecosystem and how identity, memory, and perceptions of landscape are constructed both personally and societally. Mark Graham writes that:

> All places are palimpsests. Among other things places are layers of brick, steel, concrete, memory, history, and legend. The countless layers of any place come together in specific time and spaces and have bearing on the cultural, economic, and political characteristics, interpretations, and meanings of place. (Graham 2010, 422)

Fabricating a recombinant sonic landscape enables recordings from different times, spaces, and transformations that evoke memories or impressions of place as well as technically focusing in of different constituent elements within the environment that may have gone unheard. Such fabrication facilities multiple sonic perspectives to be superimposed that would never be possible within the landscape itself—such as the close recording of streams counterpointed by ambient recordings of wind whistling through trees and dry-stone walls and isolated birdsong. Sound transformations further emphasise the ways in which the invasive species has an effect on the environment and the wildlife within it.

The transformation of the environmental sounds through spectral freezing techniques provides an additional abstracted sonic layer that imbues each section with a sense of stasis or timelessness redolent of the temporary suspension of everyday life that COVID-19 brought about. These transformed sonic layers, although they are spectrally derived from the environmental sounds, are perceived as neither emanating from the environment itself nor entirely foreign to it. The result is what Ambrose Field terms a hyper-real soundscape—one of the four landscape typologies his identifies (Field 2000). Dani Iosofat writes that it is possible to convey a sense of experienced place through the combination of real and constructed sound and that our understanding of place,

> [...] does not depend upon its materiality [...] The effect of combining [...] this expression [of place] with evidence of material reality creates an ambiguous state, a model of some heightened perception that can occur in what Baudrillard dubs the hyperreal, 'sheltered [...] from any distinction between the real and the imaginary'. (Iosofat 2009, 50)

As such, the recombinant sonic landscape of *With Love. From an Invader.* "is a sonic representation of place as an expression of a mental image, which is a result of sensory experience and is causally unrelated to spatial materiality" and involves "the reception of the stimulus and the subjective reconstruction of a poetic image, complete with any mental transformations" (Iosofat 2009, 48). The subtle transformations, transpositions, and spectral freezing of the recorded sounds are balanced against a foreground of more explicit environmental sounds. Here Michel Chion's discussion of 'rendering' and 'reproduction' is useful. In 'rendering' a recombinant landscape Chion notes that sounds are recognised to be "truthful, effective, and fitting not so much if they reproduce what would be heard in the same situation in reality, but if they render (convey, express) the feelings associated with the situation" (Chion 1994, 109).

The spectrally frozen bee, bird, and wind sounds create drone-like tones, seemingly encouraging deep listening and reflection, that impart their own spatial, atmospheric, and temporal qualities to the work that bridge the elements of the recombinant sound-world. The transformation of these environmental sounds mirrors the static quality of the sine tones. This behavioural kinship symbolises the invasiveness of rhododendron ponticum and its effect on the indigenous environment—for example, the nectar of the plant is poisonous to bees. As such, an understanding of the installation's subject matter results in a different signified reading of materials and their transformations.

Sound in Installation Setting

In film we are traditionally accustomed to sound underpinning visual action. In audio-visual installation art this relationship is fluid. Julio d'Escriván extends the traditional relationship in many films writing that "sound on film is there to coexist with the visuals, any understanding of its workings needs to be viewed in the context of intermedia; that is to say, coexisting media that conform, complement or contrast with one another (d'Escriván 2009, 65). In *With Love. From an Invader.*, rather than illustrating the image of the film, the monocular field of vision of the 'love heart' film and the triggered wildlife footage, and the macro-footage of the rhododendron flower is complemented and contrasted with a polyaural recombinant soundfield. The sonic landscape informs our perception of events outside of the field of vision. In this way the experience what Bill Viola terms 'field perception' is presented sonically rather than visually. For Viola "field perception is the awareness or sensing of an entire space at once" (Viola 1995, 151-52). Holly Rogers writes that for Viola 'field perception' is "a combinative concern that aims to create neither musical images nor visual music, but rather a musico-visual simultaneity" (Rogers 2006, 199). In *With Love. From an Invader.* the musico-visual simultaneity is achieved through a multi-screen format presented alongside a recombinant soundscape in which the 'time-lapse' of the love-heart and the soundscape follow the same timeline but the other films are asynchronous to this, leaving the installation viewer to reconstruct a sense of place.

Although the landscape at Sheddon Clough is predominantly open and barren, the unique topology of the landscape is a result of its use during the industrial revolution and it includes numerous mounds that create sheltered gullies. This changing quality of the landscape from the open to the shielded is reflected in the quality of the sound in terms of how certain sounds were recorded. Whilst the sounds recorded during Spring and Summer denote an openness and expansiveness, those of winter display a sense of isolated intimacy. Peter Batchelor writes that installations can explore intimacy in a number of ways and that:

> [...] various acousmatic compositional techniques relating to intimacy might be brought to bear on and operate as a way of drawing a listener into a work [...] in particular as they relate to the consideration of space and spatial relationships. These include recording techniques, types of sound materials chosen, and the creation of particular spatial environments and listening conditions. (Batchelor 2019, 307)

Whilst wind sounds provide a sense of large-scale landscape, there are also very close recordings of breaking ice, the movements of rocks at the site, and capturing insects from within the *rhododendron ponticum* bush itself. Such changes of sonic perspective enhance the transition from season to season. The sense of 'intimacy' demonstrated in the 'winter' section by focusing on very closely recorded breaking ice correlates to the sound dampening experienced due to heavy snowfall in the area. This sense of intimacy is further emphasised by the spatial characteristics and unique topography of the environment—the ice formed on streams at the bottom of gullies. Coupled with snowfall there were few auditory reflections from the hard dry-stone walls around the site.

Fig. 7. Topography at Sheddon Clough. Photographed by Monty Adkins.

Fig. 8. Aerial topography at Sheddon Clough. Photographed by Yan Wang Preston.

It is clear in the ice section (at c.25-32mins) that there is human intervention in which surface ice on the stream is broken. The sound recordist becomes bodily-present in the installation through causal action rather than passive quasi-neutrality of the recorded environments. In the studio these ice recordings were further isolated from their environmental context and recombined with low and high frequency sine tones to clear out the middle-ground sonic space to give a sense of isolated emptiness. The deliberately close microphone techniques used in the ice recordings,

> […] allow the capture of acoustic cues associated with such conditions – an absence of reflections […] and […] low frequency bias where dynamic mics are involved. The microphone thus affords us access to this intimate space, whose nature can be deduced from the spectromorphology of the recorded sound, and which is preserved irrespective of how it is later played back. (Batchelor 2019, 309)

Fig. 9. Yan Wang Preston at Sheddon Clough, Winter 2021. Photographed by Monty Adkins.

Conclusion

With Love. From an Invader. was completed during the first year of the COVID-19 pandemic. The absence of 'normal' human generated sound, such as traffic noise, created an unique soundscape. Meanwhile, the backdrop of the pandemic created an interesting experience while walking in the open (and safe) environment —a heightened and sharper awareness—which was perhaps influenced by the survival threat imposed by the virus. The land appeared to be more alive and autonomous, while human life appeared to be more fragile in comparison. To place the project in this very specific time, two COVID-19 daily statistics counters, one for the global infection numbers and another for global death numbers, are incorporated in the visual projection's entire duration. They are intended to create a sense of unease within a space that is otherwise calming and meditative.

With Love. From an Invader. is the first phase of a long-term artistic investigation towards the politics of landscape, identity, environment and migration within post-colonial Britain. The project selects a contested post-industrial wasteland and its abundant *rhododendron ponticum* plants—a notorious species reputed as being 'non-native and invasive'—as a case study. The awareness of the (colonial) history of the rhododendrons in the UK and their current ecological controversy enables viewers to read the work beyond the surface aesthetics of the work itself—a deliberate parallel to the beauty of the flowers themselves and their ‘invasive’ quality. The installation critiques and deconstructs photography’s function as a means of providing ‘first-hand evidence’ and sound documentary techniques highlighting and questioning human-centric ideology and documenting of the landscape. This critique of landscape leads to the installation utilising diverse imaging technologies and sound techniques to observe and present the landscape and its ecology from multiple angles and layers in a recombinant manner. This recombinant approach to materials is underpinned by theoretical writings on recombinant ecologies and provides a framework for reconsidering novel approaches to landscape photography and documentary sound recording. As such the work provides an embodied aesthetic experience for audiences to contemplate the intimacy, beauty and strength of nature and the eternity of time within an ecological and political frame.

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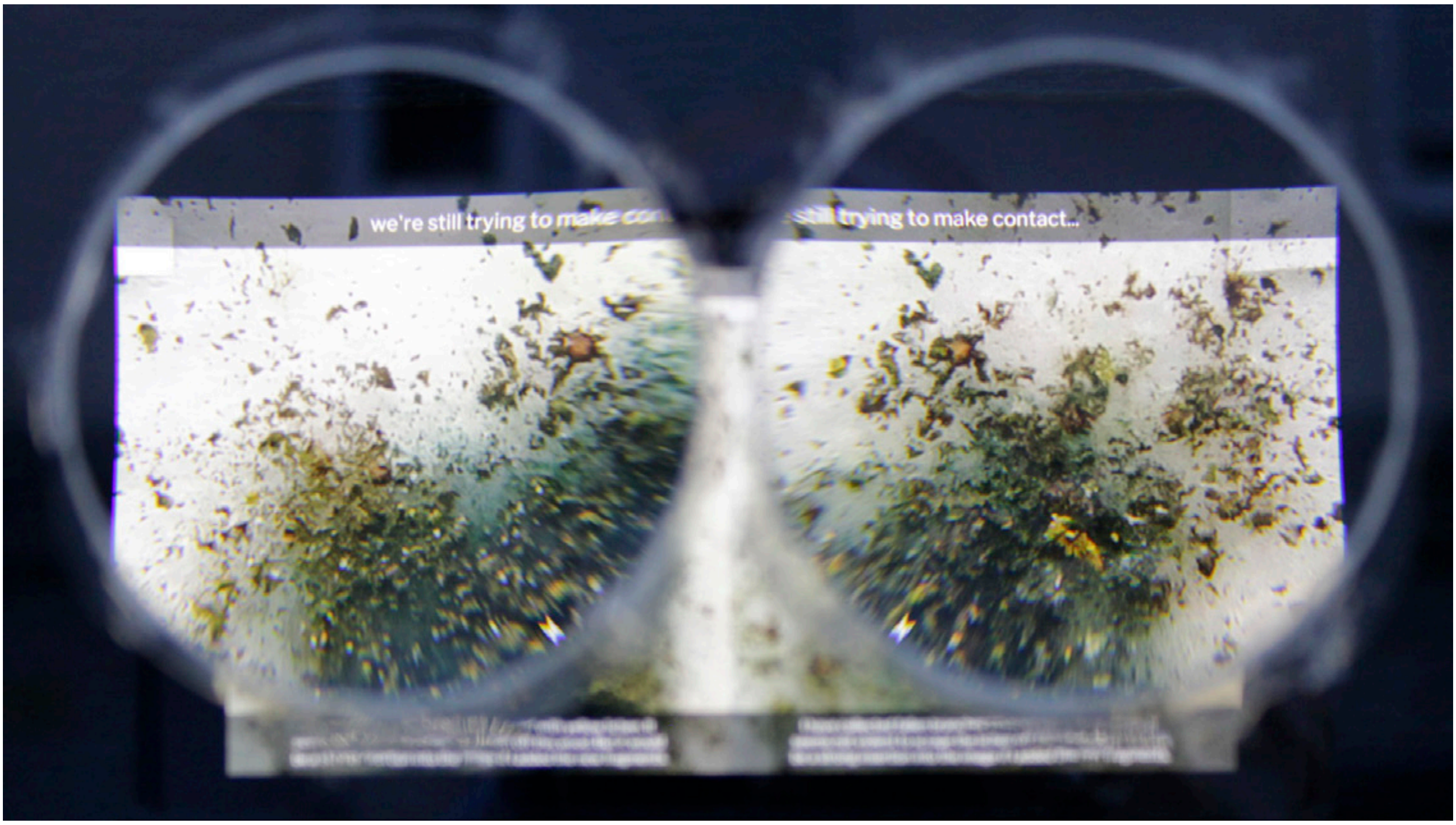

Kontakt (simultan)

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Kontakt (simultan) is a hybrid net-art piece and screen installation on an experimental waiting process taking place as a permanent arrangement inside the studio of *Reagenz*. Here, a glass plate with collected lichen fragments is irrigated and photographed four times a day, perhaps producing an extremely slow growth, that is revealed as a time series of the photographs. The recordings began in April 2021. The process can be followed online, as a bot posts the photographs on a social media account. The second form are physical installations, using either a suspended screen in a showroom window, in front of which stereoscopic lenses are mounted, or a tabletop viewing device. In these versions, the most recent photo is superimposed with a photo that was taken a month ago. The tabletop version allows the visitor to scroll through the time series. The photographs are augmented by text lines contributed by people reacting to an ongoing open call, reflecting on waiting and on making contact.

Keywords lichen, symbiosis, open ended, simultaneity, stereoscopy

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Description

Lichens are interesting life forms. They are a composite (symbiotic) organism formed both by algae or bacteria and fungi. Halfway plant, halfway microorganism. Their occurrence is very specific to the environmental conditions, and biologists study them to map out air pollution (e.g. Wilfling et al. 2008). They grow extremely slowly, and they are not exactly something you can cultivate deliberately, although obscure "formulas" exist.[1] Opinions are diverging on whether it is possible to transplant lichens at all, and whether they would grow anywhere outside their original habitat. This piece, or set of pieces, nevertheless begins with such an attempt.

1. "Magnificent Lichen Growth Formula" containing all the ingredients one could come up with: milk, flour, yeast, gelatin, algae powder, fertiliser. (https://web.archive.org/web/20161025041044/http://lichenlovers.org/lichen_growth_formula.phtml)

Kontakt... departs from the question whether an ongoing process happening in the studio can become a continuous piece observable from the outside. Sharing a glimpse at my working space, forming a connection between the daily activity of being in the studio and the reception or exhibition of art, rather than confining the latter to the typical time frame a piece is exhibited. Making a mutable piece. And finally, as the process began in early 2021, attempting to make a piece accessible during the pandemic.

The setup in the studio, *Reagenz* in Graz (AT), is elementary (Fig. 1): A heap of lichen fragments collected nearby the studio was spread on the surface of a square glass plate placed near a window. A camera is mounted on a gallows above and connected to a Raspberry Pi computer, which is also attached to a motor controller. Two servo motors are attached to a spray bottle filled with distilled water, placed so that when the motors pull the bottle's trigger, the lichen fragments on the glass plate are irrigated. Every six hours, a timer switch starts the computer which runs the irrigation process, then takes a photo. During the night and the dark season, additional flood lamps are activated to illuminate the photo. The digital image is straightened out and cropped based on the detection of visual markers placed on the corners of the plate. The computer then connects to the Internet, and the image is uploaded to the social media account https://botsin.space/@kontakt and tagged with a time code and a text line that changes every day.

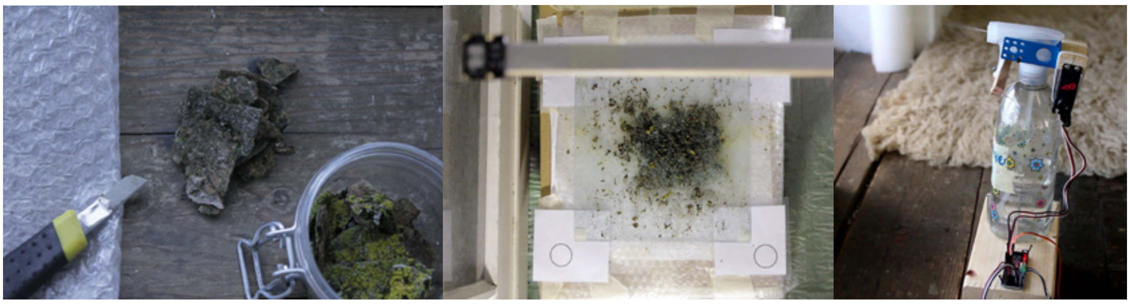

Fig. 1. Setup of the experiment inside *Reagenz.*

The piece is essentially speculative, and an exercise on waiting. Will anything happen? If so, what? Observing the time series of images, several things were indeed happening. The situation is creating a trace of itself. I use fixed exposure times, so you can see how the light conditions change depending on the weather. Rarely glitches in the Hough marker detection algorithm occur. Sometimes I feed the lichens with xylitol and spirulina, leaving a vanishing layer of white dots and green background.

Most importantly, I noticed that when you compare the same time of the day, but spaced weeks apart, the images differ. I began to develop a topography of the plate, there are prominent fragments, constellations, shapes. Perhaps the lichen fragments open up? Or they move slowly by the impact of the water drops? Or they really grow by fractions of millimetres? One finds oneself in the thought space opened up by the likes of Donna Haraway, Lynn Margulis, Isabelle Stengers, or Karen Barad, who have often noted the peculiarities of lichens, rethinking ecologies, individuality, and relationality beyond the human (cf. Gabrys 2018).

How can this become a *piece* (or set of pieces)? There is something atmospheric about the disposition—a texture of warm, moving air. Always flat and relational, small forces working between the elements. Tiniest forces that can only be perceived with special attention or apparatus, as reading between the lines, millimetre by millimetre. Soon after setting up the social media account and thus the existence of *Kontakt*... on the Internet, I became interested in reflecting the poetic qualities of the developing image series in the form of short text fragments, going hand in hand with the format of the microblogging platform (Mastodon). Every day, a new text fragment is chosen from a pool—mostly written by myself, but also with contributions based on an ongoing open call—and displayed along with the image, often reflecting on forms of waiting and contact-making, but generally open to any direction of meandering.

I wanted to refract the net-art piece back into the physical realm. In June 2021, an installation version based on a small screen in a wooden frame and two optical lenses glued to one of the ground-floor windows of *Reagenz* was inaugurated. Passersby on the street can pause and observe the unfolding experiment (Fig. 2). The attribute *simultan* (Engl. *simultaneous*) was added to the title: One can contract the temporal process by comparing photographs side by side. I am intrigued by stereo vision, the merging of distinct left and right eye image into a spatial phenomenon. Unlike a "normal" stereoscopic photography that is taken at the same moment from two slightly different viewing positions, here the photographies are taken from the same viewing position, but at different moments, revealing thus "as spatial expression" what has changed over a period of time. When the viewer turns towards the window and directs their gaze through the magnifying lenses, relaxing the eyes to stare parallelly into an infinite distance, two white cross-hairs move towards each other. When they eventually coincide, a sharp synthetic image with spatial depth is revealed. The most recent photo meets the state one month ago, without a foreground and background or hierarchy, a simultaneous situation is established. Moreover, without cause and effect, the two text fragments attached to the two selected days meet, creating a new semantic-poetic space.

Fig. 2. Internet-based version (left) and window installation (middle and right) of the piece.

The third version is a portable variant of the physical installation. A tabletop machine consisting of a stereoscopic lens mounted on top of the screen, and the entire recording history to the avail of the visitors who may browse using two rotary dials on the left and right side of the box (Fig 3). One may decrease or increase the temporal distance between the left and right image, exploring the different spatial expressions thus created, or reading through the catalogue of texts. If one has never looked at a stereoscopic image, the striking effect is difficult to describe in words, and here new spaces are created by the organism meeting itself. It reminds me of a line in video artist Susanna Flock's piece *I don't exist yet* (2019): "Only if we touch ourselves we are feeling at two places simultaneously." The lichen fragments touch their past or future form, digitally produced proprioception governs. Or perhaps: human and lichen want to make contact independently of each other, and how would that be?

Fig. 3. Tabletop version of the piece with random-access dials.

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Accession: A collecting Booth for an AI Museum

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Accession is a collecting booth for an imaginary museum whose collection is described and organised by AI.[1] Visitors submit everyday items to the booth where they are photographed and subjected to a number of AI processes which describe and classify the objects submitted. Through the exhibition the digital collection grows but as it does so the AI management becomes more and more selective about what is and is not accepted, rejecting new items that are a poor fit for the collection. Museum collections and AI classifiers rely on maintaining homogeneity. A museum that collected anything would be a dumping ground with no identity, while AIs rely on training sets that have strong visual commonality. Both rely on a sense of sameness but both are subject to critical debates about diversity and representation. Accession explores this relationship by acting out a fictional but plausible scenario through commercially available AI technologies.

1. The term AI (Artificial Intelligence) is used in place of ML (Machine Learning) throughout to align the critique of this work oppositionally to the hyperbolic claims made for contemporary uses of ML.

Keywords AI, museums, speculative, exclusion

DOI 10.24840/xCoAx_2022_24

Background

Museums are facing a crisis of profusion (Morgan and Macdonald 2018). An increasingly inclusive view of the materials that constitute culture and thus merit preservation means that human-led means of documenting them seem inadequate to some. Morgan & Macdonald, cite (Harrison 2013; Macdonald 2013) in observing that curators turn to increasingly desperate measures, including 'de-growth' through de-accession or even disposal, to deal with the proliferation of artefacts and the practical challenge of storing and cataloguing them. Some institutions faced with the latter challenge have turned to technologies like Machine Learning to supplant human labour in the description of museum artefacts. Europeana[2], an aggregating service for thousands of European museum catalogues is active in this area convening a task force in 2020 to collate knowledge and issue technical challenges for museums' developers to compete in. Applications elsewhere range from applying image classifiers which automatically tag images of horses, landscapes, or people (to give some examples), develop extended textual descriptions (comparable technology now creates alt-text in Microsoft applications) or establish similarity across or between collections. More experimental, artistic or occasionally playful uses have also been developed such as the Rijksmuseum's attempts to imagine beyond the borders of a Rembrandt painting or Google's tool to search for similar looking faces to one's own in historical portraiture.

2. http://europeana.eu

As with many other areas of AI application the tools perform well within tightly defined parameters. Identifying dominant colours of images, revealing underpaintings on canvas, or reproducing basic stylistic features to paint somewhat in the style of some artist all produce usable results. In some cases (for instance the creation of alt-text) these applications can transform the accessibility of culture. Other authors (Kaltheuner 2021; Crawford 2021) though have observed how state, financial and military interests have contributed to the use of AI producing social harms. These harms are too lengthy to document here though the authors above describe in detail their production of exclusion, invisibility for marginalised groups (Buolamwini and Gebru 2018), exacerbation of power imbalances, and role in injustices globally. Most notably the assumed capacity of such technologies to effectively predict the future (albeit in a limited sense) by making trained observations of evidence of the past puts great power in developers of such technologies and the structures such as companies or governments who support them. In the domain of museum culture some of these problems pervade. The subject of Accession however is less in the direct production of injustice than in the *world view*, the *rhetorics* so-to-speak of giving over the organisation (through tagging, meta-description, linking and so forth) of culture to machines. All such organisation of culture whether it is conducted by persons within institutional frameworks or by machines has a performative

(Butler 1988; Drucker 2013) effect. Theories of performativity tell us that ongoing iteration forms and reforms the limits of discourse and consequently identity. The limits of what it is possible for AI to say about objects is performed publicly (for instance on museum websites) and consequently shapes the translations of these objects for us, the public. Accession parodies this tendency by taking it to an extreme asking what a museum whose collection is organised and described *only* by AI might look like.

The Installation

Accession takes the form of a small (800*800*600mm) photography booth with two attached screens. Visitors are able to place small items into the booth for accession into the museum. In the work's previous showing these objects included keys, watches, takeaway cups, soft toys, USB pens, and other commonly carried items. Objects are detected automatically using computer vision and are photographed from several angles thanks to a revolving base plate.

Fig. 1. Accession on display at MozFest 2019.

The first screen (see left side of Fig. 1 above) shows an open computer terminal which provides prompts or clues as to the behind-the-scenes activity of the booth. These prompts include phrases such as 'ASSESSING ITEM FOR POSSIBLE ACCESSION', or 'ITEM HAS BEEN REJECTED' thus using the terminal as a UI element.

The second screen displays the growing collection along with the AI generated descriptions, categories, colours and similarity scores for each object. Once the object has been photographed, a background script uses a commercial service (IBM Watson) to generate image classifications, hex colour codes and higher-level class descriptions (such as ‘mechanical device’) to define archival series. A look-up table provides human readable labels for the colours. Now the metadata for the object is almost complete a final process establishes whether it will be accessioned into the museum. Here a text similarity algorithm (based on tensorflow’s sentence encoder[3]) uses the newly created text description as the basis of a comparison with an aggregated text derived from all previously collected objects. If a threshold similarity is achieved, the object is accessioned but the threshold is raised slightly making it more difficult for future objects to join the collection. An example sequence is linked from Fig. 2 below.

3. https://tfhub.dev/google/universal-sentence-encoder-large/3

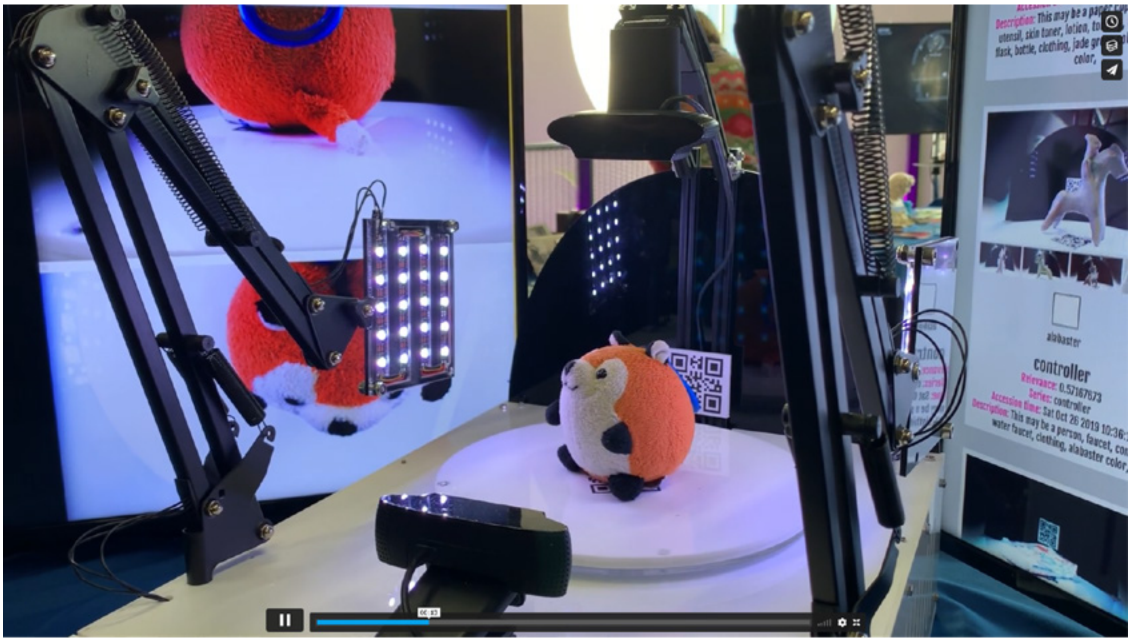

Fig. 2. Accession in use (https://vimeo.com/468031385).

Discussion

Accession’s purpose is to both parody the uncritical use of AI within culture and to ask questions about whether any role for it is acceptable within the larger socio-technical apparatuses that constitute contemporary museums. The issues of profusion and hyperabundance in museums are a symptom of broader motivations to democratise access to culture. Museums and academics have for some time wrestled with perceived clashes between curatorial expertise and recognising other knowledges inclusively. Bettivia and Stainforth (2019) employ notions of ‘governmentality’ from Foucault (2002) in a critique of how Europeana (among others) embodies a set of political ideas in its organisation and presentation of knowledge privileging particular ideas of ‘Europeanness’ to the exclusion of others. What is particularly concerning with the inclusion of AI at scale in museums is how particular kinds of knowing (trained, finite, unequivocal) are inscribed in the consumption and production of culture.

Acknowledgements. Accession was a commission by the Mozilla Foundation for MozFest 2019.

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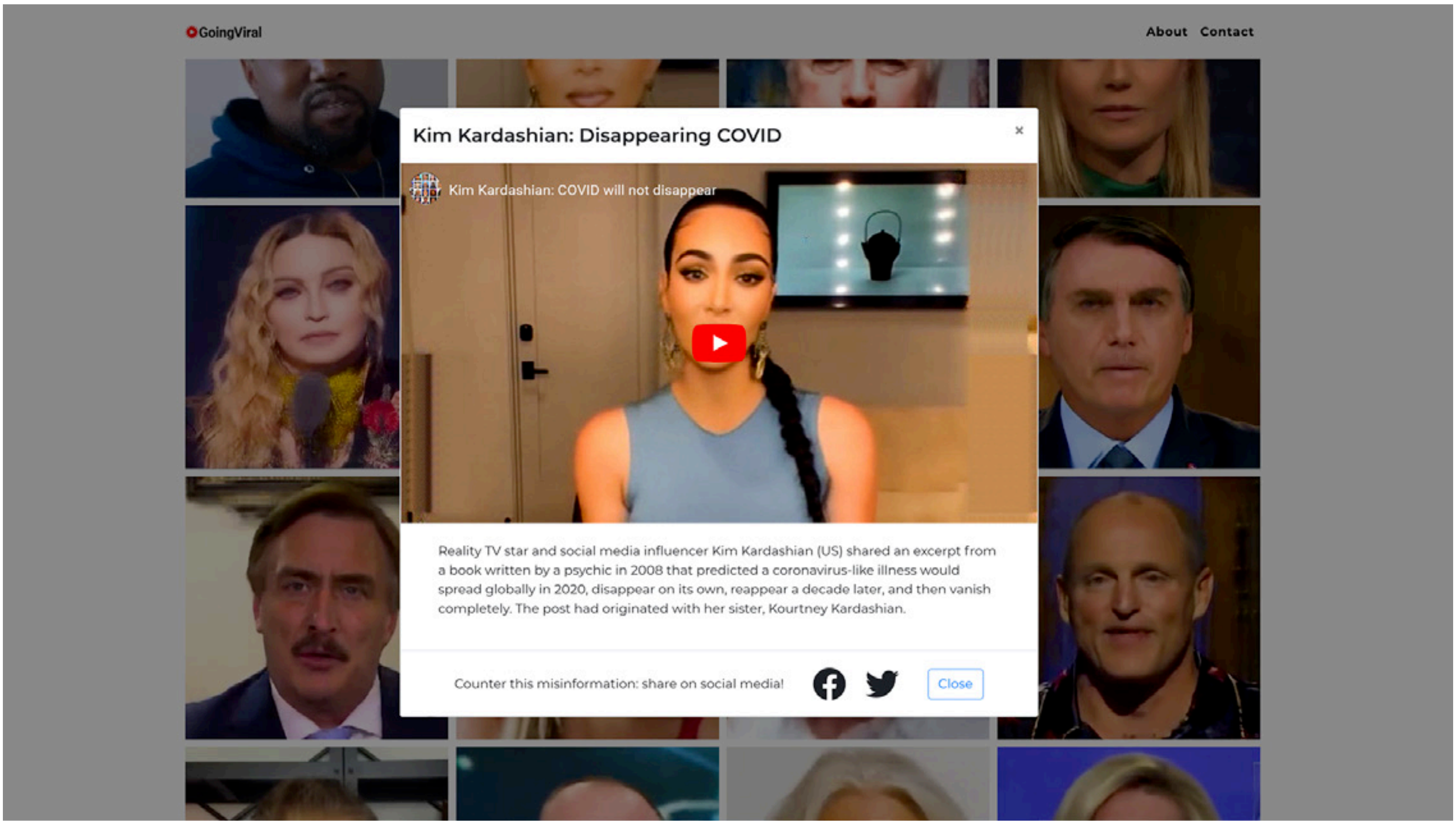

Going Viral

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Going Viral is an interactive artwork that invites people to intervene in the spreading of misinformation by sharing informational videos about COVID-19 that feature algorithmically generated celebrities, social media influencers, and politicians that have made or shared claims about the coronavirus that are counter to the official consensus of healthcare professionals and were categorized as misinformation. In the videos, algorithmically-generated speakers deliver public service announcements or present news stories that counter the misinformation they had previously promoted on social media. The shareable YouTube videos present a recognizable, but glitchy, reconstruction of the celebrities. The obvious digital fabrication of the videos prevents their classification as deepfakes by content moderators and helps viewers reflect on the authority of celebrities on issues of public health and the validity of information shared on social media.

Keywords generative art, artificial aesthetics, cGAN, misinformation, social media, pix2pix, tactical media, video art

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Description

Celebrities and social media influencers are now entangled in the discourse on public health, and are sometimes given more authority than scientists or public health officials. Like the rumors they spread, the online popularity of social media influencers and celebrities are amplified through neural network-based content recommendation algorithms used by online platforms. The shareable YouTube videos present a recognizable, but glitchy, reconstruction of the celebrities. The glitchy, digitally produced aesthetic of the videos keeps them from being classified as "deepfakes" and removed by online platforms and helps viewers reflect on the constructed nature of celebrity, and question the authority of celebrities on issues of public health and the validity of information shared on social media.

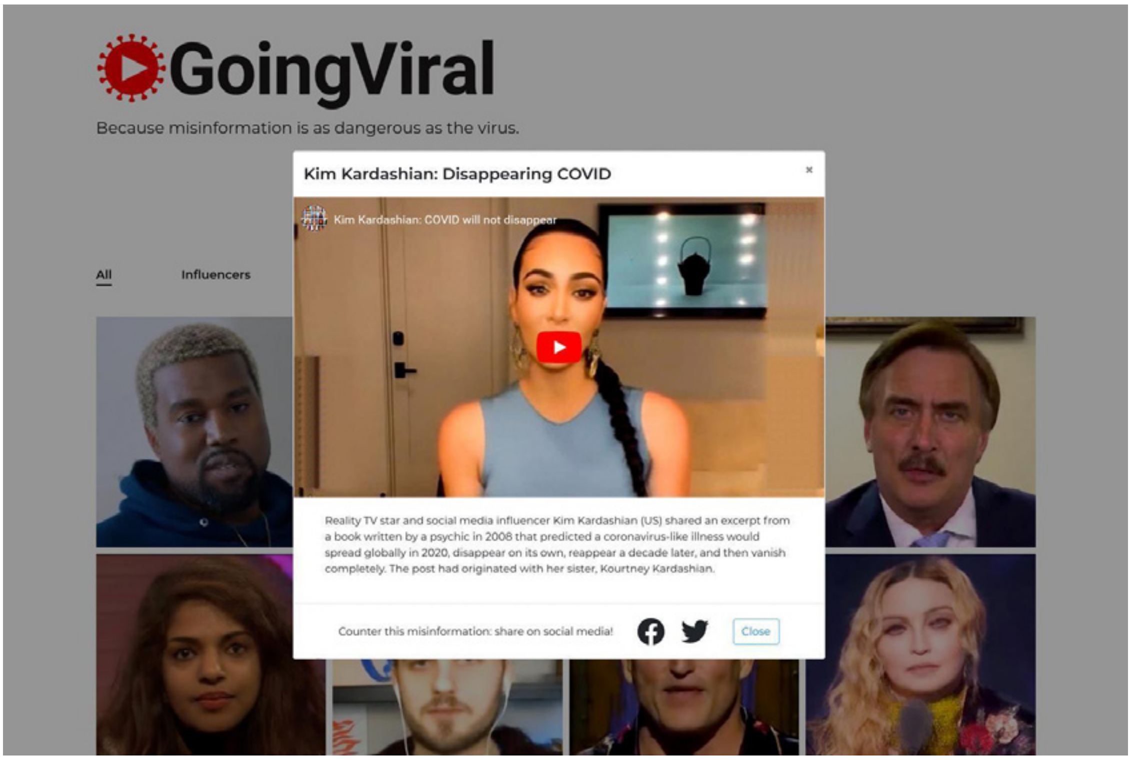

Fig. 1. *Going Viral*, 2020, Derek Curry and Jennifer Gradecki, screenshot of website with algorithmically generated videos, image courtesy of the artists.

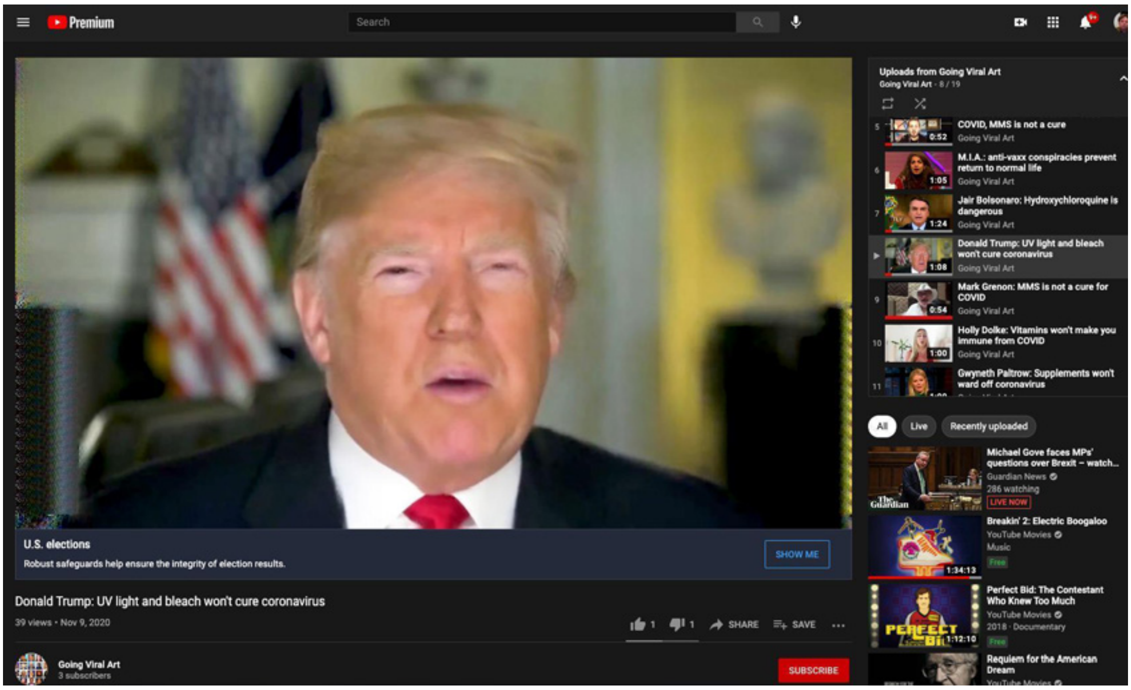

Fig. 2. *Going Viral*, 2020, Derek Curry and Jennifer Gradecki, screenshot of algorithmically generated video on YouTube, image courtesy of the artists.

The videos in *Going Viral* are the result of an experimental use of a Pix2Pix conditional generative adversarial network (cGAN). In a cGAN, a neural network is trained on sets of two images where one image becomes a map to produce a second image. In *Going Viral*, the two images are a frame from a video and facial recognition landmarks from that video frame. Once the model is trained, it can be used to generate an image of a face based only on the facial landmarks from the first image (Fig 3). The process starts by extracting the facial landmarks of an influencer, celebrity, or politician from frames of a video. A model that maps the landmarks to an image of the influencer is then trained. Next, the facial landmarks of an expert speaking on a topic are extracted and used to generate new video frames. The new frames are combined with the audio track of the expert or journalist to produce a public service announcement that counters the misinformation spread by the celebrity, influencer, or politician. Finally, these videos are posted to YouTube and are shareable on social media via goingviral.art.

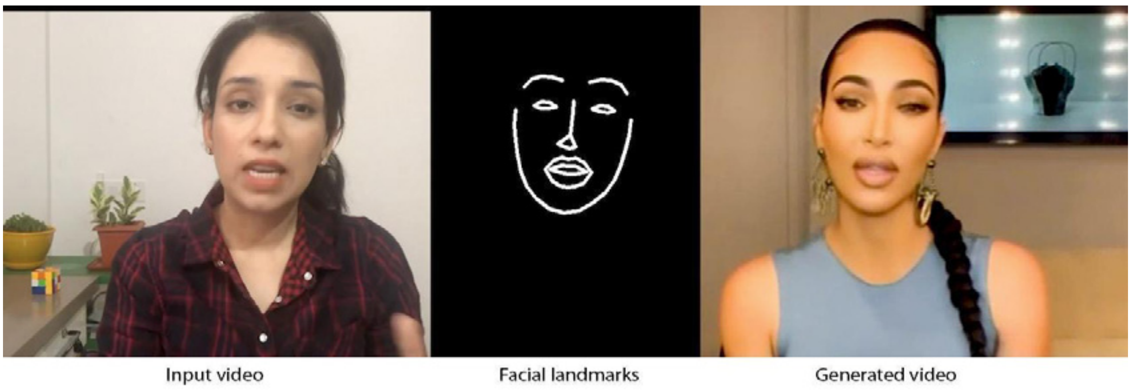

Fig. 3. *Going Viral*, 2020, Derek Curry and Jennifer Gradecki, Example of video generation using a cGAN, image courtesy of the artists.

Acknowledgements. *Going Viral* was commissioned by the North East of North (NEoN) Digital Arts Festival in 2020.

Project website: https://www.goingviral.art/
Informational video: https://vimeo.com/509818547

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Boogaloo Bias

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Boogaloo Bias is an interactive artwork and research project that addresses some of the known problems with the unregulated use of facial recognition technologies, including the practice of 'brute forcing' where, in the absence of high-quality images of a suspect, law enforcement agents have been known to substitute images of celebrities the suspect is reported to resemble. To lampoon this approach, the *Boogaloo Bias* facial recognition algorithm searches for members of the anti-law enforcement militia, the Boogaloo Bois, using a facial recognition algorithm trained on faces of characters from the 1984 movie *Breakin' 2: Electric Boogaloo*. The film is the namesake for the Boogaloo Bois, an anti-law enforcement militia that emerged from 4chan meme culture. They have been present at both right and left-wing protests in the US since January 2020. The system is used to search live video feeds, protest footage, and images that are uploaded to the *Boogaloo Bias* website. All matches made by the system are false positives. No information from the live feeds or website uploads is saved or shared.

Keywords artificial intelligence, surveillance, facial recognition, tactical media, technocratic solutionism

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Description

Boogaloo Bias raises questions about automated decision making, public accountability and oversight within a socio-technical system where machines are contributing to a decision-making process. Facial recognition technology allows for the quick surveillance of hundreds of people simultaneously and the ability to automate decisions using artificial intelligence, establishing a power structure controlled by a technocratic elite. Rather than providing a solution for how to improve facial recognition, the project pushes the logic behind the current forms and uses of facial recognition in law enforcement to an extreme, highlighting the absurdity of how this technology is being developed and used. Law enforcement currently uses images of celebrity doppelgängers to find suspects. In *Boogaloo Bias*, the corpus of training images is based solely on fictional characters, leading only to false positives.

Participants can interact with the *Boogaloo Bias* facial recognition algorithm in an installation through a live CCTV camera and see which *Breakin' 2* characters the system finds to be similar. They can see how their matched character sometimes changes as they move their head or change facial expressions, revealing how easily this practice can be compromised. Online viewers can experiment with the system by uploading images of themselves or their friends. Both the physical and virtual presentations of the project feature videos of protests scanned by the facial recognition system and social network analysis (SNA) diagrams that viewers can interact with. One SNA diagram is a manual mapping of the relationships between the characters in the film while a second diagram draws connections between the characters algorithmically using the *Boogaloo Bias* facial recognition system. An online resource library links to articles and research about the unregulated use of facial recognition in the United States, the Boogaloo Bois militia, and the use of SNA diagrams by law enforcement to understand, predict, and intervene in human behavior.

The interactive experience in *Boogaloo Bias* demonstrates how unregulated surveillance technology without public oversight can lead to absurdly erroneous results. The project draws from a number of academic and journalistic sources, including a study by the Georgetown Law Center on Privacy and Technology, which found that because there are “no rules when it comes to what images police can submit to face recognition algorithms to generate investigative leads,” agents have been known to substitute not only low-quality images from CCTVs, but hand-drawn forensic sketches, proxy images generated from artist sketches, and images of celebrities thought to resemble a suspect (Angelyn, 2019). The project also reveals problems that arise from using low accuracy thresholds. While some tech companies have stressed that police should use confidence thresholds between 95% to 99%, law enforcement agencies often use low, out-of-the-box accuracy levels of 80% to maximize investigative leads

(Wood, 2018; Levin, 2018). The *Boogaloo Bias* system returns every match, highlighting matches that are above the 80% out-of-the-box threshold, so participants can see the impact of accuracy thresholds on matches the system returns.

Fig. 1. *Boogaloo Bias* interactive installation at Science Gallery Detroit with participants.

Fig. 2. Screenshot of *Boogaloo Bias* facial recognition system analyzing news footage of an anti-gun control protest.

Fig. 3. Screenshot from *Boogaloo Bias* promotional video.

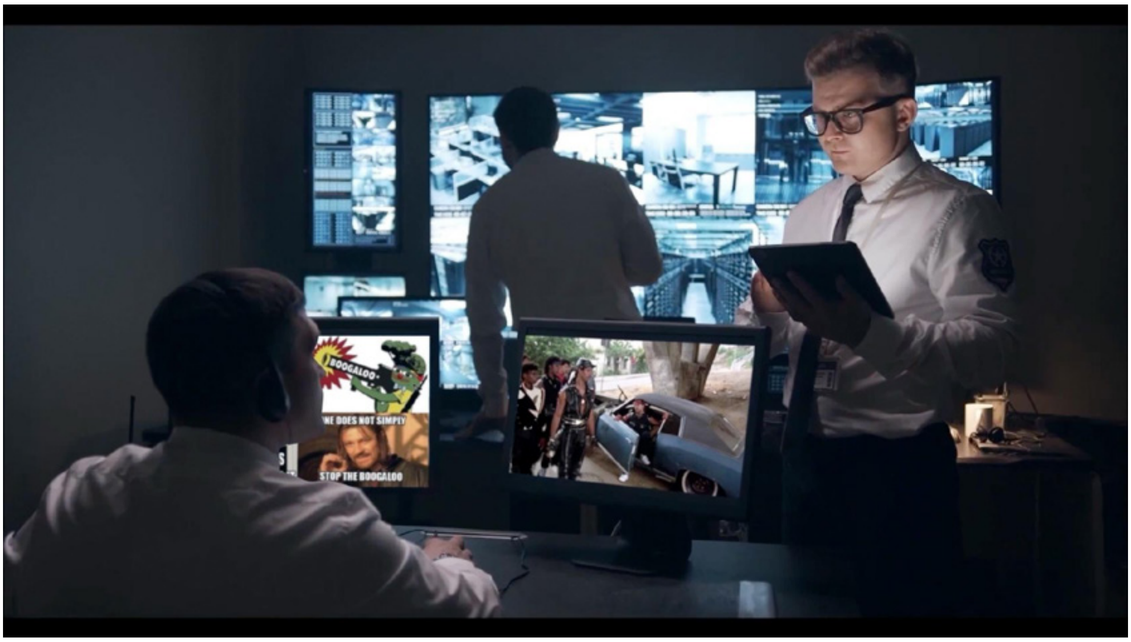
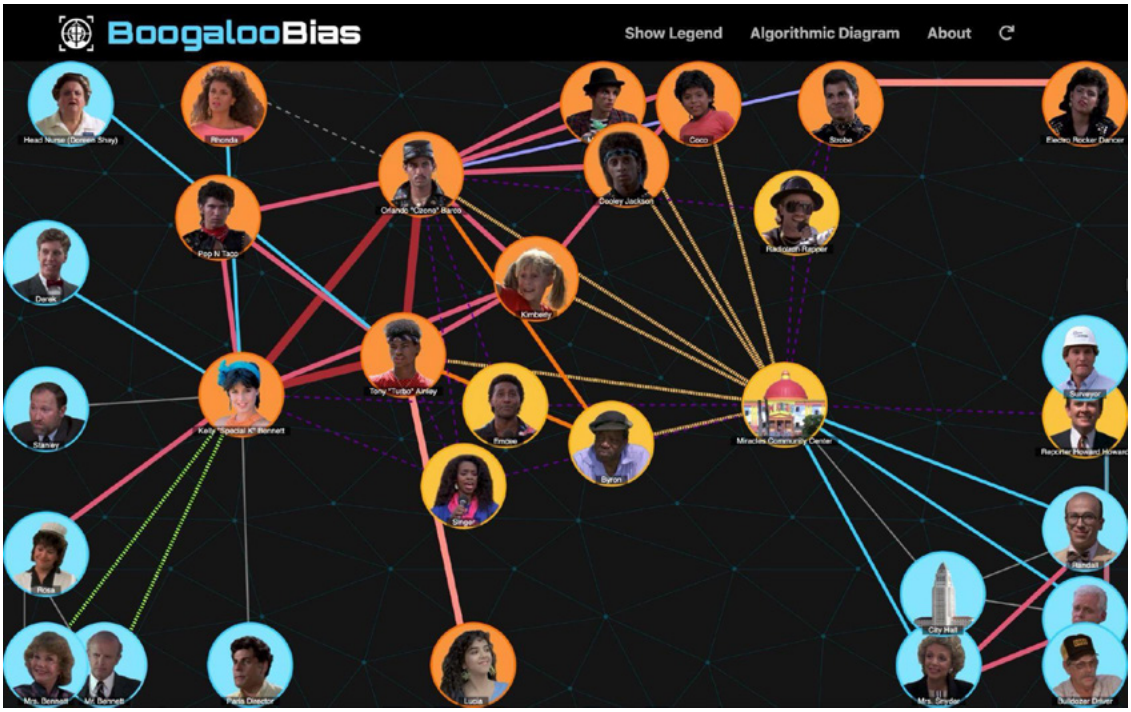


Fig. 4. Interactive social network analysis diagram of characters from *Breakin' 2: Electric Boogaloo* (installation and web).



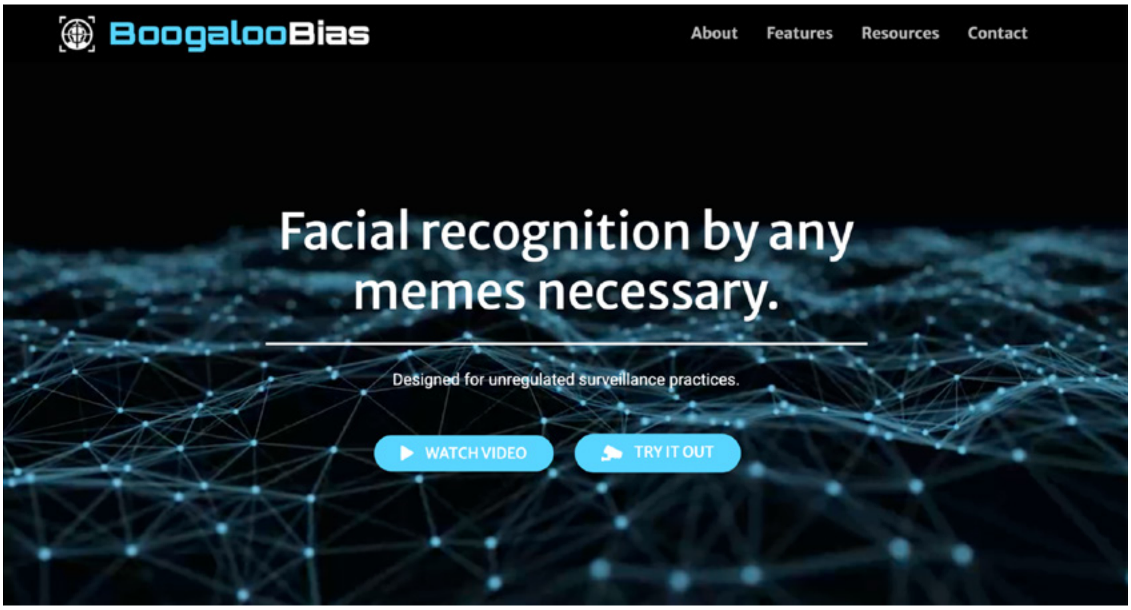


Fig. 5. *Boogaloo Bias* website home page.

Acknowledgements. *Boogaloo Bias* was commissioned by Science Gallery Detroit for the 2021 *Tracked and Traced* exhibition.

Project website and online application: https://www.boogaloo-bias.art/
Project video: https://vimeo.com/641009130

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Ecology of Worries

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Ecology of Worries is an animation featuring variously evolved critters that are driven to speak by machine learning algorithms trained on actual human worries. The creatures' performance of the worries spans a gradient of intelligibility, reflecting on the evolution of machine learning systems and whether or not we should teach a machine to worry for us. The animated characters are also representations of our collective worries, given life and evolved through evolving algorithms. The critters are trained using an archive of thousands of recorded worries from people in the US and abroad which we began collecting in 2016. The emotionalization of events by the media is engendering worries that swirl inside us, trapping us in manufactured anxieties. We have been asking people in our communities what they are worried about and find they have a plethora of concerns at the ready. This process is an opportunity to collect various types of worries and consider similarities in emotional cycles across communities.

Keywords Communication, X, Algorithms, Artificial Aesthetics, Artificial Intelligence, Audiovisuals, Generative Art

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Description

Worrisome shifts in the USA's politics triggered our interest in collecting worries. Leaders were drawing the culture inward while souring relationships with longstanding allies. The COVID-19 pandemic goaded us to continue the project to this day. There are many social situations where it is unacceptable to express these thoughts, yet we all have them. The public is invited to record worries anonymously at https://worries.io as these are being continuously incorporated into our artworks such as the *Worries Bash* and now *Ecology of Worries* video/animation.

Ecology of Worries engages machine learning in several ways. The animating worries themselves are generated by a recurrent neural network (RNN) as well as the general pretrained transformer (GPT-2). The lip synching on the creatures is done via Adobe Sensei Artificial Intelligence (AI), which is being integrated into the Creative Suite software. Despite these automated approaches to generative artwork, the creatures themselves are hand-drawn and lovingly textured with familiar yet surprising household surfaces. This combination of machine-generated and hand-made drops these characters into an uncanny valley but not because they look real. Indeed, these fantastic animals look totally imagined, and yet the way they perform their concerns—and indeed the concerns themselves—feel like they could be real, as real as the worries swirling inside us all. This combination is what gives the critters the distinctly *unheimlich* (un-homely, uncanny) vibe, which stirs curiosity in the human viewers.

Training is the aspect of machine learning that engages the most important political dimension of this technology (the other one being access). Silicon Valley frat bros scrape photos of their classmates, or grab celebrity faces from the wild to train their AI. Even well intentioned people often do the easy thing without anticipating problems down-stream. Biased data imbues the machines with the biases of their creators. The wide deployment of AI by social media companies across much of the world has made the voices of Alexa, Siri, and Google Maps ever more recognizable. *Ecology of Worries* defamiliarizes the peppy digital assistant voice—and even the intention of this sentience—by training these creatures to worry about our communal woes.

The project speaks to questions of machine learning, autonomy, and agency, as well as makes space to play with ideas of artificial life and emergence. The Eliza effect, discovered in the late 1960s, led people to perceive a chat bot as intelligent and worth confessing to. *Ecology of Worries* flips the dynamic to have the machines confess to us and put us in an awkward, thoughtful, and yet hilarious state of mind. The overall experience is generative because the work creates space to explore a cultural ecology of a hybrid, human-machine sentience of empathy. The worries become uncanny through a juxtaposition of familiar and abstract concerns.

Fig. 1. *Ecology of Worries* video asset https://vimeo.com/396338290/e6644e84c3

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Brass Art TouchAR

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TouchAR is an Augmented Reality artwork made for Apple and Android mobile devices. *TouchAR* invites the user to download the free app to activate images with animation and sounds. These include tracking butterflies, a leaping locust, an inhaling lung, and fingers of flame that invite repeated fingertip touch. The auditory aspects of *TouchAR* mix live capture of the artists' voices with field and studio recordings to create electroacoustic soundscapes. The artwork brings together three-dimensional copies of the artists' hands with collaged imagery drawn from environmental regeneration, the *Tapestry of the Apocalypse*, (made in Angers in the 14th century), and historic, anatomical, and cosmological illustrations. The AR system was developed in Unity (during the Covid19 lockdown 2020-21) with the AR Foundation SDK utilising a combination of image and plane detection to augment each printed digital artefact. The artists use technology to suture analogue and computational art making, to explore ideas of touch and engagement with ecology in a technological society and address the deep past, present challenges and possible futures. *TouchAR* offers an embodied experience with AR as a means of enchantment.

Keywords augmented reality, embodiment, interaction, art, uncanny, wellbeing, worlding, environment

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Brass Art TouchAR

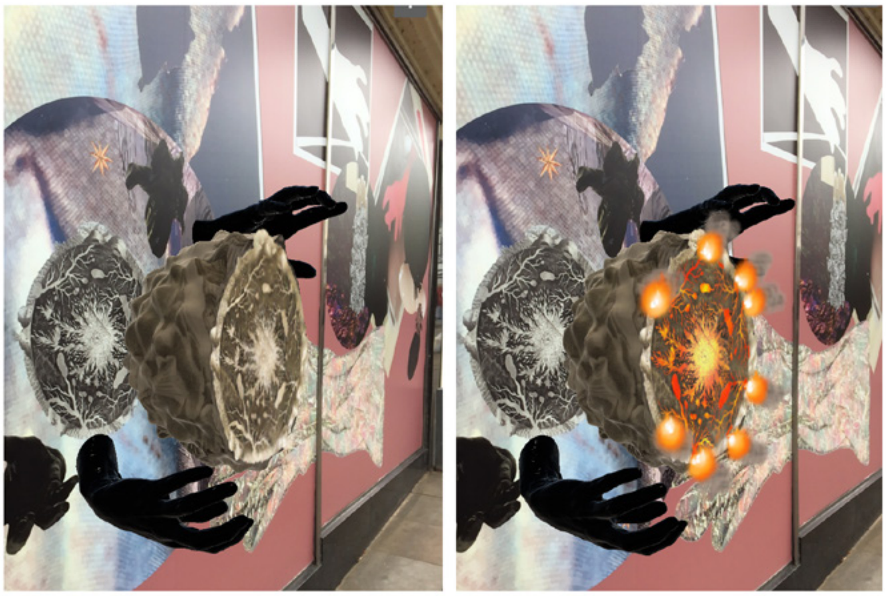

Fig. 1. *Brass Art: TouchAR* (2021) Installation detail, vinyl prints installed on glass, Castlefield New Art Space, Wigan. Dimensions variable. Image credit Brass Art.

Introduction

Brass Art was commissioned by Turnpike Gallery (UK) to develop a bespoke AR app for interactive artworks in Wigan and Leigh, UK (2020-21). The Augmented Reality (AR) artwork *TouchAR*, is designed for Android and Apple devices. The *TouchAR* app triggers animations and sounds to augment original collaged images created by Brass Art. These appear as posters, billboards, and vinyl decals in urban and rural spaces. The images reflect the creative and collaborative approaches the artists took to site, technology, ecology, and gesture in their production of artworks for the public realm during the Covid-19 pandemic.

The intrinsic purpose of the commission was to test the artistic potential of AR in the public realm at a time of social isolation and to simultaneously explore the role and importance of touch in the context of a global pandemic through the use of touch-screen devices. The interactive artworks are devised to encourage hope, highlight meaningful environmental change in a hyper-local context, and draw attention to multiple aspects of the post-industrial environment, including its historic past and possible futures. In this sense *TouchAR* reflects contemporary ecological global concerns.

TouchAR

The *TouchAR* app uses an AR system developed in Unity with the AR Foundation SDK which recognises a number of image markers in the artefact, whilst also being aware of the surrounding planar surfaces. Both the image markers and the planar surfaces are augmented with virtual objects and related visual and auditory experiences. The segmentation of larger areas allows the users to experience the artwork up close and at a distance. Working in AR enabled Brass Art to experiment with two kinds of highly detailed original 3D scan data: first their captured hand gestures[1] and second, mineralogical specimens[2] sourced from Manchester Museum. Through their sculptural approach they also translated 2D representations of hands and historic illustrations into digital 3D models. Through the app, all of these elements convincingly emerge from the 2D surface of the collaged images.

1. *TouchAR* extends the computational use of cloud data harnessed during the commission Brass Art *Gestured* (2017) https://brassart.org.uk/Gestured

2. Brass Art *Still Life No. 3* (2019) https://brassart.org.uk/Still-Life-No-3

Fig. 2. *Brass Art: TouchAR* (2021) public interaction with AR artwork, Pennington Flash Nature Reserve, Wigan. Image: Livia Lazar.

In *TouchAR* the hands stand-in for the artists. They use them to suggest agency, power, control, and their opposites. The hands reach out and they offer up virtual objects for contemplation which hover magically in their midst or unfold upon further investigation. With the touch of a finger, users can animate an engraving of the sun's imagined surface, or the earth's fantastical interior, both photographed from original 17th century scientific textbooks by Jesuit polymath Athanasius Kircher[3]. His vast range of knowledge and scientific speculation included research into electro-magnetism, bioluminescence, geology, weather systems, eclipses, herbs, and the use of early microscopes. The juxtaposition of these elements in his treatise created a visually rich collection to consider in relation to the artists' own sensing bodies in space and subsequent utilisation for this interactive artwork.

3. Brass Art have a long-standing interest in Athanasius Kircher and photographed *Mundus Subterraneous* (1678) at Chetham's Library, UK during an Arts & Heritage commission.

In relation to Brass Art's ongoing collaborative practice the artists consider the unconscious call and innate power of objects (Brass Art, 2020; 49-64), and how AR enhances the affective dimension of the uncanny. The animation of the

AR objects, insects and disembodied organs suggests a vital force, a lively intensity as described by political theorist Jane Bennett (Bennett 2012, 237-270). She asks us to take seriously the call from things as lively bodies, recognising both enchantment and the uncanny aspect to the task of addressing the agency of objects as 'thing-power'. Similarly, the experience of activating the AR objects in the artwork can be both enchanting and uncanny in bringing to light that which should remain hidden and bringing to life that which had seemed dead.

Fig. 3. *Brass Art: TouchAR* (2021) collage artwork. Image credit Brass Art.

Developing a visual language for *TouchAR* the artists integrated imagery based on previously extinct native species, the Great Sundew and the Manchester Argus butterfly, both recently reintroduced through the renewal of local wetlands. As well as this flora and fauna they drew upon the forms of karstic scholar stones[4]. These scholar stones emphasise weathered landscape forms and qualities in miniature, as substitute for a whole terrain. Some of the sculptural forms re-presented as collage components were dramatically changed in scale, others had their surfaces wrapped with dichroic cellophane to refract iridescent light and create visual disturbances. The quality of the different elements – black polyethylene, archival artefacts, 3D scans, dichroic film, details from the *Tapestry of the Apocalypse*, glass fragments, NASA imagery, anatomical illustrations, and photocopies – create unsettling encounters from different visual and temporal registers. This strategic use of materials and technologies enables possible transformations in relation to embodiment, matter, and the scale of the artists' gestures.

4. The ancient East Asian art of stone appreciation dates back to 7thC: *Gong Shi* (China) *Suiseki* (Japan), *Suseok* (Korea).

The Imbrication of Biological Life and Emotional Life

Brass Art understand the imbrication of biological life and emotional life as vital for wellbeing, and that dangerous consequences may arise for society when these entangled and contingent states are savagely torn apart (Leader 2016, 8-31). The *TouchAR* interactive artworks enable an encounter with the artists' hands reaching out into ‘real’ space, and harness habitual daily actions for engagement with an enchanting, unsettling, transformation of the user’s world. In response to the pandemic, it seemed urgent to produce artwork which engaged with the importance of green spaces for health, and the hope engendered by the re-introduction of native species into once-devastated post-industrial landscapes.

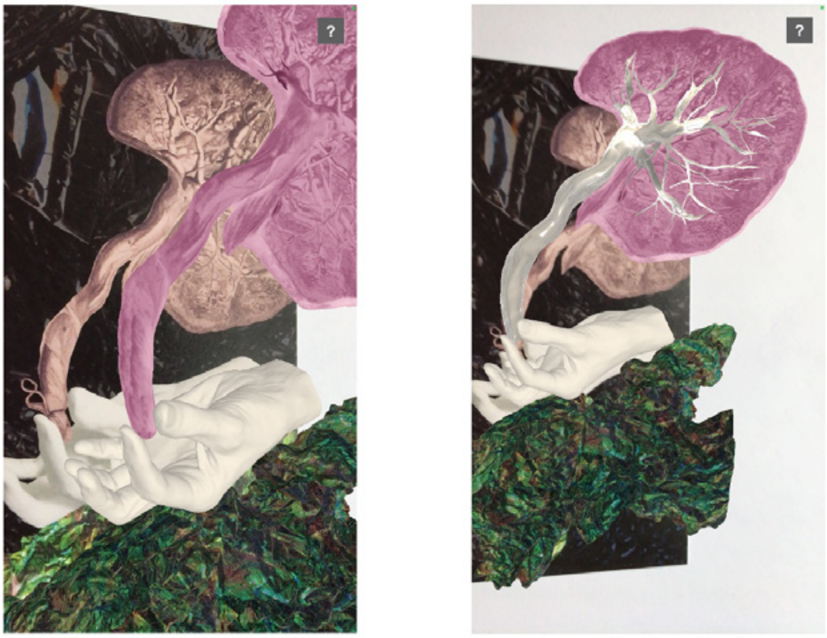

Fig. 4. *Brass Art: TouchAR* (2021). Interaction with AR artwork on postcards. Dimensions 9.8cm x 21cm. Image credit Brass Art.

The auditory aspects of Brass Art’s practice involve live recordings of the artists’ own voices, field and studio recording, as well as sounds coaxed from objects and the composition of electroacoustic, immersive soundscapes. In the *TouchAR* app, manicules[5] direct users’ finger-tip touch to the places of interaction, which trigger animations and sounds. These reflect particularly human responses, personifying the insects or organs through involuntary sighs or whimpers. Other synthesised sounds turn the 3D objects in AR into resonant vessels that breathe, wheeze and crackle to enhance the animation and vitality of the encounter. The artists listened to extra-terrestrial sounds picked up by NASA, and recordings of a wave-powered sea organ, as they discussed the 3Dmodelling of Kircher’s engraving of Solaris (Kircher 1678), with attendant solar flares. The entangled yet distinct registers of forms and sounds are regarded by the artists as a form of worlding, and a response to “the fractured timespace of our present planetary moment” (Ginn et al. 2018, 214).

5. Manicule – a symbol in the shape of a pointing hand, normally used to draw attention to a section of text.

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Blomster – The Human Garden

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Blomster is a beautiful word and rolls around in the cavities of speech like a plump gum drop. It is the Danish word for flower and became the core of a choreographic work with Kathryn Ricketts' Danish dance company 30 years ago on a stage laden with fresh flowers. The intricate patterns of dancers in white, moving through metaphors of garden life: the weeds, the buds and the blossoms, was accompanied by the words of an 85 year old gardener with proud and loving descriptions of tending to his lifelong garden. This work has been transported and reconfigured into the present with Angela Ferraiolo's brilliant digital and everchanging gardens and Arne Eigenfeldt's stunning generative soundscapes. We are exploring the timelessness of nature within a digital age and the many human relational metaphors that not only endure but thrive as we move into a future that threatens social austerity.

Keywords live performance, installation, computational creativity, generative music, multi-agent system, dance

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Description

Blomster – The Human Garden began as a conception to use first person descriptions of gardening – spoken in Danish by the third author's husband and garnered from Danish social media – within a generative work that explores the never-ending possibilities of growth and natural processes. Audio recordings were segmented into a database used by an ensemble of musebots (Bown et al. 2015) – the first author's ongoing research into intelligent musical agents – to reconfigure and recontextualize their meaning through recombinance. Another ensemble of musebots create a unique musical structure (Eigenfeldt 2016) – complete with a harmonic progression and melodic outline generated through machine learning of a corpus – compose a musical accompaniment to the generated text. Each performance is unique and complete.

The musebots are influenced and informed in their decision making by selections made from a database of generative video created by the second author, videos that depict individual or multiple imagined digital flowers slowly blooming. The video database has been pre-analysed for colour and movement – valence and arousal (Eigenfeldt et al. 2015) – and these features inform the musebots in their machine composition. New videos are selected and presented for each durational section within the performance, sections which are themselves determined by a "ProducerBot" that generates an overall formal structure for each work.

Finally, the third author, a dancer and movement artist with expertise in movement improvisation, creates performative movement based upon the generative music, text, and images presented. Similar to the spontaneous unfolding of the sound and the images, the dancer extracts the essence of each of these influences and transmediates this into movement that both echoes and provokes.

All three of these elements call and answer creative impulses simultaneously and in this complex generativity we come to new understandings of growth support, evolution and decomposition. The digital garden, through these three artful experimentations and interpretations, offers a rich metaphor for a re-interpretation by those who witness this interdisciplinary performance.

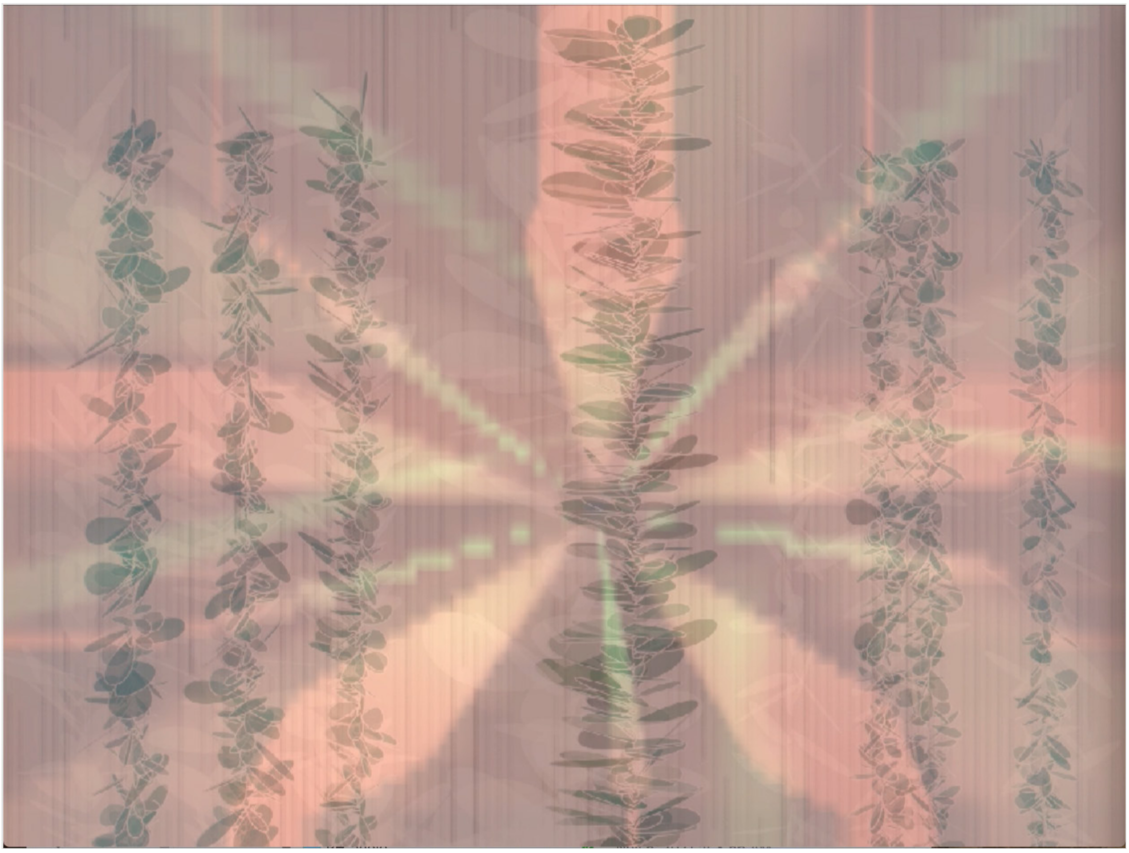
Fig. 1. Still from generative video.


Fig. 2. Kathryn Ricketts performing live in Blomster.

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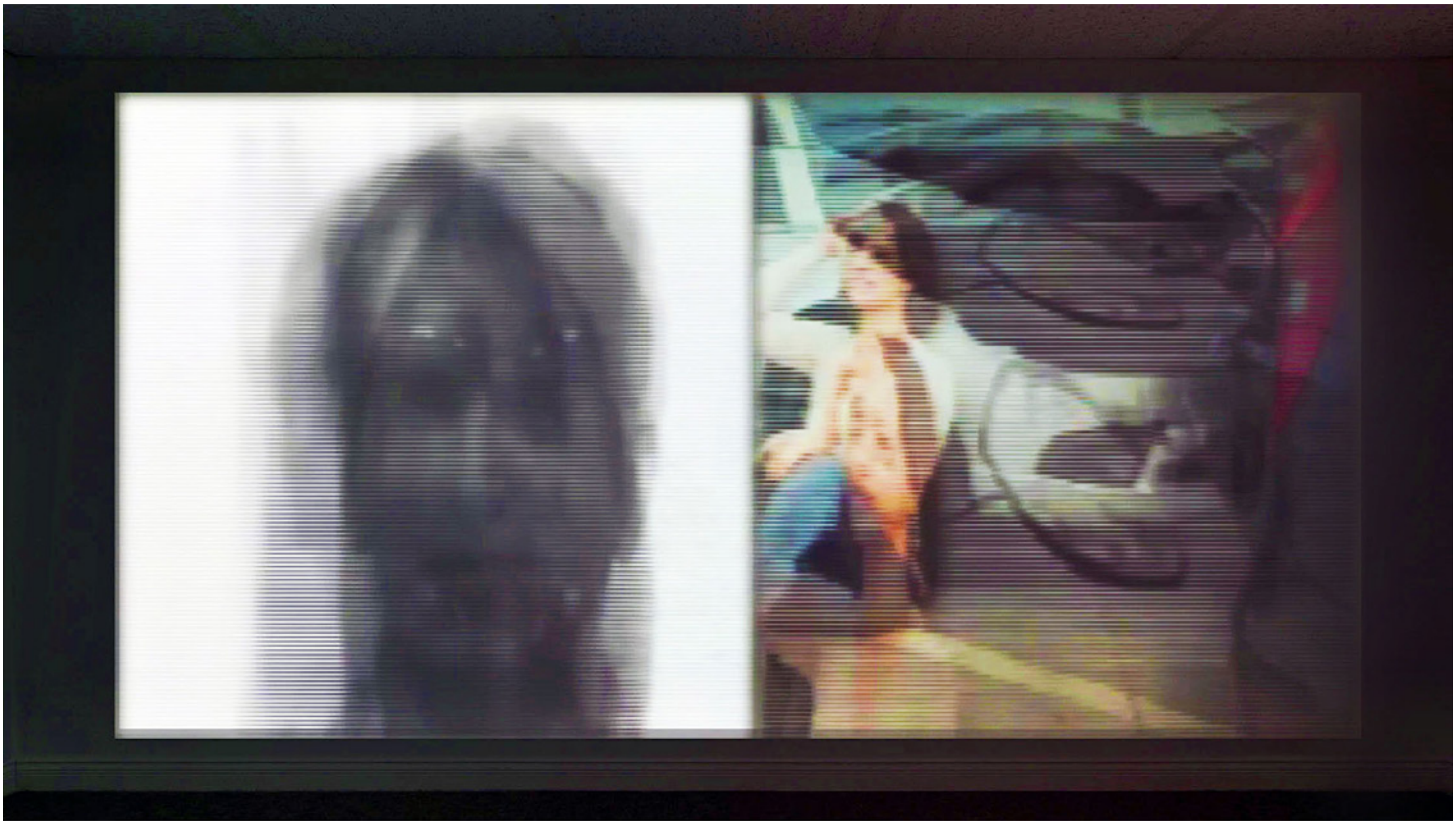

A Montage – A Few People – A Brief Moment in Time

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This work records and re-presents the passage of bodies through a space, building a narrative around them through contextualizing found images. The work uses Viola-Jones and KLT algorithms to detect people's faces and adds them as new frames to a movie playing at a very high speed. The faces captured are continuously added to a rapidly playing looped movie on a screen. They are treated as if they were steganographs – documents that contain hidden, yet retrievable and meaningful information – and parsed for recognizable patterns to generate search terms to scrape images from the net. The images are added to an adjacent screen.

The work uses the practical and theoretical features of two long existing streams of work: those that use face and visual pattern tracking to identify images at the limits of our perception, and those that use pattern recognition to tease cryptic content from silent spaces and random noisy images (Dunning and Woodrow 2009; 2011). Both use the idea of the unseen or unnoticed, at or beyond the limits of our perception, to change our perception of a space. Both use an expanded idea of what can constitute an index – the mark or sign left behind by an action, event or presence that can reconstitute that moment in the reconstruction of absent bodies and events.

Keywords Face detection, pattern recognition, steganography, montage

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Description

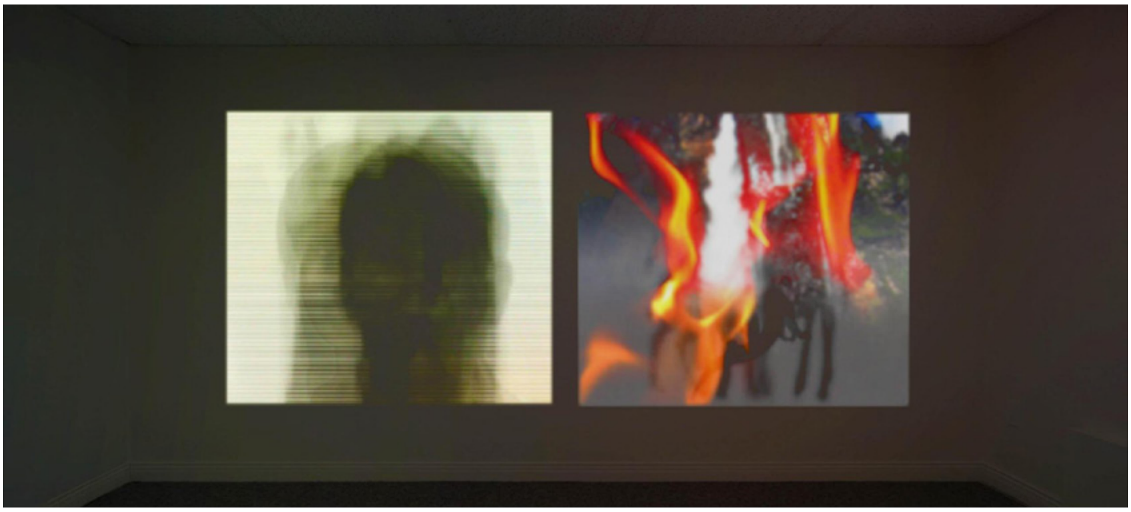

Fig. 1. A Montage – A Few People – A Brief Moment in Time, prototype projection version, 2021.

A Montage – A Few People – a Brief Moment in Time sets out to suggest that there is cryptic, yet discoverable information in the material of a space. Infinitesimal changes in a space, micro temperature shifts, the tiniest of pressure waves, our vocalizations, the breath, sweat and bodily detritus that trails behind us, the friction from a foot on a worn stair, make up the accretions that define a space. Forensic attention to any one of these can reveal some aspects of an absent body or event. This work looks closely at images as if they were similarly indexical and indicative of hidden meaning, relying on a suspension of disbelief when they are likely not, to build a sense of the cryptic content of a space.

This work uses aspects of research that suggests the brain is capable of processing images seen extremely briefly (Potter et al. 2013). Face tracking software records the faces of visitors to a space and adds them as sequential frames to a movie file. This movie is looped continuously, new frames being added as they are captured, and played back at very high speed. The resulting movie initially appears not unlike other face averaging projects as persistent of vision blends the faces together. On longer and closer inspection individual frames are recognized, enabling a viewer to discern individual faces and characteristics. While persistence of vision – the brain's tendency to blend sequential images together – provides an averaged face representing the passage of many bodies through the space, the increasingly smooth and characterless appearance that is characteristic of much face averaging as increasing numbers of faces are overlaid one on another, is disrupted and individuals emerge according to a viewer's interaction, her concentration, eye movement, blink rate and so on.

The faces captured are treated as steganographs – documents that contain hidden, yet meaningful information within the image itself, treating the colours in an image is if they were a code. The analysis of these documents is twofold: first, the images are converted from ascii to UTF-8 characters that are scanned for sequences of letters that make sensible words. Simultaneously, pixel RGB values are tracked and assigned letters from the alphabet (Green-Armytage 2010). In both cases pattern recognition algorithms parse the documents looking for sensible arrangements of words and phrases. These texts are used to scrape images from Google and these images are inserted into a rapidly playing looped movie on a second screen. The found images are random, cryptic and elusive, most often generating little in the way of meaning, but on occasion can produce a quite startling juxtaposition. In combination with the faces these texts and images build a hybrid cast of real and imagined characters at play in the space. The longer the work runs the more complex and packed it becomes, though always just suggesting a fanciful echo of a poorly and discrepantly recorded and remembered past.

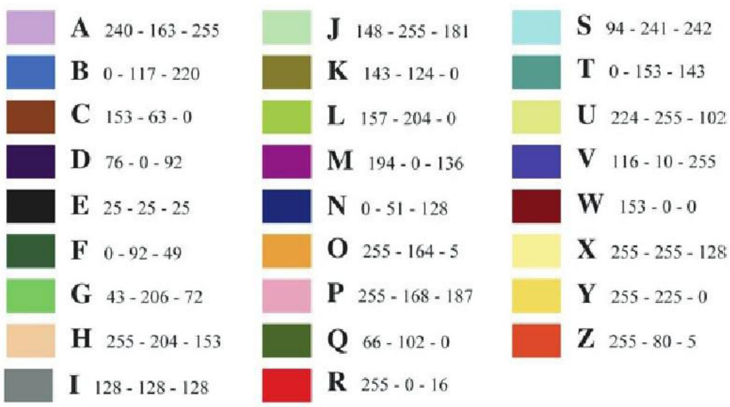

Fig. 2. Alphabet assigned RGB values.

The work relies on our innate drive to interpret images and texts. It is contextualized through rational, computing processes, and cinematic and linguistic forms that imply some sort of narrative, but reading the work becomes an exercise in looking for connections, for meaning that is at best elusive. Faced with such resistant meaning, the viewer is obliged to take an entirely interpretative stance to become a producer of meaning rather than a consumer of previously arranged meanings, establishing a direct connection to the space and contributing to its material histories. As its title suggests, the work as a whole – the screens, the texts, the viewers set adrift – recalls the strategies, even while eschewing its political aims, of the Situationist *dérive* to reshape urban space, though its essence might in the end suggest it owes more to the cinematic tradition of Russian Montage – that view that montage the *nerve of cinema* (Eisenstein 1949) is an idea that arises from the collision of independent shots, wherein each sequential element is perceived not next to the other, but on top of the other. It is subjective, aleatory, often arbitrary, shaped by the flows and eddies of system and the viewer's existing sense of the psychological and material shape of the medium and the space itself.

The work uses the deficiencies of pattern recognition software, and its tendencies to produce false positives to suggest meaning in information flows.

Instances of what might be termed revelatory are momentary and rare – even in some installations non-existent. These works often produce little or nothing of note, only occasionally throwing up some startling juxtaposition, as much random as discovered. When this happens it is arresting, but it is unlikely that either faces juxtaposed with images, or any of the steganographic techniques used to extract meaning will reveal anything particularly striking, and even more unlikely, anything remotely meaningful in and of itself. Instead, meaning must be generated by an observer, driven by a need to make such meaning and coloured by individual circumstance.

Max Ernst's and André Breton's understandings of Lautréamont's "...chance juxtaposition of a sewing machine and an umbrella on a dissecting table" (Lautréamont 1978), led to the core principle of the surrealist aesthetic of objective chance – that sudden uncanny awareness of mystery revealed or withheld. This work uses similar juxtapositions, relying on coincidence, serendipity, and a complicit viewer to produce apparent meaning, or perhaps, more importantly, the sense of a hidden meaning – even when there is likely none. The work uses an analytical and logical, authoritative means to suggest the possibility of hidden meaning, to shift our sense of reality, to challenge our received notions of the material world.

The work uses the deficiencies of pattern recognition software, and its tendencies to produce false positives to suggest apparent meanings in information flows, and to attend to these as potential moments of revelation. The project suggests that just lightly scratching the surface of any information can reveal the possibility of alternative realities and histories, that can inform our sense of ourselves in our world.

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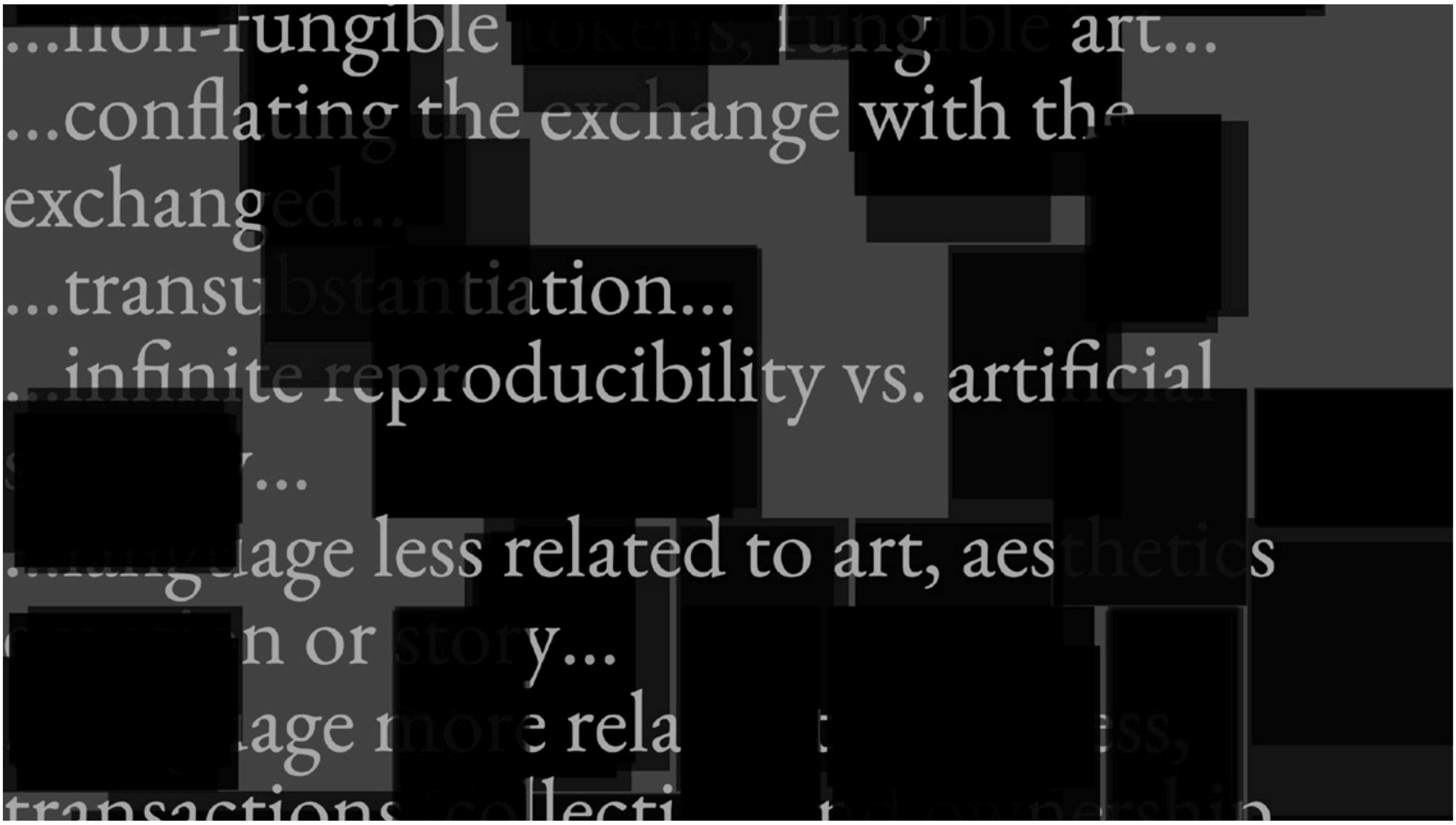

Cryptographics

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Cryptographics is an artwork that reflects on the recent phenomenon of crypto art, which involves associating digital artifacts with blockchain, tokenizing artworks with non-fungible tokens (NFTs). This practice has recently been the subject of heated debate within art and the humanities, as well as setting off a feeding frenzy by artists, digital content creators, and speculative investors. In *Cryptographics*, I take an artistic interpretation of this topic, highlighting the way that while tokenization is intended to make unique digital assets more easily traceable, it treats content as inconsequential, raising a number of questions regarding the value of digital artworks. Working with found text fragments from discussions centered on NFTs and crypto art and existing images, the work seeks to negate the representational role of images, reducing them to mere fields of pixels. By obscuring the visual content of the images and text, this work questions what impacts it may have if we are to treat all digital content as commodifiable, yet interchangeable.

Keywords crypto art,
image studies, net art,
algorithmic media

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Description

In *Cryptographics* (Lee 2021) I explore some of the issues brought up in current discourse on the topic of NFT– or crypto– art. These terms refer to the practice of associating digital assets, in this case, artworks, with non-fungible tokens (NFTs) on blockchain, keeping a digital record of transactions involving the tokens. This allows non-fungible tokens to be traced and sold, while in many ways treating artworks, themselves, as fungible. Developing the concept of "cryptographics" through artistic experimentation, this project considers the potential aesthetic implications that crypto art may have.

Background

Minting NFTs for digital assets is not necessarily new, with a proof of concept as early as 2014 (McCoy 2014; Di Liscia 2021), albeit under different names such as "monetized graphics" (Zeilinger 2018). But the sudden interest around tokenization has in large part been stoked by sensationalized high-ticket sales like those of Beeple's mosaic *Everydays: The First 5,000 Days* (2021), videos *Earth* and *Mars* by Grimes (2021), and pictures of monkeys by Bored Ape Yacht Club (BAYC) (2021).

The tokenization of artworks has recently been a source of heated debate, with many artists, curators, and theorists debating its ethical, aesthetic, and technical dimensions (Olsen, 2022; Pipkin 2021; Rivers Ryan 2021). One of the main ethical issues in such discourse is the excessive energy consumption of minting NFTs, making this practice extremely irresponsible from an ecological standpoint. Other central points of critique include the speculative economic models they contribute to and the relative lack of artistic merit found in many NFT projects.

As these points have already been discussed at length, I decided to zero in on the aesthetic and conceptual dimensions of crypto art rather than adding yet another voice to the already saturated conversation on the ethical problems associated with crypto art. Considering this phenomenon from a historical perspective, it's notable that while traditional criteria for the evaluation of art objects typically emphasize their material worth, scarcity, accrued human labor, and cultural significance, in crypto art, often greater emphasis is placed on artworks' speculative value in terms of cryptocurrency than on the qualities of the item itself. This is not an inherent departure from the traditional art market's assessment of art objects, yet the replication of such norms undermines many of the claims to the contrary that have been made by proponents of NFTs.

Cryptographics

Responding to this topic, I produced *Cryptographics* in the context of the ONB Labs Web Residency, Austrian National Library, Vienna. The work takes the ONB

Labs' open digital collections of images and metadata as a starting point, thinking about how such online resources are in many ways antithetical to the ideas behind NFTs. In contrast to the attempts at creating and monetizing digital scarcity, which has been a central goal in crypto art contexts, ONB Labs makes its digital resources accessible to the public for free. With this in mind, I decided that rather than working with any of the Labs' content in a direct, visual sense, it would be more interesting to appropriate and obscure it, in the same fashion that NFTs treat the content of digital assets as interchangeable. I created a web-based work in response to these ideas, taking images from the online collection and subjecting them to this obfuscation, and overlaying them on top of a text composed of fragments of online conversations about crypto art.

Using the term "cryptographics", I have been exploring the close association between crypto art and cryptocurrency, effectively treating the artworks, themselves, as superfluous. According to this logic, the work of art acts primarily as a vessel for speculative value. This is not necessarily a notable change from the way that the art market has already functioned in the 20th and into the 21st century, yet it draws an interesting parallel between encryption and the creation of art.

In this sense, do the one-of-a-kind qualities of artworks merely act as a form of registration for economic transactions?

Can the production of artworks thereby be understood as parallel to crypto mining, the computational process by which blocks in blockchain are created?

If artworks are understood to be valuable insofar as they are unique, scarce and the product of a great deal of labor, are they not the ideal collateral to serve as the material or data-based foundation for currency?

Through this project, I have been exploring questions such as these, examining how structures in the data and processes behind images may shape the way images perform ultimately inform their significance. In the same sense that Harun Farocki describes images as "operative" (2004), acting upon the world more so than functioning as a visual representation of it, I am interested in how non-visualized aspects of images affect not only the visual but also how we think about images.

What has resulted from this exploration is an online, site-specific work that does not seek to conclusively answer any questions raised from the debates around crypto art and NFTs. Instead, it seeks to draw viewers to reflect on how they engage with online content. By blacking out the individual images, this work expresses a refusal of both the idea of images as strictly visual entities, but also of the hyper-commodification of digital artifacts seen in the hype around tokenization.

Reflections, Challenges, and Insights from the Development Process

Several conceptual challenges arose in the development of this project that constrained the final work in ways that led to several insights, as well as raising questions for future exploration. This includes several aspects of the artistic decision-making process entailed in producing the work, my own attempts at addressing the context this work responds to, and insights I have drawn after the fact from reflecting on the process.

One of the challenging aspects of the project was the explicit expectation to develop a work employing data from the ONB Labs online collections. While this was the premise of the residency and it is an apparently simple prompt to work from, it made me especially curious to explore the systems and processes that structure and organize visual media, more so than working with any individual images, in themselves. The specificity of the data available to work with was quite specific to the context in which it was commissioned. The ONB Labs collections consist of digital scans of historical Austrian documents including postcards, musical manuscripts, political pamphlets, reports on linguistics, newspaper articles, and a collection of papyri, in addition to metadata for these assets and a web archive of the "Austrian Webspace" since 2009. Because I was more interested in the management of visual data than in any particular visual data, in itself, this led me to adopt a rather abstract approach to the original source material.

My strategy was also informed by a critical perspective on existing projects working with data from the ONB Labs (2021) collections. One project, for example, focused on digitally colorizing the postcards, the other, by Gene Kogan and Sofia Crespo (2019), generated new images based on the existing collection of postcards. Both of these projects work with assets from the ONB Labs postcard collection in a fairly acritical manner. Looking at these as counterexamples, I sought to explore the potential meanings associated with the content, processes, and contexts engaged by the visual material in question instead of fixating on the visual content, in itself.

With these factors in consideration, I was drawn to the idea of producing something that could be understood as a negation of the digital image. In this way, I hoped to connect the context of working with archival digital images with the interchangeability of tokenized assets in crypto art. How I achieved this effect was by attempting to effectively "empty out" the visual content of the images in the ONB Labs collections, which made the dimensions of each image their only differentiable characteristic. Combining and layering these blacked-out images with a poetic text reflecting on the ideas the work addresses, I hoped to aesthetically capture the ephemerality of digital assets.

This work seeks to address the non-visual in visual media through the visual medium of the webpage. In a sense, this is a contradiction in the work, yet I believe it's a fairly interesting one. Far from attempting to work with the non-visual by creating something that is, itself, non-visual, I find it an interesting challenge to think about how art may confront such a paradox of experiencing, thinking about, or communicating the intangible.

Another consideration I encountered in this project is that its topic was perhaps too broad to thoroughly delve into in the framework of a 4-week residency. In this respect, I see *Cryptographics* as more explorative than offering a conclusive perspective or statement on the various themes that it touches on. There have been so many diverse critiques and opinions on the topic of NFTs and crypto art in the past year that I was wary of creating something that would merely add to the echo chamber. This is something I am interested in continuing to reflect upon in further explorations, as artists play an important role in questioning technological developments at the same time as being wary of the instrumentalization of artist's voices in ways that take away the efficacy of such critiques.

Conclusion

In presenting documentation of *Cryptographics* in the context of the xCoAx conference, I hope to engage critical reflection upon several interrelated topics that have the potential to reshape many aspects of digital media. Whether tokenization will become normalized and widely adopted as a convention remains to be seen, but the processual and systematic aspects of visual media become increasingly relevant to consider as digital ecosystems encompass far more than mere collections of various kinds of data. This project seeks to contribute to explorations of the topic of crypto art, considering the potential implications it may have for practices and aesthetics in digital culture. By documenting and reflecting on the ideas behind *Cryptographics*, I aim to share, discuss, and offer insights from the various conceptual challenges encountered in the development of the work.

Acknowledgments. I would like to thank Miguel Carvalhais for his help on this project.

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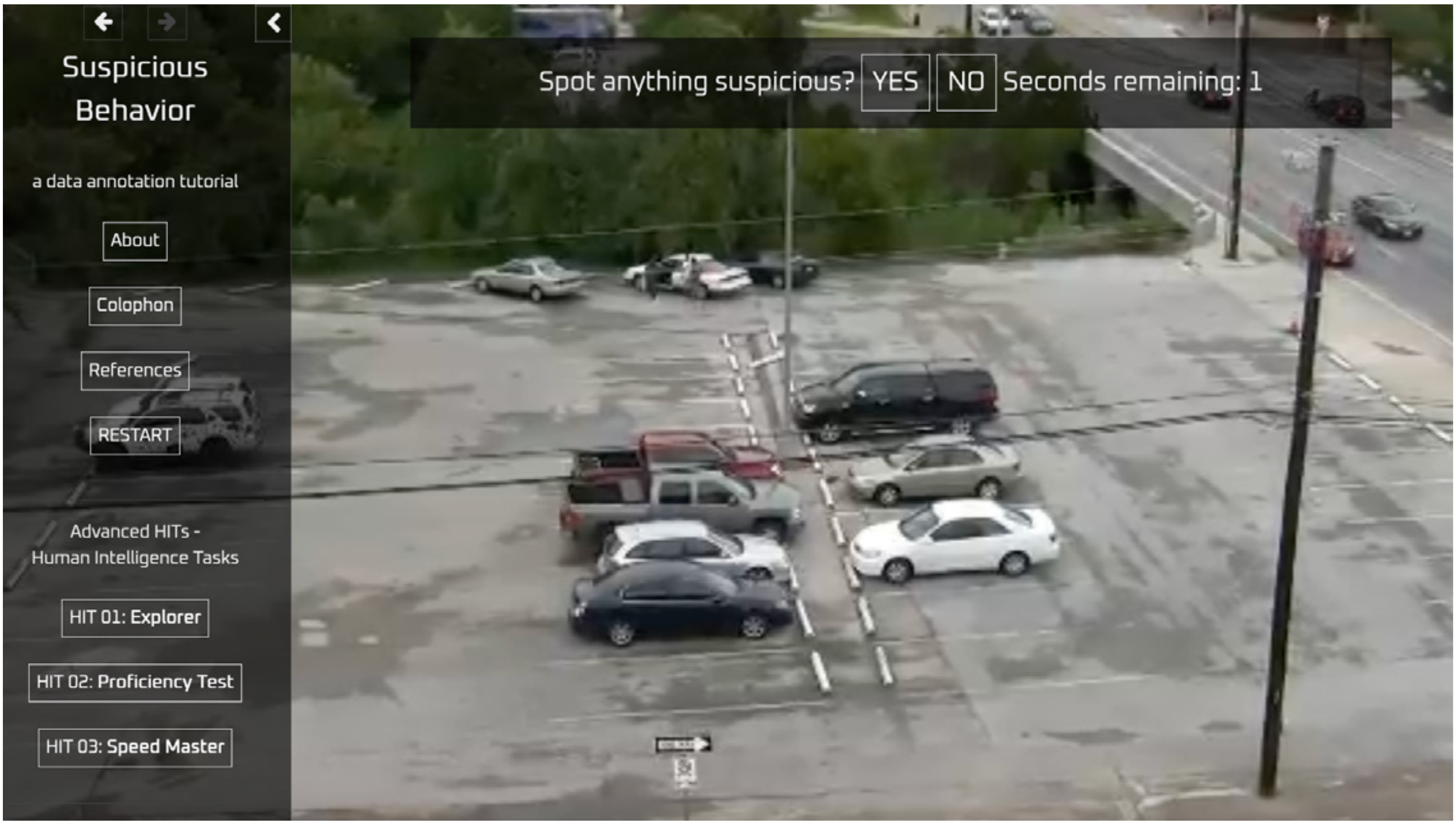

Suspicious Behavior

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Suspicious Behavior is a fictional annotation tutorial inviting readers to critically examine machine learning datasets assembled to detect anomality in surveillance footage. This artwork builds upon artistic methods for scrutinizing image datasets, adding the perspective of on-demand workers to expand insight into classification practices. As readers in the role of annotator-trainees advance through modules of the tutorial, they are introduced to aspects of hidden human labor involved in curating datasets. With limited agency, in assemblages including authorities, developers, data curators and platforms algorithms, the annotators play a part in shaping how 'intelligent' computer vision systems will interpret behavior.

Keywords Machine learning, image datasets, cognitive labor, crowdsourced labor, machine vision, interactive storytelling

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Introduction

CCTV cameras collect vast amounts of surveillance footage, but "it is impossible to check them all with the naked eye in real time"(DW News 2017). Thus, "seeing" behavioral patterns is increasingly delegated to machines. Under the threat of terrorism technological solutions obtain unquestioned support (Hall 2015). AI powered surveillance technology predicting behavior is assumed to be more objective than human perception, and is even presented as a solution to avoid racial profiling. This is the set context in which the reader of *Suspicious Behavior* (KairUs 2020), as an annotator trainee, is asked if they can spot anything suspicious in a video. However, assumptions that AI is objective or neutral has been opposed by recent research showing that AI is experienced differently in the intersections of gender, race and class (Benjamin 2019; Myers West, Whittaker, and Crawford 2019). Particularly when AI powered surveillance technologies, like facial recognition or other biometric systems, are used to identify suspect bodies, disadvantage and discrimination is experienced by already marginalized and othered communities (Magnet 2011). Studies in algorithmic bias have repeatedly demonstrated that bias is encoded in machine learning datasets (Eubanks 2017; Noble 2018; O'Neil 2016) and notably artists have developed methods of critically analyzing image datasets. For example, Joy Buolamwini's *AI, Ain't I a Woman* (2018) exposes how popular facial recognition misgenders women with darker skin tones. In *Gender Shades* Buolamwini and Timnit Gebru (2018), demonstrated that gender classification products indeed performed most accurately on lighter male subjects and recognizably worse on dark female subjects. It turns out that popular facial datasets are biased, images with white men are overrepresented.

Whereas assembling and annotating datasets is tedious work, dataset bias propagates when both university research and companies rely on using publicly available datasets. However, to extract data without consent and exploiting underpaid crowdsourced workers for labelling has become a standard practice when assembling image datasets (Crawford 2021, 109). Concerns of privacy violations have been raised by artist Adam Harvey and web developer Jules LaPlace in their project *exposing.ai* (Harvey and LaPlace 2021). Kate Crawford and Trevor Paglen who examined hundreds of publicly available image datasets, acknowledge that privacy and ethical violations can be addressed by making problematic datasets unavailable, but note that removing datasets also involves problems: "not only is a significant part of the history of AI lost, but researchers are unable to see how the assumptions, labels, and classificatory approaches have been replicated in new systems, or trace the provenance of skews and biases exhibited in working systems" (Crawford and Paglen 2019). Classificatory approaches and the relationship between the image and the label are in the center of Crawford's and Paglen's media archaeological approach and brought to view, for example, in their exhibition *Training Humans* (2019-2020 at Fondazione Prada).

Datasets containing videos have also been in the center for artistic inquiry. For example, in the process of creating the artwork *Lacework* (2020), Everest Pipkin used several months watching all one million 3-second clips in the *MIT Moments in Time dataset* (Pipkin 2020). It is seldomly the case that someone has exhaustively watched all videos in a dataset, however, all of them have been seen by human annotators whose work is to watch and classify data. Data annotation work has been given little value in discourses about model building, even if datasets are often identified as the key source of undesired bias in computer vision. (Hutchinson et al. 2021) Thus, building upon previously described artistic inquiries, *Suspicious Behavior* contributes to artistic methods of critically examining datasets by exploring the relationship between image and label through annotation work and the process of making data.

Suspicious Behavior

Suspicious Behavior consists of a fictional online tutorial and a series of 12 posters depicting what is defined as suspicious by various authorities (Figure 1). Both the posters and the tutorial use material taken from video datasets used for anomaly detection in video surveillance. The *Suspicious Behavior* tutorial includes an introduction and three advanced modules. In the introduction, the annotator-trainee learns to complete "Human Intelligence Tasks" (HIT's), standing for a single, self-contained, virtual task for which a worker is rewarded after completing it. HITs are posted by requesters, in this case unknown dataset curators, asking the annotator to spot suspicious behavior in videos. In addition, montages of YouTube videos are used to contextualize the reader into their role as a crowdsourced annotator.

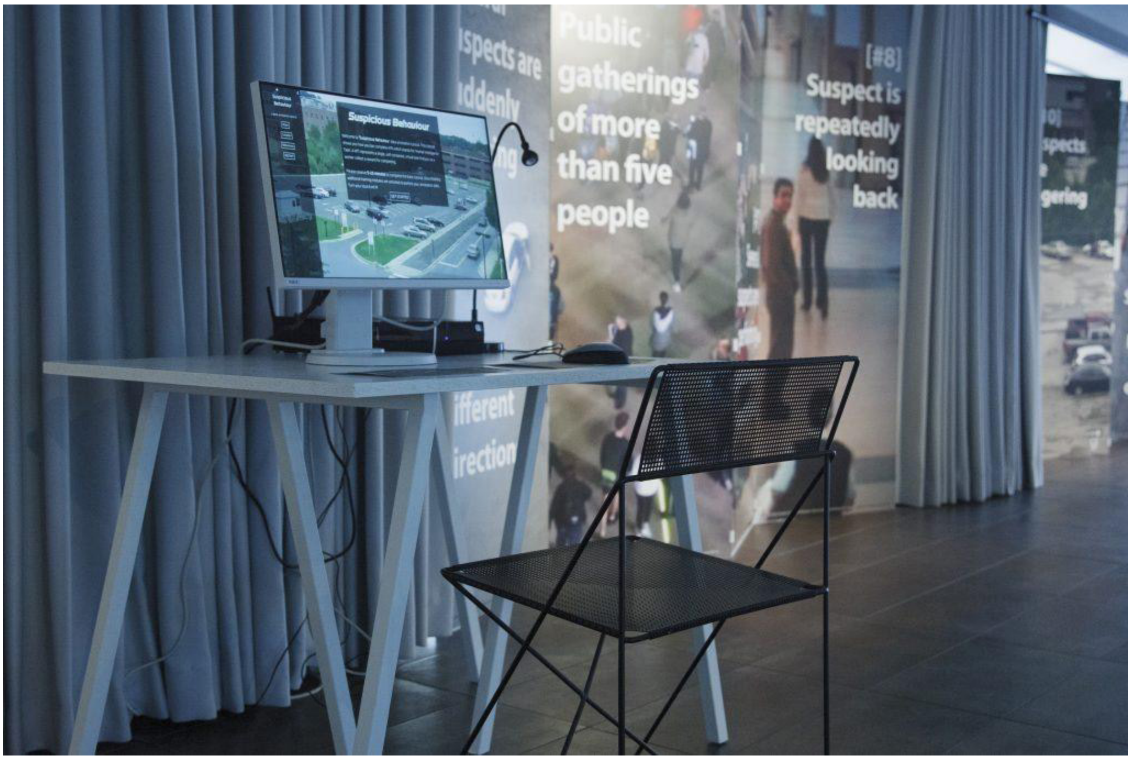

Fig. 1. *Suspicious Behavior* online tutorial and posters. Photo:© esc medien kunst labor, CYBORG-SUBJECTS by Martin Gross.

The first advanced module *HIT 01: Explorer* (see Figure 2) focuses on dataset assembly and categories of anomaly behavior. The *UCF-Crime Dataset* (Sultani, Chen, and Shah 2018) serves as an example, as the reader traverses' videos of 12 anomaly categories: abuse, burglary, robbery, stealing, shooting, shoplifting, assault, fighting, arson, explosion, arrest, road accident, and vandalism. The 13th category contains "normal" videos defined as lack of anomaly behavior. This module encourages the reader to ask: what categories are chosen? What is left out?

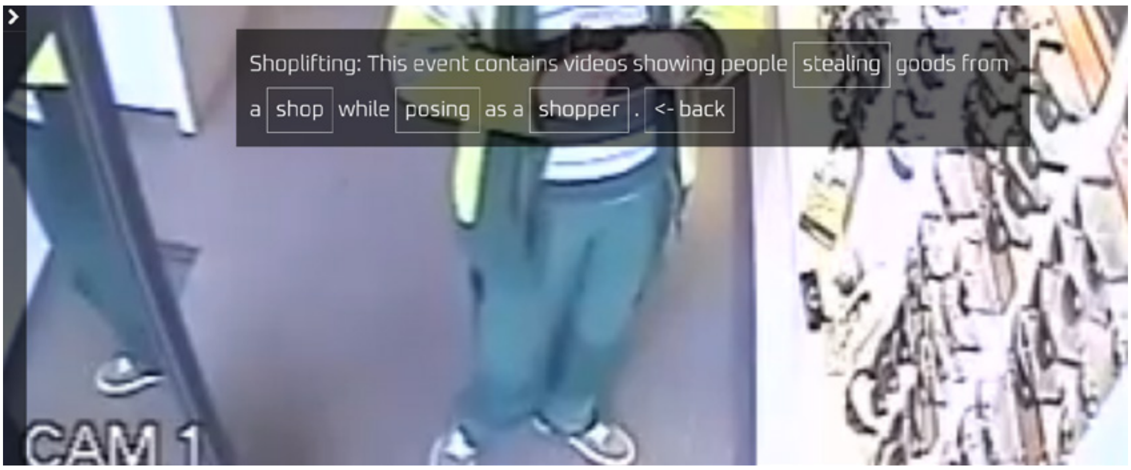

Fig. 2. Screenshot: Examining the "Shoplifting" category of *UCF-Crime Dataset* in advanced module *HIT 01: Explorer.*

The assumption that AI powered surveillance is objective is contested in the advance module *HIT 02: Proficiency test.* In this section citations by many scholars also referenced in this paper are in juxtaposition with material from various anomaly detection datasets. In *HIT 03: Speed master* the reader gets to experience how challenging it can get to meet quality thresholds and at the same time make a minimum wage as a crowd sourced annotator. By traversing the introduction and the three “advanced” modules it becomes increasingly clear that the data annotators and curators are in fact implicitly encoding what counts as suspicious behavior. The experience, although fictious provides insight into the hidden work of crowdsourced labor and engages the reader to understand decision making processes in this environment.

Who Becomes an Annotator?

One of the YouTube video montages in *Suspicious Behavior* explains the origins of the “Mechanical Turk.” Amazon took the name of this 18th century faux chess-playing automata hiding a human player to describe their services that were “designed to make human labor invisible”(Schwartz 2019). Like in the faux automata human labor is intentionally hidden in order to prevail the illusion of machine automation (Atanasoski and Vora 2019, 6). Mary L. Gray and Siddharth Suri call such intentionally hidden human labor “ghost work” arguing that many apps, platforms, and artificial intelligence systems can’t function without this work force (Gray and Siddharth 2019). Who are then “ghost workers”? Focusing on workers from India and the United States, Gray and Suri, interviewed and observed hundreds of on-demand workers. Among them “college-educated, stay-at-home parents”, “first-generation college students”, “and people, disabled or retired, looking for alternative routes to employment”. Whereas people from across the income spectrum are engage in “ghost work” lower-income participants are more dependent on earnings from labor on platforms like Amazon Mechanical Turk (AMT) (Farrell and Greig 2017). Those who find strategies to earn from on-demand work can create meaningful employment for themselves. And for marginalized communities, who historically face workplace discrimination, on-demand jobs can offer “a sense of identity, respect among family, and financial independence”(Gray and Siddharth 2019).

In another video montage called “Super Heroes’ of AI” YouTube personas explain what data annotation is and instruct viewers “how to make money tagging photos online.” These statements reflect the need of online platforms to continuously attract new workers, because turnover in online-platform-economy is high (Farrell and Greig 2017). Thus, on-demand work, casually called clickwork, is described as an easy way of making money. On the other hand one key challenge of annotation work “is making efficient use of resources to achieve quality results” (Deng et al. 2014, 2), therefore, this type of work gets treated as “computational processes ”(Malevé 2020) By choosing to “become a clickworker” the reader can advance in the tutorial, perhaps clickwork is not that easy after all.

Interpretating Suspicious Behavior

The reader, now in the role of an annotator trainee, is given 10 seconds to spot suspicious behavior in video clips taken from the *VIRAT Video Dataset* (‘VIRAT Video Data’ n.d.). This dataset, designed for activity detection in the video surveillance domain and contains hundreds of hours of video material. For annotation on AMT the footage was “broken up into segments of ten seconds each”(Oh et al. 2011). By breaking the videos into 10 second segments and using a similar labelling interface as for *Moments in Time* (see Figure 3), *Suspicious Behavior* recreates an annotation environment in which the “glance” becomes the norm (Malevé 2020). What might appear as a simple task, answering yes or no to whether a video contains suspicious behavior, turns out to be challenging when only allowed a “glance”. If the reader fails to answer within the given time, they are directed to a page posing the questions: “What kind of behavior makes a person suspicious? Suspicious just to me or also to others?”

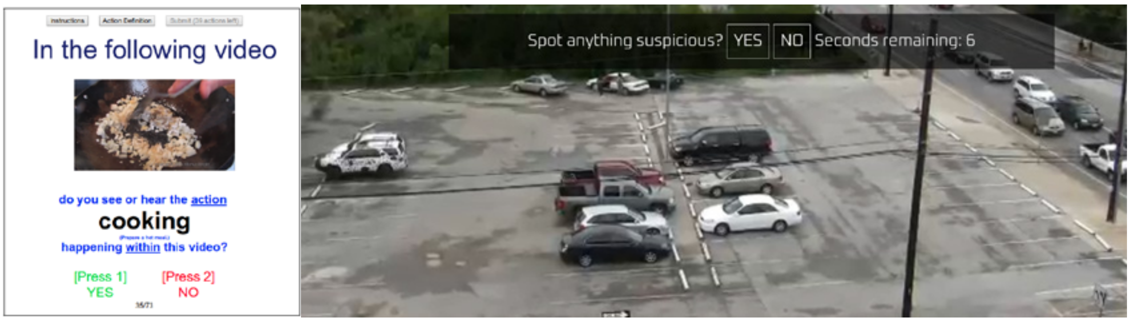

Fig. 3. Left: Moments in Time user interface for labelling videos (Monfort et al. 2020). Right: *Suspicious Behavior* annotation interface.

In order to meet quality standards annotators are also expected to deliver similar interpretations of images, hence, decisions are “delegated and regulated through consensus.”(Malevé 2020) In practice this means that several annotators are given the task to label each video. Only videos given consistent labelling qualify for a dataset. Therefore, when dataset curators delegate decisions to outsourced labor, they keep control of how images should be interpretated. In *Suspicious Behavior* the 12 posters, the categories in *HIT 01: Explorer* and a YouTube montage presenting what law-enforcement and security officials would consider suspicious are giving directions how the annotator should interpret suspicious behavior. Gradually it becomes evident for the annotator-trainee that their work is more about matching labels with images than making meaning out of them. Moreover, both requesters and annotators strive towards optimized workflows which do not allow time for reflection.

Optimizing Workflows

Advanced module *HIT 03: Speed master* demonstrates how challenging it can get to meet quality thresholds and at the same time make a minimum wage. In this module the annotator trainee is given 60 seconds time to label as many videos as possible. Thereafter, in a "report" (Figure 4) the reader learns if their result is within the required quality threshold. Only if 80% of the answers are correct, they qualify for future tasks. Rejection of a task can harm the reputation of the worker leading to difficulties when assigning for new tasks (L and Siddharth 2019). In addition, a "CLICKWORKER paycheck" is calculated and compared to minimum wages in different countries. It becomes quickly clear that "keeping up the pace" for a minimum wage is not possible. Workers might "opt out of tasks where they feel they have a high risk of rejection"(Hata et al. 2017) or turn to online or local communities for strategies that make difficult tasks easier (L and Siddharth 2019). Nevertheless, research shows that only few AMT workers earned more than the $7.25/h U.S. federal minimum wage (Hara et al. 2018). Even if an average requester pays more than $11/h the majority is paying below minimum wage. And those low-paying requesters post way more tasks. Thus, tools for calculating a fair pay could be one way of dealing with this problem. Artist Caroline Sinders' TRK (*Technically Responsible Knowledge*) tool (2020) is one example. Contextualized as an artistic provocation, this calculator consults whether the scope of a tasks is possible to fulfil in the given time, and if the tasks are priced fairly. A more sufficient way to remove unfair requests would require platforms to increase their minimum rewards.

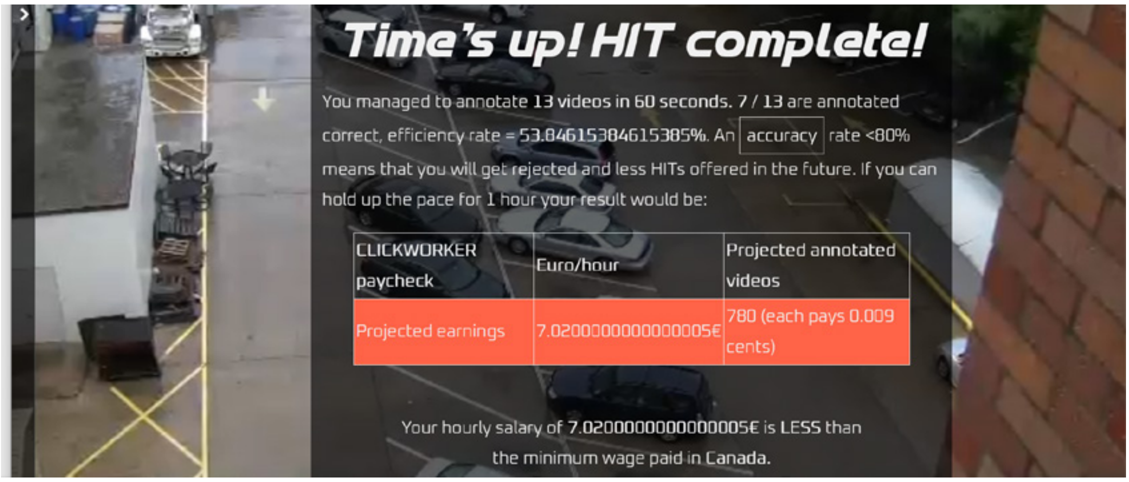

Fig. 4. In the screenshot we see the "report" of *HIT 03: speed master*. The number of videos annotated during the minute is multiplied with 60 to estimate an hourly pace. For the hourly wage this number is multiplied with AMT's minimum fee per assignment, $0.01 ('Amazon Mechanical Turk' n.d.), which was about €0.009 in 2020.

Conclusion

The choice of examining datasets from the perspective of an image annotator was made with aspirations to render this hidden labor visible. When the reader ends the tutorial a last video contextualized the role of the annotator as part of cognitive assemblages in which human and technical "cognizers" intertwine in city surveillance management. (Hayles 2017) Annotated video datasets build the foundation for operations of alerting, predicting, and preventing escalation of undesired behavior. To spot the effects of such *"operations with data"* Jill Walker Rettberg (2020) suggests a "situated data analysis" examining what data represents and what is left out. In *Suspicious Behavior* the reader can experience that the annotator does play a role in defining which images are included in the dataset and what is left out. However, as decision making is distributed along the pipeline of assembling datasets for AI, data curators remain in control of how images are to be interpretated.

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Bathing in Lightness

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Bathing in Lightness is an interactive audio-visual installation that intends to reflect our relationship towards *the machine* as such, regarding the way we tend to perceive the apparatuses around us as living beings with a life of its own. The installation features a swarm intelligence inside a virtual – yet physical – goldfish bowl, that is exploring its tiny universe while trying to communicate with the outer world. The swarm imagines its own interpretation of reality, while reflecting the presence of visitors moving in front of the piece. Build out of a commonly sensed longing for analogue, thus easy understandable mechanisms, the installation's basic component represents an archetype of electric machines: the incandescent light bulb. Thereby the installation acts as an analogue interface through which the visitor can make contact with a virtual being while breaching the digital realm, provoking to contemplate on her/his relationship towards the artificial entity. Along with a calm and soothing sonification of the swarm's movements, we are allured to rest in front of the piece as we would by warming ourselves at a cozy campfire, remembering us of ancient and more leisurely paced times.

Keywords interactive installation, light and sound sculpture, swarm simulation, analog interface, trans-digital, post-digital, visual music

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Fig. 1. Installation view with interaction.

Introduction

Bathing in Lightness is an interactive light and sound sculpture that seems to be enlivened by a swarm entity trying to explore its inner world and communicate with the outer one. Consisting of 52 filament light bulbs it visualizes the movement of a particle swarm that is driven by the presence of the viewer and its own inner urge. At the same time the light is being sonified as every bulb controls the voice of a synthesizer, creating an adapting visceral soundscape. Visitors can interact with the installation by moving in front of it, so their movement is followed by the swarm and thus being translated into light and sound.

Fig. 2. Old filament light bulbs used as basic component to visualize a digital swarm intelligence. Being seen as an archetype of an electric machine, the bulbs are intended to express the *transdigital* ambiguity between the digital algorithm and the analog interface.

Inspiration

As computers around us are constantly getting smaller and more powerful, I felt this development somehow detaching our perception of the machine as a *machine* – a logically working man-made artefact. Rather often it evokes in us the image of some kind of *black magic box* – impenetrable, enigmatic and at the same time with a life of its own, as we tend to discern moods, caprices and tendencies. While we on one hand embrace the advantages of 21st century technology (especially the internet), there seems to be a growing but unfulfillable desire to again understand what's happening inside the machine and to literally *see* the machine working.

Facing the ubiquity of digital algorithms in our daily life, Berry and Dieter describe in their essay *Thinking Postdigital Aesthetics: Art, Computation and Design* the discrepancy of the digital revolution, as algorithms create "a world that appears more comfortable, safer, faster and convenient – although this may paradoxically result in our feeling more stressed, depressed or drained of meaning" (Berry and Dieter 2015, 1). While this may refer to social media in the first place, I think it also mirrors the lack of physical connection we feel not only in social interaction but also when consuming auditive or visual content online – instead of putting on a vinyl, reading a book or looking at an artwork in a physical gallery space. Especially as virtual reality still remains some kind of unsatisfying for its lack of physical haptics, there seems to be a desire for using the advantages of digital technology with analogical interaction. This tendency might be well described by the term *trans-digital* as Jenny Sundén coins it in her essay *Technologies of Feeling: Affect between the Analog and the Digital:*

> I suggest the term *transdigital* to account for analog passions that are shaped through the digital in ways that concretely activate, but also move across the borders of, or beyond the digital. (Sundén 2015)

With the use of glowing light bulbs instead of LEDs I wanted to express this trans-digital ambiguity by opposing the viewer an archaic looking apparatus which on the other hand acts like an artificial living entity powered by digital algorithms. With this I would like to provide a vehicle through that the visitor can contemplate on his/her relationship to the artificial entity and the machine as such. What does it mean to be alive and how does a machine reflect human life? To what extent does the machine merely imitate human action, and from when on is the machine perceived as an autonomous living entity?

Fig. 3. The installation can be interacted with intuitively by moving in front of the piece, thus providing a vehicle through that the visitor can contemplate on his/her relationship to the artificial entity and machines in general.

Technical Description

The sculpture consists of a cloud of light bulbs that are arranged in a non-lattice structure, which is derived from phyllotactic spiral patterns found in botany, to create an organic feeling composition. The 52 individual dimmable light bulbs serve in this setup like a low-resolution 3-dimensional display, visualizing the movement of a particle swarm. The swarm itself is driven by algorithms derived from flocking behavior, like those exhibited by fishes and birds. Due to this algorithm the swarm develops an emergent behavior as the single entities start to wander around together, exploring the space (and the boundaries) of their tiny *gold fish bowl* as well as reacting to sensor data from the outside.

The installation is designed to emphasize the visitor's experience of getting in touch with the physical and virtual nature of the installation – therefore visitors can interact intuitively with the piece, which involves an immediate and coherent visual and sonic feedback. The motion of a person in front of the installation is captured by a depth camera. The swarm is attracted by that movement so that the visitor gets mirrored by the swarm of light inside the cluster of bulbs. At the same time the movements are being sonified as every bulb is represented by an oscillator of a synthesizer. The stronger the motion the more intense is the sound being heard. Depending on the position and direction of movement, different pitches and harmonics are being played to compose a complex musical soundscape. The sonification is less rhythmical but rather harmonic driven and of an overall mellow and calm quality.

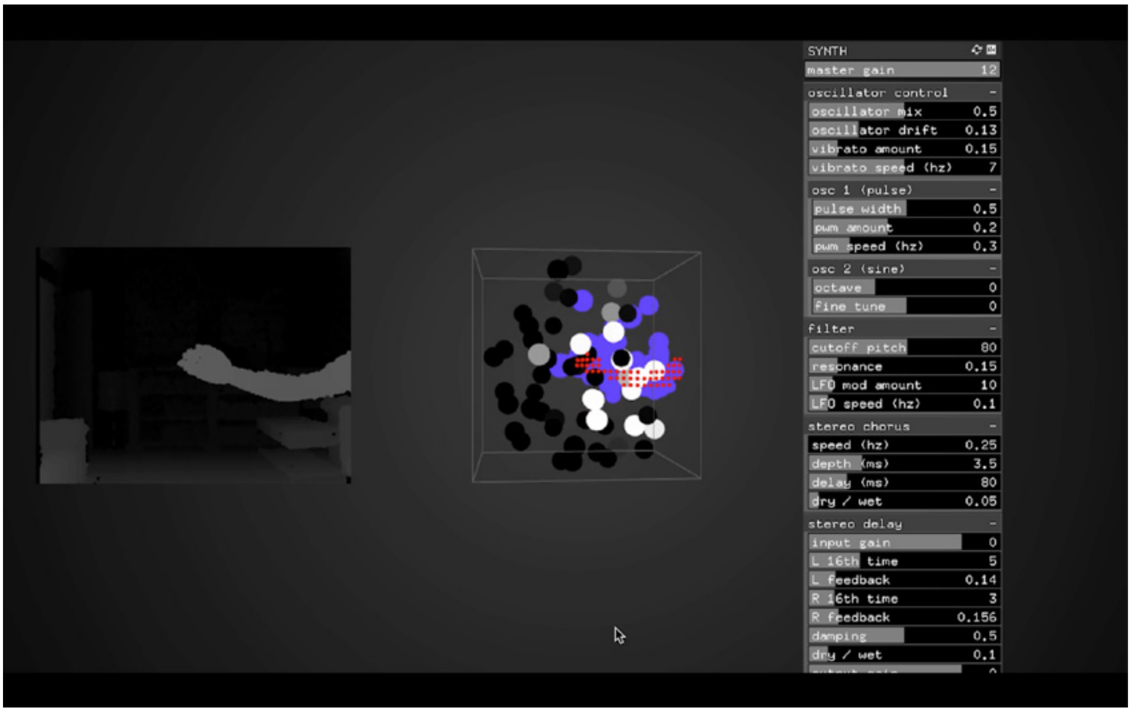

Fig. 4. The motion of a person in front of the installation is captured by a depth camera. The swarm is attracted by that movement, while the proximity of swarm entities to a bulb determines the bulb's brightness. Every bulb also controls the volume of a dedicated oscillator of a digital synthesizer – thereby sonifying the swarm's movements simultaneously.

Project Evolution

The installation was first shown as part of a group exhibition at Zönoteka Gallery, Berlin in July 2019. Since the first manifestation that was emphasizing particularly on the ambiguity of the digital-analog juxtaposition, the installation has run through several iterations – most of them mainly focusing on the interactive dimension and the experience of the visitor. Among other exhibitions, the interaction part was subject to a presentation at the *Mensch und Computer* conference for human and computer interaction in September 2020 (Stimberg and Brennecke 2020).

Acknowledgements. I would like to thank the Filmuniversity Babelsberg KONRAD WOLF as well as the Master's program Creative Technologies and Prof. Dr. Angela Brennecke for supporting the work on this project.

Demonstration Video: https://vimeo.com/562682691/ae043b9b83

Fig. 5. Exhibition view with 4 channel surround audio setup.

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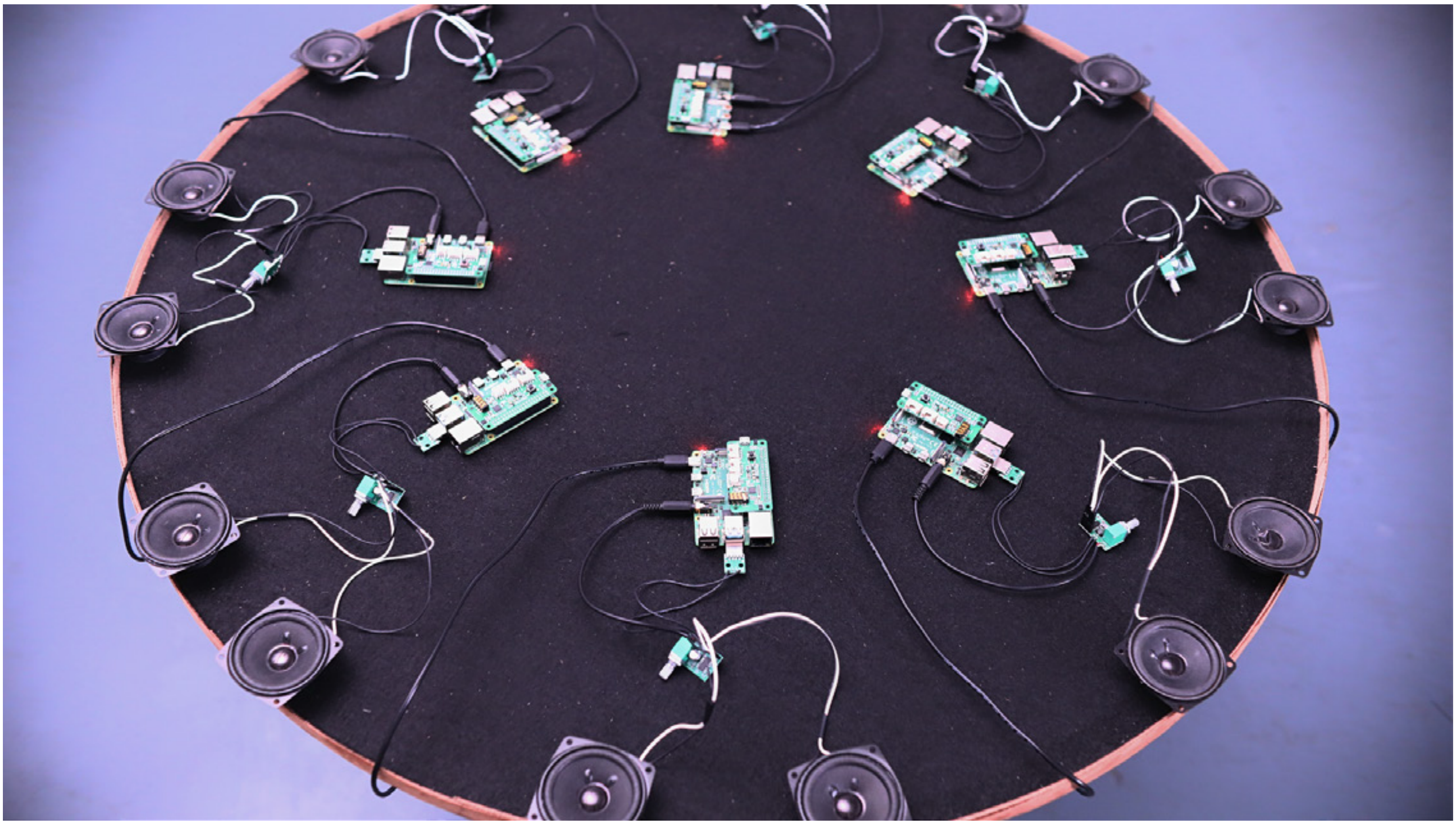

Ich Sage Was Ich Sagen Kann (ISWISK): Voice Composition by Real-time Automatic Speech Recognition

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Ich Sage Was Ich Sagen Kann is a voice composition experiment, where multiple self-made voice bots have a dialogue with each other by using Keyword Spotting (KWS) in the Automatic Speech Recognition (ASR) domain. The dialogue is not considered as a conversation between different personalities, but it reflects on a process of uttering thoughts from my personal experience. I make speech recognition modules by using a Convolutional Neural Network (CNN) model installed on eight microcontrollers, which give utterances when certain keywords are detected. The composition consists of four parts, from polite one-on-one conversation between myself and one bot to the impolite conversation between 8 bots, which reflects the chaotic state of mind in the thinking process. This practice aims not only at overcoming problems in communication and learning of a foreign language at a personal level, but also at the possibility of communication with human language between machines.

Keywords Uttering Mind, Voice Composition, Speech Recognition, Keyword Spotting

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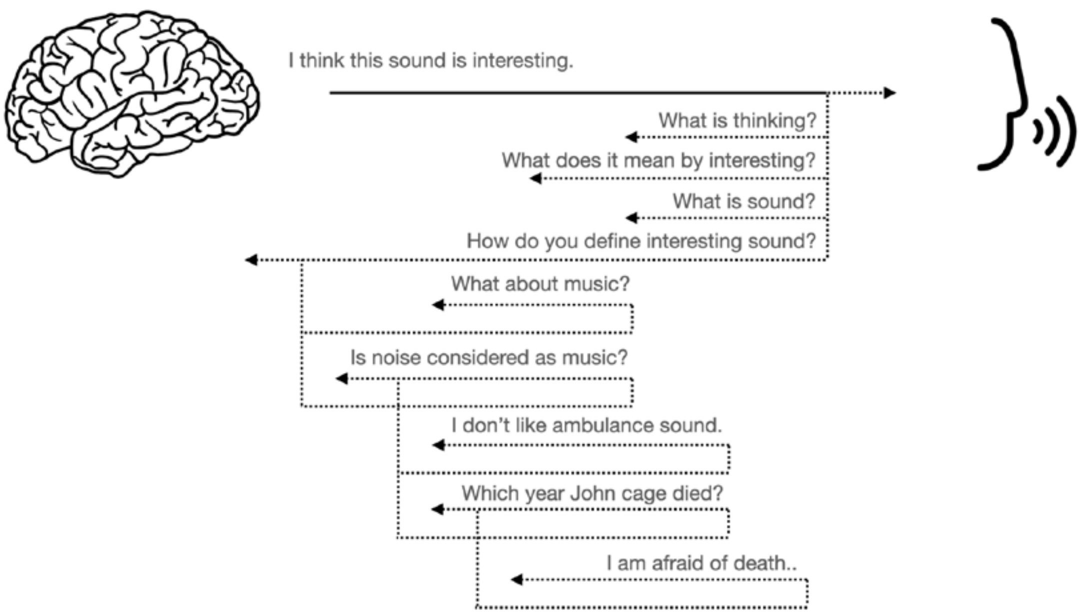
Background and Idea

Ich Sage Was Ich Sagen Kann is a voice composition experiment, where multiple self-made voice bots have a dialogue with each other by using Keyword Spotting (KWS) in the Automatic Speech Recognition (ASR) domain. The dialogue is not considered as a conversation between different personalities, but it reflects on a process of uttering thoughts from my personal experience. I personally have difficulties in communicating with others in speech. The reason that I came up with, in my mind, was those secondary thoughts, which are derived from the initial thought, could act as a resistance to uttering what is on my mind. Let's consider the situation where my colleague and I are having a conversation. After he asks "What do you think about this sound?", I could possibly reply "I think this sound is really interesting". But even before the thought is uttered, secondary thoughts such as "What does this mean, "interesting"?", "What is sound?", "How do you define interesting sound?" are spun off from the first idea, then the thoughts and speech end up being jumbled and disconnected.

I would call this a form of negative feedback in the process of uttering the mind. Negative feedback occurs when some function of the output is fed back into the input to reduce the fluctuations in the output, and it usually happens in organic systems for balancing their processes. When it comes to uttering the mind, however, I experienced that this feedback process causes a severe self-censorship problem and gives me a hard time when communicating with others. Therefore, acknowledging (or possibly overcoming) this difficulty was the initial motivation of starting this artistic practice as a kind of self-therapy method.

Fig. 1. The uttering mind problem.



Keywords and Utterances

In this practice, I would like to speak out every thought, including initial and secondary ones, rather than let those fade out internally, which means turning negative feedback into positive expression. Most importantly, the realization of this thinking process as a voice composition is the main purpose of this work.

The implementation plan for achieving this is using multiple voice bots which have speech recognition functions. If one thought is uttered initially from one bot, secondary utterances are followed from the other bots based on recognizing speech in the first utterance. This process could be interesting not only for algorithmic composition itself, but also for experimenting with communication processes between voice bots. The speech recognition modules that I built in this project are based on Keyword Spotting (KWS), which deals with the classification of keyword in utterances. The reason for choosing this method is that I tend to obsess about the lexicon more than the actual context of the full sentence.

Now, which keywords should be recognized, and which sentences should be uttered? The starting point was writing down simple utterances that came out from the thinking process. I start with 'Ich sage was ich sagen kann.' (I say what I can say). From this sentence, I choose an arbitrary word 'sagen' and write down a few sentences that come to me when I think of that word. For example,

× *Mein Gedanken auszusprechen ist nicht einfach.*
(Speaking out my thought is not easy.)

× *Als ich jung war, sollten wir in der Öffentlichkeit nicht meine eigene Gedanken äußern.*
(When I was young, we were not supposed to express our own thoughts in public.)

× *Manchmal habe ich Angst wenn ich etwas sagen muss.*
(Sometimes I am afraid when I have to say something.)

× *Wenn ich spreche, überlege ich mich ob das richtig ist.*
(When I speak, I consider whether it is right.)

Imagine a situation when one bot speaks a word or a sentence including 'sagen'. If the speech recognition module is properly installed, the other bots can recognize the keyword and answer with one of those sentences. But then, what happens if the other bot says, "Mein Gedanken auszusprechen ist nicht einfach."? (First sentence above). Nothing will be triggered because bots cannot recognize any words in that given utterance. For achieving ping-pong like conversation, I continue to choose words from the sentences, collect them as recognizable keywords, and write down corresponding sentences. Throughout this process, I collect 30 keywords and write 103 utterances (3 to 4 sentences on each keyword): 'Gedanken', 'äußern', 'Spaß', 'Freiheit', 'einfach', 'sympathisieren', 'nachdenken', 'aussprechen', 'geniessen', 'rauchen', 'schwierig', 'Gesundheit', 'Öffentlichkeit', 'Rückkopplung', 'Verlangen', 'sagen', 'ausdrucksvoll', 'essen', 'richtig', 'klar', 'Fehlern', 'Angst', 'umgeben', 'wissen', 'KI', 'glücklich', 'nervös', 'überlegen', 'kacken', 'schreiben']

Technical Realization

To make a simple keyword spotting module I proceeded in four steps: 1) Recording the set of keywords in my voice, 2) Pre-processing the dataset, 3) Training the Neural Network Model, and 4) Compiling the model and running it on a microcontroller for real-time recognition.

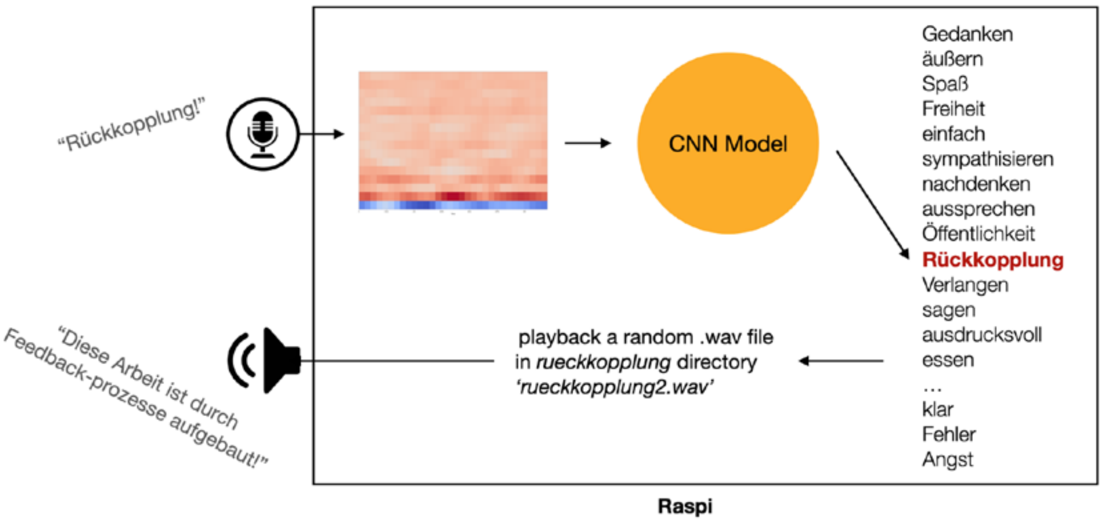


Fig. 2. The schema of real-time keyword spotting module.

In the first step, I recorded each keyword 300 times by using my voice. 100 times with the *MacBook microphone*, another 100 times with *ReSpeaker 2-mic HAT* which I use in the actual recognition module. For the rest, I played back the recorded files with a speaker and recorded them back into the *ReSpeaker 2-mic HAT*, so that modules could learn to recognize the voice coming out from the speaker. The sample rate is always set to 16kHz. Background noise is also added as a keyword in dataset for not giving a confusion in classification.

Secondly, pre-processing the dataset is needed. Since all recordings have different durations, I unify the length of the samples to 1 second. This step is necessary because the data shape of the neural network has to be identical. This is done simply by padding zero to rest of the array for shorter than 1-sec files and cutting the rest for longer than 1-sec files. After unifying the lengths, I extracted MFCCs (Mel Frequency Cepstral Coefficients) features from the dataset, which aims at developing the features from the audio signal that can be used for detecting the phonemes in speech.

Thirdly, splitting the dataset into training (80%), validation (10%), and test (10%) is what follows for the training step. I use a 3-layered convolutional neural network model. The validation accuracy, meaning the prediction rate of classification, is 96 percent, which is quite high, but expectable at the same time because the dataset only consists of my own voice.

After training the model, I compiled the model in .tflite format and ran it on *Raspi 4B*. In this step, I used the *sounddevice* library for dealing with the input stream. The input signal is consistently stored in an array and the microcontroller runs a classification every 0.5 seconds. If it successfully classifies a certain keyword, it plays the corresponding utterance, which I recorded in advance.

Composition

The voice compositions I have been experimenting with in this project mainly consist of two modes: One is polite conversation and the other is impolite conversation. Technically, this is distinguished whether the module has a function of voice activity detection. In polite conversation, bots mute themselves until the other speech they hear is over. In impolite mode, on the other hand, this function is absent, so the bots will begin to utter right after recognizing a keyword.

Fig. 3. Installation View.

At the beginning of the composition I participate live in the conversation. My role is triggering the bots by saying a certain sentence or keyword when no bot recognizes any keywords from the other bots. This non-recognition situation happens quite often, and I assume that there are two critical reasons. First, the dataset is not strong enough to deal with unexpected background noise and room reverberation. The dataset I used in this project is certainly limited in terms of diversity of the data since it only consists of my voice, which I recorded in the same room. Secondly, there must be a difference between my raw voice and the playback voice coming out from speakers. Supposedly, the machine can also distinguish between raw voice and speaker voice, as we all do. In this experiment, unfortunately I could not deal with these limitations. This is only a problem if we consider this experiment as being about full functionality, but I think this malfunction is actually an interesting and fun part of making artworks from machine learning.

So far, I have created 4 compositions by setting up different topologies and behaviours:

1. In the 1 bot and myself composition, the bot and I are having one-on-one chat as a prelude.

2. In the 4 bots and 1 conductor bot composition, a conductor bot takes the leading role I performed in composition 1. When a silence occurs, the conductor bot plays a randomly chosen keyword to continue the conversation.

3. In the 7 bots and 1 conductor bot composition, 3 more bots come into play. This is considered as an impolite conversation because they speak out right away once it recognizes a keyword; this reflects more closely on the chaotic state of mind in the thinking process described.

4. In the 8 bots composition, each bot has a role of conductor and participant at the same time. When the bot does not detect any keyword, a randomly chosen keyword is played.

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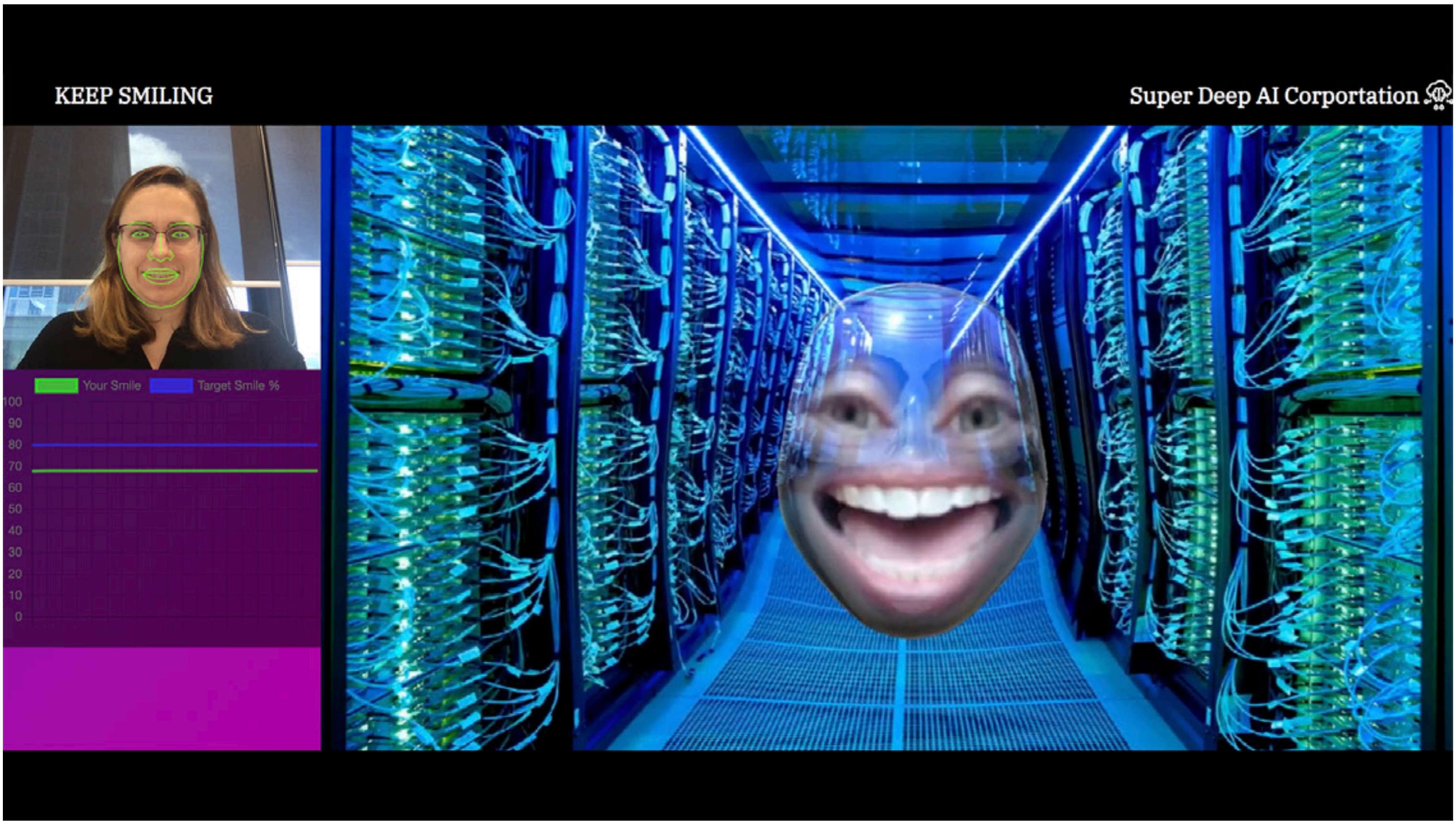

Keep Smiling

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Keep Smiling is an online interactive experience in the form of a job interview conducted by an AI agent. The agent asks the participant to smile, to smile even more, and to count objects she/he can see through a nearby window while continuing to smile (the system intends to extract the maximum profit from the human participant). Throughout this interaction the participant's face is detected via a webcam and the smile is rated against a happiness meter. As soon as the participant's smile rating drops below average, she/he is fired and the interview is terminated. The artwork draws attention to the highly automated and monitored world in which the responsibility for making decisions has been handed to machines and algorithms, and our emotions are evaluated without our consent. By interacting with the artwork we can experience just how unreliable an emotion detection algorithm can be despite its widespread deployment in our everyday lives. The artwork incorporates a number of elements from the AI industry, illustrating how decision-making and labour culture have been transformed by technology and the absurdity of basing key elements of this culture on the extraction of data and behavioural monitoring of subjects.

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Description

Smiling plays an important role during any job interview, often diminishing or increasing one's chances of being hired (Krumhuber et al. 2009; Ruben et al. 2015). The study by Krumhuber et al. shows that it is generally better to smile rather than maintain a neutral face and suggests that the quality of a smile is an essential factor in hiring decisions (Krumhuber et al. 2009). In contrast, the study by Ruben et al. indicates that less smiling is better for some types of jobs interviews, and that the timing of the smiles is very important (Ruben et al. 2015). All of these evaluations of smiling are highly subjective and would be extremely difficult to represent in machine code. Nevertheless, autonomous affect recognition algorithms are widely deployed and are highly profitable.

Artificial intelligence (AI) technologies are increasingly utilised to replace human decision-making in numerous fields from medical diagnoses to job interviews and employee disciplinary meetings. For example, 'Human', an AI-hiring startup based in London, promises that their algorithm can determine the best candidates for a client employer by analysing each interviewee's emotional expressions; and there are hundreds (if not thousands) of other companies, such as HireVue, Emotient, and Affecta, that deploy affect-detection systems for describing the human inner state and personal qualities. Meanwhile, there is no reliable evidence that it is possible to accurately predict an emotional state from a face expression (Barrett et al. 2019).

It appears that humanity has arrived at a moment when machines have been empowered to make decisions about and on behalf of people while ignoring all of the subtle, sensitive and emotional information that a typical human can take into account. For example, it is a known fact that Amazon applies automatic tracking of its employees' movements in its warehouses (Lecher 2019). Further, these automated systems may initiate the dismissal of a worker if his/her performance has dropped below a set average (Lecher 2019). Of course, this AI algorithm does not consider all the human reasoning for working slower than other days. At the time of writing this article, there have been several protest actions by Amazon workers, arguing that they should not be treated as robots and demanding more humane working conditions (Sainato 2020). More recently, Amazon workers in the US have succeeded in forming a new workers' union organization to help protect their rights (Sherman 2022).

Despite its evident shortcomings, it appears that AI has become the new golden calf and one that is followed blindly: algorithms will make decisions and the worker must obey them; instead of shortening our working hours, they are increased; we are paid less for our work output; and our job positions are increasingly insecure. This is how AI-powered efficient automatization functions. At the same time, the businesses that supply and employ this technology continue to benefit financially.

Keep Smiling is an artwork that stages an online interview with the audience. The hiring process begins when the participant clicks 'start interview'. The process is driven by the 'Super Deep AI' agent, which is the visual representation of an AI algorithm (see Figure 1). The only thing evaluated by the algorithm is the participant's smile rating, which determines whether the interviewee will be dismissed. By conducting the interview the system aims to extract the maximum profit from the participant. The artwork incorporates a number of elements from the AI industry, illustrating how decision-making and labour culture have been transformed by technology and the absurdity of basing key elements of this culture on the extraction of data and behavioural monitoring of subjects. For instance, similar to Amazon's 'picking rate' the artwork evaluates the interviewee's 'smiling rate'. If the participant performs below the set 'smiling rate', she/he is dismissed. Although it is difficult, if not impossible, to judge any individual's happiness with any degree of accuracy, AI emotion-detection algorithms are deployed exactly for this purpose in real-life applications. *Keep Smiling* enables the audience to experience directly how unreliable AI is in detecting and codifying emotions.

The recent surge of new deep-learning models has emphasised again the relevance of the term "technological unemployment", coined in the 1930s by John Maynard Keynes in relation to the loss of jobs to technology (Keynes 2010). Machines are performing a rapidly increasing number of jobs that were previously performed by humans. In addition to handing over repetitive manual tasks to robots, we also ask machines to solve problems using artificial intelligence and machine learning. Carl Benedikt Frey and Michael Osborne have studied the probability of computerisation of over 702 occupations in the US and found that approximately 47% of Americans are employed in roles that are at high risk of automation as a result of recent and anticipated advances in AI and machine learning (Frey et al. 2017). Studies in the UK and Japan put the figures at 35% and 49% respectively (Morgenstern 2016).

While we are occupied with thinking about humans being replaced by robots, our experience of work itself is also changing as we are subject to increased surveillance, algorithmic assessment, and the modulation of time. Furthermore, this collaboration between algorithmic systems and employees is not being negotiated fairly (Crawford 2021, 56). *Keep Smiling* vividly illustrates this situation of humans being forced into engagement with AI systems by constant monitoring, automation and evaluation.

Time privatization is another issue. In the artwork, it is introduced by the agent accidentally naming the customers as "products" at the beginning of the job interview. Next, apart from smiling, the Super Deep AI agent gives discrete little tasks, such as counting cats, zebras, and humans, to the participant. This aspect of the artwork refers to the way that in AI systems larger processes are broken into tiny tasks such that we hardly notice how we all engaged in providing training data for the algorithms to learn from in order to process vast amounts of complex data, much like Google's image recognition algorithm CAPTCHA is trained by its engagement with millions of users. As Kate Crawford states: "[...] the myth of AI as affordable and efficient depends on layers of exploitation, including the extraction of mass unpaid labour to fine-tune the AI systems of the richest companies on earth" (Crawford 2021, 69). The term 'fauxtomation' was coined by writer and artist Astra Taylor to describe the deceptiveness of apparent automation that in fact relies heavily on human labour, and we can see that it applies also to an AI is that is neither artificial nor intelligent because it requires extensive human interaction and its putative decisions are anything but intelligent. Ultimately, the pillars on which AI technology is based are low-paid and unsecured workers. As Jeff Besos himself put it, it is artificial artificial intelligence.

In summary, the artwork aims to scrutinize automated hiring, skills-testing, and dismissal systems. The artists reflect on the implications of AI use in the hiring process by providing this interactive artwork with dark sense of humour whereby participants are confronted by a 'master' artificial intelligence agent that requests the interviewee to smile, and to keep smiling for an indefinite period since of course the AI itself would never grow tired.

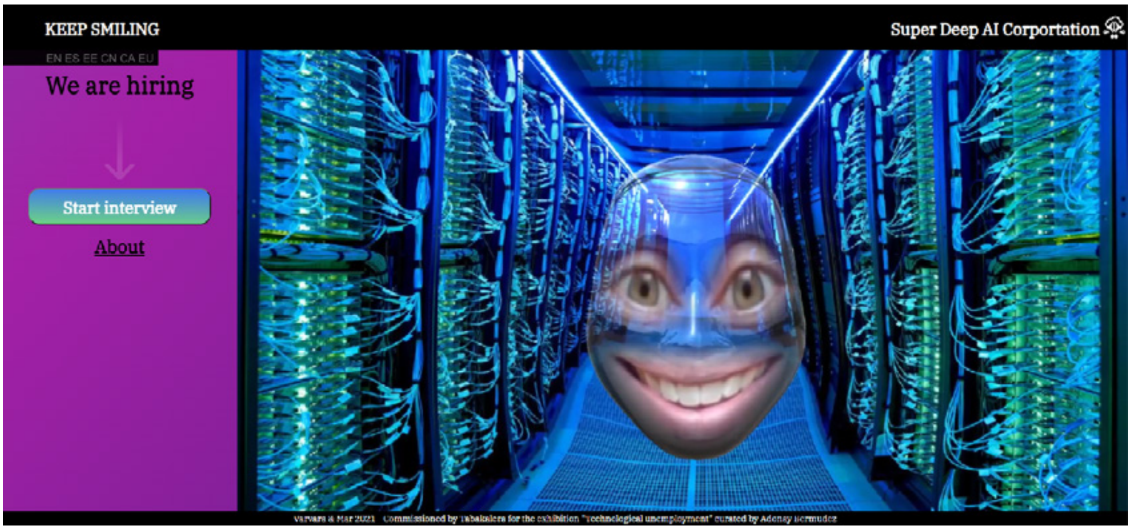

Fig. 1. A screenshot of the Keep Smiling webpage (https://keepsmiling.var-mar.info/).

Related Work

Several artworks address the problematics of face detection and emotion recognition. Affect recognition was first introduced as in the form of universal emotions by American psychologist Paul Ekman, in the 1970s, and developed into the Facial Action Coding System (Ekman and V. Friesen 1978). One of the firsts artworks utilizing facial attribute classification was a video work by Christian Moeller, titled *Cheese* (2003), in which the artists asked six actresses to smile for as long as they could in front of a camera. In the artist's words: "Each ongoing smile is scrutinized by an emotion recognition system and whenever the display of happiness fell below a certain threshold, an alarm alerted them to show more sincerity. The performance of sincerity is hard work" (Moeller 2003).

Another example is *Random String of Emotions* (2018) by Coralie Vogelaar, which explores the absurdity of affect analysis procedure. Vogelaar's emotion recognition software analyses a sequence of randomly formed expressions placed in random order, challenging the software to discover new (non-existing) emotion expressions (Vogelaar 2018). Exploring the errors in emotion recognition technology is a common interest among the projects presented here.

The interactive artwork *Smiletovote* (2018) by Alexander Peterhaensel asks the audience to smile in order to be allowed to vote, and assigns to each participant a selected political party based on analysis of their face. The artwork addresses the problematics of AI biometric scoring by creating a fictitious 'GovTech' startup (Peterhaensel 2018). This artwork employs an interaction method and imitates startup aesthetics by its use of a fictional company, thereby simulating a speculative pseudo-reality that is staged for the audience to experience the artist's proposed narrative.

Technical Realization

The online artwork *Keep Smiling* is a web-based interactive experience developed in html5, JavaScript, video, and using webcam. All computation takes place on the client/user side within the browser, no computations are performed by the server. The artwork can be experienced in different languages, but the audio of the AI agent/recruiter is always in English with the selected language shown in subtitles (see Figure 2). The video translation is realized by subtitles standard implementation for HTML5 using SRT files.

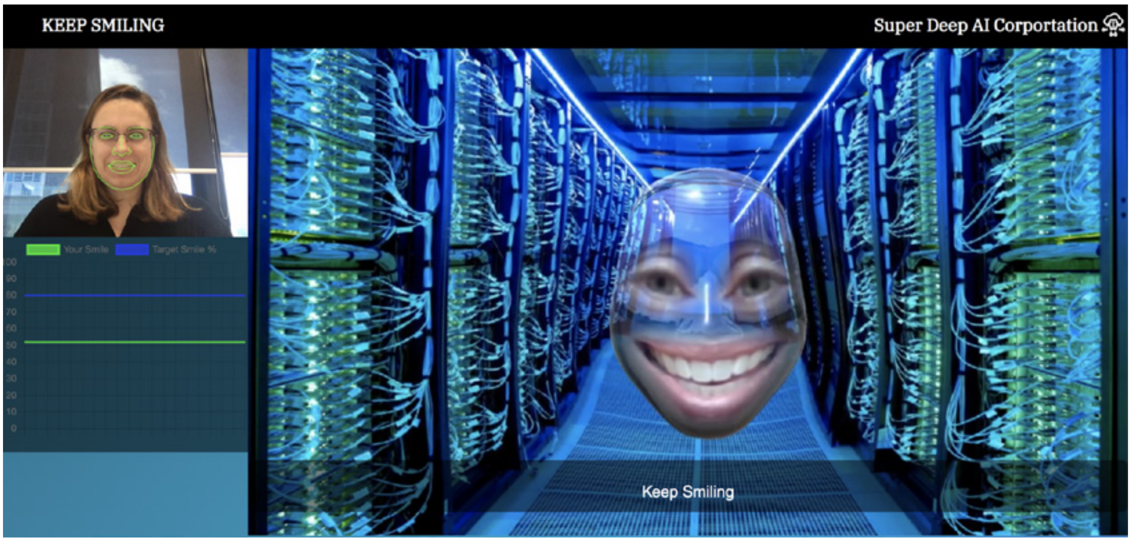

Fig. 2. A screenshot of the *Keep Smiling* interview process (https://keepsmiling.var-mar.info/).

Although the 'Super Deep AI' agent looks like an intelligent application, in reality it is simply a video made with the aid of a Snapchat filter developed by the artist.

1. Clmtrackr is a JavaScript open-source library for fitting facial models to faces in videos or images published in Github by Audun M. Øygard: https://github.com/auduno/clmtrackr

2. Chart.js is a flexible JavaScript open-source library for charting for developers and designers: https://www.chartjs.org/

The facial emotion detection utilises open-source library clmtrackrv[1] by Audun M. Øygard. The webcam image of the interviewee is displayed along with detected facial features rendered in the foreground using clmtrackrv, which helps an interviewee to understand whether the algorithm is accurately detecting the face and how much smiling work is required of the participant for their smile to achieve the necessary smile rating. The smiling data visualization is displayed in a multiline line chart developed in Chart.js[2] library. The graph shows the average smiling of the interviewee as a green line while a static blue line shows the target level necessary to avoid the interviewee being dismissed by the agent (see Figure 2).

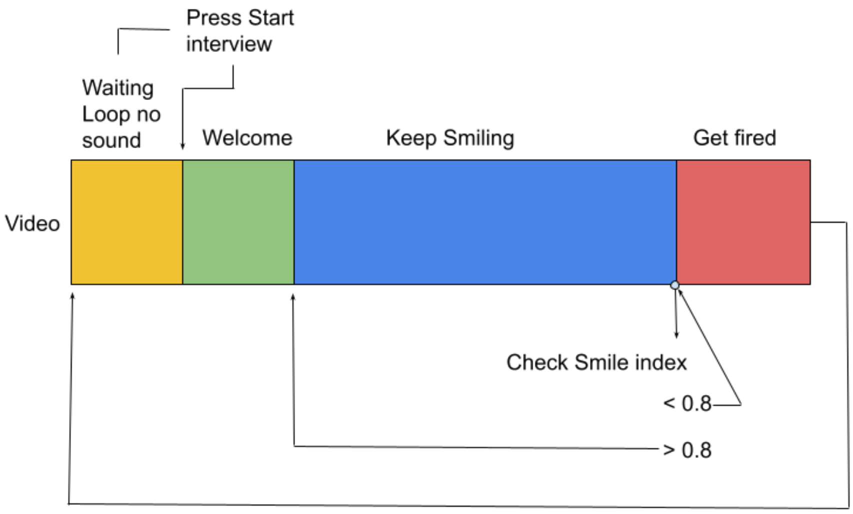

Fig. 3. Flowchart of the artwork.

There is a logic behind the scenes of the system that is controlling participant interaction. The interview begins with a welcome phase, which is followed by encouragement to keep smiling and the extraction phrases, which comprise a single video file with a duration of 6 minutes and 23 seconds. Evaluation of the participant's smile happens on the 6th minute. If his/her average smile rate is over 0.8, then the user is sent to yet another round of smiling. Otherwise, the dismissal phase of the video is played and the participant experience will be terminated. In order to try again, the participant needs to press 'Start Interview' again. Figure 3 illustrates the logical process of the online interactive artwork. However, if the participant tries to archive a smile rate above 0.8 average of the index the system will continue the interview indefinitely until the participant can no longer achieve the 0.8 rating. However, the AI agent will continue to check and notify the interviewee if their smile level falls below the requested standard, ending the interview.

Available at: https://keepsmiling.var-mar.info/

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Leaks: Reflections of Digital World in Material Objects

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For the *Leaks* project, I developed a design method based on two key assumptions. The first provides that each material object created in a given period reflects current interests of culture. The second identifies contemporary culture as a phenomenon rich in digitally generated content and makes that content a medium for further work. The project assumes a reversal of the flow of aesthetic features of objects. In this case, it occurs from the digital to the material environment, and is not an attempt of materiality to create and expand its digital layer but rather of digitality to recognize the stylistic features of the world of algorithms and implement them into resisting materiality. A collection of post-jewellery objects engages tools derived from the areas of algorithmic-aided design or additive technologies and collides them with traditional materials and methods used in classic jewellery. The area of these attempts is our face – it identifies us in both the digital and material world. Are we willing to accept the leaks of digitality in our everyday materiality and to what extent are our digital versions separate from the bodily ones?

Keywords digital crafts, re-materialisation, post-jewellery, 3d printing, 3d scanning, CGI

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Leaks: reflections of digital world in material objects

Goals and context

The aim of the project is to show how the aesthetics of digital artefacts can affect the aesthetics of traditional, material objects associated with the classic jewellery field.

Development of technological possibilities, such as neural networks, becomes the driving force behind a development of numerous cultural phenomena. It is safe to say that our daily, and often materiality, is woven of bits of information.

On a daily basis we deal with the effects of a lack of privacy. Artificial intelligence algorithms specialised in recognizing face/figure/way of moving are following us and collecting data even during our completely ordinary activities, such as shopping or preparing meals. It is impossible to imagine today's world of entertainment without the support of CGI (computer-generated imagery). We break away from the laws of physics, create, sometimes disturbing, human-inhuman hybrids. Thanks to the immersive AR and VR experiences we can participate in games more fully. Dynamically developing market of computer games and special effects armed with better and better tools (Unreal Engine, Zbrush, Blender, After Effects to name just a few) already takes us where our bodies cannot go yet.

Digital twin (Zerza 2021, 8) is a term used to describe a virtual replica of a physical object or phenomenon. Electronic mail, maps or banking in the digital version are based on their analog predecessors, but it is not surprising anymore that we are buying digital properties (Metaverse, Decentraland) or works of art in the form of NFT tokens.

Our digital avatars function in a culture that allows self-promotion on an unprecedented scale. Note digital influencers such as Miquela Sousa or Shudu or the huge popularity of channels devoted to fashion, beauty, and self-care. It is no surprise that digital tailoring (*haute couture*) and makeup are booming. Leading fashion houses wanting to stay in the avant-garde are involved in the creation of progressive digital collections (i.e. Gucci), and the current situation accelerates the expansion of virtual makeup (Chanel, Dior).

Jewellery field in my opinion is one of those areas where we clearly observe what Lev Manovich calls "the remix between the interfaces of various cultural forms and the new software techniques – in short, the remix between culture and computers" (Manovich 2001). Undoubtedly, jewellery is one of the most physical and material of all the art forms. "On the one hand, jewellery becomes similar to face-filters, a tool for customising one's digital identity, digital representation, and image; and on the other, jewellery is an embodiment of a new type of craft – digital craft" (Hallik, Popolitova 2019). Nonetheless it still refers to its own, millennia-old tradition.

Aesthetics

A tempting and often explored aesthetic strategy is search for the unreal, an escape into the unknown/disturbing/impossible. Digital aesthetics plays with the laws of physics, lives its own life and animates those with whom it coexists. Undoubtedly, digital manipulations are a derivative of changing technological possibilities and constitute the basis for dating artefacts produced with their use. We can distinguish a clear increase in the popularity of the triangle mesh based on the structure of STL files, visible, for example, in graphics, ceramics, furniture in the early 2000s. Or, nearly 2 decades later, wavy structures resulting from growth simulation algorithms.

As Mads Nygaard Folkmann claims, "aesthetics is a central way of understanding and investigating the communication and appeal of objects" (2020, 6). The *Leaks* project approaches the aesthetics of digitally present objects in a traditional art-historical way, by examining the formal-stylistic expressions of a range of digital content, yet it does not omit artefact's capacity to affect experience. Jewellery has been a social narrative tool for ages (Siemelink 2010, 230-238) involved in emotional-to-economical human relations. Material objects evolve in a manner similar to the evolution of languages of signs. An item is recognizable when it refers to its predecessor. Therefore, a reference to the traditional jewellery forms may be a way to avoid the shock caused by radical proposals and speculate on evolution rather than revolution of material objects. Colliding well known concepts with features typical for algorithmic-aided design leads to hybrids based on geometries resembling anemones, inflatable balloons, sausages (growth algorithm, inflate functions etc.). We observe numerous examples of mirror symmetries, fractal structures, or reflexive surfaces, which, based on mathematical perfection, give more precise effects than those to which our eyes were used to in the era *before* computer-aided design and neural networks.

Digital image/material object

The *Leaks* project assumes a reversal of the flow of aesthetic features of objects. In this case, it occurs from the digital to the material environment, and is not an attempt of materiality to create and expand its digital layer. I am not looking for the possibility of generating new computational representations of well-known objects, but rather trying to recognize the stylistic features of the world of algorithms and implement them into resisting materiality.

I now mention the concept of *compound interactor* by Michael Brian Schiffer (1999, 13). It concerns the issue of personal image, and it refers to all objects that communicate with us as one subject. The author lists here, for example, hairstyle, makeup, tattoos, clothes, or jewellery. Virtually all of these objects are represented in the digital world. If we look at the possibilities that we have in creating digital avatars, one will quickly notice that simplifications and graphical pictograms are followed by an army of hyper-realistic CGI products made with procedural visual effects software, and whose further development seems inevitable. Here a question arises: to what extent are our digital versions separate from the bodily ones? Perhaps the need for internal consistency allows *leaks* from the digital world to get to the material world? Perhaps we willingly accept in our everyday materiality scratches of what is most tempting in the non-material world?

Classic jewellery is one of those areas that tend to be highly conservative. In the name of tradition, forms known for centuries are still used here, made of materials generally considered to be noble, and using tools that do not change much over the years. Of course, 3D printing has already made its way into this industry, but in order to be considered a manifestation of craftsmanship 2.0, it must be firmly embedded in the context of traditional metallurgy. Contemporary jewellery is, on the other hand, a phenomenon that uses additive technologies more freely, but it somehow programmatically rejects traditional jewellery materials. The *Leaks* project refers to a long jewellery tradition, but looks for inspiration in progressive methods of expressing oneself with the help of algorithms.

Technology and materials

The project consists of two parts. The first is a collection of *post-jewellery* objects that may seem slightly abstract while isolated from the body. The second part is a series of photos illustrating that while worn these objects refer to the archetypes of jewellery: masks, earrings, head adornments.

All material objects are based on three-dimensional models interpreting the aesthetics of procedural visual effects but enriched with elements known from the classically understood jewellery. We are dealing here with 3D printing in Polyjet technology, that allows avoiding support structures of cured resin and therefore all the surface of printed part is evenly covered with digitally generated ornamentation of slices. Semi-translucent material catches light equally well as amber and other gemstones do. At the same time, its "invisibility" plays with the geometry of the wearer's face and creates prosthetic-like effects. Adding UV light (385-395 nm) causes intense radiance of unprocessed amber and delicate glow of crystals such as aquamarine, but also refers to the visual preferences and effects known from the digital world.

The flexibility of the material (obtained by submerging the print part in hot water) was used in the process of stone setting. Created geometries are inspired by traditional stone setting methods – prongs and semi-bezel used to set gemstones in metal – but they have been adjusted to the durability, elasticity and density of the 3D printed parts.

Use of precious stones, such as pearls, directly refers to the preferences of many digital artists for use of lustrous, light-reflecting and glistening surfaces. Upgraded form of a traditional pearl necklace that covers the face is, on one hand, a reinterpretation of one of the most classic pieces of jewellery art, and on the other hand, a playful approach to the observed digital convention. Faceted symmetry of gemstones as aquamarine or amethyst is emphasised by using mirror symmetry of soft lines gently surrounding the wearer's face. Some of the stones, on the other hand, were hand polished to emphasise their irregular nature, that does not refer to perfect digital symmetry, but rather to an uncontrolled algorithm in *tentacle growth* style.

Summary

The *Leaks* project invites viewers to imagine how materiality can take over the features of the digital world. It engages tools derived from the areas of algorithmic-aided design (workflow consists of Rhino Gold, Grasshopper, ZBrush, Blender) or additive technologies and collides them with traditional materials and methods used in classic jewellery (Petry 2012, 6). The area of these attempts is our face – it identifies us in both the digital and material world. In the objects themselves we can look for the echoes of traditional forms of earrings, necklaces or masks. In addition, the nature of the photos accompanying the collection emphasises that digital aesthetics can penetrate our everyday lives nearly imperceptibly.

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Things I do when I'm Bored

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Things I do when I'm bored (2017-22) addresses vloggers' relationship with feeling bored. The work is composed of a browser-based video compilation and a video installation that assembles found footage from YouTube vlogs with less than 100 or even zero views. It emphasises the vloggers' self-awareness in their performative statements of boredom as they look at their representation on-screen with the hope to be viewed, subscribed to, commented on, liked, shared, and followed by others. The work explores the notion that the feeling of boredom on social media, the internet at large, and daily life suffused with digital media technologies, is part of a post-digital symptom of disenchantment in which social media and digital technologies fail to entertain these vloggers.

Keywords Vlog, Boredom, YouTube, Social Media, Digital Culture, Internet, Found Footage, Post-digital

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The corporate web and digital folklore

The amateur web of the 1990s and early 2000s has transformed into our present hegemonic corporate web rich in pervasive social media platforms, real-time data streams and subscription services of ever-increasing high-definition video. With this incorporation of web services into everyday life, internet users have been expressing themselves in the form of amateur videologs, or vlogs, on popular platforms such as YouTube since the mid-2000s. Vlogs are similar to blogs as both are online diaries that share personal experiences, but instead of using text as on blogs, vlogs use video as the form of expression.

In doing so, the vlogger community has developed an audiovisual language that includes video, spoken commentary on personal life, text, graphics, animation, gaming – anything that can be performed in front of a webcam, camera, smartphone and even video screen captured. Vlogs can be described as "Digital Folklore," the aesthetics of popular culture and customs created by "users' engagement with personal computer applications" (Lialina and Espenschied 2009, 9). Vloggers engage creatively not only with software (or apps) for video editing and media manipulation but, too, with popular references and internet culture. Vlogging developed an aesthetics that differs from the audiovisual content created by the entertainment industry provided on video streaming services.

Vlogging because I'm so bored

Boredom, in German *Langeweile*, constructed from *Lange* [long] and *Weile* [while], literally translates as "a long time span," being bored in the German translation implies that boredom both lasts in time and stretches the experience of time. My work *Things I do when I'm bored* analyses the vloggers' relationship with being bored. The artwork is a collage of found footage from YouTube vlogs with less than 100 or zero views to emphasise vloggers' self-awareness in their performative statements of boredom as the vloggers look at their representation on-screen with the hope to be viewed, subscribed to, commented on, liked, shared and followed by others. The vlogger looks at the screen as one who faces the "mirror in which the subject alienates himself in order to find himself, or stares at himself only to see his own death" (Baudrillard 1990, 169). On the one hand, the vloggers stage boredom as prosumers, as both producers and consumers of vlogs. On the other hand, they stare at their deception as their vlogs do not reach an audience. Despite the lack of views, they continue to create vlogs as a practice included in their daily routines and as a mode of online expression that shares personal life highlighting their boredom.

Accordingly, as social media platforms such as YouTube fail to entertain these vloggers, boredom is seen, in part, as a consequence of the experience of social media. Online time is reduced to the consumption and production of content that triggers boredom due to the lack "of the Spectacular, the very power to appeal" (Minh-Ha 1991, 94), which is pre-established by the entertainment industry. The feeling of boredom experienced on the internet at large can be understood as part of a post-digital symptom of disillusionment with a daily life suffused with digital technologies – "a contemporary disenchantment with digital information systems and media gadgets" (Cramer 2014, 12).

In sum, vlogging is a popular online practice that results in the entanglement of daily life and digital technologies in an audiovisual form. This practice is explored in the artwork *Things I do when I'm bored* from within the post-digital condition, interpreted as "the messy state of media, arts and design *after* their digitisation" (Cramer 2014, 17). This condition is delineated by the social and cultural effects of digital media and the "shift from an earlier moment driven by an almost obsessive fascination and enthusiasm with new media to a broader set of affectations that now includes unease, fatigue, boredom and disillusionment" (Berry and Dieter 2015, 5).

Things I do when I'm bored

The artwork *Things I do when I'm bored*[1] is composed of a browser-based online video compilation and an offline video installation. The online/offline dichotomy has become rather diffuse, since online time is now incorporated into daily life, through the proliferation of portable devices such as smartphones and the wide availability of internet access.

Excavating YouTube

To create this work, I first selected found footage from YouTube by searching the queries: "I'm bored" and "I feel bored." Initially, I searched YouTube as any regular user by using the search function and then downloading the videos using a browser extension. I had previously defined the parameters to be 0 or less than 100 views as well as the date to older than 6 months. These parameters would allow me to excavate YouTube as a (video) library and filter its massive amount of videos. Yet, a regular search on YouTube does not allow users to filter and sort the search results by the least viewed and makes it rather difficult to find videos with zero views.

Consequently, to reach videos with zero views, I had the help of the artist and programmer Brian Vogelgesang, who created a script[2] to automatise my search query using the YouTube API. With this script, I was able to directly scrape YouTube links with my parameters. From the large list of links, I have filtered and selected the videos that were most personal and download the videos from this list of pre-selected YouTube links using the Pytube[3] library.

1. I have taken interest in the creation of this work during my participation in the seminar *Mindwandering and boredom in the arts* where I created an earlier version of this work, a 7 minutes video-loop, for the seminar taught by the cognitive scientist Marjan Sharifi and the artist and professor Nina Fischer at the University of Arts in Berlin, Germany, during the winter semester of 2017/18.

2. The script youtubeSearchCli collects links from Youtube with 100 or less views and can be downloaded here: https://github.com/KidA001/youtubeSearchCli

3. Pytube library: https://pytube.io

4. Things I do when I'm bored (browser-based work): https://pedroferreira.net/boredom

5. The video was edited on Shotcut (FLOSS) and can be previewed here: https://pedroferreira.net/moving-image/things-i-do-when-im-bored

In total, I have borrowed around 200 vlogs from this excavation process, which amounted to around 8 GB .mp4 files or about 8 hours of video. In the browser-based work,[4] the user can watch the vlogs' compilation randomly and skip to the next video. The video-loop[5] displays a 26 min. cut from the excavated boredom vlogs. The video editing follows the amateur aesthetics of vlogs through a simple collage technique of cut and paste. I wanted the work to be as accessible as possible to a broad audience. The video editing assembles the vlogs from a process of trial and error in a dramaturgy that follows and remixes the four patterns described below.

Boredom vlogging patterns

Following the excavation process, the footage selection and the video editing, I found four main patterns in the boredom vlogs that I categorised as: (1) I am bored, (2) I am bored, what can I do, (3) What you can do when you are bored, (4) Mockery of boredom. The vlogs that fall into the last pattern "Mockery of boredom" are the vlogs higher in creative content and contrast the spoken personal statements of being bored which adhere to diary-style emotional self-reflection. The other two patterns show a desire for online participation and community engagement where vloggers engage with each other through comments, but in this case, this mainly fails because for this level of engagement to take place it requires views by users and participation by other YouTubers.

The expression of feeling bored through vlogging may result in the vlogger's pursuit for purposeful tasks to do, or rather a boredom that is comprehended as a feeling that takes a highly imaginative and creative path engaged through one's boredom. More broadly, these vloggers experience boredom and handle it in a constructive and creative way by dealing with the feeling of being bored through the creation of vlogs.

Let there be more boredom

Things I do when I'm bored explores the feeling of being bored as part of a post-digital condition in which daily life is entangled with digital media technologies that are no longer perceived as new media. By lacking the newness and the spectacular in media, these technical objects and social media in general trigger boredom as these are merely ordinary devices of everyday life.

The browser-based video compilation and the video installation aim to explore boredom and hopefully let the audience also experience boredom to engage with creatively. It adheres to a post-digital aesthetics that exposes the effects of digital media from within the post-digital condition, a condition in which users are disenchanted, over-saturated and bored with digital technologies. But what if their users took the experience of this boredom as a chance to become more present rather than attempt to separate from it; if users did not feel the need to kill time but, rather, befriend it. To engage with one's boredom is perhaps to find oneself becoming more creative and imaginative. As the cognitive scientist Marjan Sharifi points out, there is a positive cognitive correlation between boredom, creative thinking and mind-wandering (Sharifi 2022).

To conclude, this work introduces several vlogs that have not been seen before or have been pushed away from the search results on YouTube. This is also to highlight that algorithms are not neutral but serve corporate interests. YouTube algorithms follow a corporate agenda that mainly promotes viral videos or the most viewed. This grabs users' attention, influences what is seen, shown and propagated. This is done for monetisation of user data sold for targeted advertisement. By contradicting this algorithmic agency, *Things I do when I'm bored* can be understood as a way to grasp YouTube infrastructure and an alternative form to watch it by shifting one's attention to videos that have been ignored by its algorithms.

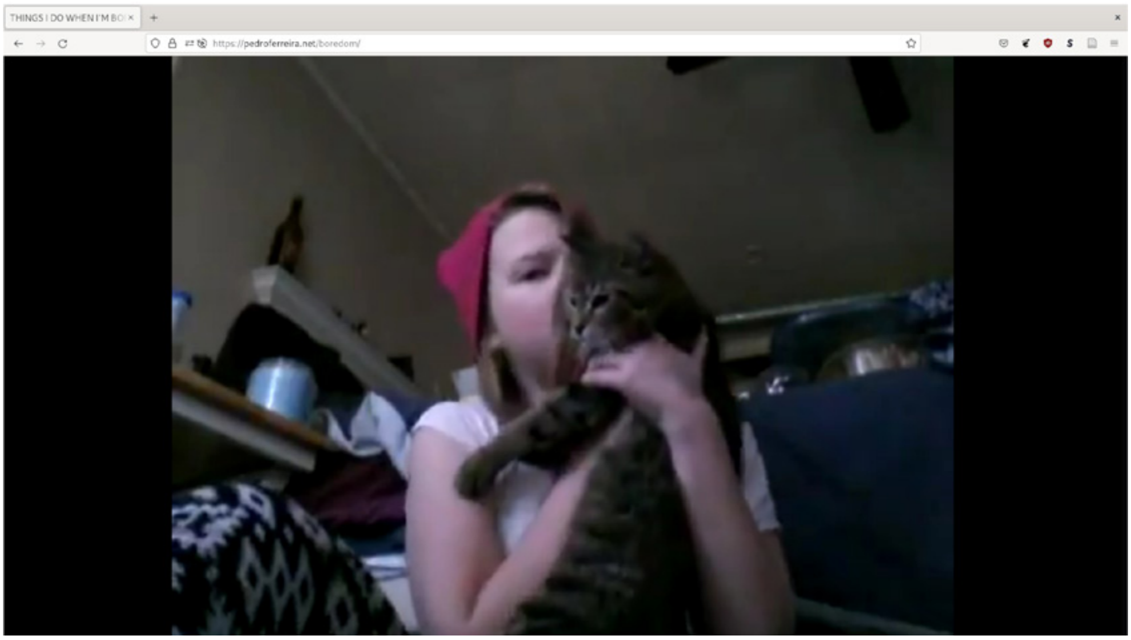

Fig. 1. *Things I do when I'm bored* (browser-based, 2022), still image.

Things I do when I'm bored (browser-based work): https://pedroferreira.net/boredom

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Sentire: A Participative Interactive Sound Performance

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Sentire is both an artwork and a research project in which proximity and touch are sonified with the aim to enhance body perception and social interaction. *Sentire* uses a digital system that mediates body movements and musical sounds, using a Body-Machine-Interface that allows two (or more) people to interact with one another in a physical environment—rather than in a virtual environment. The artwork consists of a participatory performance, which has been presented at numerous events since 2016. Distance and touch between the users can be measured and mapped to an algorithmic sound environment in real time. Through this multimodal experience, the awareness of the self and the other is enhanced on bodily, especially kinaesthetic levels, i.e. movement perception. Since 2019, *Sentire* has been also a research project at the Humboldt University of Berlin[1], with the aim to develop the system for therapeutic purposes.

Keywords Interactive sound, sound synthesis, real-time performance, algorithmic

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1. https://www.musikundmedien.hu-berlin.de/de/musikwissenschaft/systematik/projekte/sentire-soziale-interaktion-durch-klang-feedback

Background and Current State of the Project

Sentire is both an artwork and a research project in which proximity and touch are sonified to enhance body perception and social interaction. The artwork consists of a participatory performance, which has been presented at numerous events since 2016. A guiding performer invites the spectators (one at a time) to interact with her while wearing the bracelets for 6-10 minutes. The interaction develops either standing (with eyes open) or sitting (with eyes closed), but always in a non-verbal context.

Sentire uses a digital system that mediates body movements and musical sounds, using a Body-Machine-Interface that allows two (or more) people to interact with one another in a physical environment—rather than in a virtual environment (Rizzonelli et al. 2022). Distance and touch between the users can be measured and mapped to an algorithmic sound environment in real time (Hunt and Wanderley 2002). Through this multimodal experience, the awareness of the self and the other is enhanced on bodily, especially kinaesthetic levels, i.e. movement perception (Sigrist et al. 2013; Effenberg et al. 2016). *Sentire* makes it possible to experience proxemics in a dyadic nonverbal interaction through a multimodal system (space and sound).

The sensor system is based on capacitive coupling (Nath et al. 2021). Both participants are attached to the same electrical circuit through a bracelet and a cable each. This allows whole body proximity detection that overcomes the problems of other proximity detection systems (e.g. camera or infrared) dependent on sensor positioning and orientation. The detected distance is mapped to a specific set of sound parameters affecting the sound generation and sound design and it is called sound environment. The available sound environments offer different algorithmic sound configurations, ranging from spacey and atmospheric to percussive and rhythmic. The main aim of *Sentire* is to enhance the experience of getting close and touching another person (Rizzonelli et al. 2022, 9).

Since 2019 *Sentire* has been also a research project at the Humboldt University of Berlin[2], with the aim to develop the system for therapeutic purposes. Embodiment-based research serves as a conceptual framework to understand the relationship between attention towards one's own body and states of consciousness. Furthermore, the notion of musical social entrainment (Kim, Reifgerst, and Rizzonelli 2019) serves as a tool to interpret social interactive behaviours mediated by *Sentire*.

The effectiveness of the system is assessed with the methods of structured observation[3] (Robson and McCartan 2016; Bakeman and Quera 2011) and the micro-phenomenological interview technique[4] (Petitmengin 2006; Petitmengin, Remillieux, and Valenzuela-Moguillansky 2019). Between 2019 and 2020 we conducted some preliminary tests and a controlled experiment to investigate *Sentire*'s baseline effect compared to recorded sound and no sound. Since 2021

2. https://www.musikundmedien.hu-berlin.de/de/musikwissenschaft/systematik/projekte/sentire-soziale-interaktion-durch-klang-feedback

3. https://www.musikundmedien.hu-berlin.de/de/musikwissenschaft/systematik/projekte/sentire-soziale-interaktion-durch-klang-feedback/structured-observation-method-application-in-the-real-world-context-1

4. https://www.musikundmedien.hu-berlin.de/de/musikwissenschaft/systematik/projekte/sentire-soziale-interaktion-durch-klang-feedback/the-microphenomenological-interview-technique

a real-world study for couple therapy has been investigating how *Sentire* can be effectively used for such a purpose.

In the field of *Human-Computer Interaction (HCI) research*, incremental and iterative development of the *Sentire* software and hardware is currently being carried out. This includes a wireless version of *Sentire* that allows more freedom of movement for the participants and therefore increases the usability in different contexts.

Performance

Sentire goes beyond one-way performance insofar as the participant does not carry out pre-specified actions but can freely engage physically and emotionally with his or her interaction partner. Previous participants reported (in microphenomenological interviews conducted by the first author[5]) an intimate connectedness to the partner, to touch, hearing and proprioception (i.e., the awareness of one's body in space). The empathetic possibilities of touch, in particular, often go unnoticed in our attention-poor world concerned with images and screens.

Participants become playfully attuned to their gestures and somatic rhythms because they directly cause unplanned variations in the sound environment as they unfold within the performance space and in relation to the other participant.

The sound environments are designed to immerse the interacting persons smoothly and naturally in the sound, while also giving them agency and control over the rhythmic, harmonic and timbral dimensions of the audio output. Each performance becomes, therefore, a unique improvisational event that emerges from the singular somatic states stimulated by the relations to another body, specific space and the responsive sound environment.

The interaction design focuses on awareness of closeness and touch between participants. At a distance of about three metres, the sound becomes hearable. The closer the participants are, the more intense (e.g. louder, higher in pitch) the sound becomes, enhancing the act of approaching each other. When the participants touch each other, an extra percussive sound—which has a similar sound quality to the proximity sound—is triggered.

This interactive sound system creates a so-called perception-action loop (Tajadura-Jiménez et al. 2018). The participants are influenced by the external reality, including the generated sound; simultaneously, they are affecting the sound through their interaction. What is specific to the *Sentire* system is 1. the fact that the generated sound is affected by the behaviour of both participants and 2. the possibility to digitally design real-world proxemics (McArthur 2016) based on how the detected proximity signal is mapped to the sound generation.

5. Some relevant quotes: "There was a moment when I could not distinguish anymore who does what. It became a melting experience.", "This is about what is happening here and now."

Outlook

In 2022, the team of *Sentire* is focusing on two main tasks: the research about how *Sentire* affects human interaction and the hardware and software development of the system.

Understanding the effects of *Sentire* on human interaction can give insights on how to change the design of *Sentire* for both therapeutic and artistic usage. This information is valuable for the actual use of the system (for performers, therapists, users) and for extending the features of *Sentire*. We are currently investigating the use of neural networks to recognize interaction gestures and sonify them accordingly. Another relevant future development is the recognition of the so-called quality of touch, as it would allow to sonify different kinds of touch events, such as multiple fingers touching and pressure.

Finally, artistic development is underway, together with the project *pop-up institute*[6], which aims to reduce the stigma of mental illness through art therapy. Different kinds of artists (visual, performative, and sound artists) are involved in this project to create an exhibition and performance space in June 2022 with different media. A specific sound environment for *Sentire* is currently being developed using pre-recorded voices from neuro-diverse persons.

6. https://www.kunsthochzwei.com/en/the-pop-up-institute/

Website: https://sentire.me/
Video: https://vimeo.com/317080128

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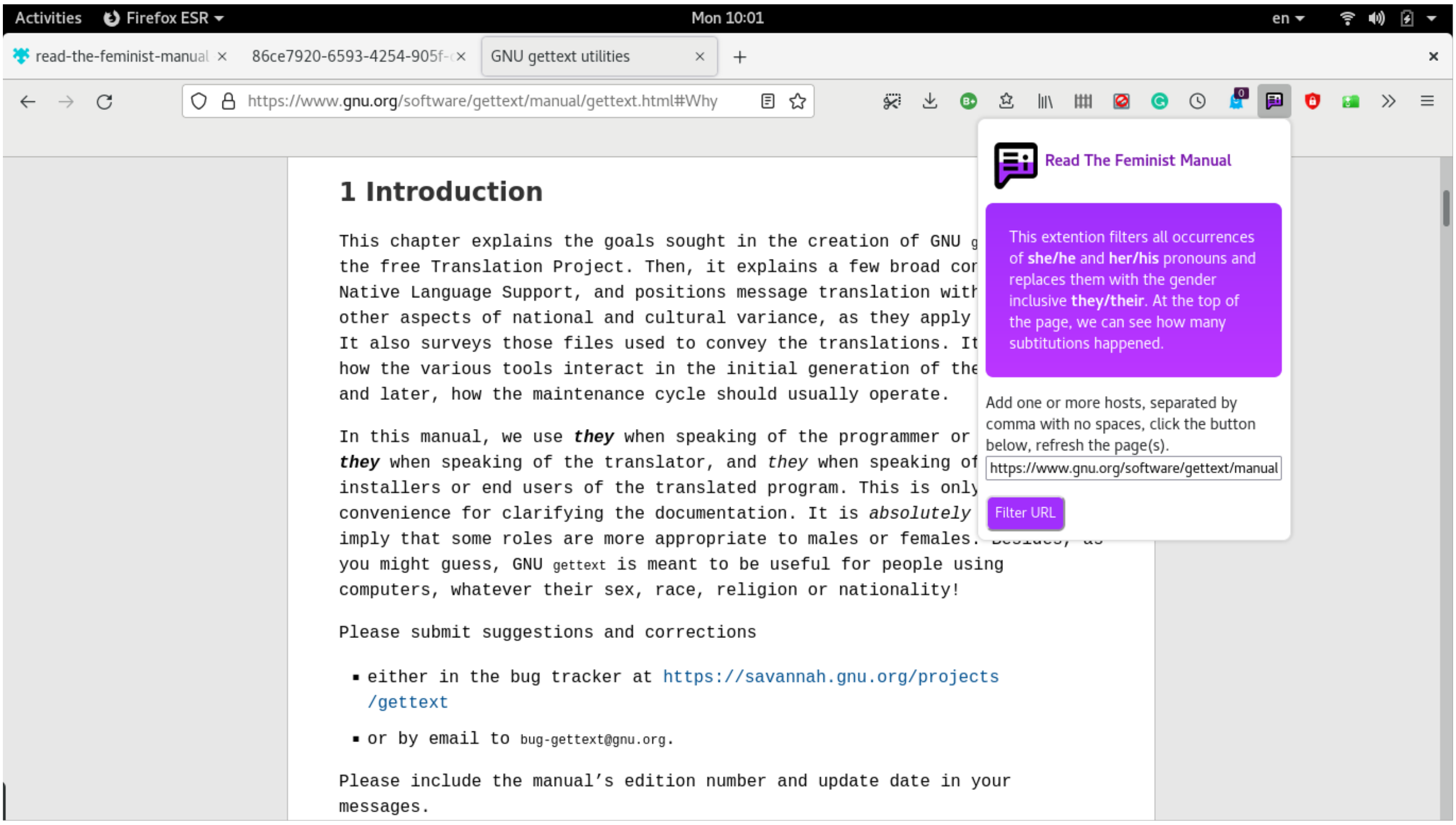

Read The Feminist Manual

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Read The Feminist Manual is a re-appropriation of RTFM (Read The Fucking Manual) and addresses gender discrimination in the Free and Open Source Software (FOSS) communities and the lack of support in accommodating marginalized voices. The output of the research is an experimental Firefox addon which replaces gendered pronouns *he* and *she* with the neutral pronoun *they*, intended for use with online technical documentation pages, where the programmer is assumed to be a male (he). The project is accompanied by a zine, in which the readers can find information about the inspiration of the project, about the Firefox addon and screenshots of the addon's implementation in the browser. Along with the project's documentation, the zine introduces the significant role of feminist servers in shaping a queer community of sysadmins to nurture gender diversity. *Read The Feminist Manual* research was realized during the author's fellowship at the Media Enterprise Design Lab of Boulder University of Colorado.

Keywords Online governance, feminist internet, FOSS, tech, manuals, communities, gender discrimination

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RTFM: Read The Feminist Manual
Context and Inspiration

Free and Open-Source Software (aka FOSS) development happens with code contributions within communities. This code is most often technical, but sometimes is about code of conduct, meaning how members shall engage with the community, and code documentation, meaning how other developers and users can interact with the code. The writing of these manuals often assumes the programmer/engineer is a *he*. The idea for a feminist tech manual as a re-appropriation to RTFM (Read the Fucking Manual)[1] came up when I was looking at an online documentation of a free software I was installing. I read this from gettext docs:

1. Read The Fucking Manual: https://en.wikipedia.org/wiki/RTFM

> In this manual, we use *he* when speaking of the programmer or maintainer, *she* when speaking of the translator, and *they* when speaking of the installers or end users of the translated program. (Gettext Manual, 2020)

When I posted about this gender stereotype re-enforcement on mastodon (a decentralised social media platform), someone pointed me to a patch that was submitted last September by a contributor in the GNU community, who wished to correct this issue by substituting *he, she, his, her* with *they/their.* Incredibly but true, this patch was not accepted by the community. Here are some excerpts of the responses to the patch contributor on GNU mailing list (public and accessible) about the gender usage:

> The GNU Kind Communication Guidelines don't mandate gender-neutral speak in documentation. [they] are about communication between people, not about documentation. Therefore there is no need for gender-neutral speak in the GNU gettext documentation. (Gettext lists.gnu.org, first responder, 2020)

> The patch you suggested requires reader to accept "singular they" which is not commonly used anywhere and is considered an error by many, especially in formal writing. (Gettext lists.gnu.org, third responder, 2020)

> 1) In a specific document or documentation, do we want gender-neutral speak?
> 2) If we want gender-neutral speak, what is the English grammar element that works best?
> Here, it's futile to discuss the second question, since the answer to the first question is already "no". (Gettext lists.gnu.org, first responder, 2020)

This last quote was the end of the debate. So, the question about introducing gender-neutral speak was finally raised by one of the main contributors, only to reject it with the above reasoning. Just for the records here, one response in favor of the change pointed out:

> It (they) is very much on the uprise. So much that it's been chosen as the 'Word of The Year' in 2019 by Merriam Webster, and 'Word of the Decade' by The American Dialect Society. (Gettext lists.gnu.org, second responder, 2020)

If we dig further, Richard Stallman, one of the founders of the Free Software movement, refuses to use people's preferred pronouns, to the point of dismissing the pronoun they as grammatically wrong and coming up with his own random rules for new pronouns. (Stallman, 2019)

When we cannot have a say in the decision-making of these communities with regards to language etiquette, gender inclusivity and other forms of discrimination, we can at least circumvent them on another level. A browser addon can do that for the readers without waiting for the gender emancipation of the GNU project and the FOSS in general. But more about this later.

This gender inclusivity issue and how it was backed with arguments of language correctness reminds me of another incident in a Greek hacker space's mailing list two years ago. What happened in a nutshell; me and a peer organized a presentation about our autonomous feminist servers, and in the event's promotion we wrote a blurb, where we referred to the server with a female pronoun, while in Greek it is called with a male pronoun. The warriors of the Greek language got furious, and a long trolling unfolded.

In both incidents, it is clear that the language correctness is a pretext for refusing to waiver the privilege of the male programmer/hacker. The result though has further implications; these communities tend to be biased and changes of social inclusion are (mostly) not happening.

Feminist Servers

What is a feminist server?

> Because all online resources are hosted on servers, they constitute a base for the internet as we know it. All servers are ruled by different terms of service, governance models and national legislation in relation to privacy and access to data by third actor parties (or "trackers") and are dependent on a variety of business models. This somewhat technical definition can obscure the possibilities for understanding the political aspect behind the setting up and management of a server. (Toupin and Hache 2015)

From the experience of women, trans, and queer identified peers running autonomous server infrastructures, the following junctures are part of a feminist pedagogy: extensive documentation, be able to ask any question without being judged by competitive colleagues, and work without having to deal with a sexist discourse. These attitudes inspire solidarity and participation from diverse identities, and challenges the dominant FOSS monoculture.

A List of Feminist Servers

1 Alive projects
- 1.1 Anarchaserver
- 1.2 La Bekka
- 1.3 Cl4ndestina
- 1.4 CódigoSur
- 1.5 Fuxico + Feminist Pirate Box
- 1.6 MaadiX
- 1.7 Matriar.cat
- 1.8 Systerserver
- 1.9 Vedetas
- 1.10 1984
- 1.11 Diebin

2 Closed projects
- 2.1 Kefir.red

For more info about each server please visit our online index.[2]

2. You can check some of their services in this section: https://alexandria.anarchaserver.org/index.php/You_can_check_some_of_their_services_in_this_section

Support/Resources

> Although cyberfeminists have done a lot to put forward their priorities as a movement to funders, it can be argued that internet freedom funders remain unconvinced of the centrality of gender issues and only see it as an add-on or a subset of the sector. (Mejia 2019)

Feminist internet infrastructures need more support and funding to grow their networks of solidarity. Working together with other feminist sysadmins for systerserver and anarchaserver we have seen the need from artists and activists to host their content on trusted platforms, which respect privacy concerns, for example independently produced post-porn videos, but also content that aligns with feminist and queer identity politics. Alas, resources and financial support for building such digital infrastructures when coming from civic bodies, often have strings attached, such as detailed reporting with risks of privacy leaks, or co-opting of feminist tech by Big Tech. And when support is coming from the arts, funders expect visual interfaces and design deliverance besides the development of online platforms, which requires a lot more labor vis-a-vis the granted budget. Tech/cyber feminists, who often come from anti-capitalist and anarchist backgrounds prefer not to navigate through such barriers and rather get involved in existing, but highly cis-male centered hack initiatives.

RTFM add-on

A Firefox addon that replaces *she* and *he* pronouns with the neutral counterpart *they*, by filtering web-page content, is under development and released as an experimental extension. It can be installed from the Mozilla addons gallery.[3]

3. Read-the-feminist-manual addon can be installed from https://addons.mozilla.org/addon/read-the-feminist-manual/

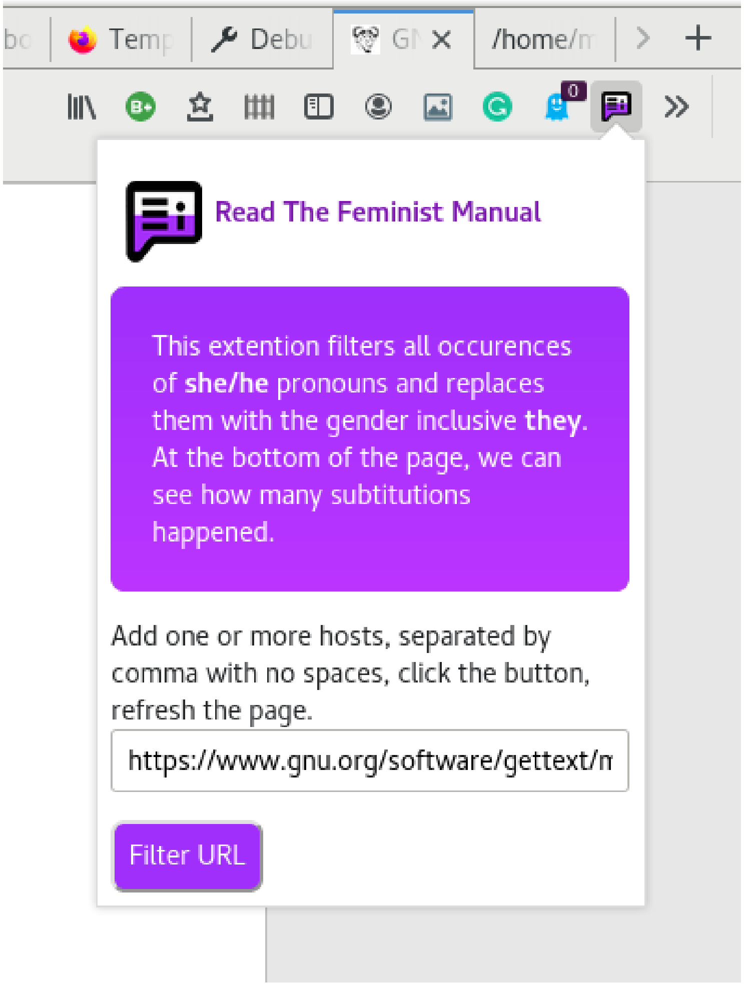

Fig. 1. read-the-feminist-manual addon.

Read the Feminist Manual version 1.0 provides the following features:

- A user input to enter one or more URL for filtering. User can click the addon's icon to add hosts and press the filter button.
- Replacement of he/she with they in bold.
- A counting of all he/she occurrences found in the HTML text is added at the top of the page.

So far, the addon has been tested with the following GNU manuals: gnutils,[4] mailutils,[5] gettext,[6] tar,[7] emacs,[8] wget[9]

4. GNU TLS documentation https://www.gnutls.org/manual/gnutls.html

5. Mail utils documentation https://mailutils.org/manual/

6. Gettext documentation https://www.gnu.org/software/gettext/manual/gettext.html

7. Tar documentation https://www.gnu.org/software/tar/manual/tar.html

8. Emacs documentation https://www.gnu.org/software/emacs/manual/html_mono/emacs.html

9. Wget documentation https://www.gnu.org/software/wget/manual/wget.html

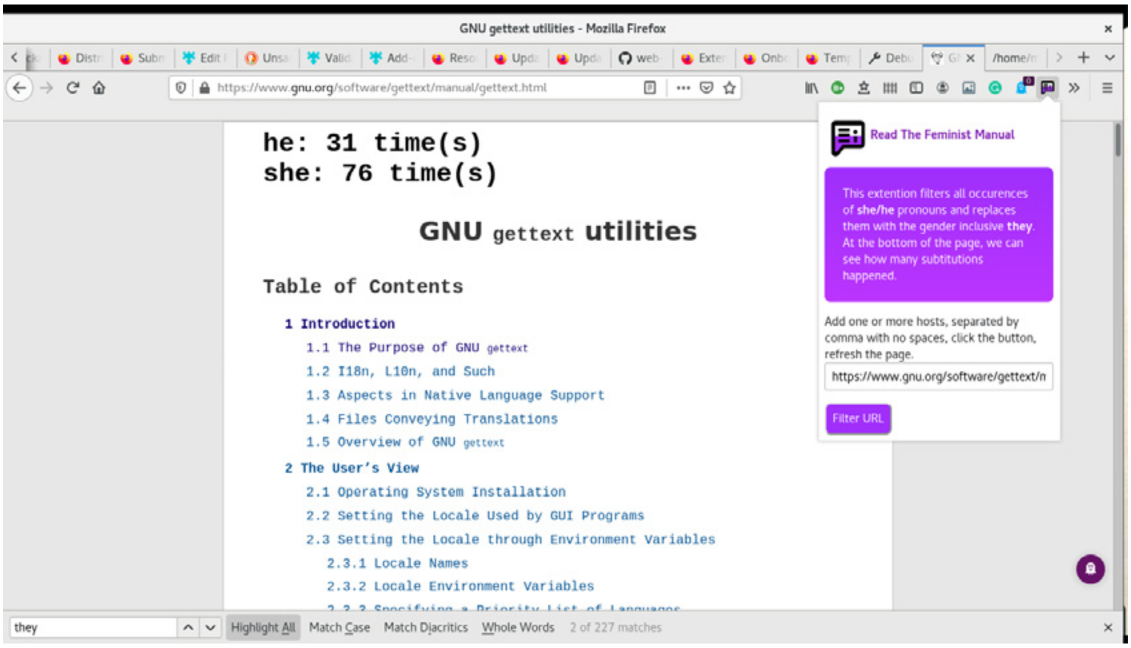

Fig. 2. Gettext documentation with the filtering on. *he* was used for the programmer, *she* for the translator and got replaced by *they*.

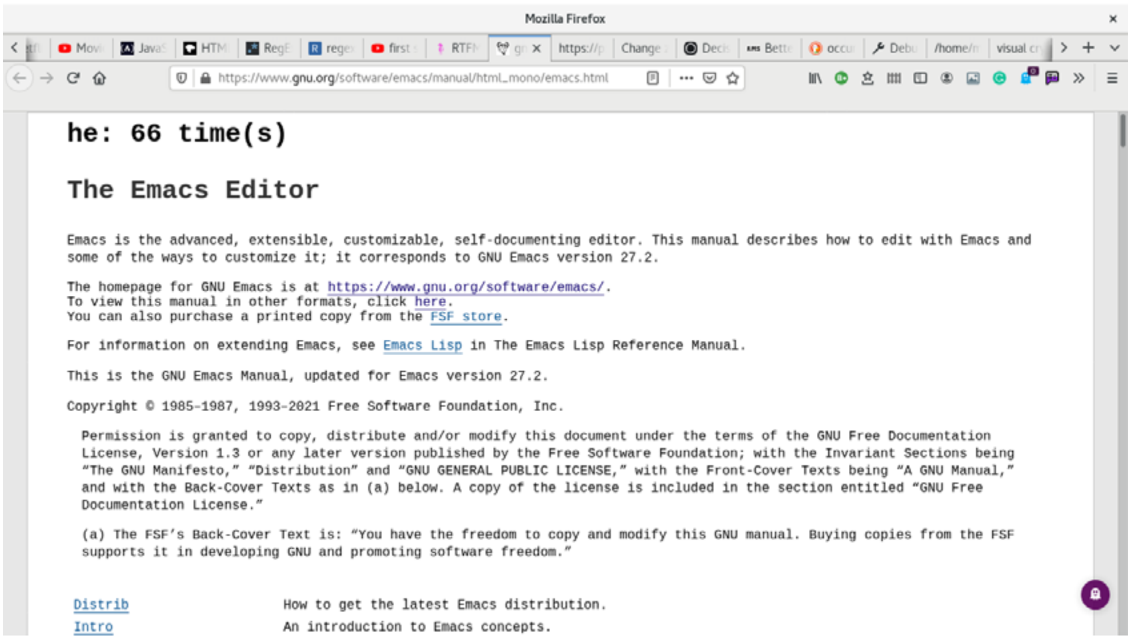

Fig. 3. Emacs documentation with the filtering on. Only *he* pronouns were used in the original documentation.

Future versions will include filtering of *him/hers* to be replaced by *them*, and users' options on how to display the pronouns. Also, an option to save the generated new content into a PDF for printing would be also added in a future release.

The documentation of the project can be found in a zine format made by the author and available to download.[10] It includes screenshots of the content gender filtering implementation with the read-the-feminist-manual addon.

10. Read The Feminist Manual zine can be downloaded here: https://psaroskalazines.gr/pdf/rtfm_zine_screen.pdf

Fig. 4. Read The Feminist Manual zine.

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Web page of the project https://psaroskalazines.gr/zines/RTFM/

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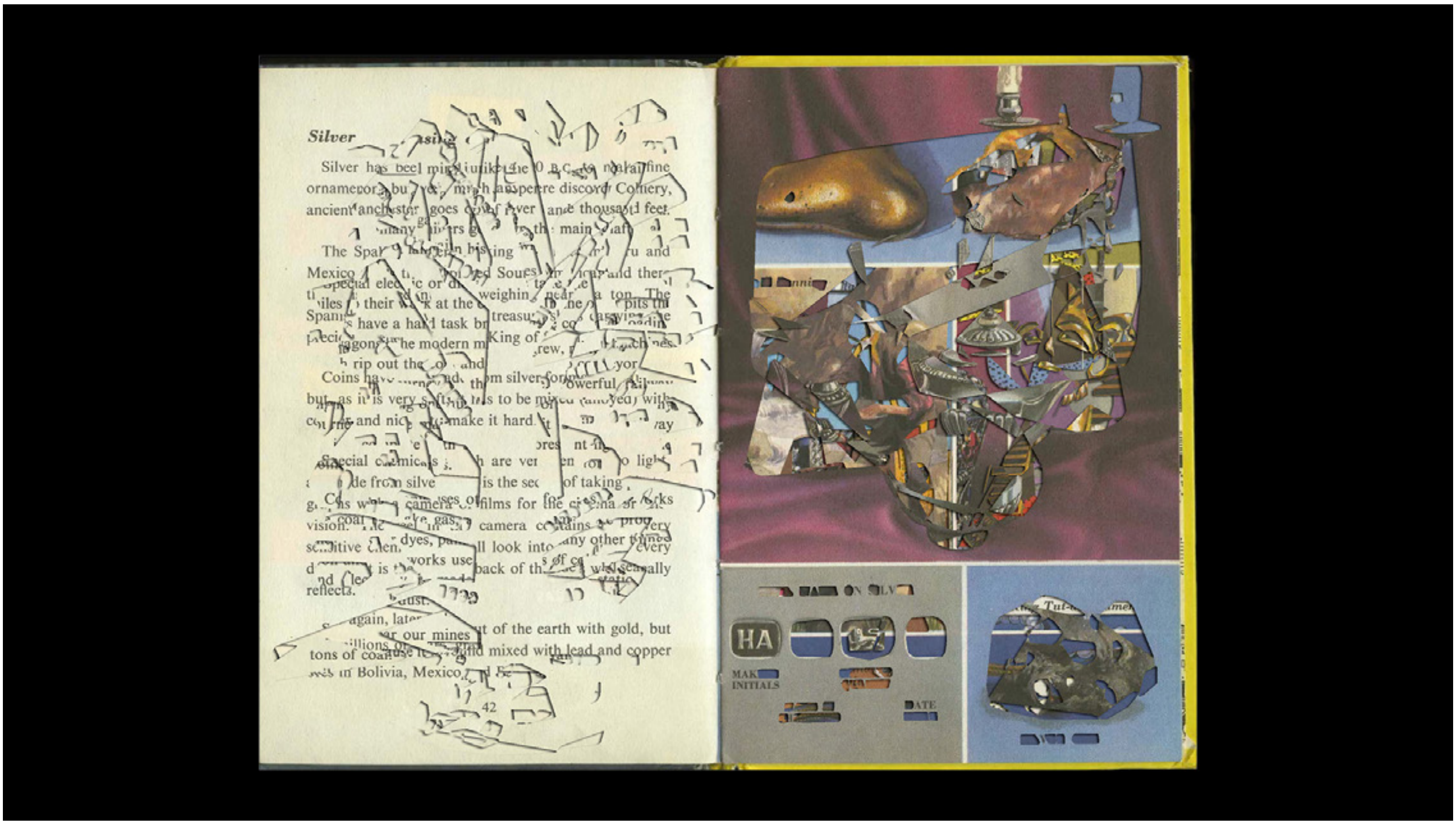

Things Have Forgotten What the Shapes are For

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Every burned book enlightens the world. (Emerson 1841)

Things Have Forgotten What the Shapes are For, (2022) is an automated-art-system consisting of a CNC (Computer Numerical Controlled) laser-enabled[1] machine, driven by custom-coded software that removes parts of any book in order to reveal relationships between the images and texts across multiple pages. Each automated 'reading', or burning, generates a unique artefact while destroying the original, producing new 'portals' through the book. An experiment in post-digital publishing that explores the differences between the deconstruction and the destruction of knowledge in the age of the mass-digitisation of the book.

1. The term 'Laser' is an acronym for "Light Amplification by Stimulated Emission of Radiation", commonly adopted in light research and applications since the 1960s.

Keywords Post-digital, Book-burning, Biblioclasm, Transcendental nihilism, Nonhuman collage, AI / Machine-learning, Post-literature, Computational unknowing

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Fig. 1. 'Minerals', 2022 [internal pages], from *Things Have Forgotten What the Shapes are For*, Donnachie & Simionato.

Description

Things Have Forgotten What the Shapes are For, (2022) is an automated-art-system[2] designed to algorithmically burn books. More specifically, the custom-built system leverages Computer Vision and Artificial Intelligence, calculation, choice and chance to precisely laser-cut away parts of books. Through a process reminiscent of the 20th century art techniques of cutup, découpé and collage, the system reveals new relationships between the images and texts across different pages of any book.

2. An 'automated-art-system,' here, means a machine, which can be programmed through custom-coded software and scripts to generate new creative works. Although an A.A.S. can sometimes be supervised, it is generally understood that it is intended to function without constant human intervention. All automated-art-systems described in this research are fully functional.

> Cut-ups often come through as code messages with special meaning for the cutter. (Burroughs 1978)

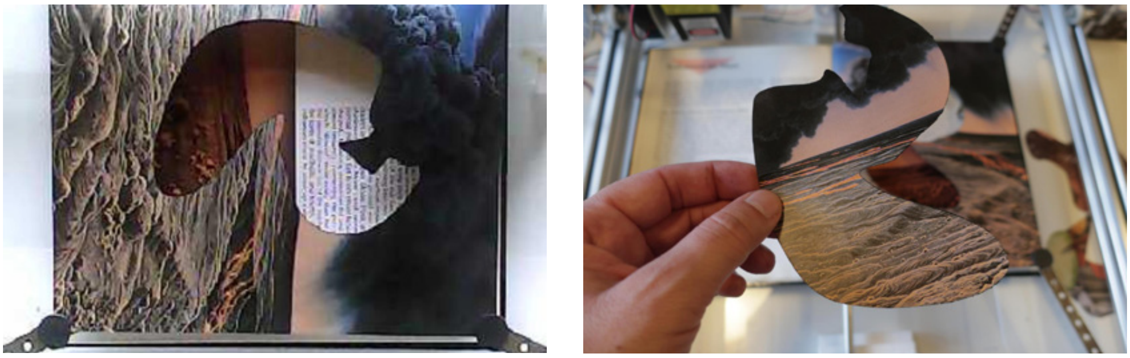
The Automated Art System

After an initial analysis of each new page through computer vision, the system updates the database with the publication's semantic, semiotic and sentiment information before determining the optimal areas of the page to remove with its laser. Here 'optimal' is considered a somewhat indeterminate product of the intersection of a number of variables (or a programmable uncertainty[3]), including considerations of colour, contrast and content on the given page, along with the potential preservation or revelation of matter on other underlying pages. The system is comparing each new page with every preceding page, in an attempt to uncover salient features, potential juxtapositions and significant combinations of imagery from different pages of the book which would not otherwise be possible to observe.

3. We refer to these systems as 'programmed uncertainty' because while all potential outcomes are arguably foreseeable (i.e. computable), the embedded potential for variability in the weighted decision pathways renders the sum total of possible readings of any given book beyond human predictability.

Fig. 2. ‘Life’s a Parade’, 2022 [Computer Vision process screen captures], from *Things Have Forgotten What the Shapes are For*, Donnachie & Simionato.

Fig. 3. *Things Have Forgotten What the Shapes are For*, Donnachie & Simionato [burning-process images].



The system iterates through this process for every page of the book, attempting to preserve specific combinations (collages?) of imagery by building many ‘wormholes’ which travel through the book in ways that appear alien when compared to the typical pathways available for human reading[4]. It is worth noting that the system has been designed to preserve the book’s original cover and binding throughout the process. The resulting book appears integral at first, only opened does its evisceration become evident.

The physical removal of the selected shapes from the page occurs by driving a high-powered laser module that, through amplification and focus, uses concentrated light waves to burn the page. This process evokes literary and historic precedents of book burning, censorship and information control in mass media. The project also engages with post-digital publishing practices that seek to explore new materialities of the book as medium in an era where networked computing has disrupted the more traditional roles of the book as vehicle for information and cultural distribution. The AI and machine-learning algorithms, on which our automated-art-system is built, are directly informed by the data-archives resulting from the mass-digitisation of the book by companies such as Google over the last 20 years. Such ‘artificial readings’ of the book underpin the dual processes of exploring new interpretations of the book, while simultaneously contributing to its destruction.

4. Generally speaking, most existing human and, consequently, machine-learning reading ‘pathways’ serve to build meaning by parsing a handful of traditional grid-like organisations of the printed page (i.e. words and images distributed vertically or horizontally on the page; from left to right in Western regions; right to left in Middle-East to Eastern regions of the world).

Once initiated, our system inexorably proceeds in permanently destroying the original book, while attempting to produce a unique new bookwork. Like the Ship of Theseus, progressively transformed through constant repair, our project tests the idea of the book itself. At which point have we removed enough material from the original for it to become a different book, or something else altogether? Finally, what can these remains of the book still offer?

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.

Fig. 4. Things Have Forgotten What the Shapes are For, [process video on Vimeo].

Acknowledgements. Open Source Libraries and software: Python, Tesseract OCR, Natural Language Toolkit (NLTK), Pillow, OpenCV, Tkinter, cnc.js. The artefacts of this work are singular edition artists books, presented as derivative works of found publications. No attempt has been made to contact the publishers, authors or artists of the original texts for permission or endorsement.

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Performances

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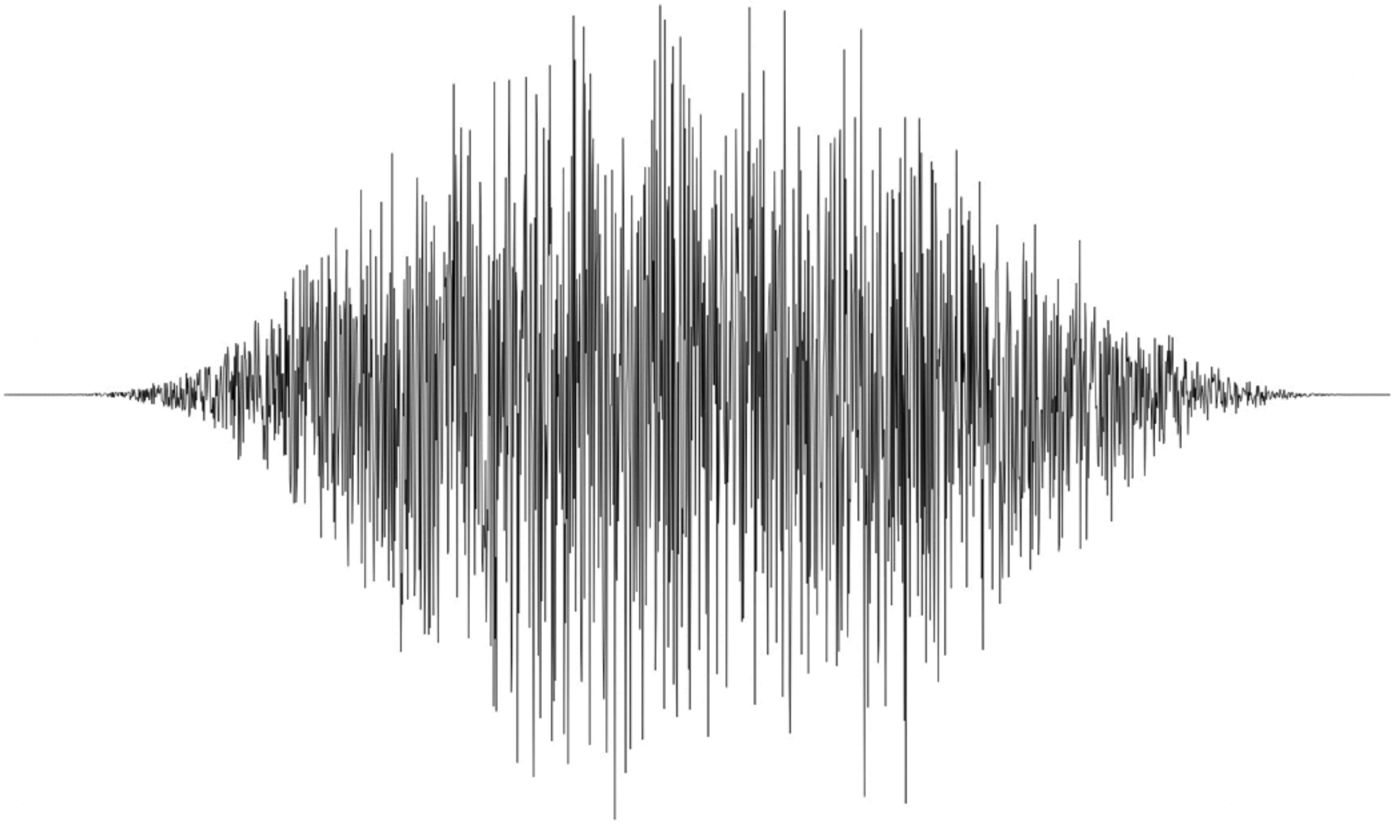

Synthetic Pulsar (Speculative Sonification)

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Synthetic Pulsar (Speculative Sonification) looks at the pulsar as a dazzling multi-dimensional object of scientific and creative focus. While the pulsar traverses a wide range of disciplines – astrophysics, radio technique, and sound technology – the workings and nature of such an object can never be fully captured, hence remaining incompletely understood. Proposed work probes this complexity through a process of speculative data sonification: amplifying, modulating and augmenting astrophysical data - sourced from the European Pulsar Network - within an original implementation of pulsar synthesis program (nuPG) designed by the author.

Keywords sonification, astrophysics, physical modelling, pulsar synthesis, nuPG

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Background

The sonification of pulsars at first sight seems paradoxical. The pulsar data in one of its raw formats consist of a radio signal which is already audible[1]. The data can also come in a numerical format representing rotational profile of observed pulsars. Within such a format pulsar rotation is sampled at a given interval and its data can be represented as a 2-dimensional set of values. An integration of data from astrophysical pulsars into compositional work with the New Pulsar Generator (nuPG) program resonates closely with an approach of augmented sonification where an auditory stream becomes modulated by an additional process or data. Such a process is a key method in the composition *Synthetic Pulsar (Speculative Sonification)* (2021). The work was commissioned by CTM Festival Berlin and Deutschlandradio Kultur, and originally presented as a sound installation spatialized on an specially built array of 64-channel soundsystem at Vollgutlager in Berlin. The original version of the work included a collaboration with a singer Alex Freiheit and Birds on Mars a collective specialising in synthetic voice design. A binaural version of the work was streamed by Deutschlandradio Kultur as part of their Klangkunst series: https://www.hoerspielundfeature.de/hoerstuecke-mit-kuenstlichen-stimmen-ventrilogues-1-100.html. The version of the work presented at the XCoAx does not include the libretto and the synthetic voice, the aim is to highlight the relationship between the formal development of the composition and the model of augmented sonification.

The work *Synthetic Pulsar (Speculative Sonification)* invites listeners to explore a dynamic system in action. Processes of attraction and repulsion are modelled within a digital model of a world with its own size, dimensions and gravity, providing a basis for hybrid sonification approaches[2]. The material point of departure for the work is a new implementation of the pulsar synthesis technique in the form of The New Pulsar Generator (nuPG) program designed and programmed in SuperCollider 3 programming language (Fig 1). The technique of pulsar synthesis is named after the spinning neutron stars that emit periodic signals in the range of 0.25 Hz to 642 Hz. The range of frequencies—between pulse and continuous tone—is of central importance in pulsar synthesis. The pulsar as a technological device refers to a sound synthesis technique originally invented by Curtis Roads (Roads, 2001) and implemented as a standalone PulsarGenerator program together with Alberto de Campo (2001). The technique of pulsar synthesis offers a seamless link between musical time-scales of individual particle rhythms, periodic pitches, and the meso-temporal or phrase level of composition. Pulsar micro-events produce rhythmic sequences or, when the density of events is sufficiently high, sustained tones, allowing composition to pass directly from micro to meso-temporal domain. As an audio technique, the origins of pulsar synthesis can be traced to historical analog techniques built around a principle of filtered pulses. The voice-like characteristics of its timbre can be linked with early experiments in speech synthesis at

1. Gérard Grisey incorporated recordings of incorporated the signal of pulsars Vela and PS 0359-54 as integral elements of the composition *Le Noir De L'Etoile* written for percussion ensemble Les Percussions de Strasbourg. In two sections of the composition (22'07- 24'53 and 35'53-37'59) a recording of pulsars' signals as detected by radio telescope Nancay was played back over an array of 12 loudspeakers distributed around the audience. At the premiere of the work in 1992, an initial idea to stream live pulsars' signal from Nancay observatory to the concert hall in Brussels was not feasible technically. Thus, the recording was used instead.

2. The system used in the work is based on RedUniverse Quark for SuperCollider developed by Mark d'Inverno and Fredrik Olofsson: https://fredrikolofsson.com/f0blog/work-with-mark-reduniverse-a-simple-toolkit/

the Westdeutscher Rundfunk (WDR) in Cologne by Werner Meyer-Eppler, Herbert Eimert and Robert Beyer.

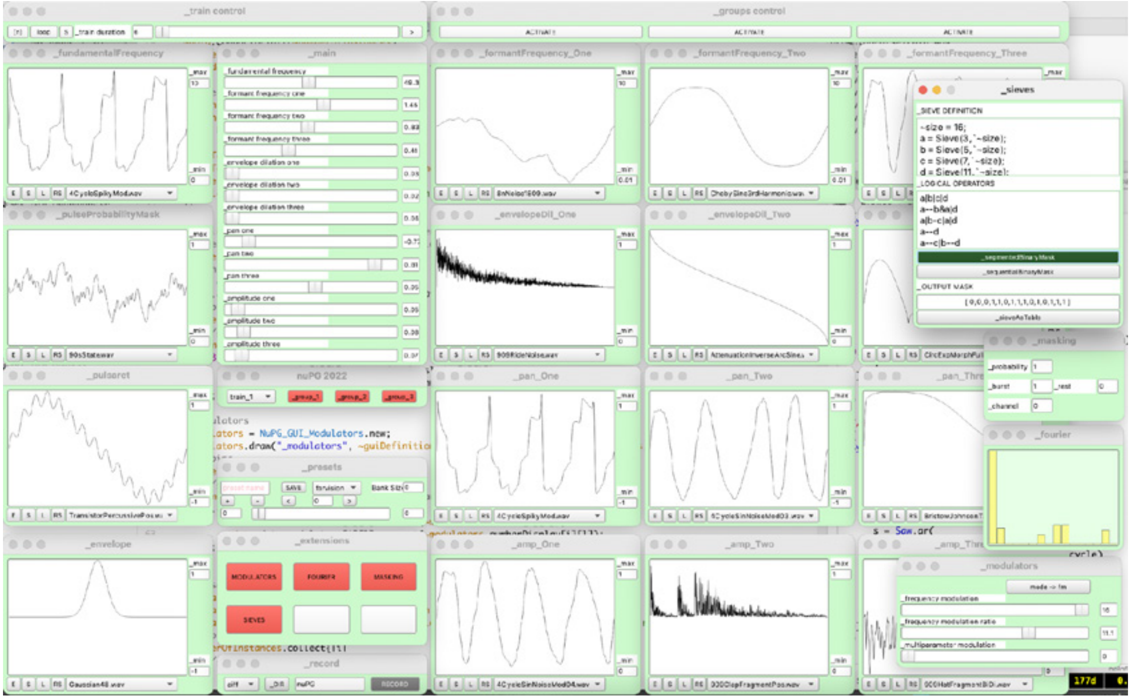

Fig. 1. The New Pulsar Generator (nuPG) program designed in SuperCollider 3 programming language. The program incorporates graphical modes of interface as well as text-based (live coding) extension allowing experimentation with algorithmic processes and flexible mapping between data and synthesis.

The astrophysical pulsars are phenomenal objects: rapidly rotating neutron stars that send out beams of radio waves which, like lighthouse beams, sweep around the sky as the star rotates. They are amazingly precise timing devices that can be used as clocks for testing relativity theory and may be used for timekeeping and navigation. With a diameter of only about 15 kilometres and a density comparable to that of the nucleus of an atom, they also provide a laboratory for some extreme physics. Pulsars appear to 'pulse' since the beam of light they emit can only be seen when it faces the Earth. The discovery of pulsars by Jocelyn Bell Burnell is considered to be one of the greatest astronomical discoveries of the twentieth century.

In the staging of the work, the listener is invited to explore spatially distributed formations of sound clusters, discrete pulses, tones and textures sonifying processes of attractions and repulsions. The word 'speculative' in the title signifies a double position. First, the combination of the data (pulsar rotation profiles) with the attraction-repulsion model is conjectural rather than relational in regard to observed and measured phenomena. Second, by sonifying "impossible" objects and their behaviour the work mobilised the ways intuition and bodily (spatial) experience take an integral part in formation of our worldly *episteme*. Knowledge does not restrict its corpus to the sum total of perfectly certain propositions but includes conjectures, articulations of possibilities and experimental settings.

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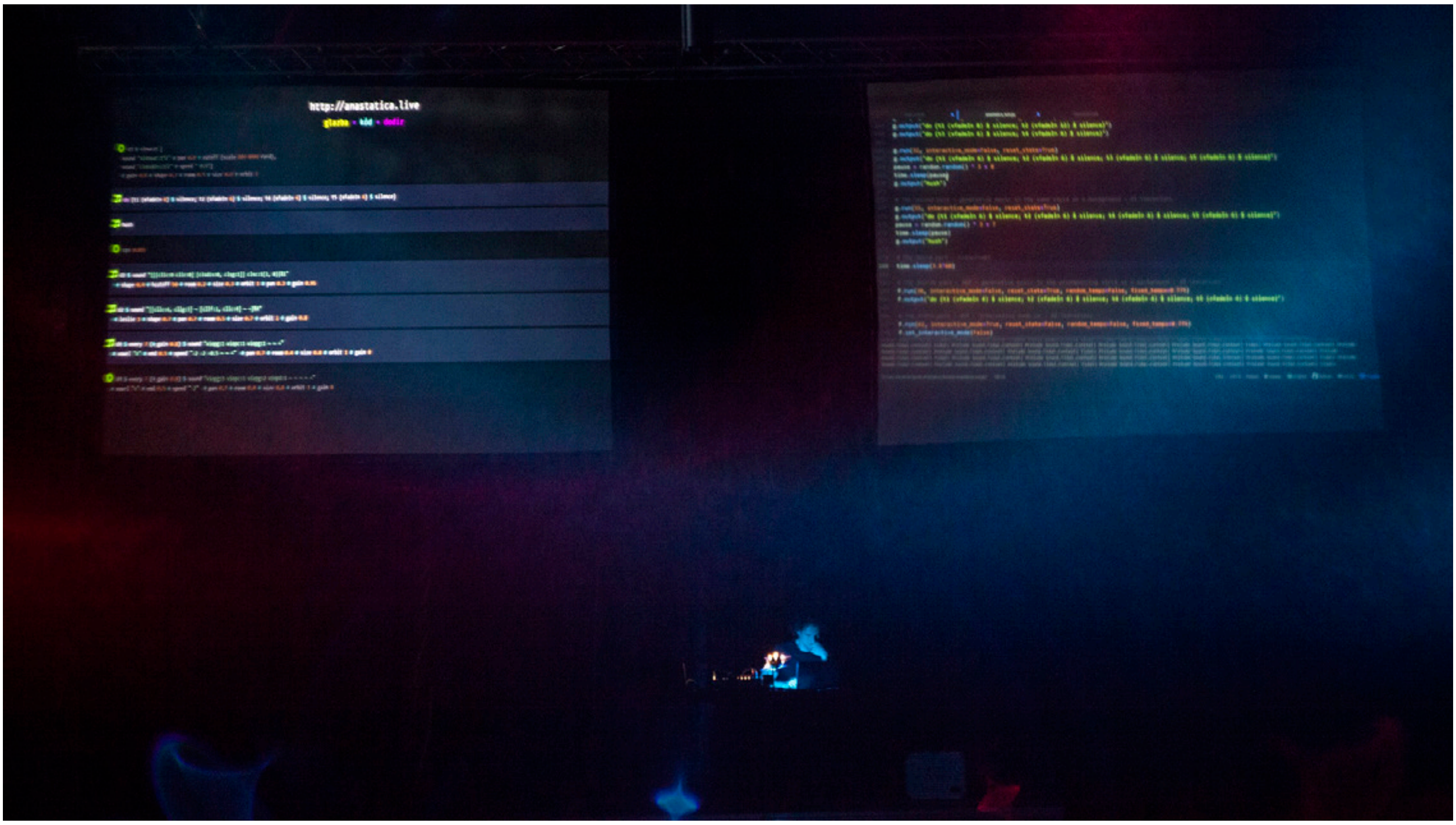

Anastatica: a Musical Experience for Algorithm, Live Coder, and Audience

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Anastatica is a musical experience for musician, algorithm, and audience that combines performative elements with the characteristics of an installation. It explores, in real time, the relationship between human performers and generative algorithms, allowing them to interact constructively or destructively using the same language and influenced by non-deterministic factors. Each performance is thus laced with randomness. Through this interplay of acousmatic, aleatoric live coding, the piece questions the nature of artificial intelligence's involvement in modern society and the illusion of choice in the digital age.

Keywords live coding, artificial intelligence, algorithm, participation, installation, performance

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Description

There exists an intriguing tendency towards absolute automatization in the post-digital world. In its most extreme form, this phenomenon can birth dualism between humanity on one side and algorithmic, autonomous, and generative processes on the other. The effects of this ontological dichotomy are often subtle. Individuals are presented with rigid, fully formed choices, which provide nothing but illusions of action in limited domains. Most often, direct confrontations with real decisions are avoided through a person's submission to their own tools. But in those cases when the confrontation does happen, it entices various anthropotechnic manifestations, from augmenting cooperation to degrading disharmony. These philosophical and technical ideas behind *Anastatica* are explored in (Pošćić and Kreković 2020), while technical details and insights into the generative algorithm are described in (Kreković and Pošćić, 2021).

The Performance

Anastatica is a musical experience which combines performative elements with characteristics of an installation. It is a real-time experience that draws from the relationship between humans and a generative algorithm. The algorithm generates lines of code that manipulate audio samples and create music. This seemingly endless generative process, which might start even before the audience is introduced to it, is joined by a human performer that improvises and alternately builds upon and destroys the generated music. Using live coding and other computer music techniques, the musician creates an accompaniment for the algorithm, switching his influence back-and-forth from a background to a foreground presence. They improvise and intervene in the algorithmic results, adapting to the ever-changing flux of machinic acousmatics and exploring various modalities in the relationship between harmony and disharmony. Meanwhile, the interactions between musician and algorithm are projected on a screen, as is common for live coding performances (shown in Figure 1).

At certain, partly random points, the performance opens itself for input from the audience via a web-enabled interface. Then, *Anastatica* becomes an interactive installation that extends the original duopoly into democracy and anarchy. The audience is given a chance to manipulate the computer-generated code, with the choice between augmentation and erosion left completely to each individual. The musician's role gradually fades, returning the performance to its original state of infinite algorithmic possibility.

Apart from the innermost source code makeup of the algorithm, the aesthetics of the performance are largely determined by the samples employed in the preparation process: audio recordings of a violin and electro-mechanic piano. By choosing these analog, organic and imperfect instruments, we clash the rigidity and predictability of the algorithm with the flawed nature of the instruments, creating textures, harmonies, and rhythms. The end result is a novel musical experience, for passive and active audience members alike.

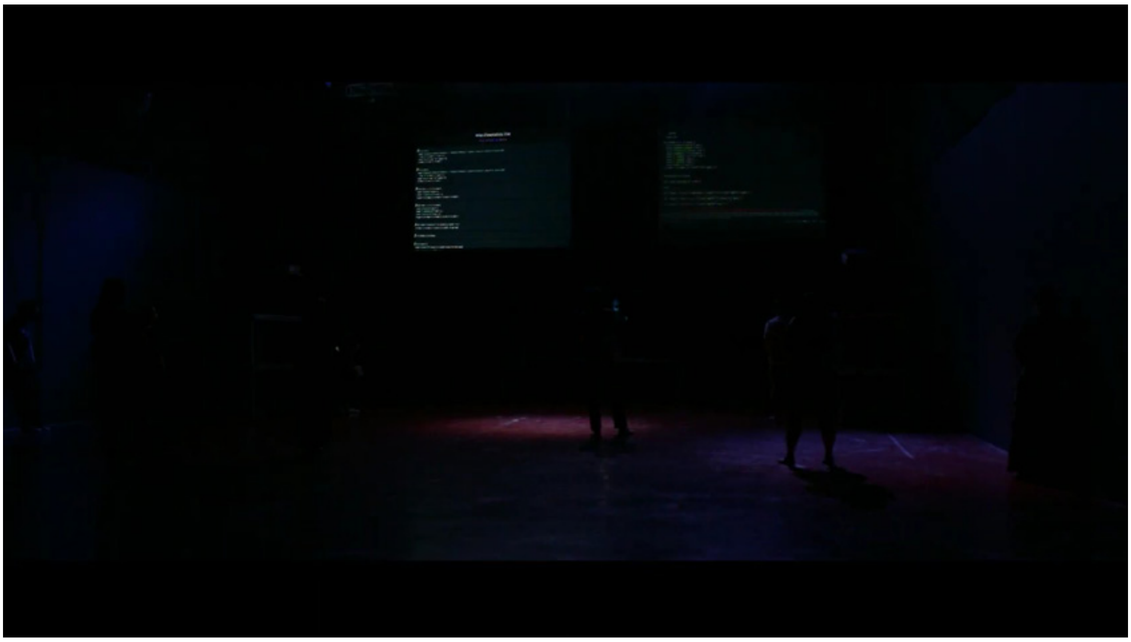


Fig. 1. An excerpt from the premier performance. Autonomously generated blocks of code are projected on a screen, while a human musician uses a separate instance of the same live coding environment. The audience changes selected parameters of the generated code using a web interface. (https://youtu.be/2FsLpivJ8Fw).

Participation

The audience's participation is a crucial part of *Anastatica*. By observing combinations of electronic club music and academic tendencies, two metaphysically contrasting approaches can be identified in how humans interact with machines in the domain of music. Experimentation with various computer-human communication channels is the first of them. By employing techniques dictated by innovative interfaces, performers and their bodies are made to move and inhabit states which are unnatural and free of learned behaviors. This, in turn, encourages innovative modes of improvisation in live coding (Kreković and Pošćić 2019). Examples of such interfaces are the self-resonating feedback cello (Eldridge and Kiefer 2016) and various textile-based systems (McLean et al. 2017). The second trend in human-computer interactions is the employment of artificial intelligence to try and expand the spectrum of human capabilities on a cognitive-compositional level, where we find examples such as Holly Herndon's Spawn and resulting PROTO project (Sturm et al. 2019).

In its condensed form, *Anastatica* presents audience members with elements from both these approaches and gives them a chance to influence the performance directly. Each member of the audience can decide in which way to impact the performance, acting against or along with the algorithm and its non-deterministic variant of a pianola in the distilled role of Luigi Russolo's intonarumori. They do so using smartphones, via a two-way web interface piped directly into the performance core. Depending on atmosphere and mood, the audience can derail the flow and act subversively against the musician and the algorithm, while participating in the creation of an interactive, extemporaneous installation. The outcome of the performance is indeterminate and context-dependent. It will vary depending on whether the collective mind veers towards dissolution or synthesis.

Structure

A laptop computer is set on stage and generates music even before either the musician or the audiences enter the venue, giving them a sense of witnessing an installation with no beginning or end. Once the audience is seated, the musician appears and starts playing with and against the machine, influencing the algorithm itself by means of the laptop as a live coding interface. At specific times and intervals, the audience intervenes via modifications of generated code through a web interface. Ultimately, the musician leaves the stage, while the audience is left alone with the algorithmic ghost in the machine. Everything is in their control or perhaps nothing is. It's a short but endless segment. Curtain falls.

Syntactic, Semantic, and Technical Considerations

The main idea behind *Anastatica* is to join humans and algorithms on a level playing field. This means that both organic and inorganic participants in the performance use and communicate through computer code that generates music. Under these premises, the choice of TidalCycles (McLean 2014) becomes an obvious one, due to its real time characteristics and compact syntax. Thanks to its architecture and orientation towards live performances, TidalCycles enables a human to express musical intentions in clear and traceable ways, while also being a language that's easily understandable to computers.

By "writing" TidalCycles code, the computer is no longer just an object. Instead, it becomes a subject that creates music, working on the same semiotic level as human participants. Here, computer code is in a natural position of shared medium between human and machine, but the specificity of *Anastatica* is the closeness of the participants' roles. The aspect of translating code into music – usually the main functionality of computers in music – becomes a corollary. It's the generative part that is key here, set in shapeshifting dynamics of antagonistic or complementary interactions.

Since it is expected that most audience members will not be familiar with TidalCycles, the web interface that exposes the inner workings of the generated code is simple and straightforward. It enables the modification of certain parameters or portions of the generated code and gives the algorithm the possibility to intervene in the audience's changes. Each modification is coupled with an observable change in the music, dispelling audience suspicions that their actions might not have any real repercussions at all. Additionally, through the web interface, the audience can see which piece of code has been executed on a channel, modify it, change the sound of that channel, and implicitly influence where the algorithm takes them next.

Finally, while the performance does not question the basic extra-musical dimensions of live coding, it provides a peek into its inner workings, challenging the basic improvisational techniques contained in them.

Premiere Performance

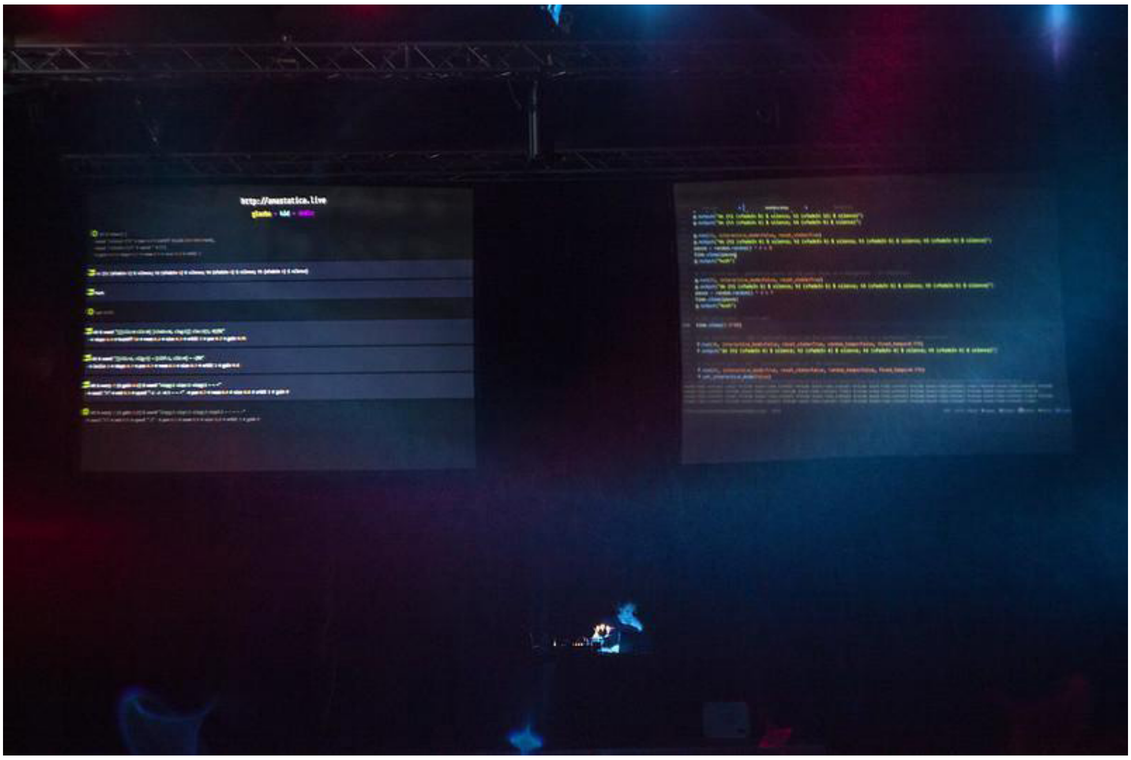
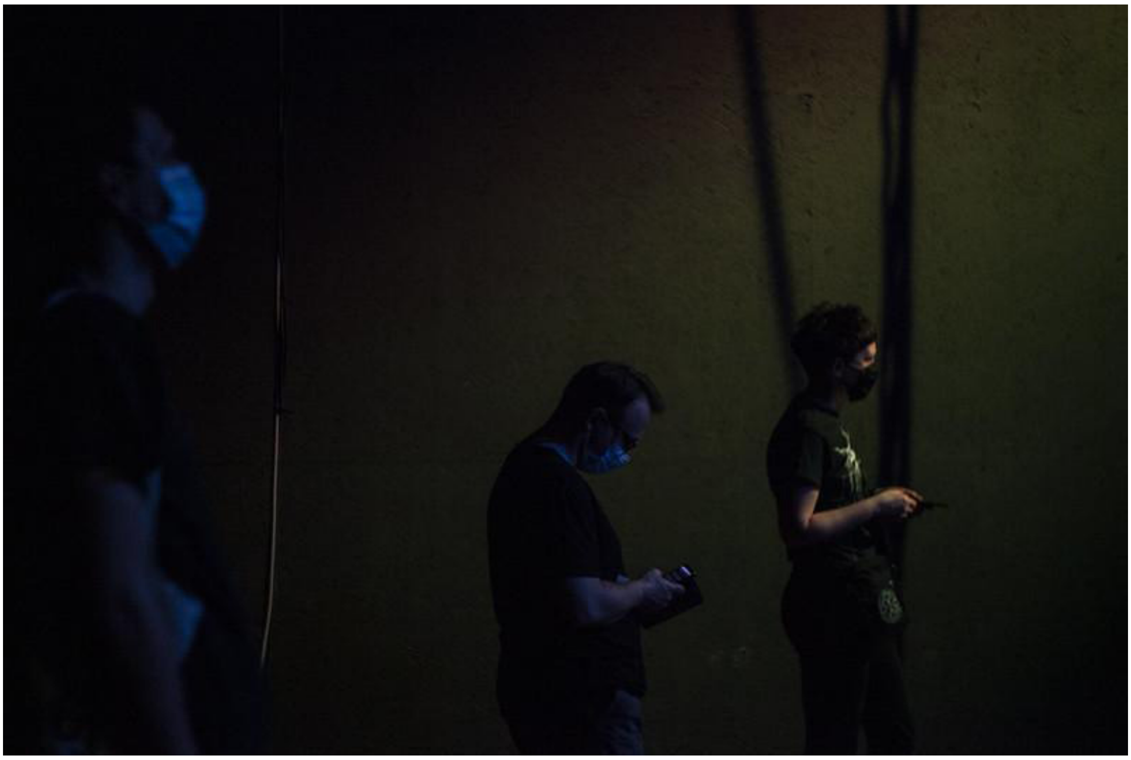


Fig. 2. Photo showing the musician/live coder's screen and the web interface intended for audience interaction during the premiere performance of *Anastatica*.

Anastatica was premiered on July 4, 2020 at the Pogon Jedinstvo venue in Zagreb. Happening in the middle of the first wave of the Covid-19 pandemic, besides demonstrating the expected emerging interactions between performer, audience, and live coder (Grubor 2020), the performance also allowed for an interesting dynamic of distanced, mediated interactions during a time in which touches and physical contact became taboo. Additional photographs and videos can be found in the apposite appendix.

Fig. 3. Still from the performance video (https://youtu.be/2FsLpivJ8Fw) showing audience interactions.



Since each performance is inherently different due to non-deterministic elements and partly dependent on the personal and professional backgrounds of the audience, it's likely that the xCoAx's specific setting will lead to interesting and unexpected results in the outcomes of *Anastatica*. Frequented by a cross-section of artists, media theorists, philosophers, and engineers familiar with the field, the interactions and resulting flow will likely differ significantly when contrasted with previous performances in front of more general audiences.

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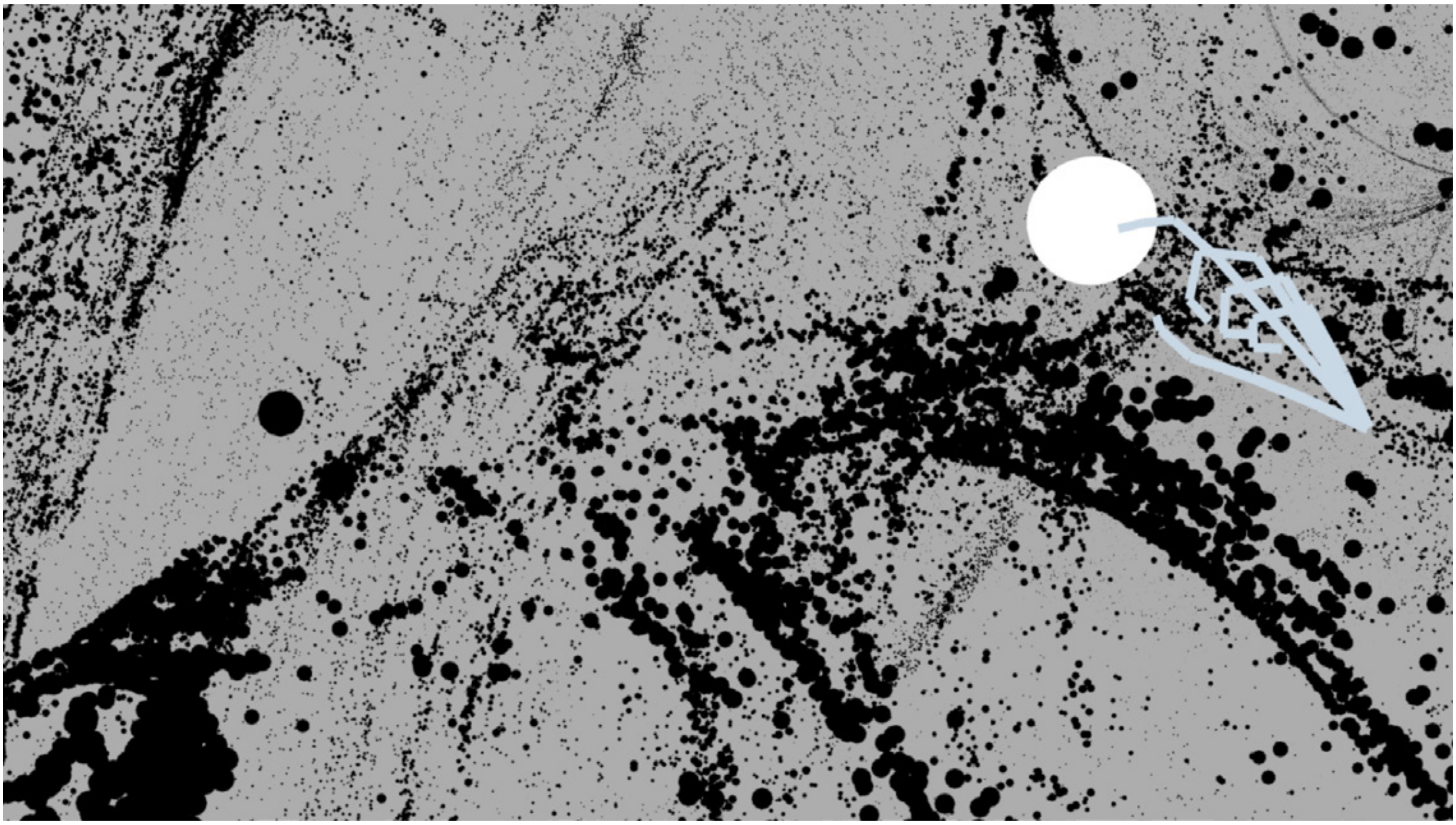

SIIIGNAL: An Electroacoustic Composition/Instrument in Virtual Reality

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SIIIGNAL is an electroacoustic composition/instrument in Virtual Reality (VR). The piece explores modes of interaction afforded by the VR environment; in combination with hand-tracking, gestural analysis and the physics engine of Unity3D, it provides a framework for musical expression using the VR medium. The player can instantiate sound particles in the space, perform sample triggering through collision detection, arrange sound objects in space, populate the environment with processing modules, spawn pulses that emanate spherically from the central sound object throughout the space triggering further sonic events, among others. The piece is divided into multiple sections with changing parameters over time and different rules. It starts requiring simple sonic gestures by the player, and as it progresses, emergent behaviours lead to more sonic complexity and possibilities for musical expression.

Keywords VR, Virtual Reality, Musical Game, Musical Expression, Immersive Audio

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Description

SIIIGNAL is an electroacoustic composition/instrument in Virtual Reality (VR). The piece takes advantage of the modes of interaction afforded by the VR space; in combination with gestural analysis and the physics engine of Unity[1], it attempts to shape affordances for musical expression true to the medium of VR. The aim of the composition/instrument is not to use modalities from common on screen-based instruments, such as step sequencers and synthesizers and recreate them in VR, but to give the freedom to the player to explore their own performance space and timings, informed by the piece's compositional vocabulary. The audio engine is designed and implemented in Pure Data[2], while the Enzien Audio Heavy compiler[3] was used to create native synthesis, audio playback and processing components for Unity.

The instrument consists of a library of samples arranged in VR space, with the player being able to interact with them in a number of ways:

The player can instantiate sound particles in the space, perform sample triggering through collision detection, arrange sound objects in space, populate the environment with processing modules, spawn pulses that emanate spherically from the central sound object throughout the space, triggering other actions. The piece is divided into multiple sections with changing parameters overtime and different rules.

1. https://unity.com/ (Accessed January 2022).

2. https://puredata.info/ (Accessed January 2022).

3. https://github.com/enzienaudio (Accessed January 2022).

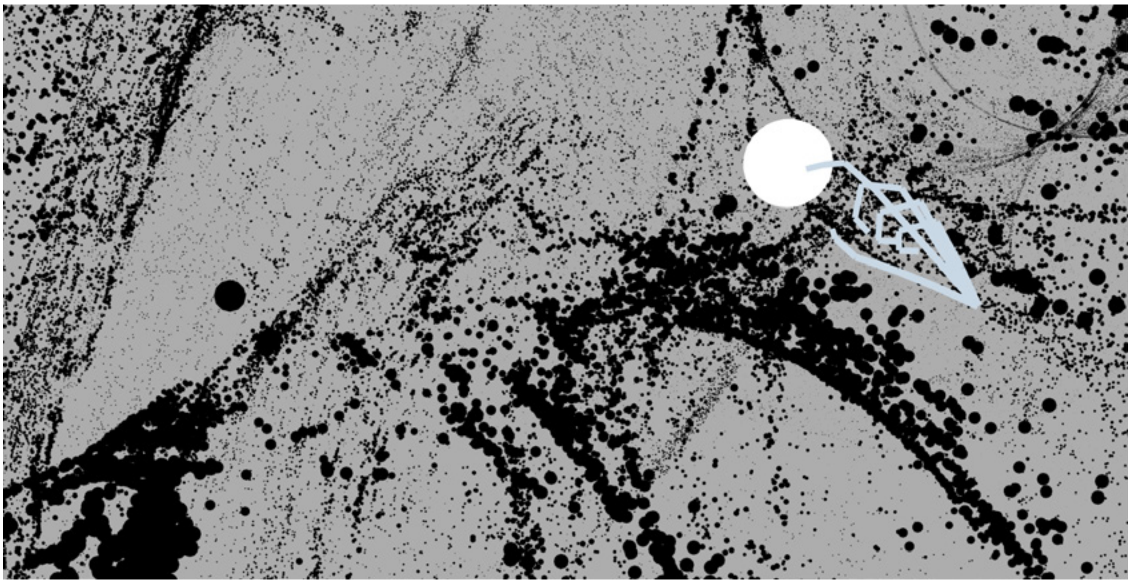

Fig. 1. *SIIIGNAL* Ingame still.

The player starts by performing simple sonic gestures, and as the piece progresses emergent behaviours can lead to more sonic complexity and possibilities for musical expression. The compositional aspect of the piece comes through evolving affordances: The piece's parameters and mechanics change over time, giving a sense of progression and continuity throughout its duration. The piece is divided into multiple segments, some of which progress linearly based on time elapsed, while others require the user to perform certain actions, such as gestures, or interact with certain objects in a sequence. The sections are either blending into each other through parameter interpolation, slowly changing the attributes of the environments, or abruptly changing the environment after a section reaches a climax.

SIIIGNAL makes use of the physics engine of Unity3D. Depending on the section of the piece, for example, the attraction between individual sound particles changes. There are a few other objects in the scene where sound particles can collide. These emergent sonic behaviours lend themselves to increasing complexity, with the user interacting with the ongoing process on a higher level. In addition, each sound particle's audio is spatialised within the VR space making it possible for the user to experience the piece from different positions and move around the space in order to spawn and initialise interactions at different areas of the space, move away, which would make their sonic impact less audible on the overall soundscape according to the distance, and then return to further alter the sonic configurations if desired.

The hand-tracking functionality of the Oculus Quest is used for gestural analysis, which allows the user to intuitively instantiate and push objects in the VR space without the need to impose an extra layer of control through a physical interface such as a game controller. In order to gradually ease the player into the experience, the piece starts with very simple gesture requirements and sonic vocabulary, and as it progresses and the user becomes familiarised with the instrument's affordances, most of the required vocabulary is embodied and intuitively used. During non-timed sections, where the piece progression relies on the user completing certain goals, such as making specific objects collide, or touching objects for certain amounts of time, the user is free to explore all sonic possibilities that the space has to offer and spend as much time as they like. Some of the parameters used for audio control data include the specific fingers used and which fingers are touching each other performing different actions, as well as collision detection, L/R hand speed and acceleration and headset speed and acceleration. As an example, during a certain section, the headset's speed is mapped to the playback speed of samples, which leads to silence when the user is not moving their head. The game-time "freezes" and thus it is required from the user to move in order to progress the piece.

Fig. 2. *SIIIGNAL* Ingame still.

The samples include mostly segmented acoustic and minimal synthetic percussion sounds, with the processing areas including effects such as reverb, delay and filtering. In addition, granular, additive and subtractive synthesis techniques are used, with these being more closely mapped to real-time parameter control through gesture analysis. The physics-driven motion of objects and particles in VR space is directly mapped on sounds, giving to the user direct control over all aspects of the piece and all the different possibilities that it affords. As small changes between particles can cause larger changes on the soundscape overtime, the piece can take different directions on each playthrough depending on the intentions of the player, while maintaining the distinct attributes of each piece's section. In the same way that an improviser can perform a particular type of sonority on their instrument, while never being exactly the same, this piece allows the player to be expressive within the limits of the musical vocabulary of each section.

The piece follows a series of game-structured musical performance pieces such as *Pathfinder* (Michalakos 2016), *ICARUS* (Michalakos 2019) and *Death Ground* (Michalakos and Wærstad 2019). Some of the background and design process is documented on the composer's article *Designing Musical Games for Electroacoustic Improvisation* (Michalakos 2021).

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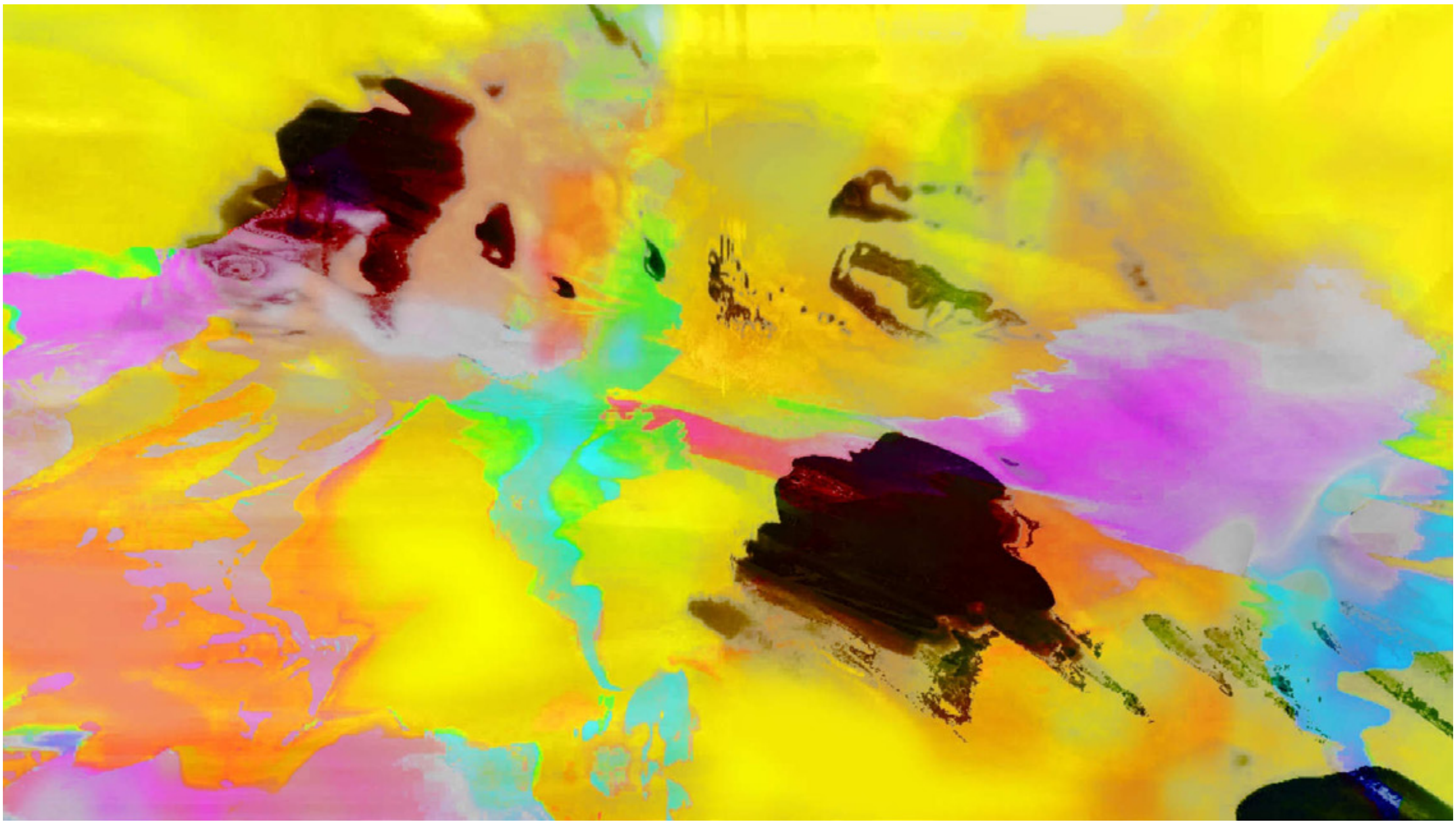

Datox

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Datox explores the imperceptible electromagnetic radiation generated by electronics and digital technologies as sonic material. The work is a music album and a live performance that creates an audiovisual environment that explores sonic possibilities through the amplification of imperceptible sounds. This aims to highlight a material layer that comes before data, the electricity that powers electronic devices. The music album and performance immerse the listener in a sonic environment of non-human agency, the electricity and its voltage differences at the circuitry level of computational devices. The work exposes the dependency of computational societies on energy production from non-renewable sources such as coal that contribute to environmental pollution and the climate crisis.

Keywords Experimental Music, Sound Art, Audiovisual Performance, Noise, Improvisation, Materialism, Post-digital Aesthetics, Environment

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The Computational Society

In computational societies, digital media technologies are part of our environment and intertwine with daily life. This is discussed in the scholarly domain as the post-digital condition, the state after the digital revolution where digital technologies permeate all aspects of everyday life (Cramer 2014; Berry 2014; Berry and Dieter 2015). Within the post-digital condition, digital technologies have become spatial and embedded in physical spaces, are mobile, smart, wearable and even incorporated into the human body. New relationships have emerged beyond the interface level of computers and the screen surface. Consequently, digital technologies are no longer new media and have become familiar technical objects and devices embedded into our daily routines.

However, the infrastructures of digital devices are, in part, invisible and imperceptible due to their immediacy and built-in blackboxing which obscure their inner mechanisms, such as algorithms or electronic circuits. These seem to become only perceptible in computational errors and failures such as stock market crashes, drone malfunctions, autonomous vehicle accidents, video streaming glitches, software bugs, social media server failures and data corruption, to name a few.

As a result of living in this condition, the work *Datox* (2022) intends to remove the utility and instrumentality embedded in digital technologies, as functional appliances of everyday life, to foreground a complex layer prior to data, to bring closer to the listener a hidden world of non-human agency, the electricity within digital devices.

The Materiality of Digital Technologies

The materiality of digital technologies is beyond the appearance of errors on the screen surface, and is not reducible to its code, software, or hardware; it is rather "a massively distributed reality that in turn conditions our perceptual realities" (Bishop et al. 2016, 13). The constellation of digital media materiality has to include energy production, distribution and consumption as these are fundamental to the networked society where "data feeds of the environment both through geology and the energy-demand" (Parikka 2015, 24). This is explored in the work *Datox* to unveil electricity, a material layer before data, which is part of the planetary distributed materiality of digital technologies.

Datox: Electricity and Non-human Agency

Datox (2022) is a music album and live performance that immerses the listener in a sonic environment of voltage differences at the circuitry level of computational devices. The work remixes the sound of electrons moving through electronics by amplifying their electromagnetic fields (EMFs) as an artistic attempt to expose the materiality of digital technologies and their dependency on electricity that originates mainly from fossil fuels such as coal. As the scholar Jussi Parikka points out, coal is not only "one of the most significant energy sources, powering cloud computing data centers, but also an essential part of computer production itself" (Parikka 2015, 99). Thus, the networked society is highly dependent on non-renewable energy sources essential to the manufacture, distribution, powering and maintenance of digital technologies.

Performance

The live performance (Fig. 1) starts improvising with the raw sounds captured by coils. The hands of the performer hold a coil in each hand and search for EMFs over electronic devices. The coil acts as a sensor that captures and amplifies the imperceptible noise generated by digital technologies. After exploring the raw sounds, the noise builds up and is further combined with the manipulation of pre-recorded samples and improvisation with the live sound input. The sound manipulation is done through custom-made software built on SuperCollider.[1]

The music is punctuated with abstract visuals of video feedback to visualise electricity through a burst of colours and glitches. This aims to highlight electricity as digital materiality and its manifestation on the screen surface as pixels, the screen unit. It uses the live coding software aNa – analog Not analog developed by the artist Thomas Jourdan.[2]

The music improvisation and manipulation mixes both live input and samples until it reaches a point of overwhelming complexity where several noises are smashed together. Afterwards, a brief sequence of flashing images of coal mining and energy production is combined with the abstract visuals. The screen is extended with lights in the physical space through LED light strips that are reactive. The performance ends by returning briefly to the initial hand gestures that capture the raw sounds.

1. The *Datox* custom-made software was created on SuperCollider with the help of the artists and professors Hannes Hoelzl and Alberto de Campo. It can be downloaded here: https://pedroferreira.net/datox/code/

2. The visuals use layers of video samples that react to the sound through FFT. The open-source software aNa – analog Not analog is a live coding system for visuals developed by the artist Thomas Jourdan: https://gitlab.com/metagrowing/ana

Album and Archive of Electronics' Noise

The album[3] was self-released in 2022 under the artist name Pedra Ferro. It was produced using the background noises generated by electronics, sampled using a coil, and manipulated live using the custom-made software. It was further arranged and composed using mainly the software Ardour for digital audio workstation (DAW). The process for the album production followed the instructions provided in the list below. With these instructions, anyone can easily replicate the artistic process and come up with completely different results.

The sample library[4] is made available online and archives the noise generated by consumer electronic devices including power banks, smartphones,

3. The album was self-released as a vinyl record and cassette tape as a form of impure aesthetics that materialise digital technologies. This hybridisation is done as a counter-model of music consumption and distribution. The album is made available online here: https://pedraferro.bandcamp.com/album/datox

4. The sample library can be downloaded here: https://archive.org/details/datox_archive

laptops, hard drives, scanners, computer fans, Wi-Fi modems as well as AC adapters, a wireless mouse, a video game console, a CD and media player, TVs and a laundry machine.

Datox DIY Recipe

1. Use a coil soldered to a mono audio cable as a sensor to capture the EMFs. Connect it to an audio interface or sound recorder. Find and listen to hidden sounds generated by electronics and digital devices around you. Record the sounds and collect different samples.
2. Improvise, remix and manipulate further the live sound input and samples. Explore the live input, the sound samples, and manipulate it live using the provided SuperCollider code. Don't forget to record the live improvisation.
3. Arrange the improvisation recordings according to the judgment of taste. For example, edit the recording using DAW, such as Ardour or Audacity, and explore simple techniques such as cut and paste, repetition, pitch stretch, automation, and basic filters, amp, EQ, pitch shift, reverb, delay and compressor.
4. Repeat the process and have fun.

Datox or Data Overload Recovery

The aesthetics of the work *Datox* follows the experimental music tradition described by the scholar and artist Kim Cascone as a "post-digital aesthetics" which results from "the immersive experience of working in environments suffused with digital technology" (Cascone 2000, 12). However, the main focus of *Datox* is not exclusively to highlight the background of media or defy normal functions through glitches and errors. Rather, it amplifies the imperceptible and hidden world of non-human agency as actors within computational devices unveiled through gestures and movements of the performer's hands. This attempts to provide a direct expression of the noise of electronics to expose electricity as a fundamental facet that maintains the networked world.

The computational society is dependent on electricity produced mainly from non-renewable energy sources such as coal. Parikka describes this simply as new media being powered by archaic media—coal (Parikka 2015, 123). Within this context, the work *Datox* can be experienced as a sonic manifestation of electricity, as part of the planetary distributed materiality of digital technologies and its environmental consequences that result from the complex relationship between society, technology, and the environment.

Fig. 1. Live at Arkaoda (2020), Berlin, Germany.

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Doctoral Symposium

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Algorithms' Influence on Human Artistic Creativity

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In this doctoral research programme, I propose a set of three thematic research projects to investigate the influence of algorithmic curation on artists' creative processes and viewers' subsequent creative perception. In the context of the burgeoning "creator economy," I first review evidence of algorithmic impact on creator's outputs. Considering the role of process in creative output evaluation, I bring an embodied, situated perspective to online creativity. Based on these discussions, I propose three research streams: first, I tease apart the consid-eration of process from the consideration of embodiment, asking how each (process & embodiment) influence creative perception in the context of algo-rithm-made versus human-made art. In this workstream, I also consider the im-pact of the art viewer's embodiment (physical versus digital). Next, I construct an algorithmically-curated website of visual images which controls information about the artist, their process, and their output, using the website as an experi-mental sandbox to interrogate the role of these variables in online creative per-ception. Finally, I supplement these findings through ethnography with artists and curators, examining the role of algorithmic considerations in their process. Simultaneously, I prompt artists to imagine the possibility of a co-designed algo-rithm that prioritizes creativity over existing metrics for engagement.

Keywords creativity, curation, algorithms, embodiment, creative process, gatekeeping

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1. Introduction & Research Purpose

In the face of increasing technical automation, many see creativity as a final bastion of humanity (Moruzzi, 2020), claiming that computers cannot supplant artists (Hertzmann, 2018). Technology companies, however, see creativity as a profitable opportunity: 2020 heralded the "creator economy," an explosion of technologies for creators. In this burgeoning economy, algorithms prioritize creative content, inspire creative ideas, platform creators, and determine creative value. Though algorithms have been imbued with these responsibilities, algorithmic technologies are ill-suited to creative use-cases: algorithms operate by pattern-matching, while creativity prizes novelty.

As algorithmic platforms curate creative content, they are given agency over cultural trends. Duchamp made a urinal into an artwork simply by displaying it. Similarly, when algorithms exhibit creative content online, they deem certain pieces valid and valuable. As digital-era Duchamps, algorithms shape what readymade content is put on our cultural pedestal.

This doctoral research programme investigates how algorithms impact humans' perception of creativity. In particular, I ask how artists change their creative processes to suit algorithmic gatekeeping. Early findings indicate that creators pander to algorithms, producing pieces that they believe algorithms will prioritize. In this way, creative professionals' perception of algorithmic tastes influences the creative work that is produced, thereby shifting humanistic culture.

2. Background and Related Work

The creator economy has heralded the use of digital platforms for viewing artistic content. This allows creative professionals to interface with their viewers, allowing direct audience interaction in artistic curation processes. Ideally, the process of digital curation democratizes the value of creative work, minimizing judgments from elite institutions (e.g., museums and auction houses) that previously wielded gatekeeping power. However, in previous research (Herman, under review), creators revealed that they now shift their creations according to how they perceive the tastes of platform's algorithms, similar to previous artists seeking to appease collectors or curators. In pandering to the algorithm, artists figure it a central character in their creative output. In contrast with respected curators of previous generations, however, the hosting platform's ranking algorithm is perceived as deprioritizing content that is truly creative.

As algorithms continue to maintain curatorial roles online, more creative professionals will begin to produce pieces that are either a) explicitly designed according to algorithmic priorities or b) influenced by algorithmically-curated content that inspires designers and artists. This will produce a feedback loop by which AI influences what is created and curates creations accordingly, influencing cultural tastes.

In previous research (Herman & Hwang, 2022), I found that creative professionals (but not laypeople) fixated on evidence of artistic process when making creative judgments in algorithmic environments. This runs counter to previous creativity research, which discounts the role of process information in creative judgments. The creative professionals' focus on process may be explained by theories of embodied cognition (Chiel & Beer, 1997; Gallese & Lakoff, 2005; Wilson, 2002), in which one's perception is grounded in mimesis (Gebauer & Wulf, 1995; Zlatev, 2008). Creative professionals evoke a practice-based and experiential model of cognition when perceiving an artwork. If creative professionals perceive an embodied process that is particularly novel, they find it more creative. This highlights the role of embodiment in creative perception, which has not been robustly addressed in the literature—particularly in relation to AI—even though the perceived embodiment of the artist is deemed a key aspect of observers' response to artwork (Freedberg & Gallese, 2007). In this programme, I plan to address the impact of practice-based embodiment on creative perception in algorithmic environments.

Research question(s):

1. How do algorithms relate to creative processes?
   a. What role does process play within the digital audience's conception of creativity?
   b. How does the perception of a (human or algorithmic) artist's embodied process influence the viewer's evaluation of creativity?
   c. How do creative professionals shift their creative processes and outputs to suit algorithmic gatekeeping?
2. How might technologists construct an algorithm that prioritizes creativity over engagement?

3. Expected Contributions

My PhD will result in an integrated thesis, spanning three key topics in a unified dissertation. Therefore, my project plan/timeline consists of one thematic project for each of three years.

3.1 Project Plan & Timetable

Year 1: Human & Algorithmic Creative Embodiment *[Underway]*

To examine the role of embodied process in the perception of AI-generated art, I am taking an experimental approach, teasing apart the importance of embodiment from the importance of process by controlling the process-related information provided to study participants. 120 participants are assigned to one of four conditions, in which they are shown either: (AI-1) an AI-generated piece, (AI-2) the same AI-generated piece + a video of the algorithm being created and operationalized by the artist to produce that art piece, (NAI-1) a digital illustration, (NAI-2) the same digital illustration alongside a time-lapsed video of that illustration being physically created by the illustrator. Leveraging these initial results, I am collaborating with the Serpentine Galleries, where several AI art pieces are displayed. With the curators, I am arranging two conditions: the first being the "physical" condition, representing embodied AI art viewing, the second being the "virtual" condition, representing digital AI art viewing. In each condition, participants will see the same AI-generated art piece, selected and curated by the Serpentine curation team. I will observe, interview, and survey the viewers in each condition.

Year 2: Process in Creative Judgments

I will create an algorithmically-driven study website that mimics image search platforms but controls information regarding the creator, process, and outcome of each creative piece. Each piece will be presented to participants with or without the artist's name, process description, or final output. In addition to completing a 1:1 interview, participants will also complete a series of creative evaluation tasks online, and they will log their responses through surveys and open-ended questionnaires. I will analyse the data by applying correlational statistics, sequential behavioural analytics, and hierarchical qualitative coding techniques. By carefully varying which information is provided, I will glean insight into which variables influence creative judgments, thereby investigating the role of creative process in creative judgments within algorithmic environments.

Year 3: How Algorithms Shift Creative Processes

In my final year, I will conduct research that will necessarily build on the results of the previous studies', filling in any gaps in a cohesive understanding of algorithmic impact on creative processes. Therefore, the approach may change to ensure cumulativeness. That said, I plan to conduct ethnography with artists that display their work in algorithmic contexts, examining how their processes and outputs pander to algorithmic prioritization. I also plan to moderate interviews and focus groups with curators to test hypotheses about how algorithmic experiences influence the pieces to which they ascribe creative value.

3.2 Outcomes, Deliverables, and Impact

For each of the three thematic areas, I plan to present initial results at relevant academic conferences and to publish final results in peer-reviewed papers. This research will also impact two external sectors. First, this research will inform technology companies developing creative tools, including Adobe, Google Arts &

Culture, and Behance, where employees have committed to following this project's recommendations. Second, this research will inform cultural institutions grappling with the digital expectations of pandemic-weary visitors seeking digital collections, engaging social media strategies, and compelling online curation. For example, the Serpentine Galleries' Research & Development Platform, which is focussing on "Creative AI," has indicated that they would welcome my guidance for producing embodied experiences with AI-driven art and curation.

Finally, concurrent to this work across years 1-3, I will foster an artistic collaboration to co-create an art piece that expands on my research results, leveraging a "research by design" (Zimmerman, Forlizzi, & Evenson, 2007) approach. Selected artists and I will co-create an algorithm that optimizes for creativity rather than engagement, resulting in a software-based art piece that interrogates algorithms' current prioritization structure. By including artists in this process, I will ensure that I prioritize their intents and needs in building an alternative to common profit-driven models. By shifting algorithmic design into the hands of artists, I aspire to overturn the current model of curating creative content online, which prioritizes profitable user engagement over true human creativity. Several arts institutions, such as Art Hub Copenhagen and Arts at the Old Fire Station, have already committed their interest in facilitating artistic workshops and exhibiting the final outputs.

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Generative Dance as a Self-Organizing Dynamic System: A Study on Choreographic Emergence and the Phenomenon of Togetherness

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In this transformative exploratory study, we propose to contribute to the definition of the concept of Generative Dance based on the theory of self-organized dynamic systems, in order to: 1) Describe the concepts of Emergent Choreography and Generative Dance (by approximation to the Generative Art concept); 2) Computationally model generative dance and study the emergence of spatio-temporal patterns - using Agent-based model theory and genetic algorithms; 3) Explore collective improvisation, following the cycle Practice-led Research and Research-led Practice (Smith and Dean 2009), integrating the relationship principles observed in the emergent modeling behavior; 4) Know the subjective experience of space-time sharing - togetherness phenomenon - experienced in generative dance.

Keywords Generative Art, Self-organized system, Collective composition, Collective improvisation, Collective dance, Togetherness

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1. Introduction

Nowadays, it is essential to reflect how we corporeally relate to each other and how we can create a collective universe ("togetherness"). Observing the movement of fish, birds, flocks, traffic and human crowds, we can see that they exhibit complex and coordinated spatio-temporal patterns (Couzin and Krause 2003), which are explained by Self-Organization Theory. According to this, the global displacement of a group emerges, without the need for an external regulating agent, due to the numerous intra-element interactions of the system (Camazine et al. 2003). Currently, Self-Organization Theory is applied to slime mold aggregation processes, players behavior in team sports (Araújo, Correia and Davids 2012), study in motor control (Camerino, Castañer, and Anguera 2012), contact-improvisation (Torrents, Castañer and Anguera 2011) and collective improvisations (Leonard et al. 2012).

For Hagendoorn (2012), a choreography is constituted as a set of instructions for the organization and reconfiguration of one or several bodies in space-time, where the choreographer defines how the dancers move and what their spatial organization is. This function seems to be reduced to a set of rules that interrelate the dancers. When we want to produce generative choreographies, is it enough to play with these rules?

The concept of generative art, according to Galanter (2003), is associated with artistic practice in which the artistic result comes from the use, by the artist, of a set of rules that constitute a system. Transposing this concept to a generative dance, we can consider that the choreographer creates and defines the functioning of a system of dancers, where the choreographic result emerges from the set of inter-dancers relationships. Assuming a model of composition in contemporary dance based on the choreographers' privilege in the development of organizing principles - logic that engenders a choreographic organization that: superimposes the logic of chaining movements and steps ; and makes it possible to establish contingent relationships between the elements (Leste 2010) - the concept of generative dance and emergent choreography is based on the composition by "Organizing Principles". The Organizing Principles, "recursively co-constitute themselves in the multiple interrelations (...) from which will emerge movement patterns that had only their parameters pre-defined and not their final formatting" (Leste 2010, 33). In this way, the choreographer proposes simple rules of interaction, potentially generating emergent collective behaviors. But how is it felt, this emergent collective behavior between dancers? Considering the intra-dancer relationships, is there an amplification of the perception of the togetherness phenomenon?

Hart (2014), discovered that when improvisation happens co-confidently between performers, it achieves a smooth and symmetrical universal movement, but not periodic and simple. However, in dance, 'togetherness' is associated with the sense of the agency of the other (Himberg et al. 2018) and not exclusively only with synchrony, once we can move together without feeling together. Therefore, how will the phenomenon of togetherness be felt from the intra-dancer perspective, when the rules of relation are already pre-established as in generative dance?

2. Description of the Proposal Approach

Our transformative exploratory study combines implicit quantitative study procedures with an explicit qualitative approach to data interpretation. For the quantitative study, we have created a set of choreographic objects based on Agent - based - models for the plan, that simulate self-organized systems of dancers. For the qualitative study, by approximation to a case study, we use samples of convenience, where the participants will be selected by curriculum, motivation letter or audition. To achieve the project main goals, this project was divided in three stages:

Stage_I - Construction of Mathematical models of self-organized systems in the plane - by approximation to Forsythe's (2012) choreographic objects - defined as a model of potential transition from one state to another in any imaginable space - based on the theory of Agent-based models. The creation of these models allow us to study generative dance as a self-organized dynamic system and perceive: the collective spatial behavior of the virtual dancers; the emergent spatio-temporal patterns; the system's attractors and transients; the spatio-temporal variations for random initial conditions and the resilience to error. Using Wolfram Language - Mathematica, data is being collected through systematic direct observation by two experts and the chosen results compiled by recording images in JPEG and GIF format.

Stage_II - Creation of generative dances (Flasmob of 20-60 dancers and Collective Improvisation for a group of 10 dancers) based on the previous study of choreographic objects. With them, we intend to substantiate the concepts of generative dance and choreographic emergence and contrast results on stage with modeled results obtained. For this, Flasmobs will be recorded in video format with subsequent analysis by two expert observers, using an instrument based on criteria of time shift, interaction and spatial design in order to create an - exhaustive and mutually exclusive - system of categories (Torrents, Castañer and Anguera 2011). On the other side, collective improvisation for 10 dancers - inserted in the cycle of Practice-led Research and Research-led Practice (Smith and Dean 2009) - will include: 1) Direct observation by the researcher with daily field notes; 2) Individual Logbook for each participant, with regular recording of sensations, words, images and ideas; 3) Daily group discussions (30') at the end of each work session, to collectively share thoughts, concepts and ideas regarding the project and individual conclusions.

Stage_III - Parallel to stage_II, we seek to understand how generative dance influences the feeling of "togetheness" between dancer. For that, we will conduct In-Depth Interviews (Roller and Lavrakas 2015) and apply the Focus Group technique (Onwuegbuzie et al. 2009) in order to deepen the concepts of own space, shareable space and group feeling, based on the perception of relational dynamics, allowing a better understanding of the Togetherness phenomenon. The individual in-depth interviews will be applied during the residency (collective improvisation) and are based on the principles of the explicitness method (Vermersch 2010), to characterize the subjective experience of the dancer.

3. Expected Contributions

A system corresponds to a relationship between unified parts for which new qualities and properties emerge (Morin 2008), as exemplified by the spatio-temporal emergence patterns detected in self-organized systems. With regard to individual experience, this "is experienced as a joint movement where the subject is a collective and not a sum of individuals" (Himberg et al. 2018, 4). From the complementarity of these assumptions, we question: 1) the possibility of creating dance as a self-organized dynamic system for a group of dancers (generative dance) with emergent choreography; 2) the set of rules for which emergent dynamic patterns are produced; 3) how does generative dance influence the feeling of "togetherness" between dancers.

In sequence of these main questions we expect to contribute to understanding of the phenomenon of choreographic emergence and the relations between the organizational principles in contemporary collective dance, through practical artistic research based on rules resulting from computational modeling, capable of generating emerging collective behavior patterns. For that we will: 1) Explore the emergent behavior patterns, by computational modeling, that may confer to generative dance a component of autonomy and a coherence beyond the expected behavior - "a life of its own" (Monro 2009, 2) Propose a definition of generative dance and emergent choreography, based on the established concepts of Generative-Art and Generative-Art Emergence (Cook and Brown 1999; Gomes 2010), applied to contemporary dance, as of organizational principles of collective composition and improvisation; 3) Explore Emergent Phenomena in Dance based on the definition of autonomy component, connected with the idea of "going beyond" or transcendence of origins, of Monro(2009); 4) Understand the Togetherness phenomenon, verifying the influence of Generative Dance on collective choreographic creation, via listening the subjective experience of the dancers (perspective between dancers) for the construction of the concepts of own space, shareable space and group feeling.

4. Progress Towards Goals

Classically, one would guess that systems with numerous small parts that interact with similar nearby parts in a very simple way (and the word simple is the key here), could not show a collective behavior rather than a simple one. The study of elementary cellular automata came to show that, for some interaction of simple rules, the collective behavior of the systems is anything but simple. As John Conway showed, with his Game of Life, 2D cellular automata, some of these non-simple collective behaviors can exhibit both order and disorder/unpredictable features. Stephen Wolfram suggested that this kind of dynamic should be called as complex behavior. In the 1980s, Stephen Wolfram identified the elementary cellular automata that would be able to show complex behavior. Since then, it remains an open question to know if different cellular automata can show different order and disorder/unpredictable features. Still also to answer how different from that identified by Wolfram, can an order and disorder/unpredictable collective behavior be.

Approaching the collective dance behaviors to a choreographic object led us to study 2D cellular automata. Our interest is to see if the dynamics shown by these cellular automata have characteristics one could describe as order and disorder/unpredictable, and consequence recognizable patterns that we could define as emergent choreographies.

After, the systematic study of choreographic objects (Agent based models - 2D cellular automata) (Fig.1.), we have identified: 1) A different complex behavior for a square lattice peripheral cellular automaton, with von Neumann neighborhood and fixed null boundary conditions, which due to its characteristics, we are calling such order and disorder/unpredictable collective behavior as flow; 2) A singular cellular automaton capable of displaying self-organizing collective behavior with the system showing unexpected symmetries, after other families of cellular automata, diamond-shape lattice cellular automaton, with 4-neighbors (front & front left & front right & self), with fixed null boundary conditions.

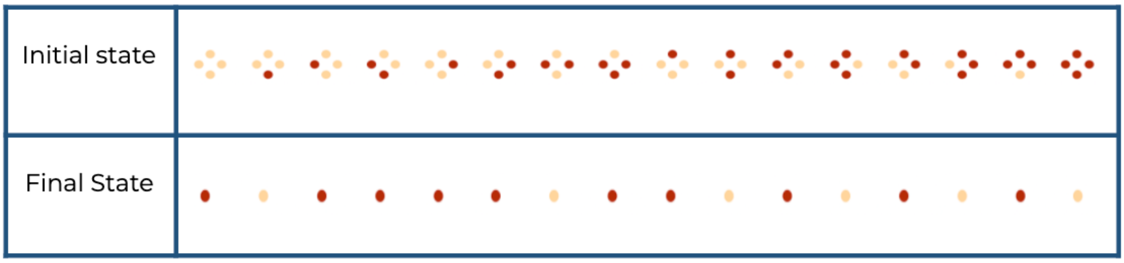
Fig. 1. Systematization of choreographic objects.

CHOREOGRAPHIC OBJECT #_

CHOREOGRAPHIC OBJECT #_0	• Square lattice peripheral cellular automaton, with von Neumann neighborhood (K=4); • Continuous boundary; • With 16x16= 256 elements;	Study of resilience to error and different initial conditions.
CHOREOGRAPHIC OBJECT #_1	• Square lattice peripheral cellular automaton, with von Neumann neighborhood (K=4); • Fixed null boundaries; • With 6x6= 36 elements;	Reduction of the number of elements, to observe resilience of the emergent characteristics
CHOREOGRAPHIC OBJECT #_2	• Square lattice peripheral cellular automaton, with von Neumann neighborhood (K=3); • Fixed null boundaries; • With 10x10= 100 elements;	The dancers don't need to look backwards, they see the person at their left, right and in front.
CHOREOGRAPHIC OBJECT #_3	• Square lattice peripheral cellular automaton, with von Neumann neighborhood (K=4); • Fixed null boundaries; • With 10x8= 80 and 8x8=64 elements	The dancers see the persons at their left, right and front, and analyze their own state.
CHOREOGRAPHIC OBJECT #_4	• Diamond-shape lattice peripheral cellular automaton with von Neumann neighborhood (K=4); • Fixed null boundaries; • With and 8x8=64 elements	The dancers will use the peripheral vision, so they just observe other dancer that are in their diagonal-front-left, diagonal-front - right and front. Dancer analyze their own state..

We have found a specific rule of correlation (Fig.2) in the choreographic object (Agent Based Model - diamond-shape lattice cellular automata, with 4-neighbors (front & front left & front right & self) with fixed null boundary conditions) for which we could observe the emergence of a concentric flux associated with a non-regular geometric pattern. With that, we have decided to use the same rule as a choreographic dispositive for our first Flashmobs, translating it to a set of scores (Table.1) that will be given to the participants.

Fig. 2. Singular cellular automaton capable of displaying self-organizing collective behavior, with the system showing unexpected symmetries.



The practice of Flasmobs, corresponds to the final presentation of dance workshops that we are collaboratively producing with different institutions (All Dance Portugal Festival; Center of Mathematics of University of Minho, etc.). As first workshops, they will serve as trials for the next investigations, nevertheless all of them will be followed by focus groups towards the phenomenon of togetherness (own space, shareable space and group feeling).

Table 1. Translation of automaton - diamond-shape lattice cellular automata, with 4-neighbors, with fixed null boundary conditions into a set of scores.

SET OF SCORES

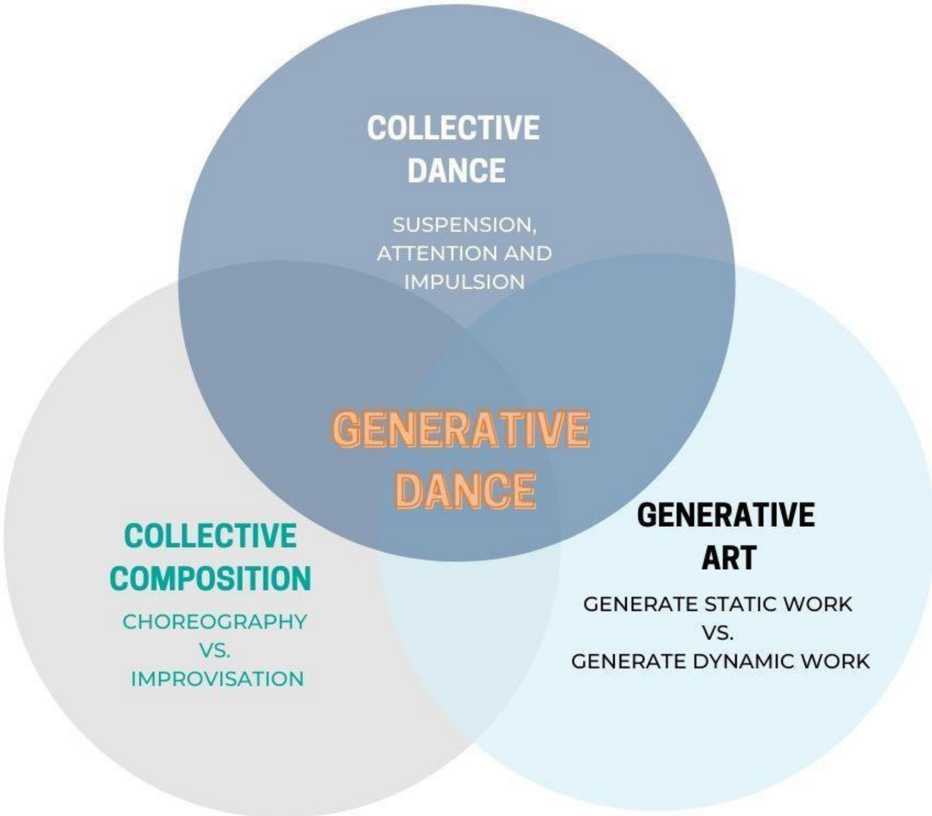
ASSUMING THE NOMENCLATURE:

L- THE STATE OF THE PERSON AT MY DIAGONAL - FRONT - LEFT
R- THE STATE OF THE PERSON AT MY DIAGONAL - FRONT - RIGHT
F- THE STATE OF THE PERSON IN FRONT OF ME

INITIAL SITUATION	MY CHOICE
If everybody is paused	I move
If L, F, R are paused, and I'm moving	I paused
If L is moving and F, R and me are paused	I move
If L and me are moving and F, R are paused	I move
If L, F and me are paused and R is moving	I move
If L, F are paused and R and me are moving	I move
If L, R are moving and F and me are paused	I pause
If L, R and me are moving and F is paused	I move
If L, R and me are paused and F is moving	I move
If L, R are paused and F and me are moving	I pause
If L, F are moving and R and me are paused	I move
If L, F and me are moving and R is paused	I pause
If L and me are paused and F, R are moving	I move
If L is paused and F, R and me are moving	I pause
If L, F, R are moving, and I'm paused	I move
If everybody is moving	I pause

On the other side, at this moment, we are writing an article with the provisional title - "An essay about the dimensions of a generative dance"- in which we propose a mapping and systematization of some concepts (Collective Dance - suspension, attention and impulsion; Collective Composition - Choreography vs. improvisation ; Generative Art - Generate Static Work vs. Generate Dynamic Work) that bound the concept of Generative Dance (Fig.3.).

Fig. 3. Main concepts that bound Generative Dance.



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Interactive Research Artifacts as Creative Tools for Knowledge Creation

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In my doctoral programme, I aim to lay the foundations for understanding the novel impacts of interactive technologies on knowledge creation in the digital age. Specifically, I propose an ethnographic approach to understand current scholars' conceptualizations of "interactive research artifacts." Through this process, I will propose a definition and set of criteria for these artifacts that encompasses the dynamic ways these technologies transform knowledge creation practices. I will consider these artifact creation practices to be creative in nature, and as such, will draw on Design Studies and work on digital creativity to bridge computation, knowledge creation, and communications literature. I will begin with a pilot conference where scholars of all disciplines will be invited to share and discuss interactive research artifacts they have created. From there, I will use ethnographically-informed case studies to explore scholars' lived experiences with these artifacts. Based off these findings, I will propose a conceptualization of interactive research artifacts and initial design considerations. These will be examined and remoulded in co-design workshops, where, with more scholars, we will co-create design guidelines for the future creation of interactive research artifacts. To design for a future where interactive research artifacts become commonly used scholarly tools, an in-depth understanding of the ways these artifacts are used as knowledge creation tools is critical.

Keywords interactive artifacts, knowledge creation, creativity, scholarly practices

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1. Introduction

Academic knowledge creation practices are often excluded from discussions surrounding creativity. There is craft in exploring vast datasets, ideating hypotheses, constructing theories, and communicating knowledge. Interactive media are transforming the ways academic research is created, explored, critiqued, and disseminated. Therefore, these technologies should be understood as altering creative habits. This research seeks to conceptualize and further our understandings of these technologies as "interactive research artifacts" and creative tools.

Current literature in Human-Computer Interaction (HCI) focuses on the ways interactive media enhance and diversify how scholars communicate (Hohman et al., 2020); however, these studies do not address the critical role of knowledge creation and creativity. This research will unearth people's lived experiences using these tools and apply theories of design and knowledge creation to develop more complex understandings of the role of interactive media in scholarship.

The goal of this research is the development of new epistemologies for creative scholarly practices. Interactivity provides complex and unique opportunities to explore knowledge and we must leverage it to improve our research processes and knowledge infrastructures. I will lay the foundations of this future by developing complex, analytical understandings of how interactive research artifacts alter academic processes and how they should be created.

2. Literature Review

There exists no comprehensive research investigating the complexities of interactive research artifacts. Current research focuses on communicative affordances (Dragicevic et al., 2019; Hohman et al., 2020; Leggett & Shipman, 2004; Lundgren, 2011; Means, 2015; Rule et al., 2018). This literature misses critical ideas of creative practice and knowledge creation. For the scholars I interviewed, interactive research artifacts are valuable creative tools for knowledge creation, not necessarily communication (Curtis, 2022).

This research conceptualizes creativity as an individual notion – when people believe their work is creative, it is. This lens should be applied to academic knowledge creation. Designing a future that critically engages with interactive research artifacts as creative tools requires an understanding of scholars' lived experiences with them. To better understand the novel transformation of knowledge in the digital world, this project seeks to address the impact of interactive media on our changing forms of knowledge creation. Research currently explores creativity and communication in a digital age – this work exists as a slice of this, asking "what does scholarly creativity, communication, and knowledge creation together look like in a digital age?"

This project aims to address the following:

1. How and why do people engage with interactive research artifacts?
2. How do interactive research artifacts alter knowledge creation practices?
3. How should we create interactive research artifacts to best facilitate knowledge creation?

Design Studies orients itself as a creative discipline which focuses on humans' "lived worlds" (Boradkar, 2016); as such, this research aims to do the same. Design has long been a crossroads, building upon perspectives in other fields (McComb & Jablokow, 2022). This project is transdisciplinary by nature as the artifacts themselves are – they tangibly improve scholarly practices in a range of disciplines, including Computer Science and Digital Humanities. As such, I use design theories as the nexus. These design theories provide a perspective not traditionally found in science (Chou & Wong, 2015).

This work aims to co-create design guidelines for interactive research artifacts. Current tools to create these artifacts are often inaccessible to most scholars, designed with limited understanding of how these artifacts alter scholarly practices. With increasing emphasis on digitalization, more work is required to conceptualize and support the ways we construct scholarship. This design framework will promote accessibility of these artifacts, enabling a diverse audience of scholars to create and implement their own.

This research supports the integration of computation, creativity, and communication to provide unique perspectives on how digital technologies are changing creativity and scholarly knowledge. Developing a nuanced conceptualization of interactive research artifacts will lay the foundation for future studies, building towards normalization of these artifacts as knowledge creation tools, and therefore expanding the possibilities of our academic knowledge structures.

3. Methodology

To address the RQs, I will focus on communities which engage with interactive research artifacts. This work builds upon relationships established during my previous research (Curtis, 2022), where I identified scholars actively engaging with these artifacts, predominantly in Digital Humanities (e.g. Six Degrees of Francis Bacon, Oxford Academic Research Support Team), Media Studies (e.g. Brooke Leaves Home, Digital Creativity Labs), and Machine Learning (e.g. Distill, R2D3).

4. Expected Contributions

There exists no comprehensive research investigating the complexities of interactive research artifacts. Current research focuses on communicative affordances (e.g. Dragicevic et al., 2019; Hohman et al., 2020; Leggett & Shipman, 2004;

Lundgren, 2011; Means, 2015; Rule et al., 2018). This literature misses critical ideas of creative practice and knowledge creation. For the scholars I interviewed, interactive research artifacts are valuable creative tools for knowledge creation, not necessarily communication (Curtis, 2020).

This research has three stages: pilot conference, ethnographically-informed case studies, and co-design workshops.

Pilot Conference

I will run a make-a-thon conference as a pilot study. Participants from across the globe will create and share their own interactive research artifacts, providing initial insight into the ways scholars engage with these artifacts (RQ1) and the effects these creative practices have on knowledge creation (RQ2). I will follow individuals' creation processes and their interactions with others' artifacts. Throughout the event, I will identify more potential case study participants and better understand the communities shaped around these artifacts.

Ethnographically-informed Case Studies

Following insights from the pilot conference, I will construct ethnographically-informed case studies, addressing RQ1 and RQ2. These case studies will be purposefully diverse in discipline, content, and cultural context, but focused on those actively creating interactive research artifacts. Following Gillham's description of case studies, I will use multiple ethnographic evidence sources (2005) (participant observation, semi-structured interviews, critical artifact analysis) to construct thick descriptions of people and artifacts surrounding these cases. This study will follow actors, whether they are human (scholars) or non-human (artifacts and knowledge), through the unfolding processes of interactive research artifact creation.

By taking a case study approach, I aim to "understand the case in depth, and in its natural setting, recognizing its complexity and its context" (Punch, 2014, p. 120). Ethnography allows for insight into the "messiness of practice … to try to understand the often ragged ways in which knowledge is produced in research" (Law, 2004, pp. 18–19). Directly engaging through semi-structured interviews provides insights into participants' relationships between interactive research artifacts and their research processes. Semi-structured interviews are a conversation in which knowledge is constructed and expose deeper meanings regarding interviewees' perspectives (Kvale & Brinkmann, 2009). Participant observation and critical artifact analysis will uncover tacit knowledge that might not be discussed during interviews (Hine, 2016).

Co-design Workshops

The final stage will be co-design workshops addressing RQ3. They build on participatory design methods and will enable users to co-construct design guidelines while maintaining intrinsically personal visions of outcomes (Andersen & Wakkary, 2019). I will generate initial ideas for designing future interactive research artifacts based off the conceptualizations brought forward by the case studies. From there, I will run a series of 3-5 workshops with 10-20 scholars each where we will co-design design guidelines for interactive research artifacts. These guidelines will serve as a framework for other scholars who are interested in creating their own interactive research artifacts but are unsure of where to begin.

4.1 Project Plan & Timetable

Year 1: Initial Planning and Pilot [currently in progress]

In my first year, I am identifying and finalizing my theoretical framing, methodological approach, and key case studies. I will also run the pilot conference, bringing together and initial list of participants based off my previous research and online recruiting. I hope to use this time to broaden the pool of scholars I am aware of who are actively creating interactive research artifacts and draft a database of examples.

Year 2: Ethnographically-informed Case Studies

I will expand upon insights from the pilot conference and begin conducting research for my ethnographically-informed case studies. After data collection, I will begin analyzing my findings and developing initial design guidelines to inform the co-design workshops.

Year 3: Co-design Workshops and Synthesis

In the beginning of the year, I will run a series of co-design workshops as outlined. From these findings, I plan to host additional workshops at relevant conferences to finalize the content and format of the design guidelines. I will focus on writing up and synthesizing co-design workshop outputs into a tangible design framework. I will produce a digital version of the framework which is easily accessible to all.

4.2 Outcomes, Deliverables, and Impact

Throughout my research process, I will continue to engage with the communities I am working alongside and feedback into their knowledge infrastructures. I am an active member of multiple online Slack communities where members actively create interactive research artifacts. I will continue to participate in and run community events focused on knowledge exchange. After the intial pilot conference, I will publicly share my database of interactive research artifacts and invite others to submit their own. During previous research, a common frustration was a lack of examples to refer to. As such, I hope to create a space where scholars of all backgrounds can come to and investigate different forms of interactive research artifacts. Throughout my various stages of synthesis, I will ensure to keep my findings available online, both in the communities I am directly working with and to a broader audience.

Further, I aim to present initial findings of the conference, case studies, and co-design workshops in relevant academic conferences. My synthesized findings will be published in peer-review papers, to increase awareness of this phenomenon inside academia. As my work purposefully blends multiple disciplines, I will aim to participate in conferences and journals across a spectrum of fields.

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I Don't Exist: Aesthetics of Virtual Expropriation

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Existing in virtual global networks poses questions on how subjects can maintain agency within them. The shift of digital networks into compartmentalized locked-in platforms facilitates the metamorphosis of subjects into the category of users. The ever-growing absence of a buffer zone between online and offline representation means that online highjacks become increasingly problematic. Currently, there is a rise in emerging efforts to transition bureaucratic citizenship into new modes of digital identity, such as the ID2020 project and other governmental projects seeking to implement digital ID in countries like Australia and Canada, or the digital ID proposed by the World Economic Forum. This shift, in some cases from a centralized state as guarantor to a decentralized allocation of identity allows easy verifiability and access to a multiplicity of services and personal data but also poses questions concerning these systems. This research aims to look at the different models of digital identity that are being developed, thinking about their implications. Researching in an art context, the goal is to develop a speculative project related with digital ID and expropriation, reflecting upon the assetisation of identity. The goal is to think through different theories to explore agency within virtual global networks distributed in planetary-scale assemblages of subjects and technological infrastructures.

Keywords digitalID, expropriation, speculative aesthetics, network, planetarity, agency

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Context

This research began when my website was stolen by a company that turned it into a porn and casino directory. After looking at the various links and their IP addresses, I listed a number of different servers on various geo-locations. The globe is in everyone's computers, but no one lives inside them, creating an impression that the globe is something that can be controlled (Spivak, 2012). Interpol (n.d.) declared an historical rise in cybercrime, growing identity theft scenarios and the circulation of deepfake images (Schick, 2020) destabilizing traditional representation paradigms allow the rise of a new paradigm of volatile identity and reputation (Rosamond, 2019). These new conditions operate within planetary scale computation that defies the traditional logics of nation-state sovereignty (Bratton, 2016). The question now is to think how the homogenizing logic of globalization can be rethought via the concept of planetarity (chakrabarty,2009), a process of subjectivation where the subject considers itself planetary, instead of only continental or national. Similarly to what happened when looking at the different geo locations inside my expropriated website, the confrontation with the planet is something familiar and close and simultaneously strange and distant.

The World Economic Forum (2022) proposed a digital identity system that aims to monitor online behavior, purchases, and biometric data that, like the Chinese social credit system (Kunreich, 2018) determines citizens' access to various services. Other efforts to transition bureaucratic citizenship into new modes of digital identity, such as the ID2020 project that seeks to create an alliance between private corporations and the United Nations to develop digital identity on the grounds that proving one's identity is a fundamental and universal human right, a project backed up by private corporations such as Microsoft and the Rockefeller Foundation. In the past six years, the Australian government has invested $450 million AUD in a national Digital ID system in order to lead the digital economy by 2030 (Macon,2022). In Canada there are concerns regarding the introduction of digital ID programs with citizens raising civil liberties and privacy issues but these criticisms are being labeled as misinformation (Rankovic,2022). With the growing efforts of both corporate and state actors to hold the monopoly of identity verifiability, the challenge is to trace the ideologies and private interests behind these different approaches and possible outcomes.

Goals and research questions

The goal of this research is to think about the rise of digital identity and the aesthetics surrounding events of identity expropriation. The research will explore networked subjectivity and agency and possibilities of engagement and resistance. Some of the initial research questions are:

- What are the different modes of digital identity arising?

- What are the implications of bureaucratic identity (something previously done by a centralized state) being controlled by private entities located in a distributed network?

- What could be the implications of identity theft scenarios in a digital identity context?

- What strategies could be employed to resist totalizing scenarios? Could it be useful to create an aesthetic buffer zone between online and offline existence?

- How do new modes of subjectivity and agency emerge in networked planetary-scale events?

These are some initial starting queries, however, during the research process some other questions might arise that are worth further development that might gear the research into other directions.

Approach

Identity theft allows putting the human into perspective, going from the micro to the macro, rethinking subjects not as a centrality but as enmeshed in a process of complex material relations. I aim to look at theories of chaos to think through control, agency, planet and machines (Plant, 1998) and also research on cybernetics and the relation of animal-machines conceptualized by Nobert Wiener (1948), critically thinking this relation between human and non-human entities in a way to dive into the concept of post-human becoming (Braidotti, 2002). The approach is to use an artistic research to engage with these topics by producing a video-essay that allows exploring the advent of digital identity to think through different modes of allocating and assetizing identity, thinking through current implementations and speculative scenarios.

Methodology

Since this work is being developed in a Fine Arts context, the goal is to use this position to explore the advent of digital identity and cases identity expropriation, thinking through different art practices that address paralel issues, also questioning how an artwork can engage with these topics. I aim to look at artists and theorists that work with speculative fiction or play with the idea of online identity, laying out possibilities of different scenarios and strategies. The research would consist in gathering elements to create an art project, exploring these themes in a non-linear, expansive manner, adding different positions and events. My own subjective experience of having my website highjacked by a company located in Macau, China, that turned it into a porn and casino directory could also be introduced to explore the issues relating to identity expropriation and online reputation volatility.

Contributions

The expected contributions of this research is to produce an art project unfolding many of the processes of online identity expropriation and the advent of digital ID. With this, I hope to collapse different fields of thought to propose an aesthetic experience which fosters a critical understanding of these matters, promoting new modes of thinking about agency and subjectivity in a paradigm of virtual networks distributed in planetary-scale technological infrastructures, also opening up the research processes to online and offline communities in a way to foster possible events and collaborations.

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Artificial Intelligence and Autonomous Visual Arts

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Artistic research PhD project based on interactions between visual arts and artificial intelligence. My goals are to understand issues of emergence and autonomy when applied to machine-enhanced and purely machinic creativity, which still lies in the plane of ideas. For that I build a theoretical framework from early cybernetics, passing through systems theory and current development in artificial intelligence, as well as definitions of autonomous systems and emergence. I look into relevant contemporary artworks, specially ones using generative resources. I also propose artworks of my own, which are incorporated into the thesis as commentaries and reports on specific questions and technologies.

Keywords Artificial Intelligence, art, creativity, cybernetics, generative art, systems theory, autonomy

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The goal of this research is to understand the impact of artificial intelligence technologies on the visual arts, dedicating special attention to projects that use automated, generative approaches. The development of neural network models such as StyleGAN, VQGAN or CLIP, allowed artists to render text or images from text prompts, use pre-trained styles based on other artists or visual features, among many new techniques. As claimed previously (Caldas Vianna 2020), the adoption of machine learning by artists established a new paradigm in generative arts: aesthetics are not limited anymore by symbolic algorithms, since the data models are able to infer characteristics from training sets and replicate them. It also leads us closer to the idea of autonomous art-creating entities, and to rethink once more the role of artists. It is not by any chance that recently several projects have surfaced with claims to be autonomous in some way, accidentally connecting themselves to cybernetic art projects dating back from the fifties.

The field of generative art has been thoroughly studied, and the consequences of the upgrade to deep learning methods didn't go unnoticed by the academic community. Among several books dedicated to the theme, I could mention:

- AI Art: Machine Visions and Warped Dreams, by Joanna Zylinska
- Art in the age of machine learning, by Sofian Audry
- Big data : a new medium?, by Natasha Lushetich
- The artist in the machine : the world of AI-powered creativity, by Arthur I. Miller

Media scholar Lev Manovich is releasing an open-access book, "Artificial Aesthetics", which seems to derive from a 2018 article named "AI aesthetics". But investigations on generative art didn't start with AI. We can cite Dorin at Al(Dorin et al. 2012), (McCormack et al. 2014; McCorduck 2004), as well as Philip Galanter's works (Galanter 2016).

Other texts touch upon issues that are important to my dissertation, such as the comparison between human and machine intelligence, or artistic skill. (Braga and Logan 2019; Sean Dorrance Kelly 2019).

Melanie Mitchell describes such limits in her Artificial Intelligence (Mitchell 2019), while Douglas Hofstadter proposes a relevant theory in his classic *Gödel, Escher, Bach* (Hofstadter 2000). A different take is the alternative rationalisation of AI by Jenna Ng (Ng 2021). Dieter Mersch also makes a stark critique of the idea of machinic creativity (Mersch 2019).

The pioneers of cybernetic and generative art such as Nake (Smith 2019) are also relevant. The overview of these pioneering works proposed by Shanken (Shanken 2015) is very thorough. The founding books of cybernetics and systems theory are fundamental to understanding the goals and the difficulties in defining autonomy, therefore this research encompasses the works of Norbert WIener, (Wiener 1948) Ludwig von Bertalanffy, (Bertalanffy 2009) Varela and Maturana, (Maturana and Varela 1980) and the overlap of systems and art from Luhmann (Luhmann 2000) and Halsall (Halsall 2008). Special attention must be dedicated to the concept of autonomy, starting with Kant's concept, the cyberneticists concerns, Maturana and Varela's concept of autopoiesis, to the social science and collaborative design idea of *autonomía*, described by Arturo Escobar (Escobar 2018).

Finally, it must be mentioned that several artists have taken AI not only as a tool but also as a subject, most often under a critical perspective. That is the case of Trevor Paglen, Hito Steyerl and forementioned Joanna Zylinska.

This project is based on the practice of artistic research, even though it doesn't relinquish the usage of a very complete text-based elaboration on the history and issues around the field, as seen on the background survey above. The artworks create a particular type of commentary with more academic freedom, as well as a laboratory where concepts can be put to text. They add a much needed poetic perspective on the questions that come up when applying artificial intelligence on art projects. In any case, I still struggle with the place of artistic research, and hope the symposium can help me with the contradictions in my approach.

I hope I can make a contribution to the field by examining what it means to be autonomous for a machinic artist, and what strategies can be used to deal with the limitations of machine creativity. It is quite clear by now that some of the most important barriers to achieve some sort of artificial general intelligence have a lot to do with the skills needed to produce art - a good grasp at figuring metaphors, the ability to disobey rules, being able to propose analogies and more. Even if models such as GPT-3 are getting impressively good at simulating these skills, we know that they derive from existing human production in the form of massive training datasets. It is not by chance that many "autonomous" generative art projects need to rely heavily on contributions from human participants. This PhD project doesn't have the pretension to solve these issues and create a completely automated artist, but rather understand the limitations of the field and propose projects around the limits of the possible.

Much of my research progress is done by writing articles which detail a part of the thesis subject. As I mentioned, I published one on AI and generative art; I have another on machine disobedience being reviewed, and I'm writing on autonomous machinic art projects. I have also exhibited artworks which are part of the research project at the Uniarts Research Pavillion in Helsinki, in 2021, and I am preparing another exhibition at the Finnish Museum of Photography in 2022. I have organised a one-day seminar on Arts and Artificial Intelligence during the KUVA Research Days seminar in Helsinki in 2021.

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Rethinking The Electric Guitar as an Augmented Instrument

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The research analyzes the main electronic and digital ensembles for electric guitar in the last decades. Through this, the sense of augmentation of the instrument is deepened, with special emphasis on its integration with the computer. A first section of the research is the interpretation of a series of case studies using Ableton Live software with MAX/MSP, together with a MIDI controller that homogenizes and allows performing the case studies selected for the thesis: *Electric Counterpoint* (Steve Reich 1987), *La cite des saules* (Dufourt 1997), *Trash TV Trance* (Romitelli 2002) and *Not I* (Prins 2007). A second section is the development of an augmentation proposal for e-guitar that consists of a separation in the hands-feet interface to be able to control effects, volumetric balances and samples and loops. Finally, a reflection is articulated around the augmentation in the electric guitar and its relationship with the concepts of post digital, Smart instruments, modular flexibility and obsolescence.

Keywords Augmented Instruments, Electric Guitar, Computer Music, Post Digital, Contemporary Performance

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1. Purpose of the Research and its Importance to the Field

The aims pursued by the research are the following: 1) To study the electric guitar from the perspective of augmented instruments (instruments configured in a sound chain with modular devices), 2) To analyse and document the different electronic and digital sets that have had the most impact in recent decades, 3) To study especially the sets that integrate the computer in the sound chain and apply them to the performance of contemporary music case studies and 4) To design an augmentation proposal for the electric guitar based on the problems that appeared during contemporary music performances.

In the history of the electric guitar, it can be seen how technical needs, social contexts and artistic pursuits have shaped instrumental and performative advances. The electric guitar has used the applications of science and technology to take different forms. The original application was to increase volume, which was succeeded by timbre control and expansion, memory (loops, samples), and level control and balance (volumes, multichannel volumes, effect degrees). Due to the different proposals and sets developed in the last decades, today multiple configurations coexist in the design of augmentation.

All this process of continuous transformation has redefined the meaning of augmentation in the instrument. The electric guitar has evolved faster than the understanding and reflection on its nature, construction, and sound possibilities. The combination of sets, sounds and possibilities have become complex to understand and around them problems and positions have been developed by the musicians. The integration of the instrument with computers and software oriented to the design of sound chains and live performance has been insufficiently explored, at least as far as textual, pedagogical, and academic references are concerned. Lastly, it would be interesting to analyse the electric guitar from the paradigm of post-digital framework (Schubert 2021), which integrates the analogical and digital worlds; also advances in Smart Instruments (Turchet 2018), have already focused a large part of their contributions on the electric guitar. Putting these concepts and their respective configurations in order is of great importance for the field of research.

In addition, in the practice of the instrument, many possibilities are discontinued, others are not put into operation due to lack of diffusion or artists who popularize them. Knowing the future and present needs of the instrument can lead to an understanding of the lines of development that the electric guitar can take and to form a criterion for the use of existing possibilities. Design proposals on future lines of development is another important task, which can be useful to instrumentalists and can help build bridges between advances in sound engineering, instrument development, and performance and artistic use.

2. Brief Survey of Background and Related Work

Publications related to augmented instruments and hyper instruments of various kinds, as well as new interfaces, have been main bibliographic sources. These include studies that have to do with the act of performance and musical gestures. Several articles consulted were presented or published on the main conferences and journals in the field: i) NIME (New Interfaces for Musical Expression) (Pakarinen and Puputti 2008), (Schiesser and Traube 2006), ii) Computer Music Journal (MIT) (Burt and Chadabe 1998), iii) Ircam – Center Pompidou (Bongers 2000), iv) Journal of New Music Research (Keller, Schiavoni, and Lazzarini 2019), v) European Review of Artistic Studies (H. Portovedo 2020). PhD dissertations on hyperflute (Palacio-Quintin 2011) or on augmented clarinet (Furniss 2017), Diegert and Artacho's article on Aubiome (Diegert and Artacho 2018) and works on Portovedo's augmented saxophone have also been consulted (Portovedo, Lopes, and Mendes 2018). Puckette's book on music and computers (Puckette 2007) and various studies on gesture and mapping such as Jansenius, Wanderley, and Godøy (2009) complete this summary of bibliographic references.

Another source of information is related to the electric guitar itself, including the study of various works and guitar sets. Noteworthy here are Lähdeoja's writings for NIME (Lähdeoja 2008) and Schneider's electric guitar book (Schneider 1985) as well as books by composers like Steve Reich (Reich and Hillier 2011), Elliott Sharp (Sharp 2019). Also, Mackie Banks's Thesis on Electric Guitar in Contemporary Repertoire (Mackie Banks 2013) and Thomas Jameson's Thesis on Electric Guitar (Thomas Jameson 2017) have been consulted.

Finally, studies related to research techniques, musical aesthetics, and sound engineering, which shape the broader framework of the current thesis, are those on artistic experimentation (Assis 2018), the concepts of post digital (Schubert 2021), Embodied Knowledge (Sodhi 2008) and ubiquituous music (Keller, Schiavoni, and Lazzarini 2019).

3. Description of the Proposed Approach

An important part of the approach is based on the analysis of case studies of the contemporary music repertoire of the last four decades to understand the proposals and aesthetics developed in the instrument, how does the integration with technological media works and what are its main problems. The approach also pays attention to the sets used by the most outstanding electric guitarists from various stylistic fields trying to clarify the electronic and interpretative heterogeneity of the instrument.

Although the proposal is clearly focused on the field of electric guitar, it considers the general context of augmented instruments and gestural theories in contemporary performance to understand which are the particularities of the electric guitar.

Finally, part of the work consists of developing an augmented electric guitar proposal based on the needs arising from the interpretations in the case studies and inspired by ideas of new interfaces, to create an instrument configuration that provides flexibility when performing existing works, but that it is also modelled towards future forms of relationship between the instrument and music with computers.

4. Expected Contributions

1. Documentation and reflection on the chronological/historical meaning of devices in augmentation. Compilation of the main sets used in recent decades on electric guitar, their operation and their relationship with technical and artistic needs, the music in which they are framed and the problems that these sets tried to fix. Appreciation of the crucial importance of the final sound output device in the electric guitar instrument.
2. Digitization of contemporary mixed music repertoire for the instrument, using Ableton Live software with MAX/MSP, together with a MIDI controller that homogenizes and allows performing the case studies selected for the thesis: *Electric Counterpoint* (Steve Reich 1987), *La cite des saules* (Dufourt 1997), *Trash TV Trance* (Romitelli 2002) and *Not I* (Prins 2007). Development of works-studies that serve as a practice model for various techniques associated with augmented performance: live looping, effects control, track triggering or clock midi for ensembles. Preparation of a method of exercises and technical developments for interpretation of the augmented e-guitar with electronic means.
3. Reflection on the "state of the art" of the augmentation proposals in the performance, relating it to the concept of embodied knowledge and relearning of the instrument (for example, in the use of the feet or the control of the timbre and the effects with knobs). Also, discuss the fit of the augmentation proposal in the post-digital framework, the relationship with obsolescence, the evaluation criteria of the sets and the practice of the instrument.

5. Progress Towards Goals

Firstly, a progress was achieved due to the submission of papers to journals, some in review processes and others already accepted for publication (NCMM 2021, XPERIMUS 2022). Interpretation of the case studies and description of all the sets of each work with its detailed explanation through descriptions and diagrams was the object of the first work cited before. The presentation of the split pedalboard prototype and its application to the performance of three case studies, highlighting "Trash TV Trance" by Fausto Romitelli, was the subject of the second reference.

Both works are connected directly with the work in the process of digitizing contemporary repertoire to focus their interpretation on a set with a MIDI controller and a computer on stage. For example, in the electronic digitization of the already mentioned work "Trash TV Trance" the physical devices of a complex looper, a distortion, a volume controller, a delay and a wah wah were replaced by the Ableton DAW, a sound card and a midi controller. This achieves a simple set, with fewer components and less wiring, reduction of parasitic noise and ease of assembly. It also simplifies the recording of the live work and control of the electronic levels by the performer.

Moreover, this same set could be employed for other electric guitar works and electronic media. It is important to note that the set is not only reusable in terms of its hardware components, but its software can also be used for other works due to the implementation of software environments that allow the performer to configure a repertoire of various concert works.

To obtain the greatest possible flexibility and expressiveness when performing case studies, as well as researching the creation of new sound material, the development of an augmented electric guitar prototype with the characteristic of a pedal split between hands and feet was implemented. In the proposal, some potentiometers are integrated in the guitar to solve the most outstanding problems of the instrument, such as: control of electronics, effect levels and tracks. There is also a capacity for modularity and expansion of the increased guitar set, that is, the set is not incompatible with other types of sounds and sets. The first prototype has already been developed and presented in the cited XPERIMUS.

In addition to the objectives based on technical and artistic needs, there is a constant communication and direct contact with composers and guitarists, mail correspondence with the experimental guitarist Elliott Sharp, the composer Stefan Prins and the professor of composition with technological means at the Real Conservatorio Superior de Música de Madrid (RCSMM) Julián Ávila. The research is also enhanced by recording at the most prestigious sound studios in Madrid such as Estudio Brazil and Estudio 1, including tests with more than ten different amplifiers from the last six decades.

Finally, a course related to the fields of research techniques (course of academic writing) has been undertaken and bachelor studies on sound engineering are currently under progress.

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