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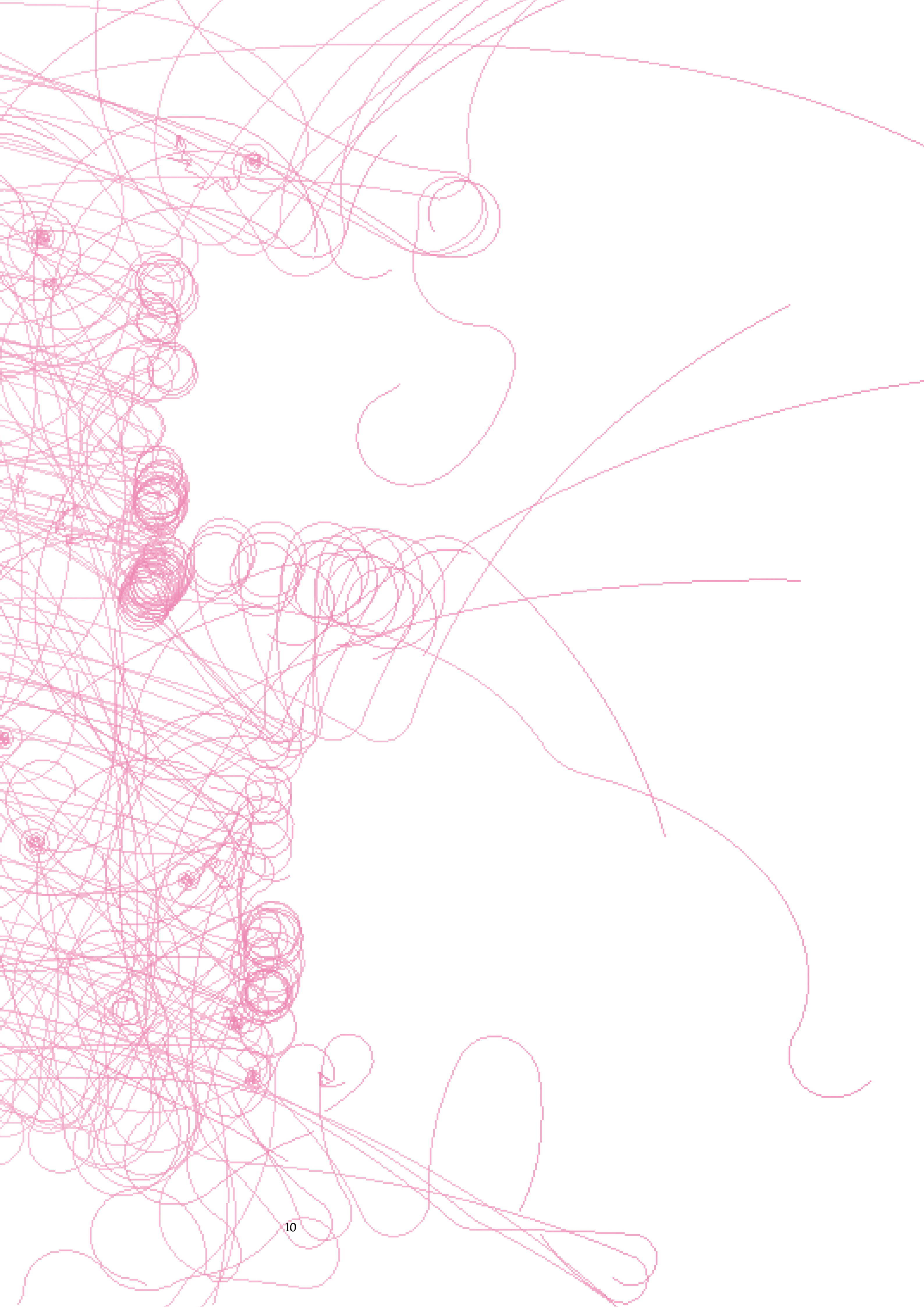


Foreword

Mario Verdicchio

Welcome to the proceedings of the first edition of "Computation, Communication, Aesthetics, and X".

Beginnings are always accompanied by excitement and enthusiasm, which in our case were furtherly fed by the overwhelming response that we got from researchers and artists from all over the world shortly after we issued the call for papers and works.

On the other hand, we cannot ignore the little chill that runs down our spines every time it comes back to us that, when all is so fresh and new, much of it is still unknown to us: who knows for sure what is going to happen?

The *Unknown* is indeed a concept traditionally represented with an X, and that is one of the reasons why our conference features an X in its name.

Still, this is not the only meaning associated with this letter: oftentimes X has been used to represent a prohibition. When we see a big black X over the symbol of a photo-camera in a museum, we know what we are not allowed to do. However, we also know that taking a picture in such circumstances is still a task that we may successfully accomplish, provided that we are stealthy enough.

When it comes to *Computation*, researchers have historically had to deal with much more than simple prohibition: they were told that some goals were impossible to achieve, and that such impossibility was intrinsically connected with the computational nature of the devices they were envisioning. According to the naysayers, it was not a simple matter of being quick with the shutter of a camera: some things were simply out of reach.

Here is the second meaning of X: *Impossibility*. Interestingly, many thought and still think that Communication and Aesthetics are among the impossible endeavors.

Obviously, Communication is not to be meant as the transmission of encoded bits from one point to another, a computational task par excellence, but as the generation and conveying of meaning, whether it is with words, images, shapes, or sounds.

The criticisms against computational approaches boil down to two main positions: computational devices are not conscious, and they are strictly governed by rules. Assuming that consciousness is necessary for human beings to acquire the meaning of words through their experiences, any consciousness-less device is then unable to learn and elaborate meaning, and hence must be considered as a simple symbol-processing mechanism, like in the famous Chinese Room thought experiment.

Moreover, given the determinism of computational rules, any result obtained by one of these devices is apparently devoid of any novelty or originality, since every characteristic of the outcome is already established in the program governing the relevant operations.

If computational devices are precluded from meaningful Communication with words, what about the use of shapes, colors, and sounds? In other words, what about Aesthetics? The response seems to be the same: without the moto-sensory and mental endowments that bless human beings with the possibility to enjoy and manipulate such means of expression, computational devices can do only so much. But how much is exactly that much?

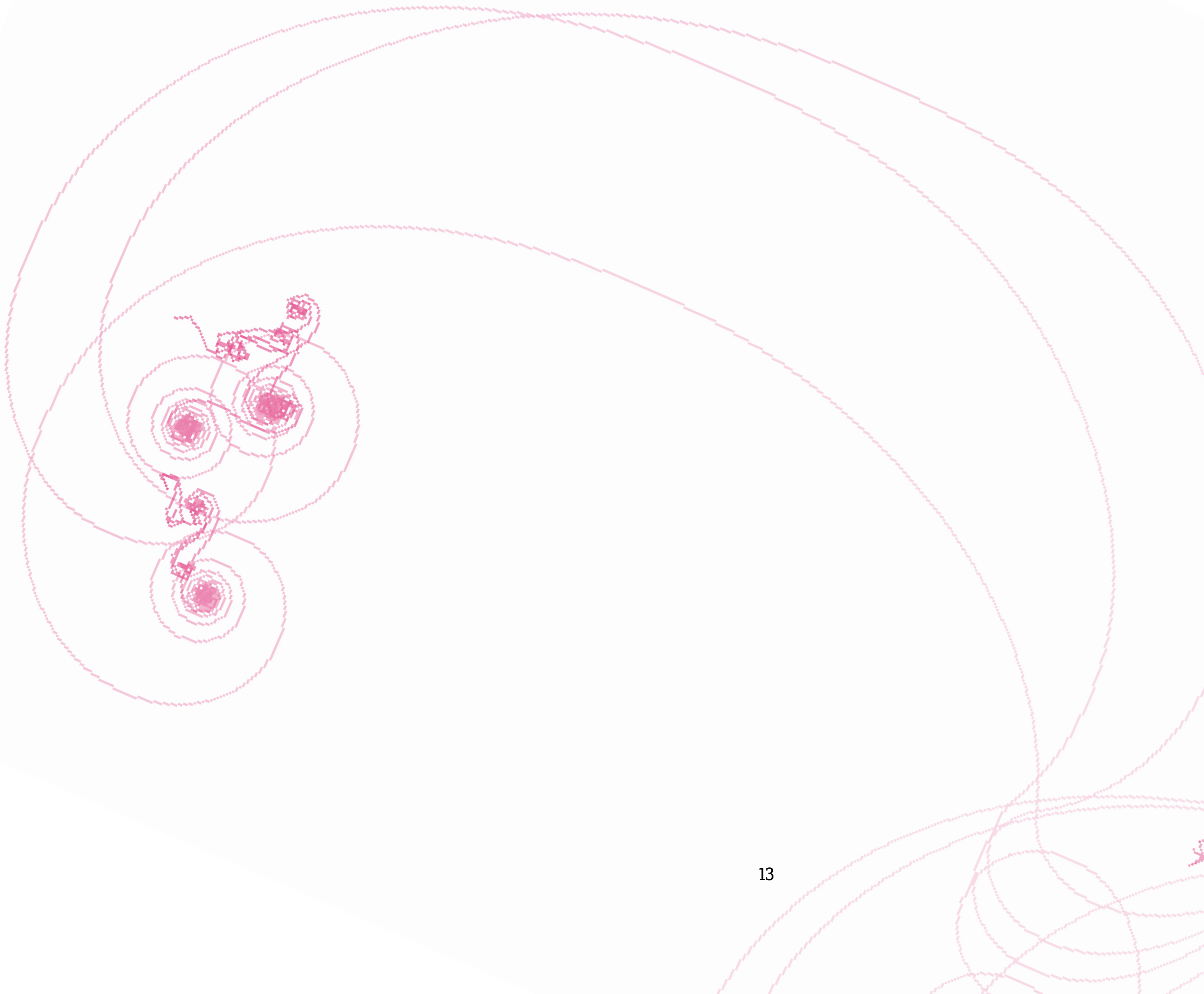
We must not forget that the aforementioned criticism emerged in the wake of the birth of Artificial Intelligence in the 1950s with Alan Turing's visionary ideas on the theoretical possibility of computers fluently conversing with people or being creative. The X of impossibility seems to rise when an artificial substitute is envisioned for activities that have been traditionally considered as typically human, but if Computation is adopted in a different role, not as a substitute, but as an aide, everything seems to proceed much more smoothly.

Computation has indeed played an increasingly important role in both Communication and Aesthetics and nobody, not even the harshest critics, can deny the immense contribution of computers in these fields: other than the already mentioned worldwide telecommunication infrastructure through which these very proceedings are distributed, several products, including the exciting artworks and performances presented in this book, are created also by means of computational devices.

Here we are at the final and maybe most important meaning of X: it is a *Crossroads* where two different worlds meet and complement each other, where the rules governing the computational devices are not seen as constraints, but as a way to channel the creative force that inspires human beings, and to organize it into templates that can be replicated, altered, and evaluated in unprecedented ways, thanks to the speed and precision of the technology used in these devices.

With computers in the toolbox, next to our pens, paintbrushes, chisels, strings and so on, we are enabled to explore a much, much wider landscape than ever before, but without fear of the Unknown, only excitement.

Let us begin.



Papers

Audiovisual Dynamics: An approach to Sound and Image Relations in Digital Interactive Systems

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Keywords: Sound-Image Relations, Audiovisuality, Digital, Art, Design, Interaction.

Abstract: This paper outlines an approach to the study of sound and image relations in digital interactive systems. It starts by addressing these relations and their different conceptions, and then centers its attention on aesthetic artifacts that use software as their medium and propose interactive experiences articulated through image and sound. It discusses the principles behind their creative shaping as possibilities inherent to the digital computational medium, and conceptually frames the nature of sound-image relations as procedurally enacted dynamic articulations of visual and auditory modes subjected to interaction. Finally, it focuses on these systems' surface analyzing distinctive features of their audiovisual dynamics.

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1. Introduction

While much has been written on the multiple histories of sound and image relations, this study responds to our belief that there is still room and need to resume the topic regarding its contemporary reinterpretations. In particular, concerning practices that explore the possibilities of software, inviting the audience to interact with dynamic audiovisual configurations. These practices do not necessarily claim the dominant or historical themes of audiovisuality. Rather, they creatively reshape it within the digital computational medium, demanding renewed concepts and forms of consideration. They place this study in the intersection of *audiovisuality* and *interactivity*, as themes of creative exploration, and as viewpoints from which to approach its subject matter.

This direction of inquiry was pursued in an exploratory manner, by examining and articulating complementary perspectives on audiovisuality, its digital computational nature, and its interactive forms. We traced the evolution of the topic of sound-image relations towards the contemporary context of digital interactive systems. We then approach these systems' *audiovisual surface* as a site for *interaction*. The specificity of software-based audiovisuality is addressed in light of its underlying *principles*, as creative possibilities of its medium. As the procedural nature of these systems is highlighted, we focus on characterizing their *dynamics*, or the variable, and often indeterminable, nature of their audiovisual behavior and responses to interaction.

These viewpoints structured the research on which this paper is based (Ribas 2012), from which we now underline the ideas that emerge as contributions to the understanding and description of sound-image relations in interactive systems.

2. Sound-Image Relations and Interactive Systems

We begin by establishing an open conception of sound and image relations, and what they may encompass, in light of a convergence between artistic forms of expression and media technologies, while also considering the perceptual and receptive implications of this evolution. Their foundations and models range from sensory, structural or conceptual analogies, to the coupling, transformation, or direct manipulation of sound and image through technological means, which points towards the process-based and interactive nature of contemporary forms of audiovisuality (Ribas 2012, 31-79).[1]

In the contemporary context, rather than confining our view to a specific typology or genre of interactive systems, we chose to encompass a diversity of aesthetic artifacts. They are defined as software-driven or computational systems, whose surface (outputs and interfaces) is audiovisual, and whose interactions specifically include the audience (as user). "*Surfaces are the faces that works turn to their audiences […] as a result of their implemented processes working with their data*" whose structures, as algorithms carried out by computers, are often unavailable to the user (Wardrip-Fruin 2006, 216).

We consider the works' processes, or the procedures that structure their behavior, from the point of view of the users' phenomenology, while taking into account this conceptual reality of the work and the principles that drive its creation. We then focus on the audiovisual surface they make available for interpretation and interaction.

1. We trace this history back to Edison's machines and Wagner's aesthetic ideal of synthesis that inspired both an operatic simultaneity and a parallelism between the musical and the visual arts. While these analogies moved towards a transfer of structural methods of creative production, the simultaneous inscription of sound and image in the film medium yields their coupling (synchronization and montage) as well as new possibilities for synthesis and transformation. Two tendencies then emerge on a conceptual and technical basis: exploring film as a perception device, and the analog electronic unicity of sound and image, paving the way for interaction. We then focus on two intersecting topics: software-driven audiovisuality and interactivity (Ribas 2012, 31-79). In its contemporary manifestations, audiovisuality becomes ubiquitous and multifarious as the ideal of synthesis finds a counterpart in media technologies as a 'digital fusion' of sound and image (Daniels and Naumann 2010, 8; Zénouda 2006, 174).

3. Audiovisual Surface and Interaction

In order to study the ways in which interaction reshapes 'audio-vision' (Chion 1994), we address this perceptual mode of reception and the cross-modal mechanisms that constitute its foundations. We can then distinguish perceptual phenomena from audio-visual objects of perception that eventually promote the binding and synchresis (perceptual synthesis) of associated stimuli.[2]

Devised with the aid of technological means, these artificially constructed relations correspond to different methods and concepts, for linking the visual and auditory, or for correlating them to other (often intangible) realms. Sound and image become abstract manifestations of their synchronic and diachronic relation or correlation.

2. Audio-visual forms often follow design strategies that try to 'emulate', or 'play' with, our basic mechanisms of cross-modal processing and integration of different sensory modalities (Whitelaw 2008b). These relate to cross-modal interactions as well as to analogies we form upon amodal dimensions or qualities, which, in contrast to the interpersonal variance of synesthesia, are common phenomena of human perception (Shimojo and Shams 2001; Daurer 2010).

3.1. Interaction: New Roles of Sound and Image

Interaction reshapes audio-vision, through an active (sensorimotor) implication of the user, involving the haptic capture of the visual and auditory modalities, as a form of perception that arises from action (Mangen 2006, 410). Interaction implies that both entities are able to act and influence each other. The system may incorporate human activity into the way images and sounds are presented, and thus perform differently (Candy and Edmonds 2002, 2002). The user is no longer dealing with a self-contained audiovisual object, but rather with 'processes and events' that are 'brought into existence', as dynamic outputs of real-time computations (Hayles 2006, 181).

Consequently, and beyond the intrinsic value of audio and visual elements or the added value effects of their combination as cinematic manifestations, the audiovisual analysis turns towards the new roles that sound and image as *means* and as *products* of interaction.

3.2. Strategies of Articulation

In this context, their relations can also be considered at different levels, as they are specified within the system (as mappings between data), or as surface configurations of visual and auditory modes that the user actually accesses and interacts with. We can therefore approach sound-image relations by distinguishing interfaces, the user actions they promote, and their possible outcomes, as suggested by Levin (2010) or Kwastek (2010). By doing so, rather than defining relations, we are describing different strategies of sound-image articulation, according to the operative and productive possibilities of each system.

3.3. Interactivity and Performativity

In order to circumscribe the scope of interactive systems we can use the notion of performativity to address works that explore how a "*feedback loop can be established between the system and its user(s)*" allowing them to explore "*the possibility-space of an open work, and thereby to discover their own potential as actors*" (Levin 2010, 271).[3] We can also view these artifacts as apparatuses (comparable but different from instruments) whose 'functionality' as 'production devices' is potentially 'unique and novel' to the user, thus inciting creative exploration (Kwastek 2011, 157).

3. This notion highlights the performative dimension of the experience of a work, as jouable (playable), as performed by its spectators (Boissier 2004).

However, this view emphasizes an instrumental nature, to which the interactive systems considered do not necessarily correspond. This entails examining alternative strategies of sound-image articulation, as well as other possibilities or principles that govern their creation.

4. Principles and Medium

In order to further scrutinize the audiovisual surface, we provide an alternative perspective by resorting to the 'principles' that, according to Levin (2010), motivate the development of software artworks that are "*concerned with (or articulated through) relationships between sound and image*". They comprise sound and music visualization, the transmutability of digital data, generative autonomy and interactive performativity.

4.1. Visualization, Sonification and Transmutability

While the common traits to sound or music visualization or notations practices are the development of "*expressive visual languages*" in relation to sound[4], or the aim to provide insight into the structure of a signal or composition (Levin 2010, 272), the concept of visualization encompasses a multiplicity of methods and aesthetic strategies.[5] In this sense, sonification is its parallel, as the use of acoustic means to convey information or concepts, often used as an alternative or supplement to visualization. It is "*used artistically, as an aesthetic concept and method*", namely as a means to make the environment audible (Grond and Schubert-Minski 2010, 284).

The principle of transmutability relies on the premise that any kid of input data can be algorithmically visualized or sonified. While mostly used as a means to an end, in enabling some "*real-world data signal*" or "*data stream of interest to be understood, experienced, or made perceptible in a new way*", it can also be an end in itself, as the "*starting point for a conceptual transformation and/or aesthetic experience*" (Levin 2010, 274). This highlights the inherent 'translatability' of data as raw material that transmutes into any chosen visual or auditory form (Whitelaw 2008a, 45–54).

4. Which display either "time-based representations of perceptual phenomena", like pitch, loudness, and other "relatively instantaneous auditory features" (Levin 2010)

5. Moreover, it can be extended to visualizations of the human voice or other user produced sounds, as well as an algorithmically defined connection between sound and image, entailing their simultaneous generation or submission to similar parameters.

4.2. Performativity and Generativity

The notion of performativity concerns systems that entail the "*mapping of human data*" or "*human performances*" to images and sounds, as "'*open works' or 'meta-artworks' … which are only experienced properly when used interactively to produce sound and/or imagery*" (Levin 2010, 275). They emphasize an interactive performativity as subject matter, rather than interaction as a mere possibility or attribute of a system.

In turn, the principle of generativity refers to the potential autonomy of a system to "*produce animations and/or sound from its own intrinsic rule-sets*" (Levin 2010, 277). It draws attention to the "*rules of creation*" of the work, as "*artistic constraints*" (Bootz 2005); as "*recipes for autonomous processes*" (Galanter 2006) that develop in time, in a self-organizing manner, potentially leading to unforeseeable results, which are not completely predictable neither by artists nor user (Boden and Edmonds 2009, 24).[6] What becomes relevant then, is how this generative autonomy is manifested and may be perceived by the audience.

6. The work occurs while running as a unique performance whose rules of creation, or procedural logic, can only be grasped through careful observation and interaction.

These principles draw attention to the specificity of software-driven systems and to their heterogeneity as aesthetic artifacts that explore distinct possibilities of their medium. They correspond to different ways of exploring the mapping of a given input data or source information into visual and auditory form, and to the possibility of devising dynamic audiovisual behaviors and responses to interaction. As such, we can extend their discussion to other notions that are used to address these creative possibilities, and to define themes or aesthetic qualities of these systems.

5. Possibilities and Qualities

The artifacts considered in this study use computers not only as storage and transmission media but require computation in order to be themselves, during the time of their experience. They are computationally variable works in which "*processes are defined in a manner that varies the work's behavior (randomly or otherwise)*", either without input from "*outside the work's material*", with input from "*external data or processes*", or with human input; the latter meaning audience interactive (Wardrip-Fruin 2006, 389–99).

These factors of variation again highlight the creative possibilities of a medium, where "*data and process are the major site of authoring*" (Wardrip-Fruin 2006, 381). In fact, the principles mentioned correspond to a rephrasing of "*aesthetic possibilities*" that, according to Levin, stress the self-referential nature of computational works that "*address as their subject matter*" the "*structures, materials and processes by which they are created*", namely: interactivity; processuality; generativity; transmediality (Levin 2003; 2007).[7]

According to this, transmediality is linked to audiovisuality, multimodality and thus to transmutability, which stresses the inherent 'polymorphism' of digital data. While these terms accent the translation processes performed on non-process elements of the work (data and its audiovisual forms), the principles of generativity and interactivity bring to the fore the processes, as operations carried out by the work (defining the surface and supporting interaction).

7. The author also mentions "connectivity" and "dynamism", adding that "naturally, these are not the only principles", but they outline aspects that "really have much more to do with features of the medium and how it operates in relation to people" (Levin 2003; 2007).

5.1. Processuality and Performativity

Processuality concerns the algorithmically structured operations carried out by a procedural system (that computationally executes rules), potentially leading to variable outcomes. As Jaschko (2010, 130) asserts, process is a "*central aesthetic paradigm*" of generative and interactive artworks, since "*live processes… generate unique configurations and dynamics*", performed either by the system, or by system and user. Process then refers to the "*time-based evolution of… sequences of events*" as results of ongoing computations, that conflates with performativity as a term designating both the "*quality of a technological artifact in operation*" (an execution) and the 'live' dimension of a presentation (Broeckmann 2005).[8] Hence, the expression and experience of these works is shaped by their modes of liveness (temporal simultaneity) and presence (spatial co-attendance), together with their visual and auditory realization (Kwastek 2009, 93).

8. As Broeckmann (2005) argues, processuality is one of the essential "aesthetic qualities" of electronic and digital artworks, whose aesthetic experience "hinges, to a large extent, on non-visual aspects" or "machinic qualities" manifested at the level of "movements, of processes, of dynamics, of change".

5.2. Surface vs. Procedural Expression

Implied in these notions is the idea that beyond the "*retinal beauty*" of audiovisual sensory perceivable results (Jaschko 2005), the "*iconographic level*" (Broeckmann 2005) or beyond the "*rhetoric of the surface*" (Bootz 2005), digital computational works entail a 'conceptual level' tied to the 'cognitive recognition' of the formal processes they carry out (cf. Jaschko 2005; Whitelaw 2010, 158). This emphasizes the procedurality that Murray or Bogost characterize as the "*principal value*" of the computer in relation to other media, or its "*defining ability*" to execute rules that model the way things behave (Murray 1997, 71). We then move towards an aesthetic level that is tied to their "*procedural rhetoric*" or "*the practice of using processes expressively*" (Bogost 2008, 122–24).

Therefore, an analysis of the audiovisual surface cannot be limited to its sensorial qualities of expression, but include the expressive qualities of the procedures that govern its behavior. In other words, these works' content "*is their behavior and not merely the output that streams out*" (Hunicke, LeBlanc and Zubek 2004, 1).

5.3. Dynamics of the Work-as-System

These notions highlight the subordination of audiovisuality to procedurality, and ultimately, how sound and image as aesthetic materials, subsume to the processual and performative aesthetic qualities of works that occur while running, as processes performed in real-time, with the participation of the audience. This provides the conceptual ground for our approach.

On one level, what is emphasized is the possibility to *create behavior* — whether autonomous, reactive or interactive. In this sense, we address artifacts whose subject matter is not necessarily tied to relations between the visual and auditory. However, by exploring the possibilities of the medium, they propose potentially unique, dynamic configurations of images and sounds. Our attention indirectly diverges from practices concerned with the mapping or translation of any kind of information or content into visual and/or auditory form, as we shift the focus towards systems where sound and image are the tangible expression and consequence of a dynamic process (emphasizing processuality and interactivity).

On another level, what becomes defined as the distinctive quality of these systems is the dynamics of their behavior.[9] In contrast to other time-based forms of audiovisuality, they not only have a *transient*, but also a *variable* nature, that entails the temporal simultaneity and spatial co-attendance of the user. 'Liveness, immediacy and presence', become characteristic aspects of the experience of these process-based and participatory forms of audiovisuality (Jaschko 2010).

Consequently, our study is then dedicated to characterizing the *observable dynamics* of the work-as-process (as an activity performed in time), and of the work-as-system (that includes the user).

9. The notion of dynamics refers to the observable 'run-time behavior of the work-as-system' as part of a framework proposed by LeBlanc to understanding computational systems "where the interaction between coded subsystems creates complex, dynamic (and often unpredictable) behavior". Mechanics, Dynamics and Aesthetics are causally linked levels of the work, as "aesthetics is born out in observable dynamics and eventually, operable mechanics" or the underlying rules that formally specify the work "at the level of data representation and algorithms" (Hunicke, LeBlanc and Zubek 2004).

6. Perspectives on Audiovisual Interactive Systems

Drawing on the previous views on the audiovisual surface, the principles behind its creative shaping, and the qualities of these systems' behavior, we propose an approach to audiovisual interactive systems that articulates different viewpoints: it considers their heterogeneity as aesthetic artifacts, and addresses both their audiovisual and interactive dimensions under the perspective of the dynamics that defines their experience. Having applied these perspectives to four case-studies, while also relating their characteristics to those of other systems (Ribas 2012, 271–319), we now summarize its main points. In order to contrast different audiovisual configurations as well as contexts and possibilities for interaction we chose two online works and two installations: Antoine Schmitt's *Worldensemble* (2002), Peter Luining's *360° rotatable* (2003), *Manual Input Workstation* (2004) by Levin & Lieberman (Tmema) and *Se Mi Sei Vicino* (2006) by Sonia Cillari.

6.1. Systems as Aesthetic Artifacts

We begin by contextualizing their themes and principles according to their self-referential nature as works that are prospective in exploring the possibilities of software, with different aesthetic intents. These artifacts are considered abstract, or non-representational, since the audiovisual surface is a product of the work's operations and interactions. Sound and image, in their dynamic articulations, express the subject matter of these works, be it their potential autonomy (as endless audiovisual rhythms), reactivity to human actions (as audiovisual abstractions of interaction) or even as translations or expressions of specific aspects (e.g. gestural expression or proxemic relations) of human participation.

6.2. Audiovisual Dynamics and Interaction

We then describe their audiovisual surface behavior addressing the nature of its elements (predefined or generated), the ways they appear associated (correlated or responding to different factors), and related to user actions or input. We therefore approach increasingly complex articulations between human input and audiovisual outputs, as well as custom interfaces and physical forms of interaction. As the behavior of these systems may be tied to different factors, a perspective on interaction is not solely focused on action-reaction patterns, but on the overall variable behavior of the work, in each occurrence and in response to interaction.

6.2.1. Interaction and Agency

In order to develop this analysis, we revisit the notion of interaction according to the roles of user and system as agents determining the audiovisual outcomes. Rather than focusing on instrumental distinctions such as types, degrees or levels of interaction, we aim at characterizing the "*aesthetic processes encouraged*" by interactive works (Kwastek 2008, 22). To this end, it becomes useful to consider the "*aesthetic pleasure of agency*", as proposed by Murray (1997), which depends on the ways our actions are aligned with tangible effects. Agency is linked to the possibility to access different spaces, as a pattern of "*exploration and discovery*", and to the "*constructive role*" the users may assume when they can "*build in some way*" the very content of the work.

We discuss the ways in which the user may *explore or configure* the audiovisual surface, resorting to derivations of Aarseth's (1997) user functions. Nonetheless, they do not necessarily correspond to an alignment between action and effect. The users "*may not realize that they are affecting the artwork, nor (if they do) just what behavior leads to just which changes*" (Boden and Edmonds 2009, 35),[10] since there may be additional factors of influence, other than those explicitly related to user input or actions.

An alternative way of putting this is considering that agency, rather than pertaining to the user, is attributed to the system, in the very sense that Murray ascribes to it — taking 'meaningful action' leading to 'observable results'. Just as a human being has the capacity to sense its environment, operate on it, and make decisions, a system can be imbued with

10. These effects may be partial or divided between sound and image, ephemeral, not clearly perceptible or even not perceptible at all.

these properties. Agency can be understood as the "*property of an autonomous entity that is its capacity to act in or upon the world*" (Jones 2011). Interaction becomes a means of testing the behavior of systems that potentially run autonomously, in a self-organizing, and often unpredictable, manner.

6.2.2. Surface Dynamics and Determinability

Having examined the variable behavior of these systems as governed by different factors we describe their *surface dynamics* in terms of changes in the number, arrangement or creation of surface instances over time. The work's behavior is also characterized by its *determinability*, or the degree to which it operates predictably in the production of surface elements or configurations, in each occurrence, and in response to interaction. However, the audio and visual dimensions may not necessarily assume a correlated behavior, and the same applies to its determinability. The latter also leaves open what can be considered an exact repetition of the same experience, thus questioning the degree to which one can grasp, or control, the factors that define the precise configuration of the audiovisual outputs (Ribas 2012, 247–65).

6.3. Discussion

This description goes beyond the previous view on sound and image as means and products of interaction, and on their relations as mapping to user input, in revealing how each of the artifacts considered devises a specific way of governing the behavior or of generating visual and auditory elements, and in this process, include (or even depend) on the user. So rather than aiming at generalizations of their sound-image relations (as data mappings), we seek to underline distinctive features of their dynamics. We emphasize how sound and image acquire meaning through action, as the products of processes (performed by the system, with the participation of the user).

This approach also reveals how interaction entails different forms of engagement with the work as a means of exploring its (variable) behavior or its productive possibilities, or as a form of influencing, or of defining, its audiovisual outcomes.

7. Conclusion

This study addressed a topic of audiovisuality that is reshaped in reference to its medium. But rather than resolving this topic, it provides a point of departure for further investigating dynamic interactive audiovisuality. Namely, we envisage the study of a wider set of artifacts in order to refine an analysis of the characteristics of their behavior. While we have focused on describing the works' dynamics, future research also contemplates how the audience experiences its features, namely through structured observations of the interaction process. In particular, we can further examine its determinability (in relation to each modality), and the degree to which it is perceived by the user as a significant aspect of the experience of the work.

We approached a segment of contemporary practices that, in their diversity, often move ahead of theory. They reshape the very conception of sound-image relations beyond its dominant themes or approaches. Acknowledging this variance, this work responds to its demands, by conceptually framing the nature of these sound-image relations, as procedurally enacted dynamic articulations of visual and auditory modes, subjected to interaction. In this manner, it provides a direction for researching the constant creative reformulations of this topic. One that embraces the diversified nature of audiovisual systems as aesthetic artifacts, their principles, and themes, and what they propose as interactive experiences. It respects this diversity by describing sound and image, and their relations, according to the distinctive dynamics of these systems, or the variable (and often indeterminable) behavior, that defines their meaning and experience.

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Found Data: Generating Natural Looking Shapes by Appropriating Scientific Data

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Keywords: Installation Art, Generative Art, Interactive Art, Data Visualization, Public Data, Appropriation, Oceanography, Sustainability.

Abstract: The installation *Breathe/Live/Speak* utilizes oceanic data to generate an organic distribution of screen elements.

This paper describes the installation as part of the *Catch and Release* research/creation project. We introduce our approach of Found Data, derived from artistic practices of Found Object and Readymade, as an alternative to the widely used Perlin Noise for generating natural looking shapes.

The approach is demonstrated in detail, and some examples are presented. We outline how these are implemented in the installation, and conclude by arguing for the relevance of this method in a time of increasingly available data.

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1. Introduction

Practitioners in Generative Art have access to a wide range of techniques and methods for generating organic, natural looking shapes. In *The Nature Of Code*, Shiffman presents Cellular Automata, Koch-Curve Fractals, L-systems and Genetic Algorithms as a variety of methods for representing nature computationally (Shiffman). Our approach is different: we represent nature by directly using data from nature.

Manovich has suggested an analogy between visual arts and information visualization, and compares the choice of data with an artist's selection of a visual motif: "Figurative artists express their opinions about the world by choosing what they paint… Now artists can also talk about our world by choosing which data to visualize." (Manovich, 13)

Our aim in this paper lies in presenting our Found Data approach producing natural looking patterns. We refrain from offering a metric or criterion to evaluate how 'natural' a pattern looks, and leave this to the reader to assess. Instead we will discuss a thematic motivation for using a non-computer-generated randomness, and present the results we achieved.

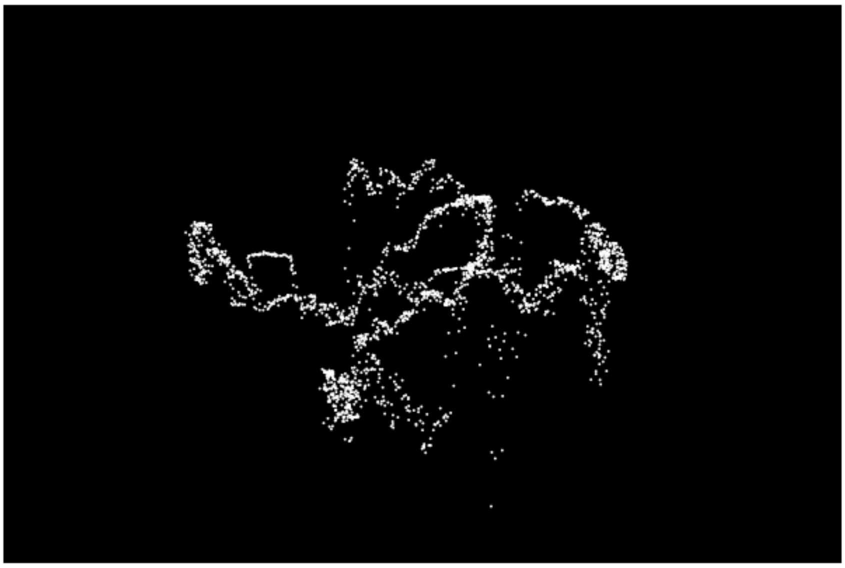


Fig 1. A Found Data plot with forms based on scientific data.

2. Catch and Release and the installation Breathe/Live/Speak

Catch and Release: Mapping geographic and cultural transitions is a research/creation project with the goal of raising awareness about current issues of cultural and environmental sustainability. This government-funded 3-year initiative acts as an umbrella for interdisciplinary art projects — interactive storyscapes that engage viewers with these issues through the immersive experience mediated by multimedia installations.

The interactive installation *Breathe/Live/Speak* is one of these projects — a dynamic composition of oceanic elements on projection screens. These elements — plankton organisms, bubbles, and typographic content — represent oceanic life, their motions suggest particles floating in underwater currents. The installation visualizes numerical empirical data from the *NEPTUNE Canada* regional cabled ocean network, which gathers live data from undersea environments in the Northeastern Pacific. An online platform makes these marine data publicly available — users find data on oxygen concentration, salinity, temperature, current, and other variables (Neptune).

By referencing the oceanic context, and through the subtle interactivity with the organisms and other screen-elements, the installation aims at raising awareness and reminding viewers of their impact on a fragile oceanic ecosphere.

3. Context

3.1. Situation between Generative Art and Data Visualization

Our work implements aspects of both generative art and data visualization. We borrow the autonomous generative process from generative art (Galanter), and the emphasis on representation of abstract data from data visualization. However, in contrast to the "clear and effective communication" Friedman demands from visualizations (Friedman), as artists we want to leave room for ambiguity and interpretation. We are not concerned with scientific semantics of our data, but will use it to generate aesthetic forms, in agreement with Manovich:

> The intent of these projects is not to reveal patterns or structures in data sets but to use information visualization as a technique to produce something aesthetically interesting. (Manovich, 13)

3.2. Perlin Noise

Shiffman observed that "In a computer graphics system, it's often easiest to seed a system with randomness." — and simultaneously pointed out problematics of this approach (Shiffman, 7). While different strategies of randomness and noise are prevalent in Generative Art, one approach is that of Perlin Noise, originally developed by Ken Perlin for textures in computer-generated animations. It is suited and widely used for generating unpredictable and "naturally looking" patterns featuring "the subtle irregularities of real objects" (Perlin, 12). Thus it would be a common approach for our purpose of generating a natural distribution of screen-elements.

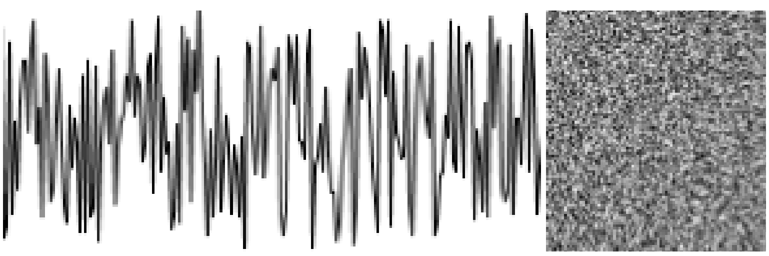


Fig 2a. The random-function: function graph and 2D pattern of grey values.

Fig 2b. The Perlin-Noise function: function graph and 2D pattern of grey values.

In contrast to a standard random function, Perlin Noise is coherent, i.e. two neighbour points will have a similar noise value. Perlin specified that “all the apparently random variations be the same size and roughly isotropic” — they will look similar in all directions and positions. (Perlin, 5).

3.3. Found Object and Found Data

Early twentieth century artists have introduced the Found Object into art history, an everyday object that obtains its state as a work of art through the selection and introduction into a new context. More particularly, with his Readymades, Marcel Duchamp

> … took an ordinary article of life, placed it so that its useful significance disappeared under the new title and point of view — and created a new thought for that object. (Duchamp)

Discussing the implications on authorship, Irvin suggests that

> Holding the artist responsible for a work means, in part, holding the artist responsible for having released it into a context where particular interpretative conventions and knowledge are operative. (Irvin)

The conventions of the new context are as important as the actual fabrication of the artifact.

In an analogy to a Found Object, we would like to suggest the term Found Data, in which data is ‘released into a context’, and a ‘new thought’ for that data is created. We present the use of Found Data as an alternative to implementing Perlin Noise.

We appropriate data for their formal qualities, and deliberately ignore their scientific denotations. The installation thus re-contextualizes scientific data and uses it for the creation of natural looking distributions of elements.

Representing physical real-world quantities, the number sequences in Found Data are mostly continuous and unpredictable as Perlin Noise, but variations may not be ‘same size’ and ‘isotropic’. As a shared objective however, we hope to produce natural looking patterns.

3.4. Our Motivations for using Found Data

The *Catch and Release* project intends to raise awareness about oceanic life. Our aim is to generate irregular patterns, which give the impression of elements being exposed to oceanic currents and turbulences. The patterns have to be capable of engaging the viewer’s capacity for seeing meaningful patterns in random data, and thus of opening an interpretive space for imagination.

The use of technical random numbers to raise awareness for nature seems to be contradictory rhetoric. Shiffman is not the only one to observe that

> Defaulting to randomness is not a particularly thoughtful solution to a design problem — in particular, the kind of problem that involves creating an organic or natural-looking simulation. (Shiffman, 7)

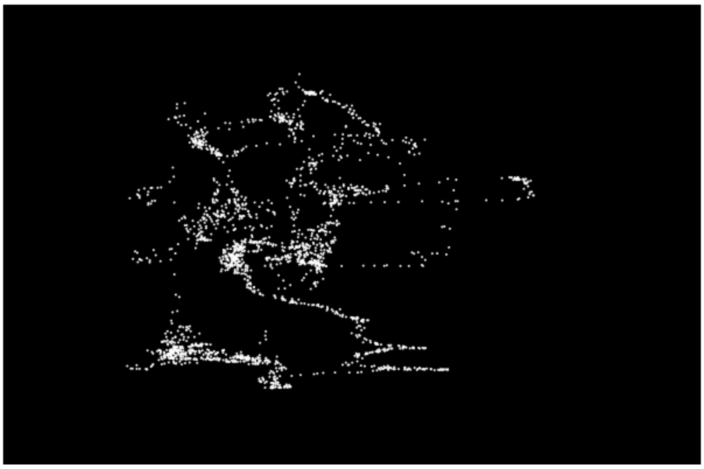
Randomness may produce counterproductive connotations of human non-involvement and technological arbitrariness. For this reason, we prefer a non-computer-driven positioning algorithm that bears a relation with the thematic concern of our installation — awareness for the ocean. By using the ocean as a data source, we provide a self-referential dimension to the work, and align the form with the content.

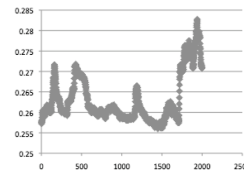
4. Research: Use of Data

4.1. Method: Drawing scatter plots based on Found Data

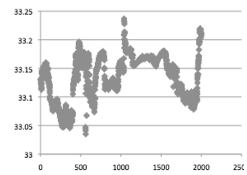
In this section, we are going to discuss in detail, how the data in the *Breathe/Live/Speak* installation is used to generate distributed positions of screen elements. Technically, our method consists of generating scatter plots of two variables. Such scatter plots are used to view and analyze a correlation between two variables. Strongly correlated variables will result in a diagonal linear distribution, whereas uncorrelated variables will not show a diagonal pattern and produce a distribution spreading over a wide range of the graph area.

For distributions with interesting and surprising shapes to arise, we look for a pair of uncorrelated variables to be plotted against each other. We choose measurements from different locations and times, to minimize interdependencies.





Barkley Canyon, Oxygen
Aug 13 2012, 15:15



Folger Deep, Salinity,
Aug 27 2012, 17:05

Fig 3. Scatter plot of two uncorrelated variables (right).

Figure 3 illustrates this method in detail. Data of *oxygen concentration* in Barkley Canyon is plotted against *salinity* from the Folger Deep sensor station. These locations are about 100km from each other, and the measurements are separated by a 14-day period, and taken at a slightly different time of day therefore we can hope they are not strongly correlated. The plot displays 2000 data points, taken in 1-minute intervals. Values of both datasets fluctuate in intervals between 10 minutes to several hours. This is long enough to generate surprising patterns, but not too long to result in a completely uniform distribution.

The graph bears minimal scientific meaning (if any at all), however we begin to see patterns, that we think have potential to be considered *natural looking*.

4.2. Requirements on the data

We impose minimal requirements on the data. We ask that data is continuous, fluctuating in intervals of the order of 100 data points, and that the two datasets are not strongly correlated. In this section we show some counter examples of data that are not suited for this method:

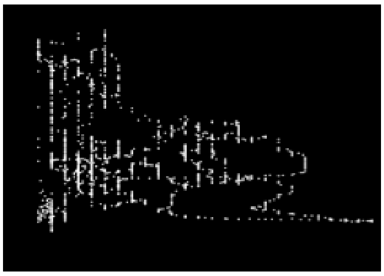


Fig 4a. Horizontal data is not continuous, but in discrete steps.

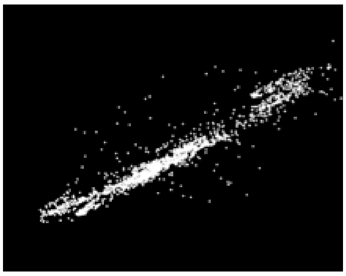


Fig 4b. Horizontal and Vertical data are correlated.

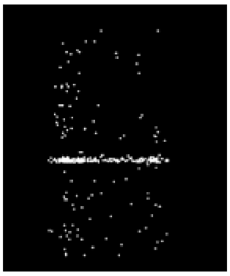


Fig 4c. Vertical data is not continuous.

We demonstrate three cases with data that are not suited for our method. In figure 4a, horizontal data is not continuous, but in discrete steps. These lead to regular gaps in the resulting pattern, which we want to exclude for aesthetic reasons.

In figure 4b, data series are taken from the same time and location — salinity and temperature from the Folger T station. The plot approximates a diagonally ascending line that we would expect from a scatter plot of partially correlated variables.

In figure 4c, the values of the vertical variable — the focus of an underwater video camera — are discontinuous and differ heavily between subsequent measurements. The data-points fill the entire space. Their distribution is mostly uniform apart from clustering vertically around an average value.

4.3. Gallery: Some examples

Fig 5. Barkley Canyon Oxygen vs. Folger Salinity.

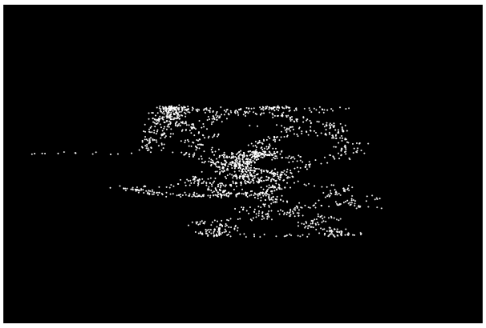


Fig 6. Barkley Canyon Oxygen vs. Folger Pressure

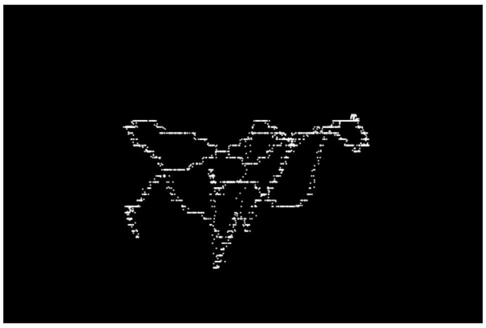


Fig 7. Folger Pressure vs. Barkley Canyon Temperature (bordeline case with discrete values).

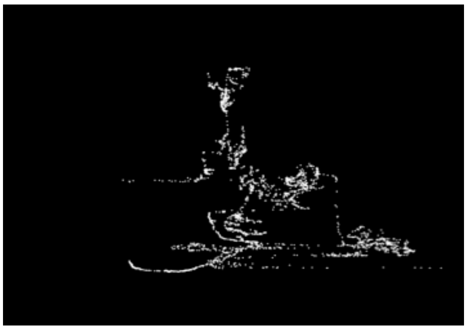


Fig 8. Folger Temperature vs. Folger Salinity.

4.4. Correlating a data series with itself, shifted in time

Fig 9. Barkley Canyon Oxygen correlated with itself, shifted by 13782 minutes.

Fig 10. Folger Temperature correlated with itself, shifted by 5461 minutes.

We also correlated data series with themselves, but shifted in time. Figures 9 and 10 display plots of data series that are correlated with series later in time, but from the same respective sensor. Our observations show, that more interesting patterns arise, once the offset between the two series is over some 1000 minutes.

4.5. Comparison to Perlin Noise

Fig 11. Perlin noise, correlated to other Perlin noise.

When applying our method to two series of Perlin Noise values, we obtain a similar pattern. However the plot looks more regular and less organic than our Found Data plots: the points are more uniformly distributed over the screen, and are lined up in quite regular distances along continuous lines. We speculate that the 'same size' and 'isotropic' properties are counterproductive for the use we have in mind.

4.6. Scaling patterns to cover the full screen

We earlier assumed that Found Data patterns may not necessarily be 'same size' and 'isotropic', thus at times they result in localized and off-centered clusters on the screen. In contrast, with our goal of creating an immersive experience, we wanted to situate the viewer *within* the data environment, rather than having her look *at* an object with finite contours. For our application in the interactive installation, we thus dynamically scaled the data to center patterns extending them to cover the entire screen area. This provides more immersion, although it compromises the density and conciseness of the patterns.

Fig 12. Off-centered plot.

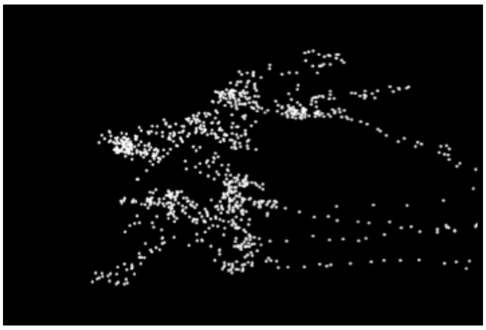


Fig 13. The same data scaled to fit screen.

5. Application

In the *Breathe*/*Live*/*Speak* installation, our method is used to position elements on interactive screens. Timing is chosen in a way so the elements appear to move as in an oceanic current, and the colour scheme further underlines this oceanic connotation. The colours, opacities and orientation angles of the individual elements are calculated using the same two datasets that were used to determine their position. We chose the range of visual parameters so as to create an evocative pseudo-spatiality contributing to the immersive aspect of the work. Viewers interact with the elements and distort their arrangement as a Kinect camera captures their body motions. Without their interference, elements will bounce back to their original, data-directed positions.

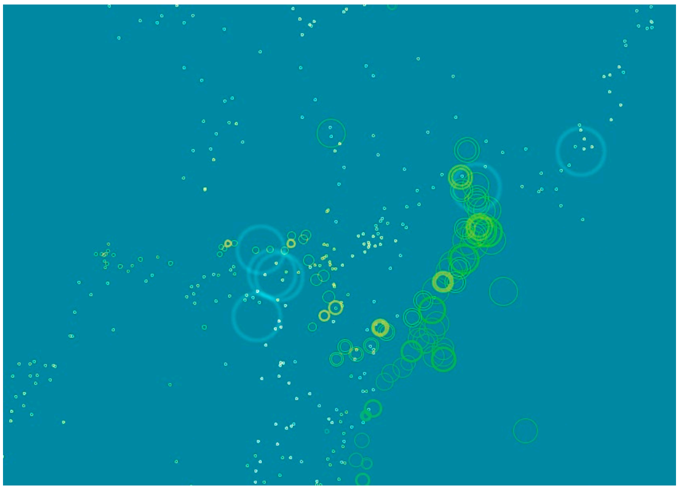


Fig 14. Installation — Screenshots: *Breathe* (detail).

Fig 15. Installation — Screenshots: *Speak* (right).

Three thematic screens illustrate different themes with varying choice of elements: *Breathe* with air-bubble elements, *Live* with plankton organisms, and *Speak* with typographic content.

6. Conclusion

We demonstrate how we use scientific data to generate natural looking patterns on aesthetic scatter plots. We chose to use empirical Found Data instead of Perlin Noise as a generative principle for positioning screen elements, as we find the method shares a thematic relation with our subject matter. Results show that our method is equally suited to produce natural looking patterns.

Our research and creative production suggests that *Found Data* may be a useful concept for directly linking the two closely related fields of Generative Art and Data Visualization. We think of it as an approach that offers a method with low predictability to enhance possibilities within Generative Art, and releases Data Visualization from the expectation of literal interpretation.

While this paper focuses in presenting the method used in our examples of installation artwork, we recognize that the method will benefit from more research to systematically clarify what kind of data will lead to interesting patterns.

Scientific and public data is increasingly accessible, and many observe an "outbreak of public visualization projects" (Lima, 97). With this paper we offer an approach for artistic use of data, and thus hope to inspire others to work with this method and to develop it further.

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Geometries of Flight: Remix as Nodal Practice

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Keywords: Audio-Visual, Remix, Hybridity, Nodalism, Video, Visual Music.

Abstract: This paper considers the authors' audiovisual work Geometries of Flight as an example of nodal practice as proposed by Philip Gochenour. The paper outlines Gochenour's concept and situates the 'remix' and the 'mashup' within this model. The paper interrogates various models of thought concurrent with Gochenour's to question the nature of the 'remix', appropriation, and originality in creative practice.

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"The task is to vision anew what is possible, but in a way that allows others to share the view."
Graeme Sullivan (2006)

1. Introduction

Geometries of Flight is an audiovisual work created by the authors in 2013. *Geometries of Flight* was commissioned by Tobias Fischer as a contribution to a publication centred on the work of Kenneth Kirschner. The brief for the project was to use any of Kirschner's compositions as the starting point for a remix. All of the sound artists commissioned were given free reign to use his work in any way with no restriction on length or media. The audio component of the project utilizes solely samples taken from Kirschner's *10 July, 2012* whilst the video uses youtube footage. The authors propose that their use of these materials goes beyond the accepted notion of the 'remix' and is an example of nodal practice.

1.1. Defining 'nodalism'

Developing out of Modernism and Post-Modernism, Deleuze and Guattari proposed in *Mille Plateaux* the notion of a rhizomatic culture, one in which hierarchical structures were discarded in favour of the concept of a planar network of connections. This concept of a rhizomatic understanding of society and culture has been elaborated further in Philip Gochenour's concept of nodalism. Although similar to the rhizomatic model proposed by Deleuze and Guattari, nodalism proposes a model and way of thinking adopted by a number of contemporary disciplines and in its 'neutrality' supersedes the cultural baggage associated with post-modernist thinking and its notions of deconstructivism, rationalization, parody, quotation and irony. Gochenour proposes that in the 21st century "*we find that our conception of the world has taken on a particular form, one of nodes situated in networks*." (Gochenour, 2011) He writes that the "*nodalistic trope can be simply described as a figure of speech that is used to portray an object or process in terms of the connection of discrete units by an open network system that has no hierarchical structure*." (Gochenour, 2011) In contemporary society the 'node' is ubiquitous — from referring to the internet as the 'web', the Facebook logo and our social networking structures, mathematics, transportation networks, computer science, economics and critical theory as well as its use in popular culture such as *Node Magazine* — a literary project initiated by Sean Kearney growing out of William Gibson's novel *Spook Country*. Gochenour maintains that nodalism "*has arguably become a dominant discourse within Western culture*." (Gochenour, 2011) Thus far this notion has not been applied specifically to music or visual culture.

We propose that nodalism is the way of approaching the production of all artwork in contemporary culture; that nodalism enables the reintroduction of a sense of *local*-hierarchy within a network and that understanding this *local*-hierarchy and its associated network is the means of interpreting and contextualising new artistic endeavour.

1.2. Riffs on 'remixing'

Understanding the concept of 'originality', where our ideas come from and how we appropriate, re-use and adapt familiar tropes is the subject of many academic texts.

Modernist texts such as Harold Bloom's *The Anxiety of Influence: A theory of Poetry* posits a central thesis that poets are hindered in their quest for an original voice because of the influence of other poets. Such an 'anxiety' can also be found in the 'ground zero' musical perspective of post–1945 composers such as Pierre Boulez and Karlheinz Stockhausen. From a nodalist perspective, however, all new artistic endeavour is a hybrid of pre-existing models, thoughts or work — or as Kirby Ferguson puts it "*everything is a remix*".[1] Michel Foucault in *The Archaeology of Knowledge* writes that, "*The frontiers of a book are never clear-cut… it is caught up in a system of references to other books, other texts, other sentences: it is a node within a network*." (Foucault, 1982) This method of thinking does not lead to a Bloomian anxiety but rather acknowledges culture and its development as an evolutionary process. Such a model is proposed in *The Selfish Gene* by Richard Dawkins (Dawkins, 1976). Dawkins' model of culture is one comprised of memes, units of cultural information that are transmitted from one individual to another. Eventually a critical mass of memes can be used to identify cultures and sub-cultures that have a shared understanding of such memes. From a nodal perspective, the identification of a genre is understood as a grouping of culturally encoded memes i.e. there is a local hierarchy of memes — certain memes are valued above others in order to form a shared sense of identity. In *Geometries of Flight* such 'memes' or 'nodes' are Kirschner's work 10 July, 2012; an approach to handling form, tonality, and sound processing that stems from the genre within which Kirschner's work is identified — a kind of instrumental experimental ambient music characterised by such labels as 12k, Room40, Spekk and Audiobulb.

1. www.everythingisaremix.info

From a compositional perspective, the conscious (or unconscious) usage of memes inherently implies the drawing together of different musical elements or stylistic traits either from within a genre, or from another genre: in other words, in electronic music — sampling (in the broadest sense of the word). This mode of thinking shares a close kinship with the post-modern sampling aesthetic of Paul Miller (aka DJ Spooky) who writes,

> Essentially, for me, music is a metaphor, a tool for reflection. We need to think of music as information, not simply as rhythms, but as codes for aesthetic translation between blurred categories that have slowly become more and more obsolete. For me, the DJ metaphor is about thinking around the concept of collage and its place in the everyday world of information, computational modelling, and conceptual art…the basic sense of "rhizomatic" thought — thinking in meshworks, in nets that extend to other nets — it's the driving force of my music and art… We live in an era where quotation and sampling operate on such a deep level that the archaeology of what can be called knowledge floats in a murky realm between the real and unreal (Miller, 2005).

Nodalism with its emphasis on interconnectedness seeks to understand phenomena through an understanding of the plurality of links or memes that link to the artistic work under examination. Nodalism, memetics and the rhizomatic are all means of discussing a post-structuralistic aesthetic in which the line between creating an 'original' artwork and one that uses elements of pre-existing material is fragile.

We argue that in light of the writings of Foucault, Dawkins, Miller et al, the concept of originality is such a loaded term that the 'material' which constitutes the piece is now not a relevant measure. To paraphrase Brian Eno, in contemporary practice it is the art of arranging and editing that is more important than content. It is this emphasis on arranging and editing material that is to be found in artists and works as diverse as Igor Stravinsky's *Pulcinella* (1919–20), William Burrough's cut-ups and John Oswald's plunderphonics.

In *Geometries of Flight*, as in the works cited above, it is the 'process' and reframing of the original material that is the most important factor in determining the identity of the new work rather than the embedding of 'samples' as referential units. In such works, material, concepts, and ideas are assimilated into the very fabric of the new work rather than merely weaving quotations into the surface level of the work.

In his book *In Praise of Copying*, Marcus Boon writes that "*The assemblage of a new artifact from fragments of preexisting objects or forms is one of the key practices of modernist aesthetics*." (Boon, 2010:145–146) Boon states that today the terms montage and collage are often taken to mean the same thing, and assemblage is often used to describe the use of similar techniques in sound and literary work. Boon continues,

> the power of *détournement*, the transformation of pre-existing elements in a new ensemble, "stems from the double meaning, from the enrichment of most of the terms by the coexistence within them of their old and new senses." It is in this sense that montage is a practice of copying, since it often involves the citation of the old object in the new. (Boon, 2010:146)

However, *Geometries of Flight* is not a montage. In a montage something is deconstructed and often, as in a commercial remix, it is important for the audience to be aware of the 'breaks'. Like Oswald's plunderphonics and Portishead's *Strangers*[2] , it is the identification of the 'breaks' that engenders understanding and meaning in the new artwork. A more elaborate example can be found in Robin Holloway's *Gilded Goldbergs* Op.86 (1992–97). The work transcends the transcriptions of Bach by Busoni to become an elaborate reworking within a contemporary idiom. Bach's *Goldberg Variations* provides the structural and harmonic framework which then acts as a springboard for musical portraits and character vignettes in the manner of Elgar's *Enigma Variations* Op.39 (1899). Holloway's work is neither a montage or a remix in that the structure of the original Bach composition — an aria and thirty variations is adhered to. Amon Tobin's works present a final and perhaps the most sophisticated example of such work. Tobin's albums *Supermodified*, *Permutations* and *Bricolage* take samples from a variety of sources and remix them into a new form with extensive processing. In Tobin's work the origin of the samples used is of less importance than their inherent musical interest to him as a musician. Although such samples when remixed nevertheless act as signposts to the original track, Tobin is not trying to 'say' anything about the specific combination of samples other than something musical. In this case the extensive nodal connections made carry no intended message rather the focus is on the resulting mix by Tobin.

2. Portishead, Dummy, Go! Beat, 1994

As such nodal practice is a more pertinent way of describing the work of Tobin and such figures as Fatboy Slim rather than the post-modern aesthetic of sampling and collage technique — also found in the work of composers such as Alfred Schnittke and Holloway.

In order to situate and understand *Geometries of Flight* as a work it is important to interrogate the notion of the 'remix'. In the commercial world of popular music the remix has a particular currency. Although exceptionally, Matthew Herbert may remix a track using only the packaging it was sent to him in, the normal process of remixing is,

> (...) to take an already finished track and remake it by using a combination of: rearranging it in a different way, removing parts, adding new parts, adding new effects, changing the genre of the music completely or whatever you can come up with to artistically make it different than the original. A remix is in an area of change from the original track that is more than just an edited version or cover version of the track but it is not too different that it becomes a new track that happens to sample the original (...) Making the original track artistically different — but at the same time keeping some essential elements of the original version.[3]

3. http://www.remixcomps.com/blog/guide-remix-contests-and-remixing-part-1 [accessed 16.1.2013]

Kirschner's *10 July, 2012* was used as a source for the sonic materials. Five short samples were taken and processed considerably. What results is a deconstruction of the conceptual identity of the original. As such it is somewhat removed from the notion of the remix cited above and also from the plunderphonics work of John Oswald insomuch that idenification of the original source is no longer relevant in the formation of meaning and understanding in the resulting artwork. In this sense Kirschner's work is not 'remixed' but becomes a repository of sonic resource to be drawn upon. From this perspective *Geometries of Flight* is not so far removed in its methodology from a work such as Elizabeth Hoffman's electroacoustic work d-ness (2011) which uses as its source material a recording of another of Hoffman's works *Red is the Rows* (2011) for two violins.

In his book *Crowds and Power* (1960) Elias Canetti maintains that imitation is only the first stage on the way to total transformation. Canetti's observations on the different degrees of transformation propose a spectrum of 'difference' between mere surface or superficial imitation and a total interior and exterior transformation. In *Geometries of Flight* Kirschner's original sonic material has undergone such a fundamental interior transformation resulting in an exterior that has little superficial sonic resemblance to the original. Yet there is still a kinship between the two. The question there is what remains of the original? Here we are reminded of Picasso's statement on abstract art which states that "*There is no abstract art. You must always start with something. Afterwards you can remove all traces of reality. There's no danger then, anyway, because the idea of the object will have left an indelible mark*."[4] Picasso's quotation suggests that there always remains a 'trace' of the original. In a commercial remix there often remains a surface level connection with the original track. Specific gestures, sound objects or motifs are embedded clearly in the remix as unambiguous signposts to the original track. In *Geometries of Flight* this 'trace' is to be found not in such blatant sonic markers but in the harmonic fields employed within the piece. The gestural language of *Geometries of Flight*

4. Pablo Picasso qotation cited from: http://quote.robertgenn.com//auth_search.php?authid=72 [accessed 16.1.2013]

is far removed from Kirschner's original. However, due to the layering of granular sound processing the harmonic characteristics of the original gestures and phrases is evident. In this sense the notion of the remix is extended to include deeper level musical processes and a more experimental approach to listening as expounded by Smalley (1997).

The remix therefore becomes not merely the reframing of elements from one node — the original track itself, but establishes a local-hierarchy of other nodes regarding the identification of style and context. In the case of *Geometries of Flight* the 'remix' involves nodes that draw together Kirschner's oeuvre, the genre in which he works, the author's own work and idiom, sound processing techniques and the sonic trace of software, reading audio-visual materials, sampling, Smalley's technological listening, as well as other audio works. It is these additional nodal connections that makes the contemporary remix such a rich creative endeavour.

2. Knowing through visual remaking

2.1. Understanding through of visual editing on verbal cues

Nodalism, beyond presenting a contemporary approach to poietics and 'originality' is also a vehicle for understanding in that it provides for a nodal hierarchy in which to traverse a work of art; it can become a research procedure as well as a creative one. Discussing what constitutes a research act in art practice, Graeme Sullivan (2006) tells us that,

> if the purpose of research is the creation of new knowledge, then the outcome is not merely to help explain things in causal or relational terms, but to fully understand them in a way that helps us act on that knowledge.

This acting is the creation of a new work of art. The visual language employed in *Geometries of Flight* is one such example of acting on new knowledge provided by the music. In conversations between the authors we found a common subjective visualisation of the large swathes of granular material as an 'epic freeze'. This new intersubjective knowledge, began to disambiguate the meaning of the new music, to paraphrase Tagg (Tagg, 2012:Loc 156), by going beyond the iconic, indexical and connotative types of semiosis we would normally expect. These were simply not obvious as the music resembled itself and other instances of granulations and ambient composition yet with a particular take on the original material (broadly Lo-Fi, irregular piano music passages revealing a recognisable sample of the original almost halfway through the piece). By placing ourselves at the receiving end of the communication process (Tagg, 2012) and trying to find common verbalisations to express the musical experience we came up with imagined landscapes of glaciation, of flight, of blinding whiteness, and of arbitrary arrangements of streaming video within the cinematic canvas. For now, let us consider the audiovisual discourse yielded by the second degree of remixing the Kirschner which is the visual mode of *Geometries of Flight*.

In an attempt to capture this 'epic freeze' image, one of the authors scoured youtube with the intention of finding vistas of arctic or antarctic landscape where ice would be prominent. This led also to the inclusion of aerial polar landscape footage. Once this material had been identified, a process of de-contextualisation began. The idea was first to create a database of 'ice materials' that brought to mind the musical strands in the audio mix, secondly it became important to make explicit that this was to be, in the words of Lev Manovich (2001:Loc 241) an instance of 'database imagination'. Much like the original Kirschner is broken down, modified, re-selected, given order and re-layered, the visuals attempted to do the same — in essence, the same nodal practice is applied in both the musical and the visual domains. The resulting edit of video attempting, again paraphrasing ideas of Manovich (2001:Loc 297) a simulacra of new media. With the visual loop at its core *Geometries of Flight* now results in a non-story that tells the gradual discovery of a visual language. And much like Manovich's assessment of Dziga Vertov as providing narrative through a gradual process of discovery of the database (Manovich, 2001:Loc 266), we have released our database of visuals as a gradual discovery of the sounding music of *Geometries of Flight*.

Rather than being an attempt at verbosity, we mention 'sounding music' in an intended contraposition to 'visual music'. The term visual music, coined by art critic Roger Fry in 1912 to describe the work of Kandinsky is perfectly consonant with our intentions for *Geometries of Flight*. In our case, the sounding music gives rise to the visual music, mediated by the authors' intersubjective experience. Garro (2012:103) gives an informative account of visual music primed for the consideration of electroacoustic music, especially in the binding of the visual experience to time (even as we regard the canvas, beyond the first general intuitive sighting, we traverse 'that which is framed' in time). Kandinsky's 'improvisations' and 'compositions' between 1910 and 1914, operate according to this timed viewing. And it is interesting to consider pieces like *Composition VIII* (1923) as an example of an image that needs to be traversed to be comprehended, the overall view not revealing anything other than multiple paths for the eye to consider. In *Point and Line to Plane* (1926), Kandinsky makes much of sound to describe what is in essence visual, eventually both becoming the same thing: organised vibrations experienced in time.

2.2. The Plunderphonic model: understanding by remaking

Plunderphonics is a good example to look at to illustrate this understanding of Kirschner's original material and deriving new knowledge from it by remaking it. In an interview with Norman Igma, John Oswald defines a plunderphone as "*a recognizable sonic quote, using the actual sound of something familiar which has already been recorded…*" Further, he distinguishes that from musical quotation: "*Whistling a bar of* Density 21.5 *is a traditional musical quote. Taking Madonna singing* Like a Virgin *and re-recording it backwards or slower is plunderphonics, as long as you can reasonably recognize the source*" (Igma, 2000). The key characteristic of the plunderphone is the ability of the listener to recognise the source. This act of recognition mediated by transformation raises interesting epistemological issues. These can be discussed usefully in three ways that are applicable to any remix aesthetic.

Firstly, by choosing objects to be remade or imitated, we begin a process of critical categorisation, and categorisation shows understanding. For instance in *Brown*, from John Oswald's 69/96. This piece is a veritable catalogue of 'James-Brownisms' where Oswald takes us on a lightning tour of funkiness. In this piece we find that the samples of James Brown are chosen and grouped according to various strands: shouts, beats, saxophone solos, hits, vamps etc. These elements are not just samples from the source (James Brown) but they are a choice of what makes James Brown into 'James Brown', from Oswald's point of view. They demonstrate Oswald's understanding of James Brown. This understanding is not expressed through language, but through placing samples one after another as well as alongside each other. The resulting listening experience is a transmission of this knowledge of 'James Brown', and is both an interpretation (hermeneutic process) communicated to fellow musicians as well as a new musical artefact gifted to the audience.

Secondly, attempting to blend together our material into new constructs, we also evidence that we understand the basic morphology of that material. Again, in *Brown*, if we look at the combination of hits, vocal cries and beats we see matching by beat, texture and general 'shape' likeness. A further level of complication comes from the 'framing' of the material for remixing. In this way a whole bar of a drum break may be cut and placed, a single "get down!" shout may be trimmed just so. The result becoming a new rhizomatic expression of 'James Brown' yet nodalised by the very act of ordering. Music, being time based, declares precedence and being amplitude sensitive, declares hierarchy (importance). In this way what is chosen as an introduction ("one, two, three, four... [stutter]") is clearly there as both an indexical sign (the count) and iconic sign (Tagg, 2012:117) (James Brown's characteristic voice and count-in). The following saxophone squeal is subservient to the beat and we know this because the amplitude of the drums is greater, the saxophone becoming just a colouring, perhaps a vocal anaphone of James Brown's funky yelling.

Similarly, in *Geometries of Flight*, an intimate relationship with the piece by Kirschner (*10, July 2012*) is evidenced by the choice and layering of granulations of the original piano material (a piece which wanders pleasantly in semi-improvisatory phrasing through cyclical note/chord sequences). Where Kirschner seems not to imply necessary harmonic, timbral or melodic precedence, *Geometries of Flight* interprets the essence of the piece as a celebration of the piano sound both in texture and register. It does this by presenting broad swathes of granulations which highlight the importance of timbre by 'freezing' and overlaying different samples of the original piano texture. The non-teleological 'cyclical' structure of the original is distilled into 'frozen' layers of sound. But further than this, *Geometries of Flight* imposes a form, thus re-framing the samples within a new 'com–position' (the act of putting things together anew). This is to say that the position or placement of the sounds obeys a new form. This new form results from basic compositional choices: what goes first; what goes second; if sounds are playing together, which should be louder?; how many sounds can co-exist at any moment in the mix, etc.

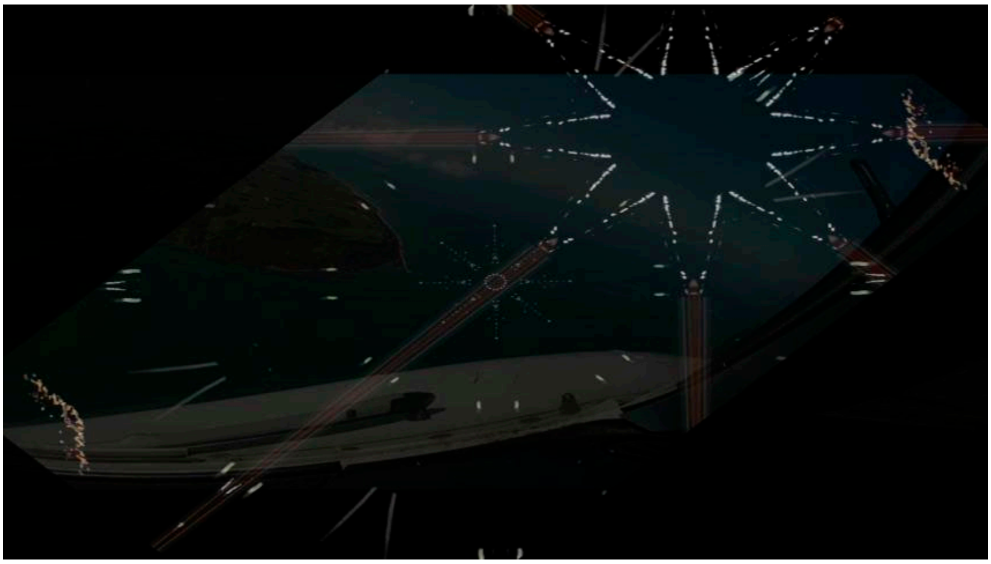

Fig. 1. Geometries of Flight: layers reframed[5]

5. https://vimeo.com/57453946

Thirdly, when remaking through mashup/remix, we show an understanding of semantic value and the ability to recombine the original material into new semantic constructs. In parallel to the audio discourse, the visuals in *Geometries of Flight* show both iconic signs (as snow and ice are presented) to the idea of 'freezing' sound through granulation and an indexical sign through synchrony with chosen moments of presumed musical importance. Iconic signs that evidence an understanding of layering within the sound world are also evidenced by visual layers of video. Each telling its own story but only partially, enigmatically, thanks to the framing of the streaming video, the choice and the positioning within the screen as 'canvas'.

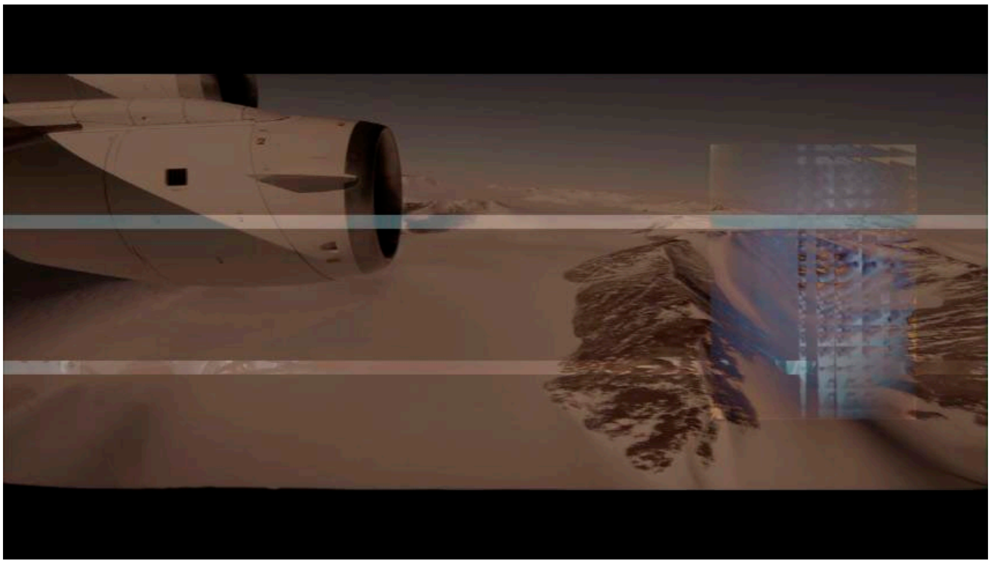

Fig. 2. Geometries of Flight: indexical and iconic signs of freezing[6]

6. https://vimeo.com/57453946

Our imagination is embodied in our art practice. Ideas become tangible as the work gets made and our 'thinking in a medium' (Sullivan, 2006) raises domain-specific epistemological issues as the piece takes shape. *Geometries of Flight* evidences audiovisual thinking as much as it does musical thinking and insights about both modalities are primed by each other.

2.3. Remaking and 'liking' as confirmation of knowledge reception

Remixing something shows at least interest in the original if not outright appreciation, yet placing the work in the contemporary social web yields further signs of acceptance (and possible understanding) for a work. Contemporary social media requires that we react to what is shared with us. The ubiquitous 'thumbs-up' icon popularised by Facebook is now to be found anywhere content is presented on internet. Twitter and Google+ have their equivalents in 'favourite' and '+1' respectively. At the same time, sites like Vimeo, Flickr or Soundcloud allow for author-enabled downloading and sometimes attaching Creative Commons licenses that tell us what we are allowed to do with the media (usually implying that we should probably think of doing something with it!). This 'liking' seems certainly a way of confirming the artistic 'message', which is the work itself. We 'like' if we like and we do not 'like' as a passive indication of either indifference or rejection (which for an artist is the same). The new Facebook Graph Search, for instance, is a way to trawl through the evidences of reception of media shared on the net as well as identifying 'meta-communities' of 'likers'. This introduces nodal thinking into the social reception phenomenon. In the same way that the artist categorises, orders and evaluates signification introducing nodalism into what was essentially rhizomatic thinking, now *liking* establishes nodalism in reception. The 'database narrative' described by Lev Manovich in his *Language of New Media* (2001) finds an equivalent in a sort of 'database reception'. Here, audio-viewers are then able to categorise, order and assess signification through the construction of playlists or collections and by grouping themselves into communities of friends/subscribers.

Although the above applies to text-based media, we could say it finds its real purpose in non-verbal media. Audiovisual art evidences the world in a non-verbal manner so it is only fair that it will demand just two things of its audience: to like or to remake. If the latter is intended, then downloading or sharing will be enabled, but the dynamics of the net are such that often sharing may be construed by the simple act of posting, with the knowledge that copying is possible and easy. In this sense Graeme Sullivan (2006) captures the interaction between artist and audience perfectly when he writes:

> There is an acknowledgment that art practice is not only a personal pursuit but also a public process that can change the way we understand things. Consequently, the ideas expressed and communicated have an interpretive utility that assumes different textual forms as others make sense of what it is artists have to say through what it is they see. Interpretive research acts build on the rich conceptual traditions associated with image making whose purpose is to open up dialogue between the artist and viewer, and among an interpretive community whose interests may cut across disciplines… (Sullivan, 2006).

3. Conclusion

Nodalism engenders a means of understanding the creative work and brings together the oft cited characteristics opposing Modernism with Post–Modernism into a neutral frame that considers all materials, ideas, and concepts can be hybridised and developed in the creation of new artwork. The authors also propose that nodalism, if one accepts a memetic understanding of culture, allows a local-hierarchy of nodes (or memes) to be re-introduced into an essentially rhizomatic model. Further, nodalism introduces tools to understand a work of art and to evidence this through remaking. Where all nodes of a rhizomatic structure are egalitarian, nodalism introduces a sense of direction by virtue of hierarchy. This then becomes useful for finding one's way through databases of creative materials.

The hierarchy of nodes is not that between 'high' and 'low' art or the inherent value of one artwork over another, but rather the preferencing of certain nodes over others. It is acknowledged that whilst larger nodal interconnections will assist in the definition of genres, more localised nodal connections will define a specific artists idiom within this genre.

In contemporary artistic practice it is the modernist Bloomian anxiety that ironically may well produce unoriginal work. It is the outward looking practice of nodalism that facilitates a plethora of resources to be plundered. It is arguable that the more nodes one is aware of, the more original one's work will be. A similar model is found in Jacques Lacan description of the linguistic signifying chain which he described as 'rings of a necklace that is a ring in another necklace made of rings' (Lacan, 1977:153). Or to put it in the language of semiotics applied to music proposed by Tagg (2012), the mapping of one semantic network made up of nodes to a new one of nodes re-made.

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Traversal Hermeneutics: The Emergence of Narrative in Ergodic Media

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Keywords: Generative Aesthetics, Computational Art and Design, Interaction, Narrative, Cognition.

Abstract: Digital technologies are capable of simulating traditional media and to give rise to new media forms that often closely resemble the experience of somatic technologies. Their interactive capabilities are partially responsible for this, but procedural authorship and poïesis are supported by process intensity and generative potential.

Designers, the systems and their human operators have very different and maybe irreconcilable points of view, which profoundly affect their experiences during the dialogical construction of the works and of their effusions. From its particular point of view during the traversal, the operator develops a hermeneutic experience during which models and simulations of the system are built. The operator's actions within the system greatly contribute to this development, but it is their capacity to create theories of the system that is paramount to the success of this effort.

The analysis and critique of these digital artifacts, indeed the procedural pleasures attainable through these systems, are indissociable from their procedural understanding. Although traditional aesthetic studies of surface structures or outputs are still possible, once we regard behaviors and computational processes as an integral part of the system's content, it becomes essential to understand how the operator relates to these beyond a strictly mechanical relation.

This paper discusses how models and simulations allow the operator to anticipate the behaviors, reactions and configurations of the systems. How they are continuously revised, confirmed or falsified throughout the traversal, and how this process results in a dialectical tension that is the basis for the development of narratives and of dramatic experiences with these, otherwise highly abstract, systems.

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1. Artificial Aesthetic Artifacts

In his book *Collective Intelligence*, Pierre Lévy proposes a classification of the "technologies used to control message flow" (1997, 45) in three groups that he terms somatic, molar and digital. Somatic technologies are defined as those implying "the effective presence, commitment, energy, and sensibility of the body for the production of signs", and that are also characterized by the multimodal nature of the messages produced and by the uniqueness of each message, that is always produced in and dependent on a dynamic and complex context that inevitably affects it.

Molar technologies, that we usually simply call *media*, much as Lévy also does, "focus and reproduce messages to ensure they will travel farther, and improve distribution through space and time." (1997, 46) They are described as technologies that inevitably affect the production of messages but that "are not, as a first approximation, technologies for sign creation", rather for the "fixation, reproduction, and transportation of somatically produced messages." (1997, 46) Their capacity to create new signs is very limited, but it may be felt in media such as film, where the processes of montage introduce some potential for the generation of new messages for, "although the raw image or sound may be stored on the recording, the global message — the film — results from (…) montage." (1997, 46)

Digital technologies stem from digitalization, the "absolute of montage" that affects "the tiniest fragments of a message, an indefinite and constantly renewed receptivity to the combination, fusion, and replenishment of signs" (1997, 48) that preserves the power to record and distribute information while bringing the technologies closer to some of the characteristics of somatic technologies. This, however, only happens when digital technologies are able to retain a certain degree of what Chris Crawford called *process intensity*, "the degree to which a program emphasizes processes instead of data" (1987), and consequently retains some generative potential (Boden and Edmonds 2009). Perhaps naturally, given the way how we tend to relate to any new medium in the light of the previously existing media (Bolter and Grusin 1999, McLuhan 1964), digital technologies tend to follow on the steps of their molar predecessors, thus optimizing for constancy and effectivity, or for *data intensity*, instead of investing the technological resources in developing procedural and participatory traits (Murray 1997, 71). Many digital media are built with the explicit intent of simulating the traits of molar media rather than trying to escape from the conventions and limitations of previous technologies. We therefore find that in such cases, the potential of the technologies is not "effectively exploited" (Lévy 1997, 49), even if they are digital and computational.

> Processing data is the very essence of what a computer does. There are many technologies that can store data: magnetic tape, punched cards, punched tape, paper and ink, microfilm, microfiche, and optical disk, to name just a few. But there is only one technology that can process data: the computer. This is its single source of superiority over the other technologies. Using the computer in a data-intensive mode wastes its greatest strength. (Crawford 1987)

The code of these technologies is where the potential for procedural authorship resides (Murray 1997) but, while opening spaces of possibilities, code may also enforce strict limitations within those spaces. The code is the *law* that governs these technologies and their products (Lessig 2001, 35), a law that one has no option besides abiding to, save for actually interfering with the code, something which may in some cases actually remain a possibility but that is far from being the norm when it comes to the experience of digital media.[1] Therefore, once one develops a digital medium as an analogue of molar media, one is building an experience that may have some benefits over the molar equivalent — such as speed, economy, etc. — but that may actually limit the freedom to explore and to reconfigure the messages being communicated. Aarseth (1997, 46) offers the example of William Gibson's 1992 poem *Agrippa (a book of the dead)* as a digital message that was built to force and preserve its linear integrity in ways that wouldn't in principle be achievable with molar media and that are strictly enforced by the nature of code.

We may therefore posit that if digital technologies allow us to develop radically new media and messages, they may also allow us to develop artifacts that outperform conventional molar media in regard to their specific traits. We are consequently faced with an ambiguous descriptor that may be equally applied to media with very diverse traits. For this reason we proposed the alternative designation of some digital media as *artificial aesthetic artifacts* (Carvalhais 2010, 2011b), a term that simultaneously points to their sensorial nature and to their essence as computational systems, as systems where computation is not only found at the *logical* or *code* layer (as defined by Lessig) but is also an integral part of the *content* layer.

Artificial aesthetic artifacts have the potential to develop what Christopher Alexander calls a "living structure" (2002): they are process intensive (regardless of whether they use data structures and of their complexity and extension), they are autopoietic and they are rich in procedural authorship.[2]

To consider a subclass of digital media as artificial aesthetic artifacts allows us to better understand the importance of the added dynamics and of the more complex user functions that are involved in their creation and experience. It allows us to better parse between digital systems that are closer in their nature and modes of operation to molar media and those that in some ways become more similar to somatic technologies. Artificial aesthetic artifacts become utterly dependent of their contexts of operation to develop messages that, regardless of the initial structures or of the intended final configurations are unique, messages that, in Lévy's words, become "inseparable from a changing context" (1997, 46). This was, of course, how Lévy described somatic messages, that are "never exactly reproduced by somatic technology" (1997, 45), and it is fitting to think of artificial aesthetic artifacts along the same lines. The contexts are necessarily different, perhaps at times less linked to physical settings[3] and more dependent on interaction, interpretation and on the procedural contexts at the core of the systems, a layer that, as we will see is difficult to perceive directly.

If digital technologies that simulate traits of molar media can, in some ways, be seen as stepping even further from the traits of somatic messages, we find that artificial aesthetic artifacts bring us closer to that original essence of the technologies for message production that are centered in the human body and that are dependent from it. If the focus of molar technologies can be described as *fidelity in reproduction*, that of artificial aesthetic artifacts may very well be *variety in every instantiation*. To keep recognizable structures or patterns between instantiations but to creatively infuse them with disorder, as suggested by Italo Calvino (qtd. in Aarseth 1997, 129).

1. Not quite with the experience of digital technologies. If in many occasions there is at least the theoretical possibility of accessing and editing the code of a digital medium, more often than not, that experience is not simple or straightforward, or it may not fit within the expectations of the users or readers.

2. We may identify this procedural authorship both in the author as well as in the readers, users or interactants, and even within the system itself, which may be the bearer of a considerable degree of autonomy.

3. Although this is naturally possible, as any message that originates in a digital medium must eventually be translated to sensorial stimuli before being perceived by humans.

Coprocessing (Aarseth 1997, 135), the human-machine regime of collaboration that is found at the heart of many of these systems, allows the conversational construction of the works and of their effusions. But as we will see, even non-interactive systems, or those where reader's inputs may be minimal, can be construed through iterative exchanges of information between the systems and their users.

According to Aarseth, cybernetic systems — as we may classify many of these artificial aesthetic artifacts — can develop three regimes of collaboration with the human, "(1) preprocessing, in which the machine is programmed, configured, and loaded by the human; (2) coprocessing, in which the machine and the human produce (...) in tandem; and (3) postprocessing, in which the human selects some of the machine's effusions and excludes others." (1997, 135) Alexander Galloway concurrently proposes the identification of *machine actions* and of *operator actions*, the first of these "performed by the software and hardware" (2006, 5) and the later by the human, clearly distinguishing them in scope but warning us of the artificiality of the division, as "both the machine and the operator work together in a cybernetic relationship", which makes both types of action "ontologically the same", existing as "as a unified, single phenomenon, even if they are distinguishable for the purposes of analysis." (2006, 5)

Notwithstanding this, if we want to understand the relevance of artificial aesthetic artifacts as communicational and artistic systems, we should be careful to maintain the distinction in the analysis because not only in the pre- and post- positions but also in coprocessing, the roles of the human operators are indeed different from those of the machines; perhaps more importantly, the points of view of the machines or systems (Bogost 2012) and of the humans at the different positions of collaboration may be quite different.

To better understand this, it may be useful to resort to Hunicke, LeBlanc and Zubek's *MDA framework* (2004), originally developed as a formal approach to game design and game research. The domain of computer games is of course one where we can find several artificial aesthetic artifacts, and one from where we can extrapolate a large quantity of knowledge for their study.

MDA, for *Mechanics*, *Dynamics*, *and Aesthetics*, is a framework for understanding games that aims "to bridge the gap between game design and development, game criticism, and technical game research" (Hunicke, et al. 2004) by proposing an approach by both the perspective of the designer and that of the player, two views through which we discover a wide range of possibilities and interdependencies in a system. MDA is developed from the assumption that games are characterized by a "relatively unpredictable" consumption, meaning that the "string of events that occur during gameplay and the outcome of those events are unknown at the time the product is finished", and that the main content of a game is its behavior, not the media that eventually "streams out of it towards the player." This is a sense in which we again discover code as the content of games, described as being "*more like artifacts than media*". MDA therefore formalizes the consumption of games by analyzing them in three distinct components: *Rules*, *System and "Fun"*; and establishing their design counterparts, described as: *Mechanics*, *Dynamics and Aesthetics*.

> **Mechanics** describes the particular components of the game, at the level of data representation and algorithms.
> **Dynamics** describes the run-time behavior of the mechanics acting on player inputs and each others' outputs over time.
> **Aesthetics** describes the desirable emotional responses evoked in the player, when she interacts with the game system. (Hunicke, et al. 2004)

Each of these three components can be considered as a "lens" to the game that is separate from, but causally linked to, all the others and that shapes the perspectives one may develop:

> From the designer's perspective, the mechanics give rise to dynamic system behavior, which in turn leads to particular aesthetic experiences. From the player's perspective, aesthetics set the tone, which is born out in observable dynamics and eventually, operable mechanics. (Hunicke, et al. 2004)

We can therefore identify the layers of emergence in the system's becoming after the preprocessing stage, and consecutively understand the converse layers through which the player, reader or interactant may peer through in the dialogue with the system. The more a system is characterized by process intensity, the more complex will the emergences from one layer to the next be, the more control and agency (Murray 1997) the author may need to offer to the user, to the system or both.[4] Therefore, by focusing and filtering the perspectives, each of these layers inevitably affects the degrees of control that each coprocessor can have within the system.

3. Reader's Roles

Although Aarseth doesn't use the term *consumption*, he addresses the unpredictability of the experience of ergodic texts[5] — and by extension of other ergodic media — through the analysis of their traversal function, the mechanisms by which units of the system are revealed as surface structures that are presented to the human operator. The analytical model — Aarseth's "textonomy" — developed in *Cybertext* is built as a descriptor of the artifacts according to their modes of traversal, each variable focusing on different aspects of the traversal function that uniquely characterize each of the systems: *Dynamics*, *Determinability*, *Transiency*, *Perspective*, *Access*, *Linking and User Functions* (Aarseth 1997, 62-64). In spite of the "relative neglect of the political, social, and cultural contexts in which texts are used" and of the "interactions of different modalities within electronic texts" (Hayles 2005, 36), the model is nevertheless possible to apply to similar traits in systems whose primary function is not "to relay verbal information" (Aarseth 1997, 62) or with outputs that are not exclusively verbal, although there is room for improvement and completion by expansion with further variables (Carvalhais 2010, 2012).

Trough the traversal, human operators always develop an interpretative function, similar to that we can find in more conventional media, where all decisions made by the reader only concern meaning. In the case of ergodic media and of artificial aesthetic artifacts, this interpretative function may be accompanied by three additional functions

4. We often refer to user as a singular human counterpart in the system's operation. We should however note that very often this user can of course be plural, and distributed, both in space and time, or the user's role can be occupied by another artificial aesthetic artifact, or by parts of the same artificial aesthetic artifact, itself a very singular form of plurality.

5. "During the cybertextual process, the user will have effectuated a semiotic sequence, and this selective movement is a work of physical construction that the various concepts of 'reading' do not account for. This phenomenon I call ergodic, using a term appropriated from physics that derives from the Greek words ergon and hodos, meaning 'work' and 'path'. In ergodic literature, nontrivial effort is required to allow the reader to traverse the text." (Aarseth 1997, 1)

postulated by Aarseth (1997, 64): the *explorative function*, in which decisions can be made regarding which paths to take along the traversal; the *configurative function*, in which the order of the parts can be rearranged and the navigable structure can be created, shaped or influenced, more than just explored; and finally, in Aarseth's model, the *textonic function*, in which these parts can be permanently added to the (textual) system. We can generalize Aarseth's textonic function by shifting its focus from textual structural components towards any component of the system's outputs (regardless of their nature or modalities) or even of the system's code, thus calling it *structural* (Carvalhais 2011b, 375).

Aarseth's user functions are very good descriptors of the nature of the human operator's cybernetic interactions with the system. The omnipresence of the interpretative function can perhaps be seen as an extraneous emphasis, especially on media from which verbal structures are so often absent and where high levels of abstraction further remove one from any apparent meaning in the systems' emanations. Markku Eskelinen, for example, warns us of how in computer games, "we interpret in order to be able to configure and move from the beginning to the winning or some other situation, whereas in ergodic literature we may have to configure in order to be able to interpret" (2001), thus displacing the primacy to the configurative function (Bogost 2006, 108). In spite of this view, and regardless of its dominance over any of the other functions, interpretation is nevertheless prevalent.

And interpretation becomes especially important in the experience of artificial aesthetic artifacts because, besides semantic interpretative acts — that may or may not occur depending on the nature of the system's sensorial outputs, of which particular symbols are produced, etc. — there are several aesthetic interpretative acts that need to be performed in order to achieve a *poetic* understanding of the system. Much as machine and operator actions fuse, so we may propose that semantic messages "expressible in symbols, [and] determining translatable, logical decisions" and aesthetic messages, "determining interior states, [that are ultimately] untranslatable" (Moles 1966, 167) may also become somewhat indistinguishable in the exchanges with the aesthetic artificial artifacts.

At the layers of mechanics and dynamics, systems most often operate in a space of possibilities that anticipates the differentiation of modalities (Hansen 2004) that happens at the layer of aesthetics. When confronted with the modal outputs of the transcoded processes, the human operator tries to deduce meaning from them, not only a message that may be communicated but also clues to the procedural nature of the outputs, to their origin and significance. As so often happens in other contexts, humans try to identify a *design stance* that explains the purpose of inanimate objects, and *intentional stances* that point to the why of the behaviors of animate objects, to their motivations and emotions (De Landa 1991). Although crossed and combined, and eventually arbitrary (i.e., not trivial) in their relation to the previous two layers, these outputs — symbols and behaviors — are the only hints, the only points of access the operator has to the "internal, coded level", that "can only be fully experienced by way of the external, expressive level." (Aarseth 1997, 40)

> When inactive, the program and data of the internal level can of course be studied and described as objects in their own right but not as ontological equivalents of their representations at the external level. (Aarseth 1997, 40)

An alternative way of understanding this relation is put forward by Douglas Hofstadter, that explains that “although what happens on the lower level is responsible for what happens on the higher level, it is nonetheless irrelevant to the higher level”, which “can blithely ignore the processes on the lower level.” (2007, 43)

So, although artificial aesthetic artifacts can still be subjected to traditional aesthetic analysis at the level of their outputs, the operator needs to develop a more comprehensive procedural interpretation of the system, in order to understand, decode, and ultimately, to relate to their mechanics and dynamics layers.

Through procedural intuition (Strickland 2007) and the interaction with the system, the human operator starts to build hypothesis about the mechanics and dynamics layers of the system. These hypothesis are developed as simulations of the system or of its constituent parts, simulations that are not consciously created but that nevertheless provide the operator with possible scenarios about the system’s outputs or behaviors, about the causal procedurality of the phenomena she interacts with (Dehaene 2009). This task is aided by cognitive processes of *patternicity* (Shermer 2011, 5) that seek patterns amidst the manifest sensorial clues in an effort to reduce complexity and to make “many symbols that have been freshly activated in concert to trigger just one familiar pre-existing symbol (or a very small set of them).” (Hofstadter 2007, 277)

Upon *establishing patterns*, the operator adds meaning to them, through processes of *agenticity* (Shermer 2011), through which she endeavors to operate along the same lines as the system (Metzinger 2009, 176), by emulating its operations and quite literally, by simulating it. These mental simulations can be developed concurrently, posing parallel hypothesis that are evaluated against each other — in their capacity to generate valid predictions or approximations to the actual behaviors of the system — and against the system itself — in the frequency with which the hypothesis are validated. The various simulations can consequently be adjusted and the models evolved in a process where the system (i.e., the external phenomenon) is used as the fitness function for the selection of the best models or simulations that are produced by the operator. During the course of several iterations (and interactions), the operator may therefore be able to develop a working model of the system, a theory of the processes within it, a theory of the artificial aesthetic artifact.

This set of simulations allows the operator to try to peer at the system from the point of view of its designer, from which the system is encoded with prescriptive rules, and even from the point of view of the system itself, a position better rendered by descriptive rules (Carvalhais 2012).

> [Theory of mind] refers to your ability to attribute intelligent mental beingness to other people: to understand that your fellow humans behave the way they do because (you assume) they have thoughts, emotions, ideas, and motivations of more or less the same kind as you yourself possess. In other words, even though you cannot actually feel what it is like to be another individual, you use your theory of mind to automatically project intentions, perceptions, and beliefs into the minds of others. In so doing you are able to infer their feelings and intentions and to predict and influence their behavior. (Ramachandran 2011, loc. 2632)

As with the development of theories of mind towards humans, animals or other entities, either real or fictional, the development of a theory of an artificial aesthetic artifact may very well stem from "an innate, intuitive mental faculty" (Ramachandran 2011, loc. 2632), a capacity that is so far unique to humans (Dehaene 2009, loc. 194).

Although, as postulated by the MDA model, while interfacing with the aesthetics layer of the system, the operator may be unable to have a clear view of the dynamics and mechanics layers, through these processes of simulation she effectively tries to reverse her view of the system, even if ultimately following models that are incomplete or altogether erroneous.[6] It is regarding the validation of these models that the next step in the exchange is taken.

6. Incomplete or erroneous models can nevertheless produce accurate enough predictions of the outputs or behaviors of a system. So a good simulation is not necessarily just an accurate simulation, rather it is an effective model for the anticipation of the system. (Carvalhais 2011a).

4. Dramatic Arcs

Traditional narratives are a fertile ground for the development of theories of mind — for characters and events, for narrators or even maybe the imagined authors — and for hypothesis of procedural causality — for mechanical events and natural phenomena. Provided the narrative is internally consistent, the reader or spectator is able to infer from the known events and information and to speculate about the narrative developments, anticipating its evolution and resolution. The reader can conjecture about narrative arcs, stable situations and unbalancing accidents, about events, goals, obstacles, commitments, protagonists and antagonists, eventually reconciling estimations as the narrative unfolds. Once the narrative is over, any further reading will most likely be aided by recollection and memorization than by further speculation and simulation, due to the stability of the narratives in these technologies.

A similar process is developed during the experience of artificial aesthetic artifacts and, while memory may also serve a role, due to the unpredictable nature of these systems — the indeterminate and unstable nature of the traversal function, according to Aarseth (1994, 61–62) — the processes of simulation must be developed even in rereadings, where the same systems may, for a variety of reasons (including, but not limited to, the operator's interactions) produce very dissimilar outputs.

The operator is constantly led to the production of models and to the resulting building of expectations to be confronted with the systems. This effort results in a dialectical pull between confirmation and violation of expectations that leads to a dramatic tension that characterizes artificial aesthetic artifacts and is a setting for the development of narratives. This is not only the aporia-epiphany pair that was identified by Aarseth in hypertext literature, at least not in the terms he proposed it, but he was certainly right in that this pair, although not being a narrative structure on itself, "constitutes a more fundamental layer of human experience, from which narratives are spun." (1997, 92)

Traditional narratives, due in part to their lower (or even absent) process intensity, relinquish procedural authorship and set the narrative in data to be replayed and perform it, presenting the reader with a single unified path to traverse. Artificial aesthetic artifacts make use of procedurality to build unique dramatic arcs from the variations and the space of possibilities that is opened by their computational nature, from the interactions and the simulations developed by the operator. These narratives tell the operator's personal story, a story that could not be without her (Aarseth 1997, 4), a story that absolutely depends on her to be shaped and formed.

This leads us to regard Aarseth's *perspective* variable, that may be so difficult to understand in the context of abstract and non-verbal artifacts, as something that far from just describing the operator's playing of "a strategic role as a character in the world [of the system]" (1997, 62), actually inscribes her as inseparable from the work, or from the particular instance of the work as it is experienced, imagined, theorized and experienced by her.

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Space and Time in Ergodic Works

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Keywords: Ergodic, Interactivity, New Media, Space, Time.

Abstract: The following paper discusses dimensions of space and time in interactive ergodic works. It starts by presenting four examples of ergodic works, describing how the dimensions of time and space are created and how they are experienced by users. These analyses use concepts and theories developed by Markku Eskelinen, Janet Murray, Lev Manovich and Espen Aarseth, in an attempt to understand space and time in relation to ergodicity.

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1. Introduction

Interactive ergodic works exist within a logic of completion by users' actions (as defined by Aarseth in 1997). Without the users' actions, which generate several possible material expressions, an ergodic work will not be fully realized. Since the work partially evolves in response to users' actions, it seems clear that the dimensions of time and space need to be readdressed in ways that go beyond the usual categories of print—based or film—based narratology. Because of its concern with the ergodic nature of certain modes of interactivity, new media theory offers concepts that are useful for thinking about these issues.

It would seem, at first glance, that the dimension of time is the one that undergoes the most significant transformations. For instance, in the case of hyperfiction, narrative discourse ceases to exist in a single order and allows for different paths, different points of access to the story, and, necessarily, different meanings. Of course, even in traditional narrative, the relationship between the time frame in which the events occurred and the timeline of their narration cannot (and, most of the times, does not) directly match, as we can see through the narratological categories of analepsis and prolepsis. The biggest problem that arises in ergodic works is the relative difficulty we have in classifying more or less random relations between the time frame of events and the timeline of narration that result from users' actions (Eskelinen 2012).

The way time is produced and experienced in interactive media is so strongly altered that several scholars have suggested, more or less emphatically, that the defining characteristic of interactive media is spatiality, instead of twentieth century's mainstream media's (cinema) temporality (one of them being Aarseth, in his 2001 article presented here as a reference). Lev Manovich, on the other hand, models his analysis of new media on early cinema and on forms of montage, which see the database as a source of temporal relations (Manovich 2002). Janet Murray in turn reads hypertextuality in terms of navigational structures that can be understood spatially (Murray 2011). In this paper, concepts developed by Markku Eskelinen, Janet Murray, Lev Manovich and Espen Aarseth for thinking about time and space in interactive media will be applied to four ergodic works.

2. Time relations in ergodic works – Camille Utterback's Liquid Time and Markku Eskelinen' theorization of time in ergodic works

Liquid Time, a video installation by Camille Utterback (Utterback 2002), has been repeatedly analyzed in theoretical texts regarding interactive media [Janet Murray being one of the, in the text given as a reference here — Murray 2011]. Given its declared relationship with time, it was chosen as my first example in this paper. I will try to relate it with Markku Eskelinen's analysis of time relations in interactive narrative works (Eskelinen 2012), and find out if some of the points he makes are present in *Liquid Time*.

Eskelinen refers to classic narratological categories about time relationships between narration and story commonly accepted by most scholars, and then expands them so that we can use them to analyze not only traditional narratives, but interactive ergodic narratives as well. Some categories survive unscathed the introduction of interactivity, but most are changed in one way or another. Basing his analysis on Genette's approach to the subject, Eskelinen considers time through the categories of order, duration, and repetition. He introduces two other possible time dimensions that can be verified with interactive media: system time and reading time. He expands these categories, having in mind the differences introduced by interactivity — for example, about order he says that while being the only category subject to changes in classic hypertext fiction, order is sometimes overstressed by scholars as the main innovation of interactive fiction. Nonetheless, the order of narrative elements is certainly altered with users' actions, maybe not in such a novel or random fashion as some scholars would have led us to believe. Analepsis and prolepsis exist in both oral and printed narrative, and chronological sequence is not always the main criterion for ordering events in narrative time. However it is possible to identify some changes in this category when subject to interaction, namely, the fact that analepsis and prolepsis can be absolute or relative, in relation to the whole or parts of the narrative: if all the possible orders have an unchangeable element, then the anachrony is absolute; if only some are repeated, then the anachrony is relative.

Eskelinen goes on to question the frequency of narrative elements, coming to the conclusion that not many differences distinguish traditional from interactive media, as traditional media categorization (by Genette–Eskelinen 2012, 146) already contemplates the possibilities of narrating once or several times either events that occurred once, or several events, in multiple combinations — thus remaining only the necessity to consider variability of frequency; and duration/speed/rhythm of the narrative, which he develops around the concepts of narrative time and screen time (as cinema's screen time, having inherited this view from Bordwell) (Eskelinen 2012, 150). It would be redundant to extensively describe Eskelinen's approach to time relationships in narratives here. The interest of his revision of narratological categories is to see how they apply to the example presented here, Camille Utterback's *Liquid Time*.

Liquid Time is described by its author as an exploration of "… how the concept of 'point of view' is predicated on embodied existence". More interestingly, for the case at hand, is how this concept is put in practice: "In the *Liquid Time Series* installation, a participant's physical motion in the installation space fragments time in a pre-recorded video clip." (Utterback 2002). The temporal dimension of this piece is visually explored and it is manipulable by the visitors — its users. We see, in a single work (a video) multiple timelines and, consequently, multiple relationships between narration time, story time, and screen time, to use Eskelinen's terms simultaneously. Hence, according to Eskelinen's categories, we can classify time relationships in *Liquid Time* as follows:

- as regards order, since *Liquid Time* doesn't have a fixed order of narration of events, we can say it presents the pre-recorded video clips in a random fashion (every time, a different order is presented); it is also non-linear, as the events are not presented chronologically or consequentially. As the video is altered by the user's proximity or distance, we can only guess that generated analepsis and prolepsis are relative, since they occur once in any possible timeline. Finally, it is possible that, since the video shows us spaces in New York, perhaps there is a different organizational principle, such as space, in which case we are talking about a syllepsis (multiple order of events, non-chronological), in Genette's words.
- moving on to frequency: the frequency of repetitions depends entirely on the user's random actions; plus, most of the times we will be talking about resemblance, and

not complete identity between repeated sequences. We can thus say that *Liquid Time* is indeterminate in frequency of repetitions' terms.

- lastly, as we consider the duration and speed of *Liquid Time*, as well as its possible relation with a pre-defined system time and a viewing time, it is possible to come to the conclusion that nothing is rigid; the work's duration and speed are a reflex of the user's actions, and *Liquid Time* is accessible for as long as the user wants. Whereas the time of the events captured in video and the time of each video sequence are fixed (and I do not, at the moment, know how they relate), the viewing time is not: each user, in each viewing, changes the viewed sequence and the relations between the time of the video capture and the time of its fruition, a reflex of the importance given by the Utterback to singular points of view. Each time a viewer affects, with his or hers actions, the sequence he or she is watching, it is being created a new instance of *Liquid Time*, a personal and unique one: in this lies the reason of its existence, as it is, undeniably, an ergodic work.

As a conclusion, I will propose that the time in *Liquid Time* is, indeed, liquid; that the analysis of its possible facets, as proposed by Eskelinen, and the way they react to each other and to the user, give strength to this idea of fluidity — *Liquid Time* is liquid not only superficially, but in all of its aspects. Time relations are viscous, never solidified; *Liquid Time* observes, in depth, and as much as I can understand, this liquidity in all categories defined by Eskelinen.

3. Space as an interaction design strategy – Simon Penny's Fugitive and Janet Murray's approach to space in new media

As time gives way to space as a crucial perceptual experience in new media environments, we must think about the ways in which space is organized and if and how it changes the user's experience. Janet Murray (Murray 2011) talks about space as an interaction design strategy, challenging common notions associated with the linearity of the twentieth century's mainstream media, cinema. The possibility of translating time into space and space into time further complicates our interface — mediated experiences in digital media environments.

The spatial affordances of the digital medium can be used for designing different kinds of interaction, including interactions in ergodic works. Murray goes on to describe several strategies for the design of interactivity, comparing them with their analog counterparts, such as containers (list and tables, the library model), landscapes and maps. Murray then discusses the nature of virtual space in the mind of the user, its relationship with discreet places, and the evermore present ubiquitous digital devices that force us to adjust to and locate ourselves within multiple spaces and the over imposed layers of information that they represent (augmented reality). Most importantly, Murray questions the ways in which virtual space expands or contracts real — life spaces — as we add layers of virtual spaces onto the real spaces, she wonders if, for example, "… gestural interfaces for video games are allowing us to think of the space between interactor and the device as a site for inscribing commands". This way of thinking is especially relevant when we think in terms of works such as *Fugitive*.

Fugitive emphatically describes itself as a non-narrative, opposing narratives to interactive media as mutually exclusive categories. Simon Penny mentions cinema as a sort of antithesis of *Fugitive*:

> **Fugitive and cinema**
>
> *Fugitive*, while screenal, is emphatically not cinema. Like all interactive media, in *Fugitive* there is no pregiven narrative. Rather a unique experience unfolds for the user as a result of her interaction with the system.
>
> **Fugitive undoes cinema**
>
> If the user moves circumferentially, the scene that is triggered is a pan. As long as she circles, the image also circles, unfolding successive frames of the pan in successive positions around the wall. If the user moves radially, the shot triggered is a zoom, corresponding to the position in the pan. Fugitive, in a sense, 'undoes' cinema, since the image is aligned, (relatively) to the original position of the camera. As the user moves toward the image, the image zooms. The system can be understood as a kinesthetic video editor. Each user makes a different movie, depending on her behavior. (Penny n.d.)

(One could argue that cinema can be interactive as well, and that statements such as "Fugitive, while screenal, is emphatically not cinema. Like all interactive media, in Fugitive there is no pregiven narrative" are perhaps overlooking a few of those cases — admittedly, not too many.)

The point we will try to focus on with this example is that, in its attempt to avoid being cinema, *Fugitive* uses space and spatial means for interaction as its main characteristic. *Fugitive* is, in short, a video projection that, inside the limits of its cylindrical screen, runs away from the user as he/she tries to approach it in more or less frantic ways, which are mirrored by the system's faster or slower movements. In addition to the movements of the projection, the images that are projected are also triggered in response to user's motion: when the user runs faster, the system chooses a video with a higher frame-rate to project; if the user moves circularly, the video will have a camera movement that echoes the user's movement. These decisions echo, in our view, Murray's questioning of the space between users and system and the possibilities that it brings to interface designers.

Penny gives some information about the system behind *Fugitive* and the philosophy that originated the project. Interestingly, he states that *Fugitive* reacts not to the instantaneous position of users but to the temporal dynamic of their ongoing movements (Penny n.d.). This aims to capture the user's 'mood', task that would not be possible if the only available data was the instantaneous position of the interactor. *Fugitive* attempts to interpret "…gross bodily movement as an indicator of "mood"…" and then respond to it, in an instantaneous (as much as possible) fashion, so as to reaffirm to the user that the piece is interactive and that its (the user's) actions have a response" — Murray also stresses the need to find transparent and immediately satisfactory ways to give agency to the users, agency being the capacity to change the system and its responses.

As *Fugitive* maximizes the space it is given, attempting to convey multiple messages (of the body as a presence in interaction, of the ways in which to interact with the piece, and so on) through interaction in a space, originating responses in different ways of travelling (visually — through the eyes of a camera) through a given space, and as such is, in our view, a valid example to discuss, if not the categories presented by Murray (only the landscape category is of some use to the analysis of the images presented in *Fugitive*), at least the spirit of her questioning and the broad strokes of her approach to designing interaction strategies that fully explore space. In *Fugitive*, ergodic intervention results in multiple outcomes that translate the kinetic and spatial relation of user to the cinematic representation of space.

4. Space and database aesthetics – Jonathan Harris' We Feel Fine and Lev Manovich's concept of database

We feel fine, a web based installation by Jonathan Harris in collaboration with Sep Kamvar, attempts to pick up every mention (on the Internet — mainly from blogs, as Harris explains in his Ted Talks (Harris 2007, 2008)) of the word *feel* or *feeling*, and then grabs the whole phrase and displays it, trying to make visible in one or another form of organized display the enormous amount of feelings floating around the world of personal expression on the Internet.

In this section of the article I will try to discuss Lev Manovich's emphasis on the database as a prime medium of expression (and, among others, artistic expression) of our computerized society, as he calls it (Manovich 2002), and cross them with the concepts behind *We Feel Fine*, in an attempt to better understand its concepts and the reasons behind its existence.

Manovich starts by naming the database form as the main aesthetic form of new media. He compares it to cinema, a (mostly) narrative form that was mainstream in the twentieth century, and establishes some parallels and contrasts between the way that database (new media) and narrative (cinema) function in their ways of conveying meaning and organizing its constitutive elements. Database corresponds to the result of a "digitizing craze" (Manovich 2002, 198) and is described as a "collection of images, texts and other data records" (Manovich 2002, 195). On the other hand, narrative is described as only one of the ways though which we can access these collected elements.

Of course not all new media objects are databases: games, for example, usually contain narrative elements, and their database is subject to an algorithm — the other half, Manovich tells us, of the "ontology of the world according to a computer". The web is, in Manovich's view, the place where the database has developed in its purest form: a "gigantic and always changing data corpus", something that operates under an "anti-narrative logic" (Manovich 2002, 196).

Interestingly, Manovich goes on analyzing some of the films of Greenway and Vertov, calling their works databases in film form, and ending his text by considering that Vertov, in particular, has done something that new media designers "still have to learn — how to merge database and narrative into a new form." (Manovich 2002, 212). He has done this by filming a database, or presenting us (the viewers) several shots, and several techniques, in a non-narrative way, in his *Man with a Movie Camera*. I will argue that Jonathan Harris has done the opposite movement — presenting narratives, or narrative pieces, in a database form — thus possible having "learned" how to combine narrative and database in an aesthetic and artistically meaningful way, and not resorting to a known form, such as a film, but using new media specificity.

We Feel Fine, as described earlier, picks up specific sentences from every web user's personal narrative. These specific sentences start, of course, by the statement "I feel" or similar. *We Feel Fine* then goes on organizing, creating statistics, rearranging, or even animating particles with data that is shown to us as we choose. There are several ways of observing how people are feeling in a given moment: all of them are at the very least dependent on spatial representation, which is, for Manovich, the only way to create a pure database (Manovich 2002, 209).

We feel fine achieves yet another accomplishment: it manages to present us with something Manovich claims is our expectation of computer-based objects (while he refers specifically to computer narratives, I will stretch this concept to any computer made object that in some way inherits analog behaviors and characteristics, such as an art work as *We Feel Fine*). Manovich says that, while we reject the modernist concept of medium-specificity, we still expect computer-made objects to bring new dimensions to traditional forms. *We feel fine*, in my opinion, does just that: explores computer conventions, ways of creating meaning and form, and uses them to create new shapes from the frequency, tone, and other characteristics of World Wide Web users' feelings and how they are expressed through it.

We Feel Fine spatially organizes data created by internet users, for us to read and interpret. Visual spaces are created each time we, as users, make choices or refresh the system. As internet users we have another interesting possibility: we can create content that will be captured by *We Feel Fine*, creating thus a feedback circle. *We Feel Fine* could not live without the event of ubiquitous interactivity. Either way, ergodicity is required to bring these informational spaces to life: as we chase the tiny circle-shaped feelings through the screen and generate different outputs of this feelings gatherer, we create, through our actions, new visual instances of a giant database — the internet.

5. Space in video games – Mary Flanagan's [Domestic] and Espen Aarseth's discussion of space in video games

As a final example, though obviously not the last possible analysis, I would like to approach space and the spatial dimension in new media twisting Aarseth's words about space in video games to include artworks that function in a video game structure. There are many such examples — in fact, growing in numbers — but, for the current research, *[Domestic]*, a piece by Mary Flanagan from 2003 (Flanagan 2003), seemed like a perfect choice, given that the author appropriates a video game space and redefines its rules for her own purposes. *[Domestic]* aims to recreate a childhood memory in a way that engages the spectator/user of the piece. The depicted event is not recreated realistically: instead, we find ourselves navigating through corridors that present us with the inner feelings and thoughts of Flanagan as a child, experiencing the traumatic circumstance of a house fire.

[Domestic] is built over the game engine of *Unreal Tournament*, a multiuser first person shooter, and allows us to use certain tools that are adaptations of *UT*'s weapons: books, literature, in the author's words, as a way to escape the horrors, an escapist tool that solves problems by erasing them from the child's mind — and our game/artwork space.

In *Allegories of Space — The question of spatiality in Computer Games* (Aarseth 2001) Aarseth considers the possibility of classifying computer games by the way they explore the spatial dimension. Space is, in Aarseth's words, "the defining element in computer games" (Aarseth 2001, 154). This idea, in these words or similar ones, is repeated several times in the article. Aarseth analyses other possible defining dimensions or characteristics — such as time — and comes to the conclusion that most, if not all, computer games, revolve around spatial exploration in one way or the other. The way such exploration is implemented varies and can be ordered in classes, given some characteristics: for example, he defines outdoors and indoors games as, respectively, games that allow free movement in contrast to others, which are "discontinuous, labyrinthine, full of carefully constructed obstacles". Other distinctions can be made between the player's "puppet" and the environment, or between games that allow the player to influence the game world and games that don't.

Aarseth then discusses the nature of virtual and computer games' spaces. Combining two extremes of virtual and real space theories, to Aarseth space in computer games is both a realistic and a symbolic representation, since it is, in the end, a reduction of real space to a symbolic form and a set of rules.

[Domestic], living on top of a computer game's structure, can be classified and analyzed under Aarseth's system. Being both a semi-indoors game and multiuser, *Unreal Tournament* presents some of the characteristics identified by Aarseth in these types of games: we have labyrinths to cross, but mostly we are playing against other humans; the landscape is not symmetrical but its usage is open to both opposing factions. Having inherited the spatial structure of *UT*, *[Domestic]* happens in a space dominated by dark corridors, niches we cannot see from a distance, and it is required of us that we clear some obstacles — the traumatic parts of the event — recurring to escapist tools. It seems, thus, that we have here the typical indoors topology — one that is mediated by obstacles we must overcome — a symbolic construction of life and what it means to live, to overcome difficulties and to reach a higher level of comfort. While walking through *[Domestic]* we build new instances of these memories — for each user, a new game becomes materialized, new sequences, different consequences, as the algorithm responds to the player's actions.

More importantly, though, *[Domestic]* is a space constructed by human dynamics — it is the spatial representation of a memory; a created space, inhabited by symbolism, that would not exist if such and such experience did not happen to Flanagan. *[Domestic]* is, in the end, a "reductive operation leading to a representation of space that is not in itself spatial, but symbolic and rule — based (Aarseth 2001, 163).

6. Conclusions

After applying the selected descriptive models to the analysis of space and time in ergodic works, I came to the following conclusions:

- Firstly, and obviously, there are significant differences in the ways we can approach the dimensions of time and space in ergodic and non ergodic works. These differences have been described and classified in multiple ways. One major highlighted difference is the way timelines mix and create new relationships after the user inputs his/her data. I have confirmed that Eskelinen's classification of new categories for these relationships are operational when applied to Utterback's *Liquid Time*, and can be expanded to fit other artworks dealing with the ergodic production of the experience of time. It would be interesting if, moving through the superficial hype surrounding the rearrangement of time in interactive objects, we, as scholars considering new media, could begin to see how time and its multiple dimensions are indeed put to creating new facets in our knowledge. *Liquid Time* conveys a message (or a plurality of messages) that can be further expanded when analyzed under Eskelinen's work.

- As we move on from the dimension of time to the dimension of space, I have tried to see if some of Murray's considerations about this factor in interaction design are similarly relevant for describing *Fugitive*. Murray's work attempts to classify every kind of object, focusing mostly its effort in prosaic new media objects, such as web pages, applications, and others, but its general meaning can be applied to artworks too. *Fugitive* allows us to test some of the concepts Murray presents, such as the possibility of actions affecting both real and virtual spaces (considering the real space of the installation and the represented cinematic space), and the space between them. The marked gap between these two spaces allows the user to pause and take into consideration his or hers relation to represented space; to space in cinema as well as to space in art; and to the space given to him or her for interaction in this particular work.
- Manovich's analysis of databases and the database culture we presently now live in seems to not only fit, but to have spawned the presented artwork, Harris' *We Feel Fine*. Artistic production exploring the rich material originated by the collective use of the World Wide Web, is more likely than not expanding the possibilities of the database form and aesthetics. Manovich's exploration of the concept is probably going to be more and more pertinent in the art world as well as in the broader new media world, and it would be interesting, in future endeavors, to continue to explore Manovich's text in confront with new media art pieces.
- Finally, in the more specific field of computer games, or video games in general, the dimension of space is one of great importance — Aarseth argues that it is the defining dimension of video games. *[Domestic]*, built over a computer game structure, is one of the possible examples of spatial exploration in ways that convey meanings and it is absolutely true that without the spatial dimension the piece would be a completely different experience.

Ergodic interactions affect our experience of space and time in new media objects in ways that differ from work to work. Although space seems to have been explored more extensively and meaningfully than time, I believe that the ergodic production of time needs to be addressed in greater detail. Critical and artistic exploration of the interactive dimension of time and space can open up new ways to create digital works, which don't simply go back to conventional formats inherited from past endeavors.

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Representation and Mimesis in Generative Art: Creating Fifty Sisters

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Abstract: *Fifty Sisters* is a generative artwork commissioned for the Ars Electronica Museum in Linz. The work consists of fifty 1m × 1m images of computer-synthesized plant-forms, algorithmically 'grown' from computer code using artificial evolution and generative grammars. Each plant-like form is derived from the primitive graphic elements of oil company logos. The title of the work refers to the original 'Seven Sisters' — a cartel of seven oil companies that dominated the global petrochemical industry and Middle East oil production from the mid–1940s until the oil crisis of the 1970s.
In this paper I discuss the issue of representation in generative art and how dialogues in mimesis inform the production of a generative artwork, using *Fifty Sisters* as an example. I also provide information on how these concepts translate into the technical and how issues of representation necessarily pervade all computer-based generative art.

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1. Introduction

In a recent paper, the author and several colleagues proposed what we considered to be the ten most important questions for generative art (McCormack et al. 2012). The fifth question on our list asked the following in relation to computational generative art:

> In what sense is generative art representational, and what is it representing?

In this paper, I will expand on this question and its implications. From the onset I should make clear that my topic relates to *computational* generative art. While generative art has many non-computational modes, they are not specifically addressed in this paper. Rather than discussing theoretical ideas, I will describe a recently completed generative art work, *Fifty Sisters*, and look at how representational issues come into play in almost every aspect of creating the work: conceptualization, implementation, and realization.

Representation and mimesis are some of the oldest issues in art, dating back at least to the ancient Greek philosophers (Scruton 2009). The idea of replicating naturalistic effects in painting came to the fore in renaissance aesthetics, where painters were concerned with a *truthful* representation of what they saw. Roughly corresponding with the mathematical formalization of perspective projections and with progressive advances in paint technologies (Ball 2002), artists' skills developed in portraying the 'real' in art. However, any art acting as a 'mirror of nature' — as was famously advocated by Leonardo — still requires 'interpretation and ordering' from the artist. Image reproduction technologies forever changed the idea of capturing the real in art, inviting the possibility for artists to focus on other kinds of 'truths'. By the time Hal Foster published *Return of the Real* (Foster 1996) mimesis had come full circle[1]. In more recent times, representation and semiotics arguably have been overtaken by other concerns, such as art as social exchange and dialogues concerning relational aesthetics. Representation and mimesis are old and well established discourses in art. Generative art reopens these dialogues in ways that other art forms cannot, because generative art brings something new to art: the idea of representing process.

1. In fact a circle and a half.

In generative art, as with other forms of art, we should expect a range of representational styles, e.g. visual art ranges from abstract, non-objective mark making and vast sways of negative space, to highly figurative and photorealistic imagery. But unlike visual art, generative art has not been so extensively analyzed in terms of how it deals with mimesis and representation. Here we seek to begin to address that deficiency.

1.1. Computers and Representation

It is almost impossible to write a computer program without — at least implicitly — considering representation. Digital computers use collections of bits (electrical signals or states standing for 1s and 0s, ON and OFF, etc.) to encode and represent data and instructions. At the level of software, programs generally represent things using atomic variables (integers, floating-point numbers, Booleans, characters, etc.) or compound collections of these variables (data structures, arrays, strings, objects), which may easily include other compound collections.

It is important to distinguish between a variable and its interpretation, i.e. it's *semantics*. I can give a variable any semantic interpretation I choose: it could represent happiness, my bank balance, or the text of this paper for example. The important point is that the programmer, not the computer, confers this meaning. The computer hardware does impose practical limitations on the kinds of interpretations that are possible. If I represent the concept of happiness as an integer, then the machine will manipulate it as an integer, not as an emotional state of being. I can interpret a variable called 'happiness' as the degree of happiness of an individual, but this representation is limited to the 32 or 64 bits typically used to represent integers.

At the base level, computers are symbol-processing machines—they transform patterns of bits that represent symbols. All symbols are subject to *interpretation*, either by the programmer, the user of the program, or the machine itself. As an added complication, symbols are often not interpreted directly (as bit patterns), but are transformed by some process.

As an example: two variables may represent the Cartesian coordinates of the center of a circle that is displayed graphically on a computer screen. As the variables are changed the circle 'moves on the screen'. An additional variable represents the circle's radius. We speak of a 'circle moving on the screen', but, like the world of *the Matrix*, there is no circle and it is not moving. Discrete patterns of bits are changing at regular intervals. We interpret the complex process of changing individual pixels seamlessly as a moving circle.

Perhaps this all seems obvious and even slightly trivial. Yet it is common for people working with computers to forget about these representational gaps. In observing a computer simulation of ant behavior, we might speak of 'ants foraging for food', but this interpretation (as it would be for a painting) is semantically loaded. They are only "ants" in as much as they homomorphically model an ant. 'Foraging' is a convenient anthropomorphic label we give to a series of discrete changes read as position, movement, behavior and so on. We use this shorthand because it is both convenient and necessary: speaking only in terms of bit patterns is not practical or enlightening (Dennet 1991), despite this being the basis of digital computer representations.

As Nietzsche reminds us, writing on a typewriter is different than writing with a pen (Kittler 1990). The tool affects our way of thinking. With the computer it is even more profound, because to translate ideas into code we must 'think algorithmically', which in turn influences how we think about the world and act in it.

In making a generative computer artwork, representation exists at many levels, not just the bit-pattern level of variables, data structures or screen graphics. Rather than expand on this in abstraction, let us look at a concrete example in generative art to see how these issues come into play.

2. Fifty Sisters

Fifty Sisters is a generative artwork commissioned for the Ars Electronica museum in Linz, Austria[2]. The work consists of fifty 1m x 1m digital images of computer-synthesized plant-forms, arranged in a 5 x 10 grid in the museum foyer. Each image is algorithmically 'grown' from computer code using artificial evolution and generative developmental grammars. The form is derived from the primitive graphic elements of oil company logos.

2. www.aec.at

The title of the work refers to the original 'Seven Sisters' — a cartel of seven oil companies that dominated the global petrochemical industry and Middle East oil production from the mid–1940s until the oil crisis of the 1970s. Fossil fuels began as plants that over millions of years were transformed by geological processes into the coal and oil that currently powers modern civilization. The images remind the viewer that the basis of an oil company's financial success is derived from plants and natural processes that operated over vast geological timescales. With 'peek oil' expected to be reached this century (if not already), we are expending this non-renewable resource in the relative blink of an eye. Two example images from *Fifty Sisters* are shown in Figure 1. More information on the work and its motivations can be found at http://jonmccormack.info/~jonmc/sa/artworks/fifty-sisters/.

The process to create each form involved a number of steps. Firstly, an oil company logo was chosen and 2D vector art created[3]. From the 2D vector art, the basic graphic elements were separated manually and then converted to 3D geometric primitives. To create each plant form custom software was developed by the artist. Technical details can be found in (McCormack 2005). In basic terms, the software simulates the growth and development of the form from a series of developmental rules, metaphorically similar to the way DNA 'encodes' the developmental plans of biological organisms.

3. Wikipedia has vector versions of many oil company logos.

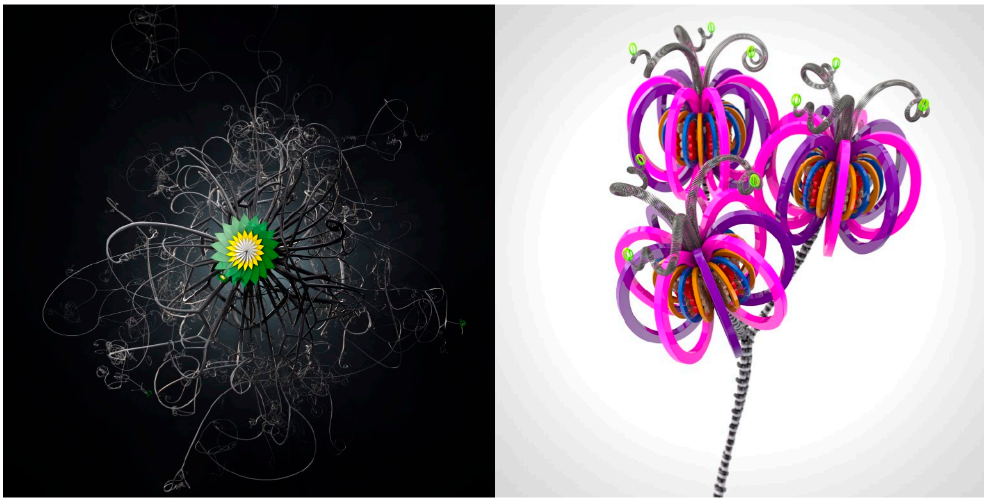


Fig. 1. Synthesized plant forms based on the BP logo (left) and ESSO logo (right).

Rules consist of any number of *developmental symbols* that represent individual or collective elements of the growing form. Symbols include continuous data, such as size, age, chemical concentrations, etc., that change over the lifetime of the developmental simulation. If certain conditions are met (e.g. size becomes greater than some fixed value), the symbol may subdivide, be replaced by another symbol, or die. This method is somewhat analogous to cell division in biology, but with far greater abstraction and simplification.

As the developmental rules are a machine-representable code, they can be subject to genetic manipulation, including mixing of rules from other forms (a kind of 'gene splicing') or guided evolution using a variant of the *Interactive Genetic Algorithm* or *IGA* (McCormack 2004). The terminal symbols of any rule can be interpreted as instructions that encode the geometric construction of form. These symbols include instantiations of the geometric elements of the oil company logos. Thus when the form is constructed, its geometry includes geometric elements of the original logo. The final form depends on how the rules have evolved and mutated. The results are often surprising; in some cases the original logoform is clearly visible, in others it is almost impossible to recognize as it has become highly abstracted. Figure 2 shows an example form (using elements from the Shell logo) and the rules, or 'digital DNA' used to generate it.

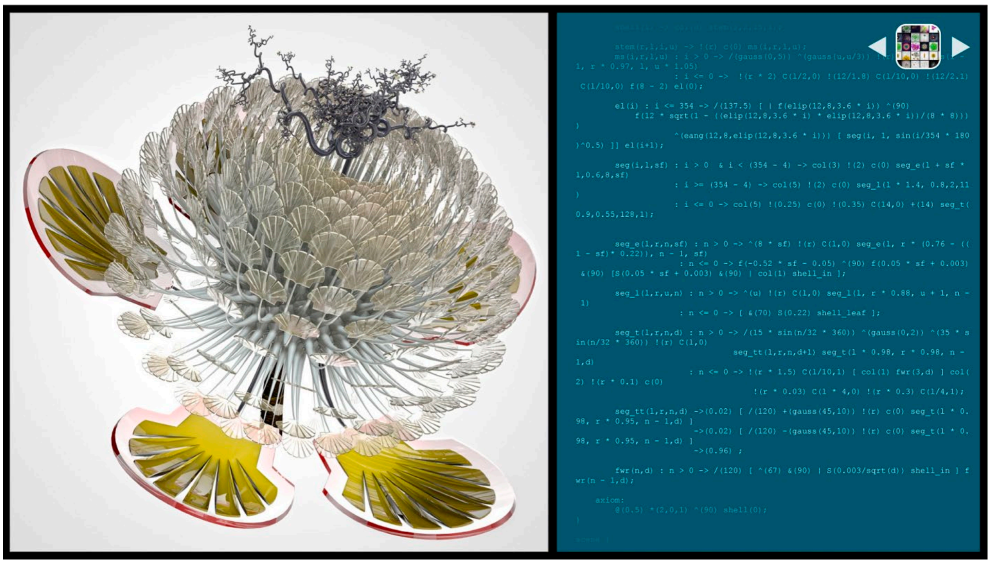


Fig. 2. Synthesized plant forms (left) and the developmental rules from which it was generated (right).

The forms generated by this developmental/genetic process are output as 3D geometric models. Most plant forms are easily expressed in only a page or two of information (a few hundred bytes), yet they generate geometric models many orders of magnitude greater (~10^7 – 10^9 bytes). The models are read into a 3D renderer, which renders an image using "photorealistic" rendering techniques.

2.1. Representation in Fifty Sisters

Fifty Sisters is a useful example of representation in generative art, because it deals with representation and mimesis at multiple levels. As images, each plant form has several representations: that of a real plant, a computer graphic, and a corporate logotype. The generative code ('digital DNA') from which each image is generated (Figure 2) is also exhibited in a separate touch screen application that forms part of the exhibition of the work. This allows the viewer to see a different representation of the form: as code that through a process mimetic to biology generates that form.

Beyond the visual and textural representations, there is an additional layer of representation to contend with, that of the generative process. What is represented in this process? The process represents another process: biological development and evolution. The artist-developed computer program simulates and abstracts the process of biological development and evolution. It is the *personal expression* of a biological process in software. So in this sense the software program, when run, represents these natural processes in a somewhat similar way to that in which a landscape painting represents a landscape.

The difference, of course, is that the viewer of the work cannot see or otherwise experience this process directly.

This idea of one dynamic process representing another is new to art, and is what best distinguishes this kind of generative art from other practices. Certainly process was often of interest in modern art. One only has to think of Sol Le Witt, Cornelius Cardew or Jackson Pollack for example. But in these cases the process of generating the art was not representing another process: Le Witt's drawing instructions were not representing anything other than instructions to draw. A computer process being mimetic to another process is different, because it involves choices about sign, signifier and what is signified. Moreover the complexity and unpredictability of a computer process (vis. Emergence (McCormack & Dorin 2001)) introduces additional properties not directly represented in the generative process itself.

2.2. Mimesis in Fifty Sisters

As alluded to in the introduction, mirroring nature involves interpretation and ordering by the artist. As simulacra or simulation, a computer process is not the same as what it seeks to mirror. This is well known in the simulation sciences, were formal methods are used to verify and validate simulations to models, and models to reality. The experimenter selects those aspects to model and those to ignore. Naturally, aspects or mechanisms that the experimenter is unaware of cannot be in the model, although through experimentation she or he may become aware of them, and then subsequently incorporate them into the model. The aspects of a phenomena or system that are modeled are subject to varying degrees of abstraction necessary for them to be practically simulated.

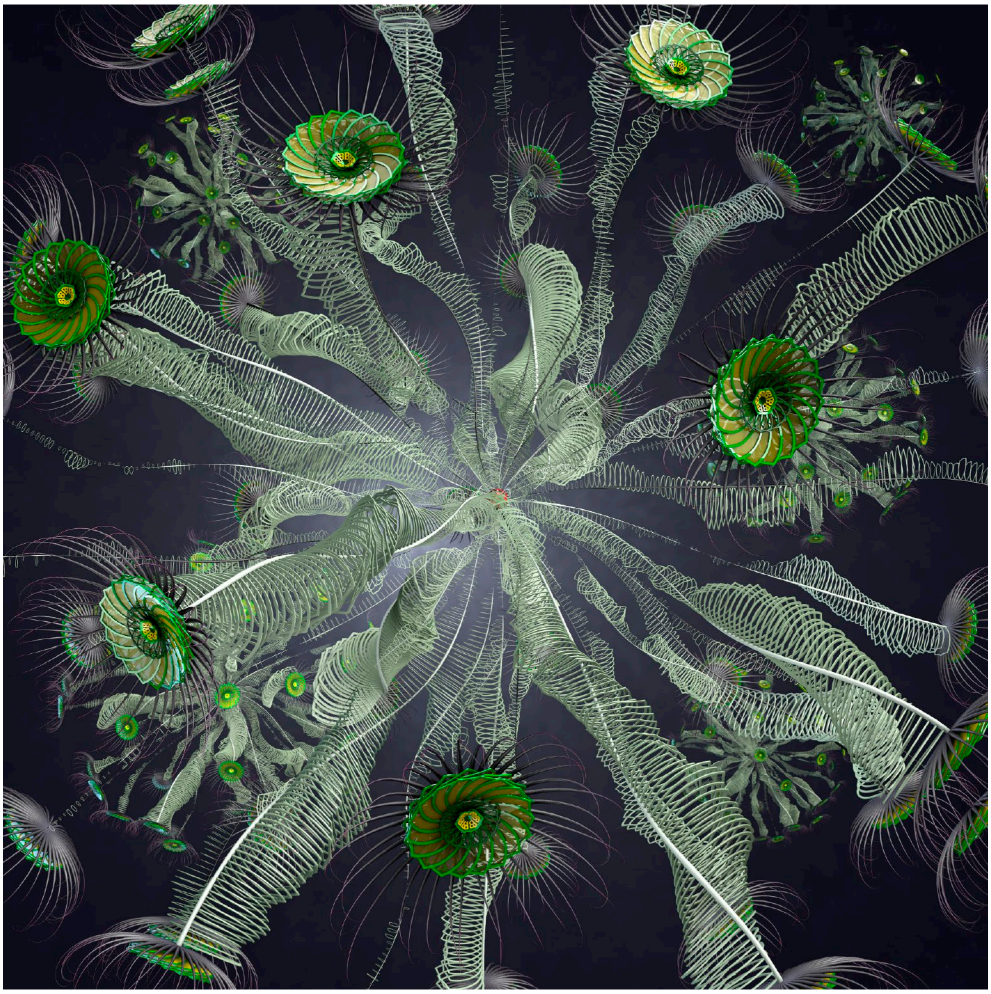
Art allows a difference license, where the most interesting works can abstract from the world of the imagination rather than the world of the real. In *Fifty Sisters* mimesis plays many roles. The plants themselves are in some way mimetic to real plants, yet no such forms could ever exist in reality. This is not really surprising; such issues have been endlessly explored in painting.

Things become more interesting in relation to process however. The generative process is mimetic to real biological development and evolution. The work speaks of 'digital DNA', 'evolution' and 'development' as signifiers to the interpretation of their biological parallels. While this simulated biology is grossly abstracted and simplified, it still exhibits some of the features of its real-world counterpart. Moreover, its conceptualization and intent as artistic concepts originates from interpretations of biological development and evolutionary process.

This analysis reveals some curious aspects about the work. For example the choice of using standard 3D rendering techniques, which focus on a Cartesian, photographic-like visual realism, whereas the biological processes focus on a somewhat different kind of 'realism'. This is partly explained by the technical constraints in developing works like this, but more importantly the aesthetic language of modern corporate communication is similarly derived from these techniques. Corporate logos are visually presented using the purity of glittering computer graphics, with its clean and sleek mathematical veneer. *Fifty Sisters* deliberately borrows from this vernacular, presenting developmentally mangled corporate logo forms using their native visual language.

3. Conclusion

In order to understand a generative artwork we must examine the process alongside what that process produces. It is important to look at what the process is representing, and how it performs this representation. For generative computer art, there always exist multiple levels of representation and it is easy to forget about how these representational structures are formed when they are so easily taken for granted. One of art's roles can be to reveal what is normally hidden or taken for granted, bringing it into awareness (or even sub-consciousness). Computer representations and processes are typically hidden from direct perception, so by bringing them into perception we reveal their most unique and interesting aspects as symbol processing machines.



```
# 1 "bpOldZoom.dna"
# 1 "<built-in>"
# 1 "<command-line>"
```

```
object spine {
    << noises >> efn;
    << math >> efm;
    < efn.gauss > gauss;
    < efm.acos > arccos;
    < efm.sin > sin;

    surface BP_old_hood;
    surface BP_old_back;
    surface BP_old_BP;
    surface sphere10;

    equiv ‘ col;

 rules:
     el(i) : i <= 47 -> /(137.5) [ ^(arccos(1 - i * 0.04000) )
                          [ f(90) elem(i) ]] el(i+1);

    elem(i) -> sph seg(100,40,5,1,10,0.1,0.1);

    sph -> !(15) c(0) !(7) C(1,0) !(3) C(1,0) !(1) C(1,0);
    seg(n,l,t,u,r,sc,v) : n > 0 -> /(t) ^(u) !(r * sc) C(l,0) [col(1)
S(sc) BP_old_hood ] seg(n - 1, l + gauss(0,v), t + gauss(0,v), u
+ gauss(0,v), r, sc + gauss(0,v), v)
                      : n <= 0 -> /(t) ^(u) !(r * sc) C(l, 1) [ col(9)
tusks(36)
 ] f(14) S(1.0) ll(18, 15, 10);

    tusks(n) : n > 0 -> [ ^(90) !(14) c(0) C(100, 0)
tusk_s(20,gauss(90,5),14,5)
 ] /(10) tusks(n - 1);

    tusk_s(n,l,r,u) : n > 0 -> !(r) /(gauss(0,5)) &(u) C(l,0) tusk_s(n
- 1, l *
0.90, r * 0.78, u * gauss(1.08, 0.067))
                    : n <= 0 -> !(r * 0.1) ^(u) C(l,0);

    ll(i,u,t) : i > 0 -> /(20) [ &(u) +(t) col(2) BP_old_hood col(1)
BP_old_back
 ] ll(i - 1, u, t)
          : i <= 0 -> [ f(5.0) col(1) lm(18,u+10,t - 4.5) ];
    lm(i,u,t) : i > 0 -> /(20) [ &(u) +(t) S(0.5) col(3) BP_old_hood ]
lm(i - 1,
 u, t)
          : i <= 0 -> [ f(5.0) col(1) ls(6,u + 10,t - 10) ];
```

```
    ls(i,u,t) : i > 0 -> /(20 * 3) [ &(u) +(t) S(0.25) col(3) BP_old_
hood col(1)
 BP_old_back col(1) BP_old_BP ] ls(i - 1, u, t);

 axiom:
    @(0.2) *(2,0,1) col(0) [col(8) S(9) sphere10] el(0);
}

scene {
    spine(time * 50);
}
```

Fig. 3. Synthesized plant form based on the BP logo (top) and the developmental rules from which it was generated (bottom).

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The Textural X

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Keywords: Computer Programming, Live Coding, Knitting.

Abstract: This paper considers the binding of analogue and digital forms in the context of computer programming. An argument is constructed based upon a knitting metaphor, relating patterning of wool with the functions of code over time. The relation between linear and cyclic time is considered, from the standpoint of the experience of programming, in particular the live coding of dance music. By way of illustration, example code demonstrating the weaving of analogue (continuous) and digital (discrete) pattern is shown, using pure functional code with visual examples.

1. Introduction

Somewhere between the Analogue and the Digital lies the whole experience of *texture*. Computers offer a cruel enactment of a wholly digital realm: a discrete, mathematical world stripped of gesture and emotion. Strangely, many who associate themselves with the term *digital art* approach the digital nature of their medium with disgust[1], and have constructed an analogue substrate, where code is hidden from view, and pixels are merged into beautifully anti-aliased, continuous shape. But even this substrate must stand the charge of being impoverished; human-computer gestures are increasingly reduced to prods and smears on flat glass. This charge extends to interactive digital art; see Figure 1 for an extreme example of the role spectators are reduced to in art and design exhibitions. It seems that in order to escape the digital environment, we have created a farce of the world outside[2].

1. For example, see Simon Penny's commentary on his artwork *Fugitive II* (accessed 20th January 2013).

2. This polemic should not get in the way of celebrating the many fine examples of interactive artworks which live between these extremes.

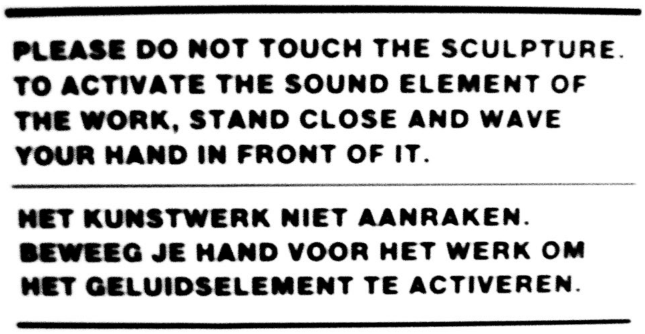


Fig. 1: Instructions for interacting with an artwork, seen at STRP festival, 2009.

Perhaps instead of focusing on either digital or analogue aspects, we should instead focus on how they mutually support one another in perception (Paivio 1990). After all, the shift from digital to analogue is a reversal of history; the discrete form of text emerged from imagery, and is made from imagery. Rather than thinking of computers as devices either for textual communication, or for systems that support gestural tools, perhaps we should use them to search for an illusive X which binds the two. As this X has continued to flow between us over evolutionary timescales, the vocal tract has developed as its primary conduit. Over this time our mouths have articulated not only to eat and breathe, but to form grunts, drones, chants and words; an organ for *digital* phonetic symbols, slurred into diphones and with *analogue* prosodic gesture and rhythm. We do not fully understand the operation of the vocal tract, but the trace of X is clear, in the poetic whole emerging from the simultaneously discrete and analogue articulation, intertwined in mutual support.

2. The loop

Along with the need to communicate with the voice, comes also the need to keep warm. Somewhat neatly, *knitting* provides metaphorical patterns and knots with which we may bind language with form. Knitting patterns are a kind of natural, domain-embedded programming language (Gold 2011), and mechanical computers and textile looms share early history (Babbage and Lovelace; Essinger 2004). In the following then, we use knitting as a metaphor on which we build an alternate viewpoint of the experience of programming, with focus on time.

Time itself is an arrow, and we are propelled forward with it. It is also a circle, for example the cycle of life, returning to where it began. These two views are hardly reconcilable, in linear terms it is the future which comes to meet us, and in cyclic terms it is the past. So it is with knitting socks; a line of wool, five straight needles, a cyclic pattern tying loops into circles, the heel turns but eventually the sock emerges.

We often understand computers in terms of an algorithm (pattern), converting analogue inputs into digital discontinuities (wool into knots) and the form of text(ile) that results. But how often do we attend to the experimental possibilities of the loop? Nowadays computer processes rarely run to a conclusion, but loop continuously, oscillating in sympathy with human interaction. Perhaps we should consider software not as tools, applications, or frameworks for producing something, but as a fabric which captures the oscillations of hardware, to be experienced in its own right.

Notionally, the present moment is a durationless point in time. Experientially, a perceived moment has a duration of sorts, for example we do not experience sound in terms of states of airpressure, but in terms of fluctuations which deliver the experience of a discrete, momentary sound. We can extend this argument to the cyclic pattern of a rhythm, which may last from seconds to minutes. If the cyclic period of a rhythm matches with the duration of the present, we freeze, lost inside feedback. In this state, we step out of time, but also bring time into sharp focus; small changes amplified against a stationery ground. In terms of the sock, a repeated pattern forms vertical striations of purl against knit; a small change in the cyclic pattern causes a sharp discontinuity, making those striations appear smooth.

3. Knitting with time: Live coding

Live coding is the use of programming languages in exploratory work, where code is dynamically interpreted so that edits take effect without restarts. Live coders often work before a live audience, such as in improvised music performance (see figures 2 and 3, and also Collins et al. 2003). This is a radical departure from conventional software development, breaking down artificial barriers between technologists and creative users, and has taken electronic music research by surprise (Emmerson 2007). Time will tell whether the Live Coding movement will really contribute to fundamental widespread change, but it is useful to criticise technical practice (after Agre 1997), and look for points where the ongoing narrative of technological determinism may be broken.

Fig. 2: Dave Griffiths and Alex McLean live coding as two thirds of the band *Slub* (http://slub.org/) in Mexico City, November 2012. Their screens are projected behind them, so the audience can see their code, in-line with the TOPLAP manifesto (Ward et al. 2004).

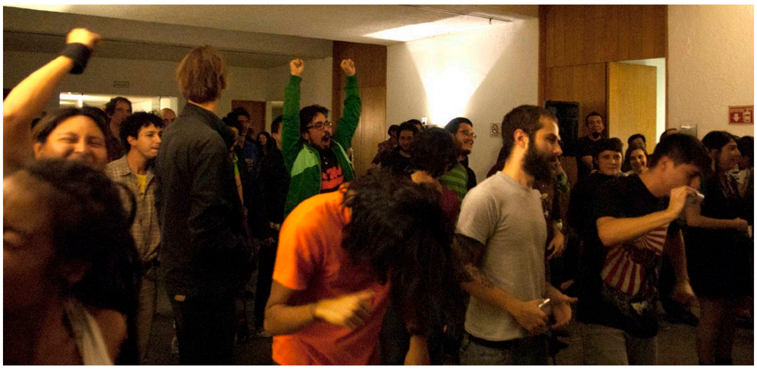


Fig. 3: Audience dancing to the live coding performance shown in the previous figure.

In 1987, Nintendo trialled a knitting machine controlled by a computer games console. Industry commentators recall this as a hilarious aberration, a prototype quickly dropped after a bemused executive failed to find words to sell it to management. In this moment, knitting and computation, so close in Babbage and Lovelace's time, had the possibility of being reunited once more in console gaming. We can imagine this as a 1980's paradigm shift that never was, an ungovernable flow of scarves emerging from every child's bedroom. This could have created a very different expectation for human-computer interfaces, with progress towards interactions more textural rather than those prods and smears currently in vogue.

The knitting metaphor may still serve us well. Live coding music is very much like knitting with time. Time is a livecoder's wool, not so much in the sense of recorded tape, but more in terms of the line of a monster curve. The line is twisted, knotted and transformed by patterning structures, thereby creating new dimensions of experience.

Although knitting of socks is enjoyable, the real purpose of socks is to be worn. We wear code by running it, constructing environments that we listen and dance to. In dancing the encoded meter, we set the ground: we find an implied pulse and feel it with the whole body, where the pattern is experienced in contrast. By stepping into the music, we become part of the program interpretation. But, when we are finished, we are left with nothing. Live coders knit a live fabric, not an end product; we can touch it, but then it is gone.

4. Knitting with code

This line of thinking may be set more concretely in the practice of computer programming, by considering sourcecode as a pattern for physical experience. In particular, using *Tidal*, a domain specific language for musical pattern, embedded in the pure functional programming language Haskell. Pure functional programming is a familiar topic in computer science, and occasionally found in mainstream programming practice. What makes a programming language *pure* is that a function has no effect beyond turning one value into another value. What makes it *functional* is that values can be higher order constructions, such as "add 5" or "make twice as fast".

Tidal represents music as a pure function, which takes time as input, and outputs sound events. This maps from the single dimension of time into multidimensional dance music, and has a direct analogue with knitting thread into two dimensional texture. Both involve repetitive, looping patterns, forming a shape that fits the body.

In Tidal, the knitting of time into music is represented using the following datatype:

```
data Pattern a = Pattern (Arc -> [Event a])
```

In other words, a Pattern is a function from an Arc of time, to a list of events of type a, where a can be replaced with any other type. The above datatype makes use of the following type synonyms:

```
type Time = Rational
type Arc = (Time, Time)
type Event a = (Arc, a)
```

Time here is a represented as a rational number, of arbitrary precision. An Arc is a pair of Time values, to represent a start and stop Time. An Event is a value that occurs over a particular Arc.

A Pattern may behave in two distinct ways, depending on whether it represents discrete or continuous patterning. Figure 4 illustrates the behaviour of a discrete colour pattern in visual terms. A Pattern should only return events active for some part of a given query, although they may start or end beyond the query. Note also that the returned events may overlap, in order to represent polyphony.

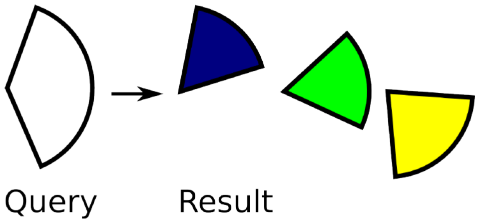


Fig. 4: A discrete colour pattern, showing that a pattern, as a function, may return a number of colour events active within the given arc, each occurring within their own arc.

This allows a simple representation of transitory values, each of which exists for a discrete period within a timeline. The timeline is notionally infinite, and we can probe for events using any Arc within it. As implied by the name *Arc* though, time is not only conceived as linear, but also cyclic. As Figure 5 illustrates, a cycle has a period of 1, which can be subdivided with arbitrary precision. This does not preclude polyrhythmic structures, but a fundamental loop, of period 1, is the focus. This accords with experimental evidence provided by London (2004), supporting his hypothesis that humans only attend to one meter at a time (although may have control over which they attend to).

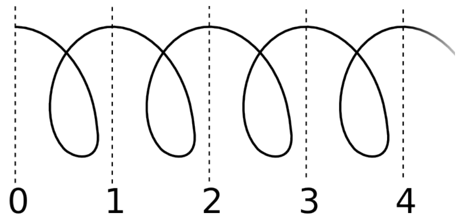


Fig. 5: A visual conception of a timeline as a spiral or coil, along which repeating patterns unfold and develop.

So far we have talked only of discrete patterns, but the same representation can be used for representing analogue, continuously-varying patterns. This relies upon the simple intuition that the closer you look at a continuous pattern, the more detail you are able to see. So, to represent a sinewave, a Pattern may return the average value of the given arc. In this way we are able to represent continuously varying values (as in Functional Reactive Programming; Elliott 2009) accurately, choosing what granularity or rate we use to sample values from it later.

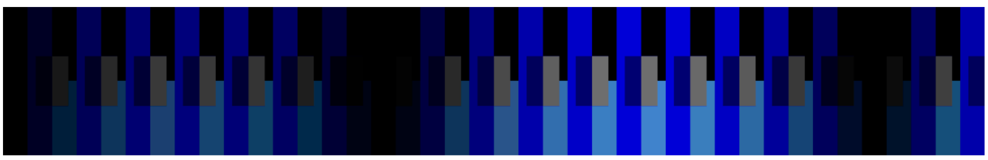
The distinction between these two kinds of behaviour is the same as the distinction between analogue and discrete views of texture, as discussed earlier. They are distinct, but can be combined in mutual support. Tidal is built around ways of using discrete and continuous together in rich, multidimensional, musical patterns. This amounts to the melding of the analogue and digital in computer language, but we will not go into further technical detail, instead turning towards some examples of use.

5. Tidal in action

It is difficult to get music across on paper, so in sympathy with the present medium, the following patterns will be of colour. Please consider the the horizontal axis as time, and the colour onsets and blends to construct temporal structures, which as music would be explorable through bodily movement.

The following code, shown above its output, multiplies a sinewave with a triangular wave (which has half the period), and applies the resulting signal to darken a sequence. The sequence here is described as superimposed sequences of colour, which are separated by commas. The important thing to observe is that simple continuous and discrete patterns can be combined, and that we can simultaneously perceive a continuous transition over a discrete pattern.

```
density 10 $ flip darken
             <$> “[black blue, grey ~ navy, cornflowerblue blue]*2”
             <*> (slow 5 $ (*) <$> sinewave1 <*> (slow 2 triwave1))
```

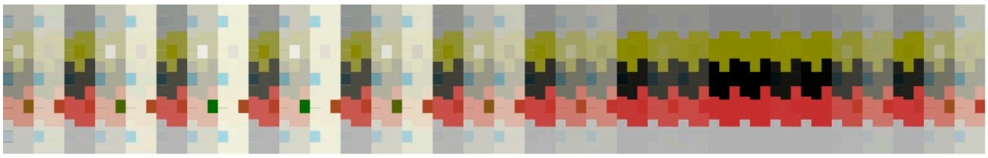


The following pattern is similar, but takes two sequences, and uses a sine wave to blend between them.

```
density 12 $ (blend’
              <$> “blue navy”
              <*> “orange [red, orange, purple]”
              <*> (slow 6 $ sinewave1)
             )
```

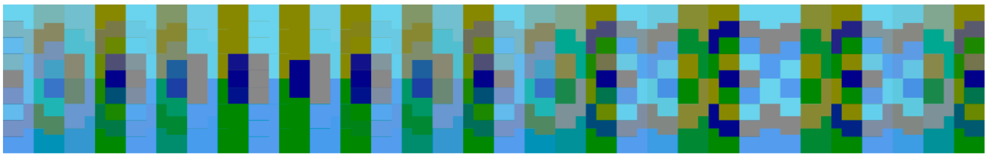
The following pattern uses a continous pattern to modulate the opacity of one sequence that has been placed over another.

```
density 32 $ flip over
             <$> (“[grey olive, black ~ brown, darkgrey]”)
             <*> (withOpacity
                  <$> “[beige, lightblue white darkgreen, beige]”
                  <*> ((*)
                       <$> (slow 8 $ slow 4 sinewave1)
                       <*> (slow 3 $ sinewave1)))
```



Finally, the following pattern blends between two instances of the same pattern, at different densities.

```
density 2 $
  do let x = “[skyblue olive, grey ~ navy, cornflowerblue green]”
     coloura <- density 8 x
     colourb <- density 4 x
     slide <- slow 2 sinewave1
     return $ blend slide coloura colourb
```



6. Conclusion

We have seen various family resemblances between knitting and programming, providing fertile metaphorical ground to explore the X of programming, taking an alternative view from the usual metaphors which are often born from commercial and military contexts. In particular, it allows us to consider both the experience and purposes of programming in terms of binding analogue as well as discrete forms. The code examples above may be simplistic, but are offered in support of this view, where the composed, discrete text of source code may evoke rich experience, much as the text in a novel evokes rich scenes within a narrative. Where we work with such code live, to which groups of people come together to dance, we have a good place to search for the elusive X.

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Are Luminous Devices Helping Musicians to Produce Better Aural Results, or Just Helping Audiences Not To Get Bored?

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Keywords: Performance Studies, Electronic Music, Laptop Performance, Interfaces, Gestural Information, Perception, Conformity.

Abstract: By the end of the 90's a new musical instrument entered the stage of all stages and since then, played a key role in the way music is created and produced, both in the studio and performing venues.

The aim of this paper is to discuss what we consider to be fundamental issues on how laptopers, as musicians, are dealing with the fact that they are not providing the 'usual' satisfaction of a 'typical' performance, where gesture is regarded as a fundamental element. Supported by a survey conducted with the collaboration of 46 artists, mostly professionals, we intend to address and discuss some concerns on the way laptop musicians are dealing with this subject, underlined by the fact that in these performances the absence of gestural information is almost a trademark.

1. Introduction

> Hearing represents the primary sense organ — hearing happens involuntarily. Listening is a voluntary process that through training and experience produces culture. All cultures develop through ways of listening[1].
> *Pauline Oliveros*

1. http://faculty.rpi.edu/node/857 accessed January 18, 2013.

Since the first moment a laptop appeared on stage, there is no musical genre that has not been influenced by it, in one way or another. It may have been a fundamental piece in the process, or the least an important one, yet it is very difficult to ignore its vitality in the actual process (praxis) of making music. It may be in a studio while composing a music piece, drafting sounds on the road or processing a live performance for contemporary creators. It is already part of our days, nights, best dreams, and worst nightmares. The history of creativity in music performance has changed, not only because of the laptop, but also because of the laptop. The same happened with visuals in live contexts where fundamental burst of new talents are carrying and implying new ways of doing, new aesthetics results, and above all, new ways of production.

In 1934, Walter Benjamin wrote a text that would become central to the history of arts: *The Author as Producer* (Benjamin 1992). After 79 years, this text is still a fundamental object of reflection when we consider the role of the artist, simultaneously, as an artist-producer of himself.

Benjamin could not figure how much he would be reproduced and replicated among authors, journalists, naive writers in forums, essays, blogs, books, articles, etc.

Despite the sharpness and contemporaneity of the German author, we must say that it is not our intention to evaluate the global content of his work. From Benjamin, we would like to emphasize the role of the artist as producer, and the question of the reproducibility, to a certain point.

Thereby, following the dichotomy introduced by Benjamin (author/producer), we will try to create a framework of discussion around the laptoper, our subject of study, as an example of a model-no-model (creation versus production) wherein he is observed and examined as carrier of the subject raised by Benjamin, when he talks about the author as someone that in a certain circumstance, "has had revolutionary evolution, from the point of view of the convictions, without being at the same time, capable to reflect in a truly revolutionary way about his own work, their relationship to the means of production, or on their technique ". (Benjamin 1992, 143)

What we would like to emphasize, here, is the perception that we are living in a world in which the artist must face the implications of the perception that he is generating. Therefore, he should not turn his back to the world where he is producing his own artistic work.

2. Brief resonances from the laptop world of music

> With electronic/digital media developments, especially in computer technology the possibility to control every parameter that modifies sound became possible. Yet, even today there is a tendency to recreate traditional music instruments interaction model which focus on pitch and dynamics. (Barbosa 2006, 93)

2.1. Flashbacking from academia

In 2000, Kim Cascone, an acknowledged composer and activist in the field of electronic music, released *The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music* (Cascone 2000), an article that became one of the groundbreaking texts about failure in electronic music, with a brief chapter on glitch, back then a relatively recent line of action started around 1995, with great glow around Mego, a music label based in Vienna. Farmers Manual, General Magic, Peter Rehberg, Fennesz and Tina Frank on live visuals and graphics[2], are only a glimpse from what could be a long list of artists using the laptop, on and off stage.

Christian Fennesz reported September 1995, on Flex Club (Viena) as his first time with a laptop in a live performance. (Joaquim 2012/13).[3]

Least recognized on that article, is the relevance that Cascone applied to the idea of "Power Tools" in what concerns the proximity between creation and production. "For the first time in history" he wrote, "creative output and the means of its distribution have been inextricably linked." (Cascone 2000) From that time on, dozens of articles included the term 'laptop' on the header to invoke all kinds of qualifications and solutions around the systematic doubt raised from the absence of visual feedback and gestural information.

David Wessel and Matthew Wright, pointed out in an article from 2002, an observation from Zicarelli (1991) in which he would consider the association that office work computers may bring to the realm of electronic music made with computers (Wessel and Wright 2002).

2003, was probably one of the most prolific year of the decade with Glenn Bach writing about the laptop as "dwelling", as a "vessel" and as "loom" (Bach 2003). Tad Turner, Nick Collins, Caleb Stuart and Tara Rodgers are also on this year's list of authors writing specifically about the laptop and the relationship with the audience. It was a very productive year in terms of critical mass in the realms of the academia.

Sergi Jordà, who introduced the term "digital lutherie" (Jordà, Digital Lutherie Crafting musical computers for new musics performance and improvisation 2005) is probably one of the most consistent authors about this significant asset, with a long list of reflexive articles starting in 2001, in which he questioned the practice of electronic music, bringing to the upfront of the discussion some fundamental issues, pointing out at the same time, possible paths and practical solutions. One of those solutions emerged on the Music Technology Group of the Universitat Pompeu Fabra in Barcelona with the Reactable, a project started in 2003 with many goals in mind. He wrote: "The foremost goal was to design an attractive, intuitive and non-intimidating musical instrument for multi-user electronic music performance, suitable for everyone to start playing from the first minute

2. http://www.lovebytes.org.uk/2003/docs/pages/tina.htm

3. Sergi Jordà (b. 1961) reported 1989/90 in Vitoria, Spain, as his first concert with a laptop in live context, and Atau Tanaka (b.1963) pointed 1993 at Etablissement Phonographiques de l'Est, Paris, as his first live performance with a laptop. (Joaquim 2012/13)

and yet capable of the more subtle and the more complex." (Jordà, On stage: the reactable and other musical tangibles go real 2008).

What Reactable was also capable of, was to establish a visual relationship with the user in a way that it could simultaneously became interesting to the audience (listener-viewer) and by this way, induce a blurring in the problem of the visual feedback and the absence of gesture.

In recent years, we have observed a tremendous increase in the commercial production of visual solution for laptopers, and also a big investment from the scientific world in finding ways to make new approaches in human computer interaction (HCI), accompanied by big efforts in tangible user interfaces (TUI), and all imaginable ways to reduce or neutralize the *ghost-machine*, which prevents man to express himself gesturally in all its fullness and splendor (read: irony).

Marcelo Wanderley, recognized researcher in the field of gesture, on his article *Gestural Control of Music*, reveals the issue that became one of his central motivations for research in music field. He says:

> Digital musical instruments do not depend on physical constraints faced by their acoustic counterparts, such as characteristics of tubes, membranes, strings, etc. This fact permits a huge diversity of possibilities regarding sound production, but on the other hand strategies to design and perform these new instruments need to be devised in order to provide the same level of control subtlety available in acoustic instruments. (Wanderley 2001)

A few years later, in 2006, Mark Zadel pointed on his research, a solution that gave the name to his thesis: a *Software System for Laptop Performance and Improvisation*. The aim was "to bring a sense of active creation to laptop performance" (Zadel 2006a). Through the use of drawing, among other operations, the performer could imprint a sense of freshness and create an impression close to the experience that we have when attending a regular concert with regular musicians. Zadel expressed that quality of imprint as a process of "infusing the music".

Simultaneously to the attention dedicated in academia, there was also a myriad of events in which the laptop started to gain protagonism, like occasional concerts, festivals,[4] and publications. *The Wire Magazine*[5] documented in the cover, the arrival of new stars like Pole and Merzow in 2000, Oval and Kid 606 in 2001, Autchere, Matmos, Aphex Twin and Raster-Noton in 2003, Fennesz, Wilco and Ikue Mori in 2004, etc.

The web was also very active in the analyses of the laptop phenomenon, in 2006, Marc Weidenbaum, musical journalist, editor and publisher of Disquiet[6], wrote *Serial Port: A Brief History of Laptop Music*,[7] an article with approx. 6.600 words and a large number of pictures. It was an extensively and well documented report on the activity, mentioning the work of artists such as Joshua Kit Clayton, Matmos, Taylor Deupree, Fennesz, Kid 606, Monolake, Ikue Mori, Scanner and many more, exposing simultaneously some historical information about software and hardware, not leaving behind some historical perspectives about key role players like Leon Theremin and Pierre Schaeffer. The article, generated a series of reactions on the web, about what *does it mean being a laptop musician*. In reaction to those questions, Weidenbaum felt compelled to explain and justify in

4. Examples: www.emefestival.org, http://www.aec.at, http://www.transmediale.de, http://www.sonar.es

5. http://www.thewire.co.uk

6. http://disquiet.com

7. http://www.newmusicbox.org/articles/Serial-Port-A-Brief-History-of-Laptop-Music

another text[8], what was in consideration within the concept of the article. On his original text, Weidenbaum emphasized, among other aspects within the laptop performance, that laptop music "isn't really a genre, and since the laptop can run such a variety of music software, it may be inappropriate to simply call it an instrument". He stated as a "phenomenon". (Weidenbaum 2006)

Among others, Weidenbaum is referenced by Rebecca Fierbrink, Ge Wang and Perry R. Cook, in the article *D'ont Forget the laptop: Using Native Input Capabilities for Expressive Musical Control* (2007).

One year before, in 2005, on the same web page (New Music Box[9], a web page dedicated to the music of american composers and improvisers) , Roddy Schrock, dedicated also an article to the subject on Laptop Music for Beginners[10].

> Miniaturization and increased performance render the personal computer portable, the desk environment (desktop) is now located in the lap (laptop) or in the palm (palmtop) of the user. (Grossmann 2008)

Throughout this brief overview that was not intended to be comprehensive, we may have observed that the generalization of the laptop in the musical scene, was accompanied with the problem of the visual feedback, lack of action and absence of gestural information in performances. This problem is extensively reported since the first moment of its appearance on stage, by the mid 1990's, when people like Oval, Pita, General Magic and Farmers Manual started to introduce laptops on stage. Has Peter Worth states on his Ph.D. thesis, "The release of the G3 PowerBook in 1997 was roughly the point at which it became possible (and affordable) to do the same kind of audio processing on something a fraction of the size and weight." (Worth, Technology and ontology in electronic music: Mego 1994-present 2011, 30).

Atau Tanaka pointed 1998 as the turning point with the arrival of the Powerbook G3, a portable computer that allowed "to do real time audio signal processing native on the laptop, and with that no longer needing hardware synthesizers and samplers" in consequence, it was also possible to "pass from Max to MaxMSP (then later to live visuals with NATO and Jitter)" (Joaquim 2012/13)[11]

2.2. Key strokes from laptop artists

> Working with electronic music has come a long way: from the humble beginnings of the early frequency- / synthesizer-music pioneers to today's ubiquitous, ultra-flexible, emergent, personal audio production environments and customizable sandboxes. (Popp 2011)

Navigating in a completely different map from the academia, artists began to feel all the problems arising from the lack of visual information on their performances.

In 1995, General Magic (duo of Ramon Bauer and Andi Pieper, co-leaders of the *Mego* label at the time)[12] was already mapping a circuit of concerts *placing* the laptop in front of the stage, sharing audiences with Peter Rehberg producing sound, and in some occasions, with Tina Frank on visuals[13].

8. http://www.newmusicbox.org/articles/Upwardly-Mobile-What-we-talk-about-when-we-talk-about-laptop-music

9. NewMusicBox, is a multimedia publication from *New Music USA*, dedicated to the music of American composers and improvisers.

10. http://www.newmusicbox.org/articles/Laptop-Music-For-Beginners

11. Information retrieved from the surveys addressed to laptop practitioners.

12. http://www.discogs.com/search?q=General+Magic&type=all, accessed January, 17, 2013.

13. http://www.lovebytes.org.uk/2003/docs/pages/tina.htm accessed January, 17, 2013.

In 1999, Mego released the second Pita album, *Get Out* (Mego 029), an album that was made "using an Apple Powerbook 1400cs/133"[14], "often considered a benchmark in the 'laptop' genre, evidenced by descriptions such as 'a milestone in early laptop music' (Sohns 2008) or 'the first major musical laptop statement' (Keenan 2008)." (Worth, Technology and ontology in electronic music: Mego 1994-present 2011, 30–31)

Florian Hecker[15], another laptop pioneer and Mego affiliated, referred also the Powerbook 1400cs/133 as his "first portable machine"[16]. During private correspondence, Hecker was very prudent in avoiding being identified as a laptop musician, while expressing deep concerns on the subject, despite all the public documentation showing him with hands on laptops. What Hecker may indicate with this concern, shared by other musicians, is probably what we have pointed out in our Introduction, as a concern reflex on the subject of the author as a producer of himself. Hecker explains: "I've always been critical about a coinage such as 'Laptop Music', an invented genre, where thinking beyond genre would be fruitful (...) In most of my performances since 2006 (...) with a few exceptions, I stepped back from working intuitively with real time DSP during a performance"[17].

Probably one of the most popular caricatures about the laptop performance started to rise in the turn of the millennium: the artist as someone that may be reading e-mails or playing files from the hard-drive, while everything looks meaningful to audience.

> A common complaint about many electronic improvisers is the lack of obvious action on stage, the "they might as well be reading their e-mail up there" line of criticism.[18] (Abbey 2002)

In another level of production, moved by other forces, Brian Eno, when comparing past and 'present' of musical studio, wrote *The Revenge of the Intuitive — Turn off the options, and turn up the intimacy*, an article in which he stated:

> (...) now I'm struck by the insidious, computer-driven tendency to take things out of the domain of muscular activity and put them into the domain of mental activity. This transfer is not paying off. Sure, muscles are unreliable, but they represent several million years of accumulated finesse. (Eno 1999)

We presume that when Eno invokes "several millions of years" as an argument *against* the "mental activity", he is in fact, trying to convey the idea that without gesture, musical performance is losing something that is innate since the beginnings of times. Transposed to the world of the laptop production, this premonition does not seem to prelude a great future for its proponents and practitioners. However, over the years, it seems that history has not given reason to Eno. On the contrary, laptops (*the machines with no gesture behind*) are now spread over the world, and it is hard to imagine a stage without a laptop, from one side to the other of the musical spectrum, considering all levels of production, from clubs to stadiums, from experimental to contemporary music. Laptops are around us, and behind each one, there is always someone making choices, whatever they might be.

In 2013, we are now on the verge of imagination, facing a multitude of options and reactions, where every artist is confronted with a myriad of opportunities. Ranging from commercial products to custom made patches of Synthesis Software, from hardware

14. http://editionsmego.com/release/eMEGO+029

15. http://florianhecker.blogspot.pt

16. Private conversation.

17. Private conversation.

18. http://www.annetteworks.com/artist/worksmade/mimeo/index.htm accessed January, 17, 2013.

solutions to plug-in miracles, the laptoper has many more options than he can imagine or afford. Eventually, part of those solutions, end up having a significant visual impact (and effect) on stage leaving on the background the main reason why a sonic solution has been implemented: help the musician to achieve a better aural result.

Madeon (b.1994) a very young star in the world of electro house and pop music, presented himself at the MTV EMA's, 2012 surrounded by 3 Launchpads (Ableton) a laptop and a Xone controller (A&H). The event was extensively advertised on the web and Madeon was promoting the concert with pictures of himself with the 192 pads (from the 3 controllers) blinking like luminescent lamps in a party. Obviously, it does not make sense to question the quality of his work, or the reasons for choosing this or that equipment. What is really important to investigate on Madeon, is: why is he positioning the controllers towards the audience and not towards himself? What we can infer is that he might be interested in deliver visual feedback from what he is doing, as a way to engage the audience in the process. In his field — the show business — that determination to please the crowd, is regularly recognized as an entertainment quality, and represents a heritage that may find its roots in the old Greek theater tradition, where artists, above all, should please the audience.

We must underline that one single video from Madeon called "*Pop Culture (live mash-up)*", with him pressing pads on the Launchpad, filmed with one single shot in close-up over the hands — no cuts! — is now, hitting over the 16 million plays in Youtube.[19]

Not on the same artistic range, but with the same type of motivations, Sergi Jordà and all the pioneers of live coding, each one on his side, have arrived at another type of solution. According to their own points of view and aesthetic options, they choose to express themselves in different ways. However, they have in common the same motivation that compelled Madeon to the glamour of blinking lights (i.e. please themselves and the audience). The basic problem was/is persistently omnipresent, and what they opted to do, was/is only another variation on the angle of approach.

Jordà, opted to research and write about the subject, and also to develop his own "digital lutherie" (Jordà, Digital Lutherie Crafting musical computers for new musics performance and improvisation 2005) that culminates in the realization of the Reactable. Coders, on the other side, started to play everywhere, whenever and whatever possible delivering to the audience, via video projection, all the elements implied on the process of making their own music. Instead of generating entertainment for the masses, the live coder generates information in real time about the processes that are being carried throughout the performance. His goal is to turn the attention of the audience into the information generated on the moment, using code, the same way that a guitar player uses the strings: to generate sound.

To summarize, we can look into these facets, and observe three completely different types of reactions (solutions):

a) *Reactable* as a result of academic research

b) *live code* as a political statement

c) *triple dose of fancy luminous controllers*

Still, we may observe and conclude that the responses are, metaphorically speaking, like three sides of the same triangle. They are facing different directions, but they are reacting to the same *stimulus*. In this way, they behave like different parts of the same body.

19. http://www.youtube.com/watch?v=lTx3G6h2xyA accessed January, 17, 2013.

As if one part was thinking, the other was pushing and the other was kicking.

Through the diversity of examples, we hope we have drawn attention to the fact that so many artists, working in all kinds of aesthetic fields, share this concern far beyond the limited area of compositional and aural motivations. It is a general concept that the stage is an immense space of exposure and for exposure, but we must keep in mind also, that every space has, by definition, boundaries circumscribed by the will of the author, as the fundamental drive of the event.

2.3. Resonances from the will

> Not only do different people listen differently, but also the very temporality of our presence in a place is a form of editing. (López 1998)

Affected by the prospect of a *boring* performance, some laptop artists introduced (and are still introducing) several types of solutions to keep audiences interested. One of these solutions, is observed with the use of luminous controllers to 'interact' directly with the software and, indirectly, with the audience. By this way, the artist can generate also a visual feedback that facilitates the momentum of the performance by turning the result into something much *more pleasant and communicative*.

Considering this option, we shall face all the elements of the equation (author's will, audience's desire, aims of the piece, space of the event, etc.) and raise one simple question: by this way, are controllers helping musicians to produce better aural results or 'just' entertaining the audience?

Throughout the years, we have listened and read a large amount of justification and arguments on this large field of speculation, but it is not easy to find a straight and common perspective that can be shared by the whole community implied on the process. That may happen, probably, because we are dealing with a high level of uncertainty in which a large number of ideas are not anchored on facts but on ideas, taken as facts. That confusion is determining in the end, a complex triangulation of facts, mutual expectations, and even fiction.

It is not easy to define and turn tangible what in general is not tangible.

So, let us rephrase the problem again, from another angle: are performers affecting or changing what they do live, because of the audience? Because they are concerned about what might be the correspondence to a certain model of 'delivering content'? Because they are afraid that they might be not accepted, or at least in a condition wherein they feel unsafe or unsecured about a satisfactory aural performance? And because of that, not so well accepted? And, in consequence, affecting all the work based in a preconception of what is the *right model*?

> What is behind that curtain?
> *Laurie Anderson*[20]

20. From "Born, Never Asked" from the album *Big Science* (Warner Bros. 1982)

3. Do laptopers have something in mind?

3.1. laptop artists under survey

> I can honestly say that I do not recall ever feeling better about the quality of a performance because of the presence of an audience. (Glenn Gould, Mach 1980)

If we look deep inside the universe of the performance space, recognized as stage, we must consider a general overview into the reasons why laptopers still want to perform, despite all the indicators pointing to the fact that "audiences can be unsatisfied with the apparent lack of activity and lack of visual cues it sometimes offers" (Zadel e Scavone, Different Strokes: a Prototype Software System for laptop Performance and Inprovisation 2006b)

Through knowledge of the reasons which remain at the option of each laptopers on playing live, no styles or categorizations included, we will find in all of them, a common ground that resonates in the deep desire to do it, to go on stage, and just do it. Deep analyses on the subject should turn in itself a research in the fields of the psychology, associated with all the performativity activities as common ground.

In the specific field of the laptop performance, what we can infer, and that is our point of departure in this article, is that we are in presence of a will to do it. That will, may be stronger in some cases than in others, but there is always a will, an energy that compels a normal person to become a communicator, and through this option go on stage.

The reason of the will, we believe, is different in every case, relatively impenetrable, and not necessarily associated with an obscure desire to be admired, or adored. In fact,just because someone likes to play live, it does not mean necessarily that the person likes to be on stage. It only means that the person goes on stage. All the rest are conjectures. It is possible that the person wants to show his or her own work in a live context instead of pressing a CD or uploading a file to the World Wide Web and chooses the stage as a way to do it. Or, the person is possibly seduced by the physical experience of hearing through a powerful and highly qualified sound system, something that we normally do not have at home.

So, in order to learn directly from musicians, and what they think about the experience of using a laptop in live performances, we conducted a survey, via direct enquiry, with six questions and an open item for observations. The survey targeted active practitioners of laptop and ex practitioners, both genders, ranging from 29 (José D. Correia (Re:Axis)) to 65 years (Carlos Zíngaro), with geographical origin in 15 different countries, from almost all continents (Australia not included).

On this list of practitioners, we include 6 visual artists (Alba G. Corral, Hugo Olim, Lia, Laetitia Morais, Sladzana Bogeska and Tina Frank) to enrich the information, gain perspective and wide open to other experiences.

Intentionally, because it was an open questionnaire, the issue of the absence of gesture was keep out of the frame. That was in fact, the primary reason to do the survey in a non-directed format, with open questions.

List of questions:

- Q1 — When did you first acquired your first laptop?
- Q2 — When and where did you first used a laptop in a live performance? Please, specify with all possible detail.

(Can you provide a picture/video-link of that first performance?)

- Q3 — What made you start using a laptop in live performance?
- Q4 — From your point of view, what are the qualities of a laptop? Please, try to specify your points in order. (10 points to fill)
- Q5 — From your point of view, as a user, what are the inconvenients of a laptop? Please, specify in order.
- Q6 — How many concerts you did since you started playing live with a laptop?
- Observations

3.2. Preliminary results and analysis (part 1)

A general evaluation is being conducted in a long term research project, but we would like to present some preliminary results, particularly connected with a few ideas shown in this paper. With special relevance: what is the idea that laptopers have of themselves and what are the critical insights that they have on the choices they make.

So, from the outcome of these 46 questionnaires we would like to highlight *20* individual allusions to descriptions that conveyed, directly or in similar meanings, the experience of the laptop performance as a "boring" experience. This result, represents 43,4% of total respondents, excluding repetitions of the same idea from the same responder. We should underline that the survey does not allude, in any way or moment, to this particular factor. Under evaluation, are *only* the "inconvenients" of the laptop (Question 5).

The responses are given within a frame that corresponds to the accumulated experience of the responders as practitioners but we must not forget that they have also the experience (not negligible) of attending concerts while they are touring. According to this possibility, we should consider the experience as a global experience, not only as a practitioner's point of view.

Considering the number of concerts performed with laptop, from the responses, we estimated an average of 133 concerts per each person — since the first concert with laptop until the last one. This average, excludes 2 extreme cases: one with an estimated number above 500 (Christian Fennesz) and the other with an estimated number above 800 (Julien Ottavi).

7 other subjects did not reply to that point. The tendency on these 7 elements for not responding was associated with lack of information ("countless", "don't remember anymore", "never counted"...).

This information, considering estimated values by the artists, corresponds to a global number of 6.582 performances.

From this block of information, grounded in the announced numbers, we can extrapolate that experienced laptopers, in general, are aware that there is in fact, a problem of perception derived from a problem of non-expression that is inherently to the nature of the *instrument*.

This conclusion, is consistent with the examples presented on 2.1 (academia) and 2.2 (laptopers), and raises a significant list of issues that are presented in our final part.

Not included on the list of 46 subjects who replied to the survey, 2 artists (L1, L2)[21] expressed in correspondence that they did not respond to the survey because they cannot identify with the idea of being laptopers, or their music associated with the concept of *laptop music* (we never used that term on the survey or in the correspondence leading to the survey)[22].

21. We will keep the identities under privacy.

22. Can we infer from this observation that they are reacting in a projective way? Anticipating and avoiding a possible coinage of their work as *laptop music*, thus consistent with the argument that we expose?

Two responders (L3, L4) from the group of 46, tried to avoid or skip the written format of the survey, and showed interest to approach the subject using personal contact or by the way of an interview, outside of the framework of this survey.

Going now into the 20 previously mentioned allusions (descriptions that conveyed, directly or in similar meanings, the experience of the laptop performance as a "boring" experience) we would like to emphasize some lines of thought presented autonomously by the responders.

3.3. Preliminary results and analysis (part 2)

Oswald Berthold, from Farmers Manual[23], one the first musicians to go on stage with a laptop, at least in a consistent way, mentioned that standing in front of a computer "(no matter what type) is not an attractive mode of performing."

As he mentioned:

> I perceive it as somewhat shortsighted and pop-culture related to emphasize the *objectness* of the instrument too much. Use of a particular emblematic object (electric guitar, laptop, ...) somehow is driven by pragmatic concerns, develops and intrinsic aesthetic and cultural dynamic, which is a feeback process with symbol (as in icon) iteration and discourse in culture. The question is rather, how much processing power can conveniently be put into one place (or some coherent perceptual domain) and how much of that is put to use for the generation of unforeseen dynamics. Regardless of using a laptop or not, of doing an interactive or autonomous machine performance, the main item of interest is how well the intricacies of the processes involved are represented in the perceptual channels.
> *Oswald Berthold*
> (Joaquim 2012/13)

This association with perception was also highlighted by Marc Behrens[24], when observing the laptop computer as an object primarily designed to use "while seated", That is why, in Behrens words, "it can be a hermetic machine" and "not give any indication to an audience of what the 'performer' is doing." Thus, from his point of view, he likes to "over-emphasize the performative by repeatedly lifting the laptop around, moving its support, climb chairs and tables etc."

We believe that this challenge as stated is substantiated in the idea that this particular musician has about *laptop performance*, "a misleading term for a group of people who mostly "perform" in the way they would when typing." (Joaquim 2012/13)

André Aselmeier, from Incite[25], is very clear about this problem and what can be a possible *solution*. He says:

> I think the Laptop should not be in the center of the show, the artist and his/her work should be. With Incite, we thus always cover the glowing apple-logo as it would be the brightest spot on stage and it carries a message that has no relation to the art involved.
> *André Aseilmeier*
> (Joaquim 2012/13)

23. http://web.fm/twiki/bin/view/Fmext/WebHome

24. http://www.mbehrens.com

25. http://www.incite.fragmentedmedia.org

26. http://endliche-automaten.de

27. http://www.random-industries.com

28. http://www.simonwhetham.co.uk

29. http://www.helenagough.net

Marek Brandt, member of the Endliche Automaten — Laptoporchester Berlin[26] regarding a certain impact on the performer and observing the performance from the inside, confesses that is "too much staring at the monitor (and) static (disconnected with the rest of the body — except hands and head) while live performing" (Joaquim 2012/13).

Sebastian Meissner[27] man of multiple artistic personas (Autokontrast, Autopoieses, Bizz Circuits, Klimek, Open Source, Random Industries, Random Inc) expressed this generalized concern about what might be happening behind the screen with some humour: "you have to answer questions if you are playing solitaire…". Sense of humor, is in fact, a characteristic that we can find with some regularity in the replies. In another tone, Meissner emphasizes that it all depends on what kind of music you want to play. Also, "if you want to perform and entertain people (expose yourself in a physical way on stage) or if you want to play and present your work to audience which have the patience to listen to instrumental music." (Joaquim 2012/13).

By this way, underlining the act of listening (having a more attentive audience) Meissner introduced a shift in the perspective. In fact, audiences are also part of the equation and should not be left behind.

As Simon Whetham[28] said, "audience can be left feeling unengaged". That is why he makes the decision of changing his setup, contrary to the way how audiences usually attend concerts:

> I now tend to play either from behind or within the audience, (a) to control what they hear more accurately, and (b) so there are no expectations of my presence on a stage or in front of the audience.
> *Simon Whetham*
> (Joaquim 2012/13)

According to Whetham, there is no reason for regret or complain about the use of the laptop on stage; actually he finds the laptop "the perfect tool for performance and composition when using field recordings and pre-recorded material."

In a very close position to Whetham, Helena Gough[29], admitting the absence of "physical or gestural aspect" mentions that "many audiences are unable to adjust their expectations to this and focus on listening alone". When referring to the audiences, she declares:

> They come to a concert with expectations that are still connected to the classical music tradition — they want to see the music and the 'performer'. The assumption from this perspective is that a laptop is lacking something because it doesn't offer this visual aspect.
> *Helena Gough*
> (Joaquim 2012/13)

Helena Gough, which has a great experience as violin player, noted that being behind a laptop, "involves tedium and discomfort", some problems with "posture" and "repetitive strain injuries". Despite the list of inconveniences, she sees the laptop as her own studio and place to compose, and does not give special credit to the expectations of the audiences. More, she has a response for that:

The response I have to this is quite simple: change your expectation and come to a performance involving a laptop open to the idea of listening and being absorbed in sound. From here you will realise that focusing on only one sense can be an intense and rich experience, and that when you close your eyes, you 'see' with the mind and the imagination. I consider my performances to be visual only in this particular manner.
Helena Gough
(Joaquim 2012/13)

Ramon Bauer from General Magic[30], another laptop pioneer with reported concerts starting in 1995, states that the problem is anchored in the fact that a laptop is "not a purpose-build instrument", resulting in a non-appropriate haptic interface to "play". Like other laptopers, he finds that the relation with the audience needs to be questioned and relocated in a proper context. In Bauer's words:

30. www.metropop.eu

Keyboard and mouse are not adequate at all. Even with fancy external controllers, the laptop musician is still (often) stuck in a physical position that hampers the performer to actually perform (physically). This, in my opinion, hampers the communication with the audience, which (often) has no clue about cause and effect of what they hear (or/and see — in an (audio-)visual context).
Ramon Bauer
(Joaquim 2012/13)

Despite the general perception conveyed by the 46 laptopers and by 20 in particular, one specific case attracted our attention: Keiko Uenishi, did not conform to the rest of the inquiries, and introduced a contradictory argument. When asked about what made her "start using a laptop in live performance?" (Question 1) she replied: "to look boring, so audience may stop looking at me/performer on stage. (That's what I hoped for)"[31].

31. Part of the content correspondent to the survey answered by Keiko Uenishi (o.blaat).

In this way, she derived the answers in a completely unexpected direction if we consider the average reactions from the other responders. Uenishi example became quite surprising, pointing to further discussion on how to find space for various personal tendencies in approach to performance. Later, on question number 4, when listing the "qualities" of the laptop, Uenishi stated on first place, (i.e. as a positive statement) the idea that the laptop is "boring to look at (unimpressive-looking plain machine)".

This idea is complemented and clarified when Uenishi (question number 5, about the inconvenients of a laptop) states that "people are 'still' trying to look at performers sitting in front of laptop on stage (and complain if they're not entertained by looking at them.)". On the same line of explanations, she stresses that "maybe, it's better to give up looking at them" or, otherwise, maybe "performers and/or organizers of the event may need to restructure different ways to present them (if they're interested to be seen…)". (Joaquim 2012/13)

We may infer from these examples that some artists are aware of the impact caused by a performance with no visual feedback, in which the gestural information is almost absent. But in practical terms, they tend to conform to the norm, even if we admit that they react in personal terms and in gradient ways.

Beyond this conclusion, we can recognise that each one is reacting to the issue in different ways but the vast majority tends to conform.

Thus, a possible speculation may arise: what are the necessary conditions to trigger a change in the way events are being conceived and produced?

As we have seen on chapter 2, academia tried to address the 'problem' by implementing 'new solutions'. We have seen also that artists have found ways to overcome and adjust themselves to the 'problem', but in this particular survey, we presented a case of a laptoper that where others see a flaw or a problem, she sees a virtue and an advantage.

For future work, we plan to select some individuals and conduct personal interviews with the objective of determining the specific ways how each one stands in particular contexts and situations.

The will, the will to do that...
coronel Kurtz (in *Apocalipse Now*)[32]

32. Coronel Kurtz, role played by Marlon Brando on the long feature film, Directed by Francis Ford Coppola (1979).

4. Conclusions

Going back to our top question, in accordance to the elements part of this article, we assume that there are strong indicators pointing to a positive answer. Yes, we believe that artists are too much concerned about the visual satisfaction of the audience, and leaving their own aural expectations being compromised by what can presumably be a desire of the viewer. Not the listener, but the viewer.

Besides, nobody proved until now that a flashing interface with 64 buttons in sync with the BPM of the track is bringing added value to the aural program. What we can prove with this is that there are more lights turning on and off on stage.

If the artist, as performer, is concerned with his aural impact on audiences, he or she should take into consideration, more than ever before, the fact that it is fundamental to think not only in artistic terms, but also in production terms. Like Walter Benjamin said:

> We all must bear in mind the vastness of the horizon, from which must be rethought forms and categories (...) consistent with the technical circumstances of our current situation, to get to the forms of expression. (Benjamin 1992, 141)

As we have seen through the examples, according to the model of conformity developed by B. Douglas Bernheim, the problem of interaction in groups exists and is recognized for a long time; therefore artists should keep in mind that audiences tend to conform to the norm despite what each person may think individually.

And because laptopers are also part of the population, they are also under pressure to keep on the same "homogeneous standard of behavior" (Bernheim 1994) of the audiences. Therefore, it is so difficult to establish and impose an operative model in the form of another format of performance in which the aural content is the center, and the only information to be perceived in the space.

For future work, we envisage a deeper debate around conformity in the frame of the electronic music en general, and in particular in recent genres and processes associated with the laptop performance, with special emphasis on non-idiomatic genres like, glitch, drone, ambient, live coding, generative, etc.

We end by formulating and synthesizing 3 fundamental issues in the form of open questions.

One of the fundamental issues is: are we in presence of a phenomenon of conformity in which audience tends to replicate what is the average tendency of preferring a certain degree of visual entertainment (served mostly by the gestural information) in detriment to the *absolute* value of the aural performance?

Furthermore: Is this tendency to conforming occurring also with the laptoper, i.e. is he or she, also worried about the “social interaction” as a fundamental aspect of his “status as well as *intrinsic* utility (which refers to utility derived from consumption)”? (Bernheim 1994, 841).

In fact, as Bernheim puts it, “status is assumed to depend on public perceptions about individual’s predispositions rather than on the individual’s actions”.

Third and finally: why have we not already implanted in our global model of performances, one *type* of performance that consists uniquely in an aural experience of content?

Some people would argue that is happening already at home, where many people enjoy listening music in the dark. But we argue that is not the same, at all. And is not the same, basically because sound is form in itself, manifested in SPL, and a private room and a home sound system are not comparable in any circumstance to a venue or a sound system with large speakers. Hearing is physics, not only, but firstly, and without pressure level there is no sound. The situation is a similar, but the experience is absolutely different. We may compare it with a picture from Guernica in a book, and the real Guernica in a wall.

Plus, where is the crowd, that fundamental element in all live performances?

We hope to have raised through this study, a broad debate on the issue that gathers in the same arena creators and audiences, observed under the microscope that represent the perceptions of both sides, as well as the perceptions on the perceptions of others.

As Walter Benjamin underlined about the artist, the laptop performer must imply him more on the production process and keep in mind that the production of his own work is a fundamental step towards a better aural result. Laptops do not need to turn themselves into luminous lamps and do not need more light. What they need is to satisfy their primary needs in terms of sound, if they work with sound; and on visuals, if that is what they do.

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The Human Fingerprint in Machine Generated Music

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Keywords: Generative Music, Machine-Learning, Heuristics, Aesthetics of Generative Art.

Abstract: Machine-learning offers the potential for autonomous generative art creation. Given a corpus, the system can analyse it and provide rules from which to generate new art. The benefit of such a musical system is described, as well as the difficulties in its design and creation. This paper describes such a system, and the unintended heuristic decisions that were continually required.

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1. Introduction

Machine-learning offers the potential for autonomous generative art creation. An ideal system may allow users to specify a corpus, from which the system derives rules and conditions in order to generate new art that reflects aspects of the corpus. High-level creativity may then be explored, not only by the careful selection of the corpus, but by the manipulation of the rules generated by the analysis.

Corpus-based re-composition has been explored most famously by Cope (Cope 2005), in which his system, EMI, was given representations of music by specific composers — for example, Bach and Mozart — and was successful in generating music within those styles (Cope 1991). Lewis used autoethnographic methods to derive rules for the creation of free jazz in his *Voyager* real-time performance system with which he, and other improvising musicians, interacted in performance (Lewis 2000). My own work with genetic algorithms used musical transcriptions of Indonesian Gamelan music to generate new works for string quartet (Eigenfeldt 2012). In the above cases, artistic creation was of paramount concern; as such, no attempt would have been made to *avoid* aesthetic decisions that would influence the output of the system (in fact, they would have been encouraged).

Using machine-learning for style modeling has been researched previously (Dubnov et al. 2003), however, their goals were more general in that composition was only one of many possible suggested outcomes from their initial work. Their examples utilized various monophonic corpora, ranging from "early Renaissance and baroque music to hard-bop jazz", and their experiments were limited to interpolating between styles rather than creating new, artistically satisfying music.

The concept of style extraction for reasons other than artistic creation has been researched more recently by Collins (Collins 2011), who tentatively suggested that, given the state of current research, it *may* be possible to successfully generate compositions within a style, given an existing database. This paper will describe our efforts to do just that, albeit with a liberal helping of heuristics.

2. Background

People unfamiliar with the aesthetics of generative art might be somewhat perplexed as to why any artist would want to surrender creative decision-making to a machine. Just as John Cage pursued chance procedures to eliminate the ego of the artist (Nyman 1999), I would suggest that generative artists have similarly turned to software in a search for new avenues of creativity outside of their own aesthetic viewpoints. The benefit of corpus-based generation avoids Cage's modernist reliance upon randomness, and investigates a post-modernist aesthetic of recombination.

As a creator of generative music systems for over twenty years, I have attempted — as have most other generative artists — to balance a systems' output between determinism and unpredictability. In other words, I approach the design process as both a composer — I want some control over the resulting music — and a listener — I want to hear music that surprises me with unexpected, but musically meaningful, decisions. Surprise is generally agreed to be an integral condition of creative systems (Bruner 1992).

Following in the footsteps of forerunners of interactive music systems (Chadabe 1984, Lewis 1999), my early systems equated 'surprise' with randomness, or, more specifically, constrained randomness (Eigenfeldt 1989). Randomness can generate complexity, and complexity is an over-reaching goal of contemporary music (Salzman 1967).

However, it becomes apparent rather quickly that while randomness — even constrained randomness — may generate unpredictability, the resulting complexity is, using a term posited by Weaver in 1948, *disorganized* (Weaver 1948), versus *organized* complexity that results from interaction of its constituent parts. In other words, randomness could never replicate the musical complexity exhibited in a work of music that plays with listener anticipations and expectations (Huron 2006). These expectations potentially build upon centuries of musical practice that involve notions of direction, motion, intensity, relaxation, resolution, deception, consonance and dissonance — none of which can be completely replaced by random methods.

2.1. Machine-Learning and Art Production

It makes sense, then, that in order to replicate intelligent human-generated artistic creation, it would be appropriate to apply elements of artificial intelligence towards this goal. Machine-learning, a branch of AI in which a system can learn to generalize its decision-making based upon data on which it has been trained, seems ideal for our purposes: not surprisingly, adventurous artists already have explored its potential, and with some initial success.

However, as is often the case with AI, such moderate initial successes have tended to plateau, and tangible artistic production examples are harder to find. ISMIR[1], the long-running conference concerned with machine-learning in music, has, since 2011, included concerts of music that incorporate machine-learning in some way; based upon attendee's informal responses, these concerts have proven to be somewhat unconvincing artistically. Music Information Retrieval (MIR), as evidenced by the vast majority of papers at ISMIR, is currently focused upon music recommendation and content analysis, two avenues with high profit potential. Those few papers with a musicological bent usually include a variation on the following caveat: "the audio content analysis used here cannot be claimed to be on a par with the musicologist's ear" (Collins 2012).

The problem that is facing researchers in this particular field is that it is extremely difficult to derive meaningful information from the necessary data: audio recordings. Computational Audio Scene Analysis (Wang and Brown 2006) is a sub-branch of machine-learning that attempts to understand sound — or in this case music — using methods grounded in human perception. For example, an input signal must be broken down into higher level musical constructs, such as melody, harmony, bass line, beat structures, phrase repetitions and formal structures — an exceedingly difficult task, one which has not yet been solved. Our own research into transcribing drum patterns and extracting formal sections from recordings of electronic dance music (EDM) generated no higher than a 0.84 success rate, a rate good enough for publication (Eigenfeldt and Pasquier 2011), but lacking in usability. Therefore, we have resorted to expert human transcription: graduate students in music were hired to painstakingly transcribe all elements of the EDM tracks,

1. http://www.ismir.net/

including not only all instrumental parts, but signal processing and timbral analysis as well. This information can then be analysed as symbolic data, a much easier task.

3. The Generative Electronica Research Project

The Generative Electronica Research Project (GERP) is an attempt by our research group[2] — a combination of scientists involved in artificial intelligence, cognitive science, machine-learning, as well as creative artists — to generate stylistically valid EDM using human-informed machine-learning. We have employed experts to hand-transcribe 100 tracks in four genres: Breaks, House, Dubstep, and Drum and Bass. Aspects of transcription include musical details (drum beats, percussion parts, bass lines, melodic parts), timbral descriptions (i.e. 'low synth kick, mid acoustic snare, tight noise closed hihat'), signal processing (i.e. the use of delay, reverb, compression and its alteration over time), and descriptions of overall musical form. This information is then compiled in a database, and analysed to produce data for generative purposes.

2. http://www.metacreation.net/

Applying generative procedures to electronic dance music is not novel; in fact, it seems to be one of the most frequent projects undertaken by nascent generative musician/programmers. EDM's repetitive nature, explicit forms, and clearly delimited style suggest a parameterized approach. As with many cases of creative modeling, initial success will tend to be encouraging to the artist: generating beats, bass lines, and synth parts that resemble specific dance genres is not that difficult. However, progressing to a stage where the output is indiscernible from the model is another matter. In those cases, the 'artistic voice' argument tends to emerge: why spend the enormous effort required to accurately emulate someone else's music, when one can easily insert algorithms that reflect one's personal aesthetic? The resulting music, in such cases, is merely *influenced* by the model — a goal that is, arguably, more artistically satisfying than emulation, but less scientifically valid.

Our goal is, as a first step, to produce generative works that are modeled on a corpus, and indistinguishable from that corpus' style. There are two purposes to our work: the first purely experimental, the second artistic. In regards to the first, can we create high quality EDM using machine-learning? Without allowing for human/artistic intervention, can we extract formal procedures from the corpus and use this data to generate all aspects of the music so that a perspicacious listener of the genre will find it acceptable? We have already undertaken validation studies of other styles of generative music (Eigenfeldt et al. 2012), and now turn to EDM.

It is, however, the second purpose which dominates the motivation. As a composer, I am not interested in creating mere test examples that validate our methods. Instead, the goals remain artistic: can we generate EDM tracks and produce a full-evening event that is artistically satisfying, yet entertaining for the participants?

3.1. Initial success

As this is an artistic project using scientific methods (as opposed to pure scientific research), we are generating music at every stage, and judging our success not by quantitative methods, but qualitative ones. When analysis data was sparse in the formative stages of research, we had to make a great deal of artistic hypotheses. For example, after listening to the corpus many times, we made an initial assumption that a single 4-beat drum pattern existed within a track, and prior to its full exposition, masks were used to mute portions of it (i.e. the same pattern, but only the kick drum being audible): our generative system then followed this assumption. While any given generated track resembled the corpus, there was a sense of homogeneity between all generated tracks. With more detailed transcription, and its resulting richer data, the analysis engine produced statistically relevant information on exactly how often our assumption proved correct, as well as data as to what actually occurred within the corpus when our assumptions were incorrect (see Table 1). This information, used by the generative engine, produced an output with greater diversity, built upon data found within the corpus.

Table 1. Actual data on beat pattern repetition within 8 bar phrases.
Phrase patterns are the relationships of single 4-beat patterns within an 8-bar phrase.

Unique beat patterns in track	Unique phrase patterns in track	Probability
1	1	.29
> 1	1	.21
> 1	> 1	.5

4. Heuristic Decisions

What has proved surprising is the number of heuristic decisions that were deemed necessary in order to make the system produce successful music. New approaches in AI, specifically Deep Learning (Arel et al. 2010) suggest that unsupervised learning methods may be employed in order to derive higher-level patterns from within the data itself; in our case, not only should Deep Learning derive the drum patterns, but should be able to figure out *what* a beat variation actually is, and *when* it should occur. While one of our team members was able to use Deep Learning algorithms to generate stylistically accurate drum beats, the same result can be accomplished by my undergraduate music technology students after a few lessons in coding MaxMSP[3]. I would thus suggest that the latest approaches in AI can, at best, merely replicate a basic (not even expert) understanding of higher-level musical structures. In order for such structures to appear in corpus-based generative music, heuristic decisions remain necessary. One such example is in determining overall form.

3. A common music coding language, available at www.cycling74.com

4.1. Segmentation

As music is a time-based art-form, controlling how it unfolds over time is of utmost importance (and one of the most difficult aspects to teach beginning composition students). While it may not be as apparent to casual listeners as the surface details — such as the beat — form is a paramount organizing aspect that determines all constituent elements. As such, large-scale segmentation is often the first task in musical analysis; in our human transcription, this was indeed the case.

All the tracks in the repertoire exhibited, at most, five unique segments:

- Lead-in — the initial section with often only a single layer present: synth; incomplete beat pattern; guitar, etc.;
- Intro — a bridge between the Lead-in and the Verse: more instruments are present than the Lead-in, but not as full as the Verse;
- Verse — the main section of the track, in which all instruments are present, which can occur several times;
- Breakdown — a contrasting section to the verse in which the beat may drop out, or a filter may remove all mid– and high–frequencies. It will tend to build tension, and lead back to the verse;
- Outro — the fade-out of the track.

Many of these descriptions are fuzzy: at what point is does the Lead-In become the Intro? Is the entry of the drums required? (Sometimes.) Does one additional part constitute the change, or are more required? (Sometimes, and sometimes.) Interestingly, during the analysis, no discussion occurred as to what constitutes a segment break: they were intuitively assumed by our expert listeners. Apart from one or two instances, none of the segmentations were later questioned. Subsequent machine analysis of the data relied upon this labeling: for example, the various beat patterns were categorized based upon their occurrence within the sections, and clear differences were discovered. In other words, intuitive decisions were made that were later substantiated by the data. However, attempts to derive the segmentations autonomously proved less than successful, and relied upon further heuristic decisions as to what should even be searched for (Eigenfeldt and Pasquier 2011).

4.2. Discovering repetition

EDM contains a great deal of repetition — it is one of its defining features. It is important to point out that, while the specific patterns of repetition may not *define* the specific style, they do determine the uniqueness of the composition. Thus, for generative purposes, as opposed to mere style replication, such information is necessary for successful generation of *musical* material.

Table 2. Comparing the number of beat patterns per track, by style.

Style	Average # of patterns per track	Standard Deviation
Breaks	2.58	1.82
Dubstep	2.5	1.08
Drum & Bass	2.33	2.14
House	1.58	0.57

For example, Table 2 displays some cursory analysis of beat patterns per track, separated by style. Apart from the fact that House has a lower average, and there is significantly more variation in Drum & Bass, the number of patterns per track does not seem to be a discriminating indicator of style (see Table 2).

However, in order to *generate* music in this style, the number of patterns per track will need to be addressed: *when* do the patterns change (i.e. in which sections), and *where* do they change (i.e. within which phrase in a section)? As we were attempting to generate music based upon the Breaks corpus, further analysis of this data suggested that patterns tended to change more often directly at the section break, or immediately before it. Statistical analysis was then done in order to derive the probability of pattern changes occurring immediately on the section change, at the end of the section, or somewhere else within the section. Generation then took this into account.

The decision to include this particular feature occurred because we were attempting to emulate the specific musical characteristics of a style, Breaks; as such, it became one (of many) determining elements. However, it may *not* be important when attempting to generate House. House, which relies much more upon harmonic variation for interest, will require analysis of harmonic movement, which isn't necessary for Breaks. As such, heuristics were necessary in determining which features were important for the given style, a fact discovered by Collins when attempting to track beats in EDM (Collins 2006).

4.3. Computational Models of Style vs. Corpus-based Composition

As mentioned, our research is not restricted to re-creating a particular style of music, but creating music generatively within a particular style. The subtle difference is in intention: our aim is not to produce new algorithms in machine-learning to deduce, or replicate, style, but to explore new methods of generative music. As such, our analysis cannot be limited to aspects of style, which Pascal defines as a "distinguishing and ordering concept, both consistent of and denoting generalities" (Pascal 2013). As discussed in Section 4.2, how beat patterns are distributed through a track is not a stylistic feature, but one necessary for generation.

Pascal also states that style "represents a range or series of possibilities defined by a group of particular examples": this suggests a further distinction in what we require from the data. Analysis derives the *range* of possibilities for a given parameter. For generative purposes, this range becomes the search space. Allowing our generative algorithms to wander through this space will result in stylistically accurate examples, but ones of limited musical quality. This problem is more thoroughly discussed elsewhere, but can be summarized as the generated music being 'successful', but lacking *surprise* through its homogeneity (Eigenfeldt and Pasquier 2009).

Our new approach considers restricted search spaces, particularly in regard to consecutive generated works: composition A may explore one small area of the complete search space, while composition B may explore another area. This results in contrast between successive works, while maintaining consistency of style (see Figure 1).

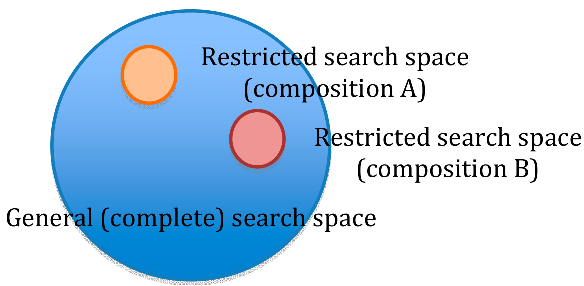

Fig. 1. Restricting search spaces for generative purposes.

5. Future Directions

Our current goal is the creation of a virtual Producer: a generative EDM artist that is capable of generating new EDM works based upon a varied corpus, with minimal human interaction. Using the restricted search space model suggested in Section 4.3, a wide variety of output is being generated, and can be found online[4]. The next step will be to create a virtual DJ: a generative EDM performer that assembles existing tracks created by the Producer into hour-long sets. Assemblage would involve signal analysis of every generated track's audio in order to determine critical audio features; individual track selection would then be carried out based upon a distance function between the track data and a generated timeline, which may or may not be derived from analysis of a given corpus consisting of DJ sets. This timeline could be varied in performance based upon real-time data: for example, movement analysis of the dance-floor could determine the ongoing success of the selected tracks.

4. soundcloud.com/loadbang

6. Conclusion

This paper has described the motivation for generating music using a corpus, and the difficulties inherent in the process. Our approach differs from others in that our motivations are mainly artistic. While attempting to eliminate the propensity to insert creative solutions, we have noticed that heuristic decisions remain necessary. We propose the novel solution of restricted search spaces, which further separate our research from style replication.

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Formalization Using Organic Systemization in Musical Applications

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Keywords: Artificial Intelligence, Conway's Game of Life, Cellular Automata, Electronic Music Performance, Generative, Robotic Musical Instruments, Sound Art.

Abstract: This paper presents the application of Conway's Game of Life within the field of music in a live performance, addressing concerns such as setup, control and aesthetics. A discussion of selected works identifies the limitations in hardware and software, and explains the approach about these constrains to the realization of a system in a recent work.

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1. Introduction

With the advancement of audio technology since 1945, the shift in performance aesthetics of electronic music has been significant. This began with Pierre Schaffer's *Programme de la Recherche Musicale* (*PROGREMU*) in the late forties (Dack 1999); Karlheinz Stockhausen's *Gesang der Jünglinge* that is based on aleatory, serialism and emphasis on sound spatiality (Ungeheuer and Decroupet 1998) and Edgard Varèse's multimedia performance of *Poème électronique* during the mid-late fifties (Ouellette 1973); David Tudor's emergent behaviors within electronic circuits; and Iannis Xenakis's *Unité Polyagogique Informatique CEMAMu* (*UPIC*) system and his integration of probability, statistics and physics in music in the seventies (Xenakis 1971). It is evident that the introduction of new technologies extends the aesthetics of performance and composition in electronic music.

Within the field of generative music and the use of biological algorithms in composition, the aesthetics has been shifting towards its ability to self-organize and generate emergent behaviors (Dorin 2001). The use of artificial intelligence in musical systems allows us to explore the new and unexpected from the known (Rosenboom 1990). This may also be applicable in uncovering new aesthetics within the practice of contemporary sonic arts.

> The game made Conway instantly famous, but it also opened up a whole new field of mathematical research, the field of cellular automata… Because of Life's analogies with the rise, fall and alterations of a society of living organisms, it belongs to a growing class of what are called 'simulation games' (games that resemble real life processes). (Gardner 1970).

Since the publication of the *Game of Life* in 1970, there have been many variations of the system and its integration in other disciplines. One example of the integration of the *Game Of Life* is by a philosopher and cognitive scientist, Daniel C. Dennett. In his book, *Consciousness Explained*, he used the *Game of Life* as an analogy to illustrate how human's philosophical constructs, such as consciousness, can evolve based on the physical laws of our universe (Dennett 1991). Within the field of music, *Cellular Automata Music generator* (*CAMUS*) uses Conway's *Game of Life* to determine the two intervals between three notes (Burraston et al. 2004). *Automaton* by Audio Damage uses the *Game of Life* to drive modulation effects onto audio signal. Other musical applications that feature the *Game of Life* algorithm as a pattern generator include *Game of Life Sequencer Bank* by Grant Muller, *Newscool* in Reaktor by Native Instruments, *GlitchDS*, *Runxt Life* and Tehn's *Conway's life* for Monome.

Most applications focus their time in the use of *Game of Life* as a tool for composition and in post-production works, focusing less on its live performance aspect. Furthermore, a review (Burraston and Edmonds 2005) has been written on the historical and technical aspects of cellular automata in generative electronic music and sonic art. Many researchers in this field currently focus more on partitioning their time between different systems of cellular automata (often in its different applications in composition), and less on its performative aspect. Instead of following popular research or commentaries, this paper aims to discuss the aesthetics and methodology on utilizing Conway's *Game of Life* in a live performance setting.

Section 2 briefly reviews the basic concepts of Conway's *Game of Life* to allow sufficient understanding of the subject for this discussion. The third section presents the aesthetics and perspectives that motivate the idea. Thereafter, selected works are discussed in a chronological timeline leading up to the case study of a recent performance, *Bots Formalization*. *Bots Formalization* is the author's milestone in research and study of integrating the *Game of Life* in a live performance that involves human-robotic interactions. This paper concludes with a brief overview of future works and applications that extend the current research and practice.

2. Background – Conway's Game of Life

The *Game of Life* is a two dimensional cellular automaton[1], devised by mathematician John Horton Conway. It is a simulation based on the births and deaths of living organisms in a system (Gardner 1970). A two dimensional cellular automaton is a mathematical model, in which cells are assigned a particular state, which then changes by turn according to specific rules conditioned on the states of the neighboring[1] cells. Two-dimensional simply notates the movement of the cells in both x and y–axis. (Krink 2003) Theoretically, the cellular automaton is based on an infinite square grid lattice; however, the size of the board is usually defined so that the number of cells present in the arrays is finite. In the automaton, a cell has two possible states: living or dead. These states are usually represented by colors. Black counters usually represent living cells, while white counters represent dead cells. (Gardner 1970) The state of the cells is determined by the state of the 8 neighboring cells surrounding it at every generation. The rules that determine the state of the cell for the next generation are as follow: (Gardner 1970)

Let the number of neighboring cells be n,

1. A dead cell becomes alive if $n \equiv 3$. **(Birth)**
2. A living cell becomes dead if $n \leq 1$ **(Death by exposure)**
3. A living cell becomes dead if $n \geq 4$ **(Death by overcrowding)**
4. A living cell stays alive if $n = 2$ *or* 3 **(Survival)**

The automaton begins with an initial pattern. Rules of birth and death are applied throughout the array to form the next generation. These rules are applied to the new generation that results from the initial pattern again. Here is an example of a simple pattern:

Let generation be g, hence at initial pattern, g=0

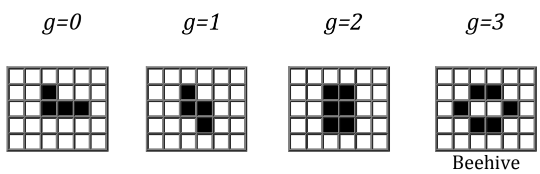


Fig. 1. Illustration of the 'life history' of a simple pattern. (Conway 1970).

1. Cellular Automaton is created by John von Neumann and Stanislaw Ulam to study the process of reproduction and growth. (Weisstein 2012)

Figure 1 (above) shows the life history of a simple pattern of tetrominoes, four rook-wise–connected counters. (Gardner 1970) At g=3, the automaton ceases. This is because the resultant pattern of the cells in the subsequent generations is constant. This pattern produced is called a still life. The automaton will cease, when any of the following occurs (Gardner 1970):

1. All the cells on the board are dead.
2. The cells settle into a stable pattern that remains unchanged in the subsequent generations.
3. The cells oscillate in a cycle of two or more periods.

3. Aesthetics and Perspectives

While the aesthetics differs with its applications, it stays within its fundamental of formalization using organic systemizations, specifically Conway's *Game of Life*, to bring about structures. This extends to applications, the phenomenal of organic systemization in which an initial configuration evolves and brings about emergent behaviors based on the algorithm's grammar.

The outlook to performing and composing with the mentioned methodology can be explained in an analogy as such:

> The perfect rhythm of the last slogan breaks up in a huge cluster of chaotic shouts, which also spreads to the tail. Imagine, in addition the reports of dozens of machine guns and the whistle of bullets adding their punctuations to this total disorder. The crowd is then rapidly dispersed, and after sonic and visual hell follows a detonating calm, full of despair, dust and death. (Xenakis 1971)

The initial patterns can be perceived as the initial state of order. By starting the automaton and applying the rules of the game to all the cells on the board, the initial pattern breaks into chaotic generations of births and deaths. It ends in one of three ways: cells fading away completely, settling into a stable pattern that remains unchanged, or going into a stable oscillating phase with two or more periods of cycle. (Gardner 1970)

It is important to note that one has to have a good understanding of the *Game of Life* to utilize it strategically within compositions. (Burraston, Edmonds 2005) With the mastery of theory and practicum, one can alter the system to do the following: prolong or shorten the generations of births and deaths, resume lives, or put the system to a stop. If one is able to control the system amidst chaos, one should be able to manage a series of events, or in musical terms, articulate musical gestures eloquently. In such cases, the theory refers to the grammar and vocabulary of Conway's *Game of Life*, while the practicum refers to its performance — the deliberate strategy of making choices that are aesthetically successful within the composition and the *Game of Life* in a live performance.

The main aesthetic of performance using Conway's *Game of Life* is driven towards the search and discovery of new aesthetics in contemporary sonic art practices. The use of *Game of Life* establishes a unified and equal field, setting decisions free from the boundaries of stylistic influences. The performers are able to perform music in the analogy of the *Game of Life*, blurring rhythmic rigidness, structure, while disregarding the unwavering radiance of tonality and harmony. The criterion of musicality is two-fold. The first is how two or more sonic materials interact with one another to create different sonic textures and timbres. The second is how these different sonic textures interact with each other. As such, the classification of music as being either 'ugly' or 'beautiful' is disregarded. This also implies that any interaction between two or more sonic materials can be considered musical. However, this should not be taken for granted, as the strategic choice of play used for the organizations and interactions are crucial points to yield a performance of valid musicality.

4. Case Studies

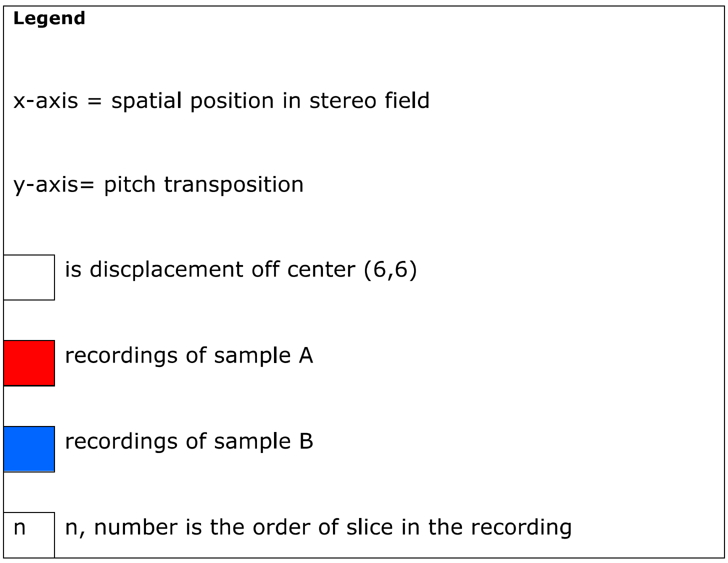
4.1. FD–2.111209

An initial musical application with the use of the *Game of Life* to further examine the plausibility of taking the *Game of Life* to a performance stage is *FD–2.121109*.[2] Created in 2009, *FD–2.111209* is an electronic composition based on the organization of musical motifs using Conway's *Game of Life*. (Figure 2) While this work focuses on the compositional aspect; it set the foundations of studying to the *Game of Life* in a performance setting.

The main objective of *FD–2.111209* is to explore how events in the *Game of Life* relate to the intensity of musical events that takes place, and how parameters from the *Game of Life* can be mapped to musical attributes such as spatial location and pitch. In this work, two gliders set in a head-on collision path is used as the initial seed configuration, in an 11 by 11 grid array. The sequence lasts for 12 generations and ended with a 2 by 2 still life, more commonly known as 'the block'.

FD–2.121109 further ascertains the importance of how certain cell configurations bring about different musical outcomes. *Parametrical Thinking* involves the use of variables from a systemization to control the values of musical attributes that are bounded by upper and lower limits. (Cope 1991) It brings to attention that *Parametrical Thinking* is an essential element to integrating the *Game of Life* in musical applications.

2. https://soundcloud.com/ /jprecursor/fd-2-121109



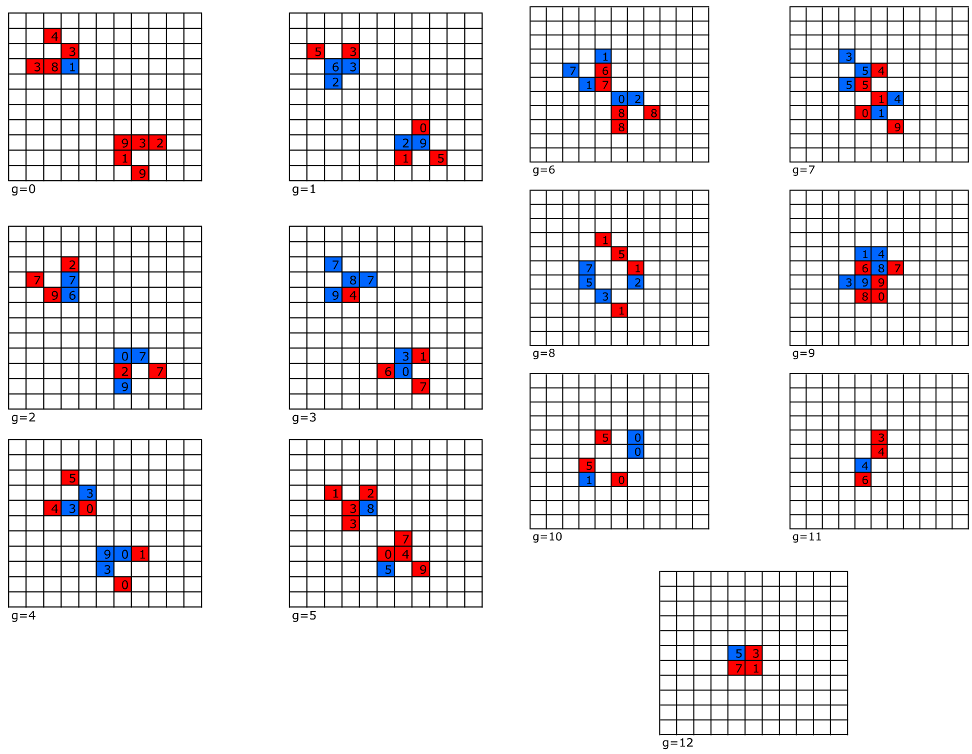


Fig. 2. FD–2.121109 Score Sequence.

4.2. Déboulerait

Prior to designing a unique system for performance utilizing the *Game of Life*, *Déboulerait*[3] utilizes the commercially available midi controller, Novation's Launchpad, and a port of the *Game of Life* algorithm — which was originally created for the Monome (Carbtree 2008). Based on the Monome's version of the code, a version specifically for the Launchpad was ported in *ChucK*. *ChucK* is a new (and developing) audio programming language for real-time synthesis, composition, performance, and analysis (Wang 2008). It is chosen for its highly precise scheduler that has no compromise on the dynamics and expressiveness of the control rates.

Premiered at *COLAB 2010* (LASALLE College of the Arts Graduation Showcase, Singapore) with two performers, *Déboulerait* features the Conway's *Game of Life* as an instrument and focuses on its ability to play the game of life as an instrument during the piece. It consists of a sequential track of events that guides the performers in their improvisation by sending visual cues to the performers' instruments. Conway's *Game of Life* performs the role of an instrument in this piece. An overview of the system set-up is shown in Figure 3. The motivation drives towards the discovery and exploration of using the algorithm and the rules of an organic mathematical model as the basis of an instrument.

3. http://vimeo.com/19728681

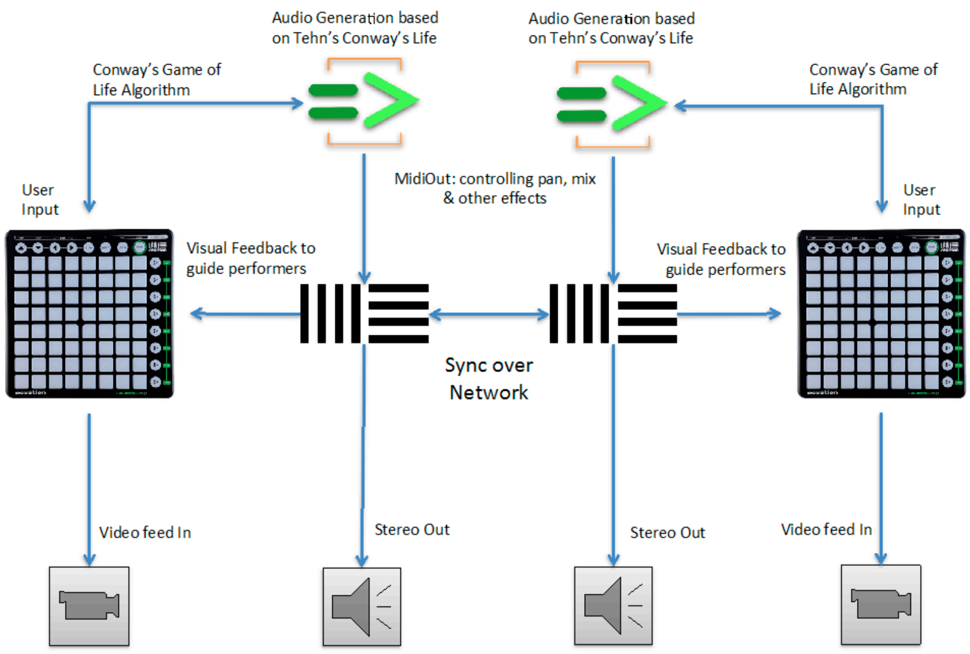


Fig. 3. Overview of the system: Déboulerait.

While in most electronic performance, the audience does not get to see what is happening on the screens and controllers of the performers. *Déboulerait* features a projected live video stream showing the performers on their instruments. This adds an additional element of visual performance aesthetics, as well as draws attention to the performers' aesthetic choices in the Game of Life during the structured improvisation.

The following limitations were found in the progress:

1. The interval between each generation is too consistent, resulting in the rigidity of rhythmic structure and texture.
2. The dynamics are either too consistent or chaotic (if a random function is in place), resulting the performance to be musically bland in color or too incoherent.
3. The grid array is finite, therefore limiting the performers in precision and diversity in control.
4. Only one instance of the *Game of Life* can be run on a singular device.

Henceforth, the above limitations became guidelines to the realization of a new performative setup in the most recent performance, *Bot Formalization*.

4.3. Bot Formalization

Bot Formalization sets out to test the newly customized performative system that integrates Conway's *Game of Life*. It explores the perform-ability through the formalization of custom-built robotic musical instruments. A designed systemization interfaces the mechanical onsets of actuators to a controller that breathes the *Game of Life*. This is similar to the agent-based system for robotic musical performance (Eigenfeldt 2008), but in addition to that, extends it to an array of robotic musical instruments with the use of the *Game of Life* cellular automata.

The custom-built robotic musical instruments[4] (Figure 4) residing in the Machine Lab at California Institute of the Arts (Kapur 2011) include seven independent robotic units

4. Further information: http://dev.karmetik.com/ /labs/robotics.

that have a total of 170 actuators, consisting of idiophones and membranophones. They are connected to a main server, communicating with the users in *Musical Instruments Digital Interface* (*MIDI*) through a Local Area Network.

Fig. 4. MahaDeviBot (left) and GanaPatiBot (http://www.karmetik.com/labs/robots)

The most important basis to the successful utilization of the *Game of Life* is mapping the automata's parameters to musical attributes as mentioned in the earlier section. These parameters from the *Game of Life* and the robotic instruments are shown in Table 1.

Table 1. Parameters from Game of Life against robotic musical instruments

Game of Life		**Robotic Musical Instruments**	
State of cell	On / Off (0, 1)	**No. of Actuators**	170
Coordinates of cell	x– axis / y– axis (integer)	**Volume**	soft–loud
Interval between generations	time (float)	**Speed**	slow–fast

The *Game of Life* is setup in the program to send and receive either *MIDI* or *Open Sound Control* (*OSC*) messages. The outcome of each cell can either be its position coordinates and current state (x, y, state) or a cumulative message consisting of position coordinates converted to midi notes and the state scaled to midi velocity (midi note, velocity).

This allows the communication between the *Game of Life* and an external device. The use of a controller interface bridges the user and the game itself, while enabling the performer to figuratively 'play' away from the computer screen. The interface controller used in this setup is the grayscale64 by Monome. It consists of 64 buttons and an accelerometer that registers 2 axes. (Figure 5).

Fig. 5. The Monome Grayscale64. (http://www.monome.org)

To further extend the compatibility of the controller closer to the number of actuators in the robotic instruments, the controller is setup to run 2 instances of *Game of Life* synchronously and independently.

Table 2. Overview of Mapping

Controller	Game of Life	Robotic Instruments
Buttons (64 × 2)	Cells	Actuators (128)
Accelerometer: x–axis	Duration of each generation / State	Speed of Actuators / Hitting Velocity
Accelerometer: y–axis	State / Duration of each generation	Hitting Velocity / Speed of Actuators

In summary, the buttons are mapped to the cells in the *Game of Life*. The additional accelerometer sensors in the grayscale64 allow us to add further control to the *Game of Life* system. In this case, the x–axis is mapped to the time duration of each generation and y– axis is mapped to the *MIDI* velocity. The mapping of the axes is switched in the second instance of the *Game of Life*. The state of each cell also acts as a gate to allow the passing of accelerometer data for *MIDI* velocity (Table 2). These mappings give the user additional control to dynamics and rhythm, which increases the articulation.

Bot Formalizations[5] is driven towards a structured improvisation of the analogy mentioned above in Xenakis's quote of the series of events that proceed one after another from the state of order. It also aims to explore the discovery of new organization in timbres and rhythm using the *Game of Life*.

5. Selected Video Excerpt of Performance: http://vimeo.com/channels/vie/55973717.

5. Conclusion

The system used in *Bots Formalization* overcame the limitations mentioned in Section 4.2. Dynamics and the fluidity in rhythm and structure are achieved by mapping the temporal and velocity attributes to a volatile parameter in the *Game of Life*. By increasing the number of instances of the *Game of Life* that runs synchronously and independently, the restriction of diversity in control is reduced.

In San Francisco (1996), Brian Eno referenced *Metaphors We Live By* by George Lakoff and Mark Johnson. Eno mentions that the use of different metaphors for a situation will change one's perspective towards the situation. (Eno 1996) The metaphorical representation of living organisms will evoke different insights to performance, uncovering vibrant dynamics within human–*Game of Life* interaction. This may also extend to influence the creation of different timbres and textures, as well as rhythmic structures that one may overlook during conventional process.

This paper addresses the live performance aspect of using the *Game of Life* automata, bringing crucial elements such as dynamics and temporal parameters into discussion, which are often not discussed. Focusing more on the perspective that resulted when using the *Game of Life* in a live performance, a discussion of selected works[6] leads to the realization of a designed systemization[7] that addresses the limitations of array size, dynamics and rhythmic structures.

Future works include designing a universal system that works in MIDI and OSC, extending this further to other forms of cellular automata and perhaps its integration and application other performing arts, and pedagogy for performance using Conway's *Game of Life*.

By way of conclusion, while there may be areas of considerations that may be omitted in this discussion, this paper presents a specific methodology and perspective that leads to the realization of a tool that brings the musical application of Conway's *Game of Life* to a live performance setting.

6. Other applications that extend further the ideas mentioned during this discussion can be found at: https://vimeo.com/ /channels/vie/

7. All works mentioned are to date as of December 31st, 2012.

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What Are You Telling Me? How Objects Communicate Through Dynamic Features

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Keywords: Design, Communication, Dynamic Products, Sensory Features.

Abstract: Product sensory features are handled by designers to convey implicit messages to users. However, thanks to technology advances, traditional static product features are becoming dynamic, able to actively change over time. Exploring how these new properties can communicate a different layer of information is the aim of the study presented in this paper. To achieve the goal, a case study analysis was performed, by collecting real products, prototypes and concepts which present dynamic sensory features. The analysis of the selected samples led to the identification of a number of categories of dynamic products, within which it was possible to stress some parameters and criteria useful for designing such artefacts. Relations among the senses activated, the contents of the communication and the source of the information have been identified, and insights have been proposed as results.

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1. Introduction

Artifacts have the ability to communicate messages to users through different languages and media. Product form has always been considered as a communication means: products convey messages to users through their sensory properties (visual, tactile, auditory, etc.), and their communicative potential has been widely investigated in the last decades by the field of product semantics (Krippendorff 1989, 2004; Demirbilek and Sener 2004). However, as Krippendorff and Butter (1984) affirm, products convey messages not only through their physical features, but through three main channels: information displays, graphic elements fixed to product surface and product form, shape and texture.

We can thus affirm that the information which products convey is static and related to the product itself (affordance, mode of use, symbolic meaning, character) when the medium is the product form. But such information can also be *dynamic* and connected to external situations, phenomena and sources: this happens when the medium is a display or an interface. Indeed, displays and interfaces are able to communicate information that change over time, but in order to do this, they traditionally use a language that is outside the domain of product semantics (Krippendorff and Butter, 1984): the verbal, iconic or numeric language.

However, recent advancements in electronics, computation and material technologies, revolutionized the concept of product aesthetics and form as traditionally conceived. Sensory properties (shape, colour, sound, smell, texture, surface, etc.) of artifacts can in fact be transformed over time, becoming dynamic (e.g. a kettle which indicates that water is boiling by showing a texture on its surface. Fig.1). These new features actively transform artifacts forms in response to either external stimuli, users' interactions or automatic pre-programmed schemes.

Fig. 1. One Kettle by Vessel Design. The product changes its own surface when the water boils.

From the product design point of view, the possibility to create dynamic features gives designers additional material to work with:

> Designing such products and systems requires an aesthetic that goes beyond traditional static form aspects. It requires a new language of form that incorporates the dynamics of behavior. (Ross and Wensveen 2010)

The emotional content of these dynamic products seems to be very high and stems from their capacity to surprise and delight users' senses. For this reason, in many cases, where dynamic sensory features are embedded into products, the aim is mainly to engage, surprise, or provoke users. Nonetheless, changes in the product form (intended as the mix of product's sensory properties) may be a language through which it is possible to convey information and messages to users in a more intuitive and less conventional way than using verbal and iconic language. The advantage is that the communication, even if less complex, may become more engaging for users, and the interaction with products more pleasurable.

The potentials of this revolution in the design field are very high, but it seems that research in this area is still lacking a theoretical base that could support the adoption of these new communication possibilities by the design practice.

1.1. Objectives

The present study analyses, through the collection of a number of case studies, the possibility to communicate messages through product dynamic and active sensory features. The final objective is to shed some light on the issue of dynamic sensory features from the product design perspective, in order to outline a first theoretical framework in this area of research. In more details, our study intends to answer the following questions: is it possible to communicate to users through dynamic changes in the product features? What kinds of contents can be conveyed? To what extent different senses can be activated in conveying a message? Have senses different roles in the transmission of the message?

The answer we intend to give is theoretical and in form of hypothesis. In the next section, the research process we followed is described in details.

2. The research process

Our starting assumption was that nowadays, in order to communicate a message to the final user, the designer can exploit also a product physical change. Indeed, in recent years, a number of commercial products, prototypes and concepts showing dynamic sensory features have been developed, and the interest towards this topic seems always growing. However, research in this field is still at a embryonic stage, and there are no theoretical approaches to the analysis of this new artefact category.

In order to have an overview of what has been occurring in this area, we decided to adopt a case-study strategy, through the collection and examination of a number of concrete examples. As Baglieri et al. (2008) state, this research strategy is appropriate "when the research subject is still emerging, to suggest some propositions to be verified afterwards in different contexts, in order to reach a shared theory." Through this procedure, we intended to extrapolate some theoretical insights by an inductive process, starting from what has already been done in the design field in terms of both products and concepts.

The case-study research process followed three steps:

1. Selecting samples
2. Describing and classifying samples
3. Analyzing results and shaping hypotheses

2.1. Step 1 : Selecting samples

The samples selection was performed among design concepts, prototypes and commercial artifacts. The samples sources were the following:

- papers and journal articles (i.e. the International Journal of Design and Design Issues).
- concepts that have entered international design contests (i.e Red-Dot and Samsung Young Design Award)
- design blogs (i.e. Design Boom, Core77, Yanko Design)
- well-known design universities and design research centres (i.e. TU Delft, TU Eindhoven, Cambridge Consultants).

At the end of the first selection process, 70 samples were collected. In figure 2 some examples are shown: *solid poetry* concrete tiles (fig.2a) change their colour when wet, creating different patterns; *flower lamp* (fig. 2b) changes its shape on the basis of the electricity consumption in the house; *scent of time* (fig. 2c) clock releases a different smell in the environment at each hour; *wearable detect air* (fig. 2d) is a jacket that lights up and vibrates when detecting too much pollution in the air.

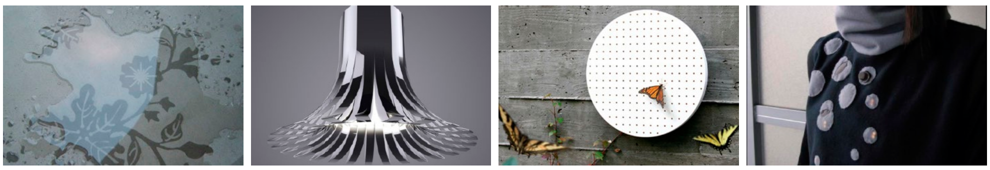

Fig. 2. **a.** Solid Poetry by Studio Molen; **b.** Flower lamp by Interactive Institute Swedish ICT; **c.** Scent of time by Hyun Choi; **d.** Wearable detect air by Genevieve Mateyko and Pamela Troyer.

On these 70 samples, a further selection process was performed, on the basis of a number of parameters hereafter described.

First of all, we evaluated the communicative intent of the product. This way, we identified two different categories of dynamic products:

- *communicative* products, which aim at transmitting a message to users through changes in their sensory features (e.g. Flower lamp, which indicates the electricity consumption through its changing shape; fig. 2b)
- *expressive* products, in which the dynamic change has just an expressive, aesthetic or emotional aim (e.g. Solid Poetry is not designed to convey a specific message, but just to pursue an aesthetic intent; fig. 2a).

Thus, we decided, on the basis of our objectives, to discard expressive products and to focus our analysis on the category of communicative products, that were further evaluated on the basis of the novelty factor. This way, we discarded products which adopt standardized dynamic signals, such as common LED lights or sound alarms embedded in appliances. At the end of the selection process, we obtained 45 samples.

2.2. Step 2: Describing and classifying samples

In this second step, our aim was to identify some parameters useful for the classification of dynamic products. The three parameters we considered were: who or what is sending the message (i.e. the message source); the nature of the message; the stimulated senses.

The classification of the samples according to these three parameters helped us in understanding in what situations dynamic products can be adopted to inform the user, what kinds of messages they are able to convey and which senses can be activated in order to convey a message.

2.2.1. The source

The information source is the sender of the message. According to this parameter, samples were classified into three different categories:

- products transmitting messages coming from the product itself (e.g. when they communicate their internal states, the progression of their works, their energy consumptions, and so on. An example is the Coral cooking, a pot that changes color from blue to red to indicate the increase of its temperature; fig. 3a)
- products transmitting messages coming from the external environment which they are part of (an example is the E-Plant, that lights up and changes colour to indicate the electricity consumption in the house; fig 3b)
- products transmitting messages coming from a person that wants to keep in touch with another one or wants to communicate his/her own emotions to others (in this case we talk about human-human interaction. For instance, Firefly is a soft sphere which reproduces the heart bit of the beloved person, emitting a pulsating light; fig. 3c)

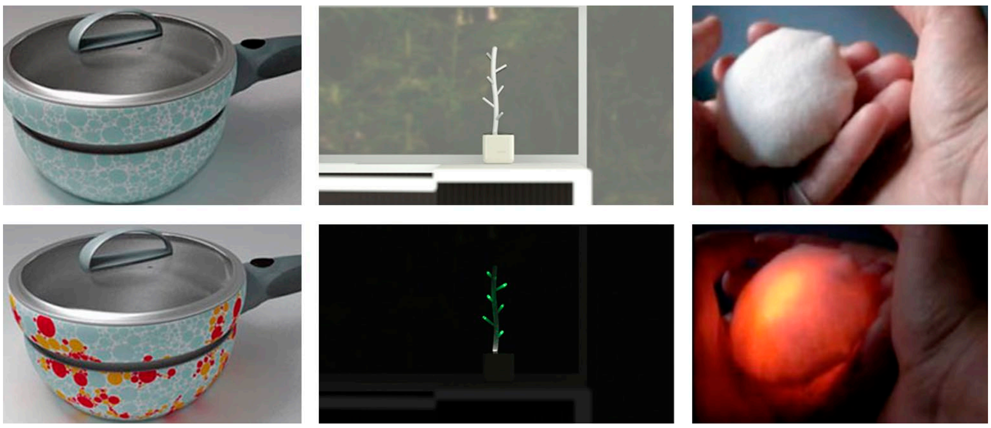

Fig. 3. **a.** Coral cooking by William Spiga & Juliana Martins; **b.** E-Plant by The Signers; **c.** Firefly by Secil Ugur

2.2.2. The message

The content of the message can vary a lot, going from the temperature of a room, to the emotion of a person, to the reminder of an action that has to be undertaken by the user. Even though the content is so varied, messages can be classified on the basis of their purposes. Indeed, from our analysis, it emerged that a message can be aimed either at just informing the user about something (in this case, we talk about *cognitive messages*) or at exhorting the user to take an action (in this case, we talk about *exhortative messages*).

In the first case, the product aims at transmitting an information that does not demand any immediate intervention (e.g. "the room is warm", fig. 4a). In the second case, the product requires the user to do something (for instance "you are dehydrated, drink water!", fig. 4b).

Fig. 4. **a.** Heat-sensitive wallpaper by Shi Yuan **b.** I-Dration by Cambridge Consultants.

2.2.3. The stimulated senses

Human beings decode information with their senses, thus, in the communication process, senses can be defined as the receivers of the message (Crilly 2004). For this reason, in the selected samples, we analyzed which senses are stimulated by the dynamic features. To do so, we divided all the samples into sensory categories, identifying visual, tactile, auditory and olfactory products. Then, for each sense, we classified the stimuli adopted by the products to activate it; for instance, the visual modality is stimulated by changes in product colour, shape or light, while the tactile modality by changes of temperature, pressure, position and vibration (fig. 5).

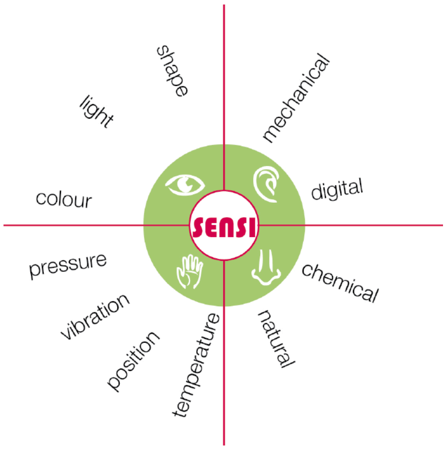

Fig. 5. Map of the sensory stimuli.

2.3. Step 3: Analyzing results and shaping hypothesis

In order to extrapolate results and shape hypothesis from the case-study analysis, we summarized each sample into a card (fig 6). In it, the source, the kind of message and the activated sense are indicated. Subsequently, graphics were created in order to link both the source and the message to the activated sensory modality. From this, hypothesis were shaped and, finally, some considerations on the differences between prototypes and commercial artifacts have also been made (fig 7).

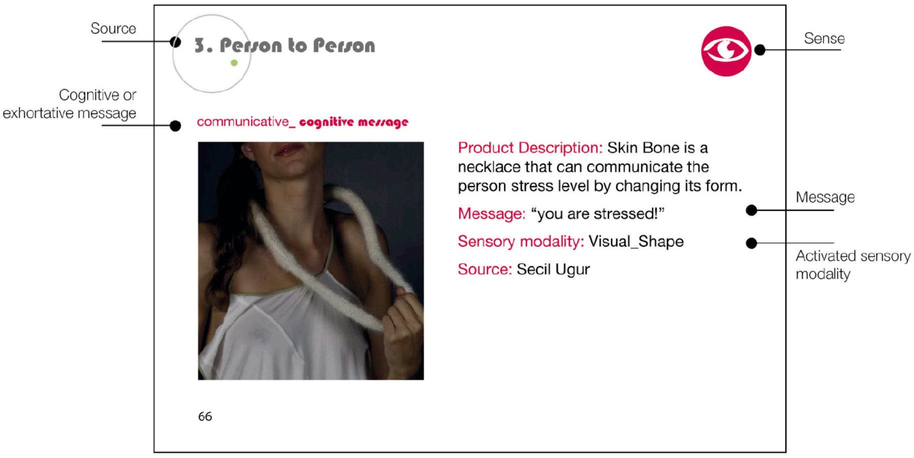

Fig. 6. Card sample.

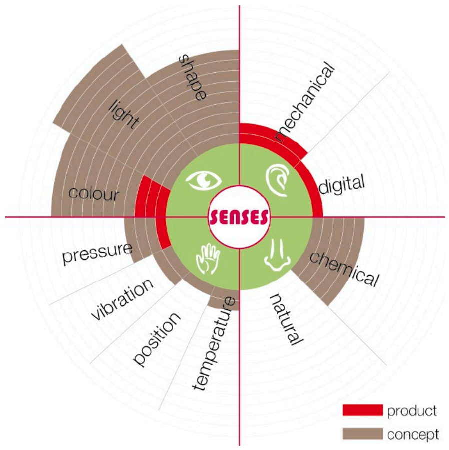

Fig. 7. Products and concepts distribution. Each coloured area corresponds to a sample.

Source vs. senses

Each sample has been represented on the sensory map according to the source of the message and the sense it activates (fig. 8). Hereafter, for every sense, some considerations are drawn.

Fig. 8. Relations between the sensory stimuli and the messages sources.

VISUAL STIMULI. The majority of the case studies uses visual stimuli to transmit messages. The change of light intensity is the most used stimulus in the selected samples, but it is employed just to convey messages coming from environment and person; indeed, messages coming from products (e.g. internal state or work progression) are conveyed only by shape and colour changes. Colour is an important stimulus as well, but it is not adopted to transmit personal messages. To investigate if these results are casual or depending on semantic reasons, a further study may be necessary.

TACTILE STIMULI. Tactile stimuli are the second in use and they are mostly adopted to transmit messages coming from a person; in this case, the employed stimuli are pressure and temperature changes. Basing on the studies of Gallace (2010), who describes the touch stimuli like an affection expression, we can interpret pressure and temperature like a simulation of the beloved person's touch. Vibration is employed when the sender is the environment, for instance to communicate that there is too much pollution in the air (fig. 2d).

AUDITORY AND OLFACTORY STIMULI. Sound and smell turned out to be the less used senses in our selected samples. In regards to sound, this can be explained by the fact that one of the parameters for the selection was the novelty factor: since the use of sound is already well established in the market, it is likely that, when developing new concepts, its investigation results less stimulating. Indeed, sound is used just in commercial products. On the contrary, smell is used only in concepts and prototypes (fig.7). Generally, smell is the most overlooked sense in design, despite its ability to convey messages and its high emotional potential. In olfactory products, the fragrances used to communicate messages are chosen by the user; this can stem from the assumption that smell is strongly connected to people's memories (Cavalleri 2009): by choosing one's favorite fragrance, one can more easily remember the information the product wants to convey. This is, for instance, the case of Scent of Smell (fig. 2c), in which every hour releases a different fragrance chosen by the user.

Message vs. senses

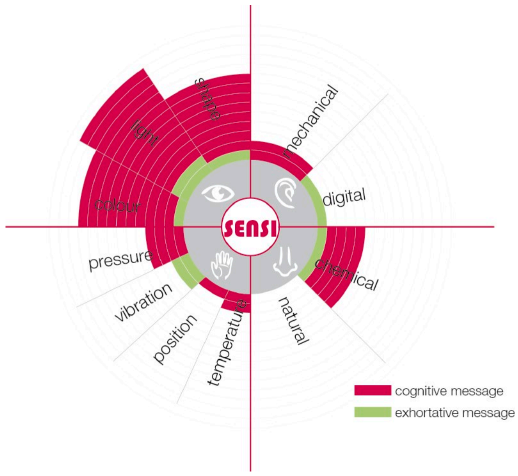

Fig. 9. Relation between sensory stimuli and message nature.

According to figure 9, most of messages conveyed by dynamic sensory features are cognitive, i.e. aimed at transferring some knowledge, instead of exhorting to do something. Specific sensory stimuli are associated to a particular kind of message. For instance, within the touch category, vibration is used in order to exhort users to take an action, while pressure is chosen to convey exclusively cognitive messages.

3. Conclusions

The samples analysis confirmed us that the designer, in order to communicate a message to the final user, can design a product physical change. Through such changes, the product can transmit messages that originate from either itself or the environment or a person who wants to communicate with someone else.

The case studies analysis confirmed that dynamic products can rely on all the sensory modalities. Indeed, also transformations in tactile and olfactory features can communicate specific kinds of information to users. However, sight is still the most employed sense, likely because it has always been the dominant modality in human perception (Hekkert 2006). Moreover, it emerged that designers do not pay equal attention to the different sensory modalities. Touch and vision, linked to the materiality of the product, are usually the main focus of designers' activity. Hearing and smell, on the contrary, perceive qualities that are linked to immaterial features, and are often added to the product in the final steps of the design process (e.g. for digital sound). This might be the reason why, so often, these two senses are overlooked in product design practice and are left to specialists, that design these features as added properties (this is the case for sound design).

The results we propose in this work are based on the case studies analysis, with references to previous research. The direct verification of these hypotheses, for instance through tests with users, may be a subsequent step of the study.

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Recursive Digital Fabrication of Trans–Phenomenal Artifacts

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Keywords: Recursive, Generative, CAD, 3D, Fabrication, Bell, Acoustic, Sounding Object, Trans–Phenomenal.

Abstract: The concept of a trans–phenomenal artifact arose from a project to digitally fabricate a series of bells, where each bell is shaped by the sound of the previous bell. This paper describes the recursive process developed for fabricating the bells in terms of generic stages. The first bells fabricated with this process raised the question of whether the series would converge to a static attractor, traverse a contour of infinite variation, or diverge to an untenable state. Reflection on these early results encourages further development of the recursive fabrication process, and lays groundwork for a theory of trans–phenomenal artifacts.

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1. Introduction

Digital fabrication is typically considered a one-way process, from the digital to the physical object. But could the process be considered as a transition between different states of the same artifact? The difficulty is that the 3D structure of a physical object is static, frozen in time. It cannot morph in response to changes in parameters like a digital structure can. However there is an aspect of every physical object that is temporal and dynamic — the sounds it makes. Physical acoustics are influenced by shape, size, material, density, surface texture and other properties of an object. Larger objects produce lower pitched sounds, metal objects are louder than plastic, and hollow objects produce ringing sounds. The acoustic properties of an object may be analysed with spectrograms and other signal processing techniques. A spectrum contains all the information required to re-synthesise the sound from simple sine tones, and this is the theoretical basis for the electronic music synthesizers. Could the spectrum recorded from a sounding object also contain the information to reconstruct the object that made the sound? This speculation lead to the idea to digitally fabricate an object from a sound recording. A sound could then be recorded from the new object. What would happen if another object was then fabricated from that sound? This recursive process of digital fabrication would generate an interleaved series of shapes and sounds shown in Fig. 1.

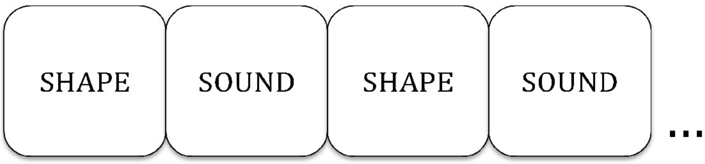


Fig. 1. An interleaved recursive series of shapes and sounds.

The rest of this paper describes experiments that explore this idea. The background section describes related concepts of synaesthetic transformation in painting, music and sculpture. It also describes previous work on sculptural 3D representations of music, and the digital fabrication of acoustic phenomena. The following section describes a first experiment to digitally fabricate a bell. This is followed by an experiment that develops a recursive method for generating a series of bells in which each bell is shaped by the sound of the previous bell in the series. The process is broken down into stages with parameters that can be adjusted to explore the space of possible outcomes. The discussion reflects on the results of the experiments, identifying theoretical issues and directions for further research.

2. Background

Wassily Kandinsky's invention of abstract painting was inspired by the abstract structure of music, and in his writing he refers to the synaesthetic composer Alexander Scriabin's 1915 score for *Prometheus: a Poem of Fire* which included a colour organ that projected arcs and waves of colour onto overhead screen in time to the music. The first abstract paintings in Australia were also inspired by music. Roy de Maistre's painting *Rhythmic Composition in Yellow Green Minor* featured in a controvertial exhibition in Sydney in 1919 (Edwards 2011). His interest in relations between sound and colour may have been inspired in part by his attendance one year beforehand at recitals on the colour organ by Alexander Hector in 1918. De Maistre developed a formal Colour Sound theory in studies such as *Rainbow Scale D# minor–F# minor*, and his works were popularly known as 'paintings you could whistle'. Some of his other musical paintings include *Arrested Phrase from a Haydn Trio in Orange-Red Major*, *Colour Composition Derived from Three Bars of Music in the Key of Green*, and *The Boat Sheds, in Violet Red Key*.

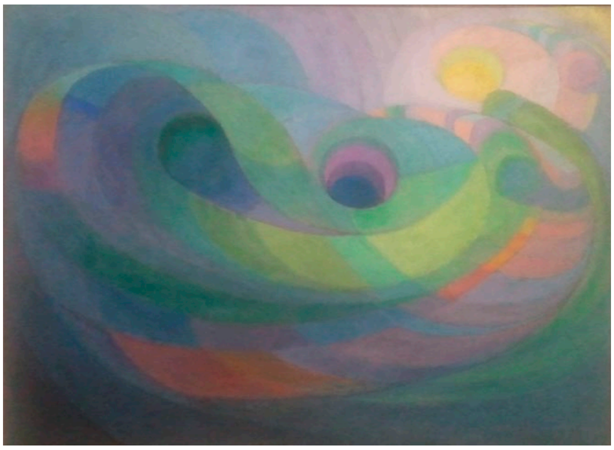


Fig. 2. Rhythmic Composition in Yellow Green Minor

In 1993 the Australian coder Kevin Burfitt released the open source music visualization program Cthuga that was the forerunner of the visualization plugins in media players such as iTunes, Windows Media Player and VLC today (Music Visualization 2013). Music visualizations map the loudness and frequency spectrum of sound into 3D graphics and image effects. The peer competition within the Cthuga community, and the ongoing commercial competition between large companies has resulted in high production values and well developed aesthetics in music visualizations.

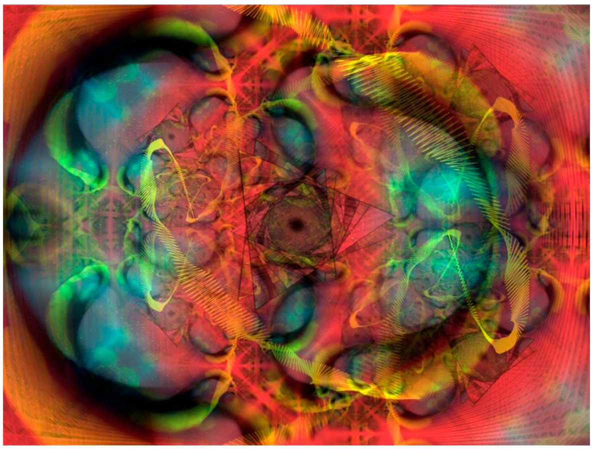


Fig. 3. Music Visualisation from MilkDrop

Computer programs have also been used in the inverse transformation from graphics into sounds. The UPIC program, developed by algorithmic composer Iannis Xenakis in 1977, allowed waveforms and volume envelopes to be drawn on a computer screen with a tablet to be electronically synthesized. HighC, shown in Fig. 4, is a graphic music creation tool modeled on UPIC that is available for download at http://highc.org/.

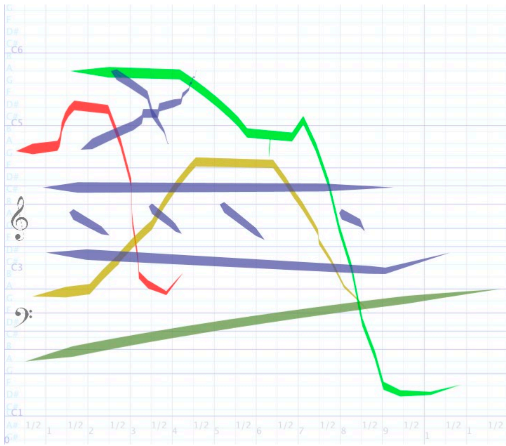


Fig. 4. Graphic Music composition using HighC.

The representation of sound in visual form is extended to three dimensions in the Sibelius Monument created by Finnish sculptor Eila Hiltunen in 1967 to capture the essence of the music of the composer Jean Sibelius. The unveiling of the sculpture constructed from more than 600 hollow steel pipes welded together in a wave-like pattern sparked debate about the merits of abstract art that resulted in the addition of an effigy of Sibelius.

Fig. 5. Sibelius Monument in Helsinki.

Digital fabrication provides a new way to create physical objects from sound. A search for 'sound' in the Shapeways.com community for digital fabrication returns a set of 3D models titled 12Hz, 24Hz and 48Hz (shown in Fig. 6) constructed from images of vibrations on the surface of water (Shuuki 2012).

Fig. 6. 48Hz sound vibration in water.

A further search for 'music' on *Shapeways* returns several flutes, pan-pipes and whistles that may be fabricated in either plastic or metal. There is also a wind-chime fabricated in glass or ceramic. These examples show the potential to use 3D CAD tools and personal fabrication services to custom design sonic objects and acoustic structures.

Neale McLachlan used a CAD package and computer modeling to design a set of 200 harmonically tuned bells for the Federation Bells installation in Melbourne in 2000, shown in Fig. 7. He identified the geometric factors that influence the harmonics as wall thickness profile, wall curvature, conical angle, the circumference of the opening rim, the thickness of the rim, and the overall width and height of the bell (McLachlan 1997). Bells are complex 3D shapes that flex in 3 dimensions, and they are much more difficult to tune than one-dimensional wind or string instruments. Tuning a bell was traditionally done by skilled craftsmen who manually lathed the thickness profile of a cast bell. Due to the high costs of casting bells in the modern era, McLachlan manufactured CAD bells by pressing sheet metal, which had the advantage of very consistent geometry. The fixed thickness required tuning of harmonics by shaping the wall curvature, rather than lathing the thickness (MCLachlan 2004).

Fig. 7. The Federation Bells in Melbourne.

Advances in digital fabrication technology have brought new materials, such as stainless steel, bronze, silver, titanium, glass, and ceramics. The introduction of metal shaping technologies in the iron and bronze ages resulted in the invention of bells, gongs, singing bowls and other resonating musical instruments. Could the introduction of metals in digital fabrication herald a new era of sounding objects that could not be arrived at by manual crafting?

3. Digital Fabrication of a Bell

This section describes an experiment to extend previous work on CAD bells by digital fabrication, with a view to more complex sounding objects in the future.

Digital fabrication places constraints on size, thickness and level of detail, depending on the material. The *Shapeways.com* service constrains stainless steel to a maximum bounding box of 1000×450×250mm, wall thickness of 3mm, and detail of 0.6mm. This is quite limiting but does allow for the fabrication of small bells.

A bell shaped 3D mesh was constructed from graphic primitives using the processing.org open source environment for graphic programming. The outer hemispherical shell with diameter 42mm and height 34mm was duplicated, scaled and translated to make an inner shell. The rims of the outer and inner shells were 'stitched' together to make a watertight shape. A handle was added so the bell could be held without being damped. The digitally constructed bell, shown in Fig. 8, was saved as a CAD file in STL format.

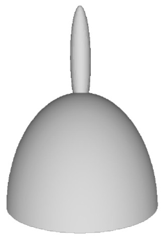


Fig. 8. Graphic rendering of the CAD mesh of Bell00.

The CAD file is limited to 64MB and the polygon count to less than 1,000,000 for uploads to the *Shapeways* site. The high resolution mesh was reduced in size and count by merging close vertices in the Meshlab open source system for editing unstructured 3D meshes (http://meshlab.sourceforge.net/). The mesh was then checked to be watertight and manifold using the Netfabb software for editing and repairing 3D meshes for additive manufacturing (http://www.netfabb.com/). This carefully prepared CAD file was then uploaded to *Shapeways*, and fabricated in stainless steel with bronze colouring, to produce the first prototype of a digitally fabricated bell shown in Fig. 9.

Fig. 9. Digitally Fabricated Bell.

When the bell was tapped with a metal rod it produced a ringing tone. The sound was recorded at 48kHz sampling rate with a Zoom H2 recorder in a damped room. The recorded waveform in Fig. 10. shows that it rings for about 1s.

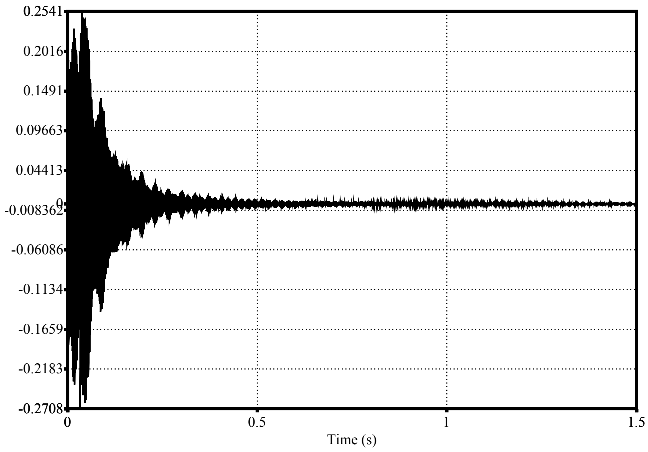


Fig. 10. Waveform of Bell 0.

The spectrogram, in Fig. 11, shows partials at 2971, 7235, 13156, 20359 Hz. The first rings for ≈1.2s, second ≈0.75s, third ≈0.5s and fourth ≈0.2s. The temporal development of these partials produces the timbral 'colour' of the bell. Although the partials are not harmonic, the bell does produce a clearly pitched tone.

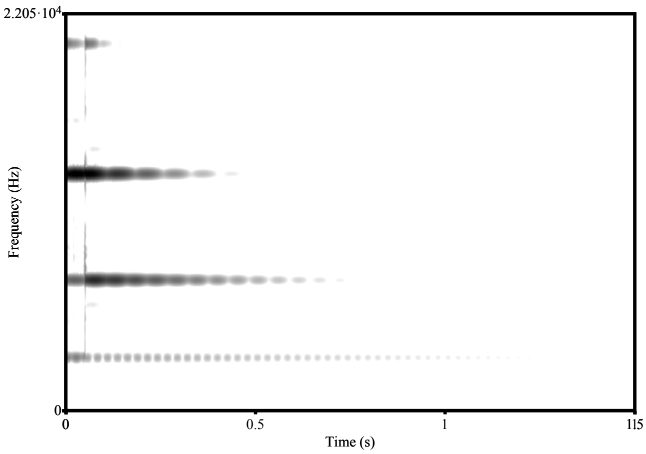


Fig. 11. Spectrogram of Bell 0.

The Long Term Average Spectrum (LTAS) is a 1D summary of the spectrogram. The LTAS in Fig. 12, shows the peak amplitude for the four main partials, along with the four main regions of resonance that produce the ringing timbre of the bell.

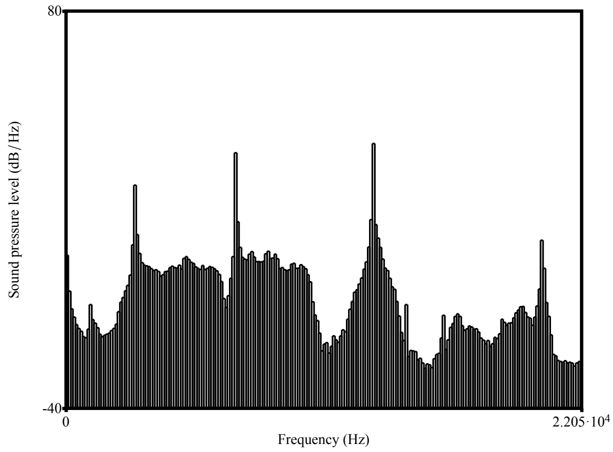


Fig. 12. Long Term Average Spectrum (LTAS) of Bell 00.

The prototype demonstrates that a bell can be digitally fabricated, and opens the door to more complex acoustic objects that cannot be manufactured or made manually.

4. Recursive Bells

This section presents an experiment to design of a recursive series of bells where each bell is shaped by the sound of the previous bell in the series.

The stages of the recursive process are shown in Fig. 13. The process begins with the CAD file specifying an initial bell, labeled as BELL 0. The CAD file is fabricated as a physical shape, SHAPE 0, which is the stainless steel prototype bell constructed in the previous section. The sound of SHAPE 0 is generated by tapping the bell, and recorded as SOUND 0. This sound is then transformed into PROFILE 1 by a process labeled XFORM. Then PROFILE 1 is added to BELL 0 and the new CAD file is fabricated as SHAPE 1, which is the next bell in the series. SOUND 1 is then recorded by tapping SHAPE 1, and XFORMed to create PROFILE 2, which is added to BELL 0 to create the second recursive bell. This recursive process can be repeated ad. infinitum to produce a series of interleaved SHAPES and SOUNDS generated from each other.

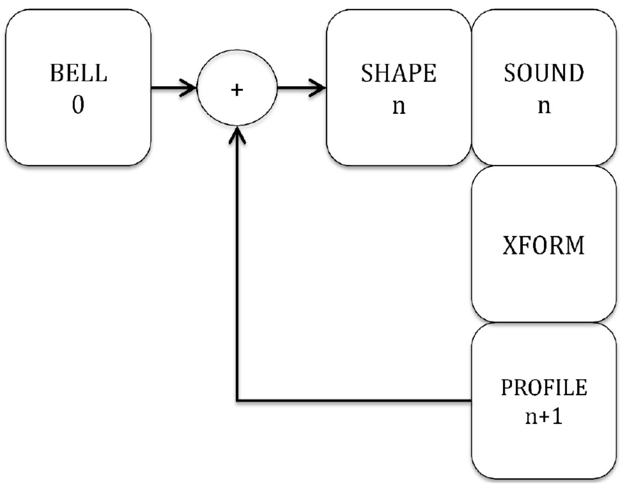


Fig. 13. Recursive fabrication process.

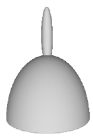
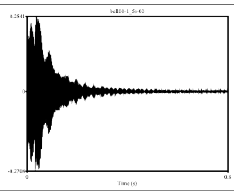
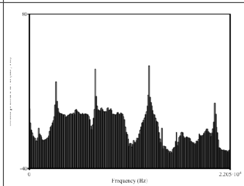
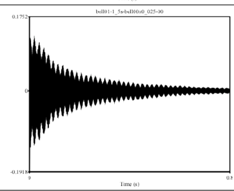
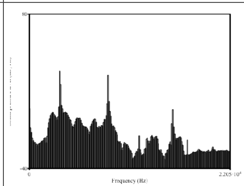
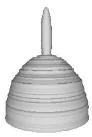
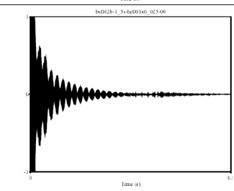
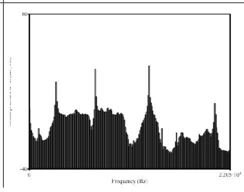
4.1. XFORM

The XFORM is a mapping from sound into a thickness profile that can be added to a bell shape to change the sound it makes.

The LTAS analysis of the prototype bell captures timbral features in a 1 dimensional format that can be used to algorithmically construct a thickness profile as a 3D quad mesh. The LTAS has low frequency and high frequency ends that could be mapped onto the bell shape in two different directions. The physical acoustics of vibration mean that lower frequency resonances are produced by larger objects, and higher frequencies by smaller objects. This led to the decision to tonotopically map the low frequency end of the LTAS to the large circumference at the opening rim, and the high frequency end to the smaller circumferences towards the crown.

The first experimental series of bells generated using this XFORM is shown in Table 1. The first row shows the CAD rendering of the basic bell, a photo of the first prototype fabrication, the waveform of the sound it produces when tapped, and the LTAS profile with 4 partials. The second row shows Bell 1, with thickness PROFILE 1 constructed by XFORM from the LTAS of Bell 0, and fabricated in stainless steel. The waveform rings for ≈1.5s, and the LTAS shows 3 partials that produce a higher pitch, but lower timbral brightness. The third row shows Bell 2 shaped by the XFORM of LTAS 1, and constructed in stainless steel with gold colour. Bell 2 rings for 0.75s, but has only two main partials. The pitch is higher than Bell 0 and lower than Bell 1, and the timbre is brighter than either.

Table 1. Recursive series of bells 0, 1, 2.

n	SHAPE *n*	BELL *n*	SOUND *n*	LTAS PROFILE *n*+1
0				
1				
2				

4.2. Profile weighting

Bells 1 and 2 look and sound more similar to each other than expected. The weighting of the shape profile relative to the bell template can be adjusted in the mesh generating program. The ability to alter this weighting has been added to the process diagram as a parameter labeled T in Fig. 14.

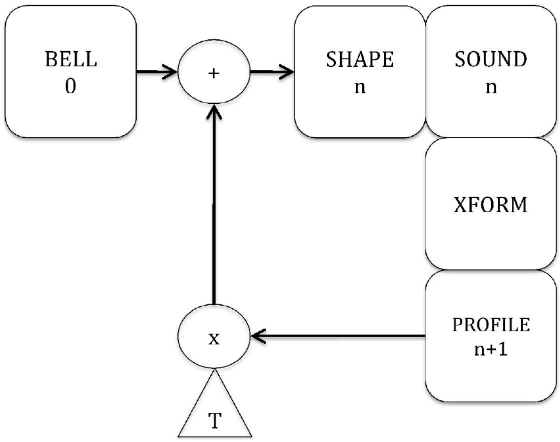
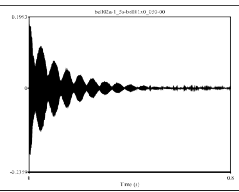
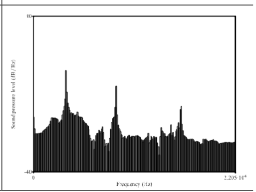


Fig. 14. Process with profile weighting T.

The next experiment tested the effect of varying parameter T on the sound of Bell 2. An alternative Bell 2+ was fabricated with T double the previous level, thereby doubling the geometric effect of the PROFILE generated from the sound of Bell 1. The results in Table 2, show an amplitude modulation in the ringing sound that is heard as a tremolo effect. There has also been an increase in the frequency of the two main partials. Bell 2+ is distinctly different in timbre from Bell 2, and Bell 1.

Table 2. Bell 2 with doubled parameter T.

n	SHAPE 2+	BELL 2+	SOUND 2+	LTAS PROFILE
2				

This result suggests that increasing T may generate more variation in the series of shapes and sounds. To explore this further the value of T was raised to 3x and used to generate the next bell in the series. The CAD rendering of Bell 3++, shown in Fig. 15. has wide flanges that indicate that raising T too high could transform the geometry beyond the point where it will function as a bell. On the other hand, these flanges may introduce unusual timbral effects, such as tremolos and vibratos, that are not heard in conventional bells. At this stage the bell has not been fabricated and the experiment is still work in progress.

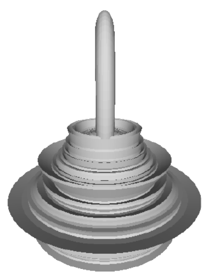


Fig. 15. CAD rendering of Bell 3++

4.3. Material

The Bells in the experiments have so far been fabricated in stainless steel. However, other materials, such as ceramic and glass, also have good acoustic properties. The recursive generation process is updated with a stage for materials in Fig. 16. What is the effect of using these materials on the acoustics of the bell?

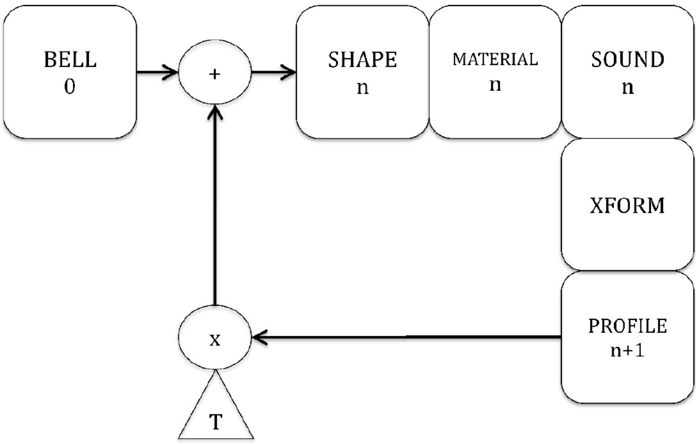
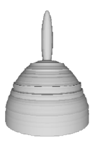
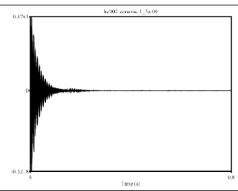
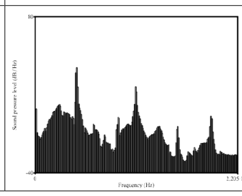


Fig. 16. Recursive process incorporating material

Bell 2 was re-fabricated in ceramic. This version of the bell is smoother and has less detail, as can be seen in Table 3.

Table 3. Bell 02 fabricated in ceramic.

n	SHAPE 2+	BELL 2 ceramic	SOUND 2 ceramic	PROFILE 3 ceramic
2				

Tapping the ceramic Bell 2 produced a short, sharp, high pitched, percussive sound very different from the ringing produced by the stainless steel version. The LTAS profile has 3 partials that look generally similar to previous bells. However the short duration makes it difficult to hear spectral details. The reduced detail of the ceramic fabrication effectively low pass filters the LTAS profile. Does this reduced detail have a perceptible effect on the sound the bell makes? This could be answered by fabricating a low-pass filtered version of Bell 2 in metal, and then comparing the sounds produced by the smoothed and original bells.

5. Discussion

The effect of varying the T parameter raises the question of whether the series will converge to an attractor shape, traverse a contour of endless variation, or diverge to a point of destruction? Is there a value of T on the boundary between convergence and divergence? Is the recursive process a random walk or does it have a trajectory of some kind?

If the series does converge, the bell will produce a sound that has an LTAS profile that is identical to its own thickness profile. The shape of this bell is a blueprint for the sound it produces, and the sound contains the blueprint for the bell that produced it. This attractor bell and its sound would be bilateral transformations of the same trans–phenomenal object. Does such an object actually exist, and can it be found with this process?

The XFORM mapping between the sound and shape in these experiments has been a simple mapping of LTAS to thickness profile. The decision to map the LTAS in one direction raises the question of whether mapping it in the opposite direction would make a difference. There are also other ways that features of a recorded sound could modify the acoustics of a bell. The audio waveform could be wrapped in a spiral down the bell shape, etching into the profile in a manner similar to a needle groove on a wax cylinder or record. The frequency axis of the 2D spectrogram could be assigned to the radial angles of the bell with the amplitude affecting the profile in the radial directions. Other kinds of timbral analysis could be used, such as mel frequency cepstral co-efficients (MFCC), or granular centroid, flux, kurtosis, and skew.

6. Conclusion

These experiments to generate a recursive series of bells and sounds have identified generic stages in a systematic process. The XFORM stage is a mapping between sound and shape. The T parameter controls the level of feedback in the recursive circuit, and the amount of variation in the shapes and sounds that are generated. This parameter may also affect whether the series converges, traverses a contour of variation, or diverges to destruction. The material has a significant effect on the acoustics of the object, and different materials may cause convergence to particular attractor nodes, for example the lack of detail in ceramic shapes and sounds may cause rapid degeneration to a singular point.

The bells in these experiments open the door to the design of more complex shapes than can be made with conventional manufacturing techniques. The geometry of acoustic shapes could be generated using a 3D fractal such as the Mandelbulb, or a rule based L system. These shapes can have complexity that is beyond the state of the art in acoustic simulation with finite element meshes. Digital fabrication allows rapid prototyping of physical objects that could allow research on the acoustics of shapes that are more complex than hitherto been possible.

These experiments have raised many theoretical questions to guide further experiments which are still in progress. Can the recursive process be used to find a trans–phenomenal artifact where the acoustic response contains the blueprint of the object that produced it? What new shapes and sounds will be generated through this process?

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Rhythm Apparatus For the Overhead Projector: a Metaphorical Device

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Keywords: Embodied Cognition, Philosophical Toys, Audiovisual Performance.

Abstract: The rhythm apparatus for the overhead projector is a robotic device that can be used to demonstrate core concepts of the theory of embodied cognition. At the same time, it is also an instrument for audiovisual performances. Combining the communication of scientific insight with amusement and entertainment, it stands in the tradition of philosophical toys. Such a device is introduced here and used to illustrate, in a step-by-step manner, principles of embodied cognition: emergence and the interplay of brain, body and environment.

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1. Introduction

In this paper I present a robotic device for demonstrating core concepts of the theory of embodied cognition. At the same time this robotic device is used as an instrument for an audio-visual lecture and performance using an overhead projector. It can be seen in the tradition of philosophical toys (Wade 2004) because it is designed to experimentally show scientific insight while at the same time providing popular amusement through a play of shadow, light and sound. The presented work also relates to contemporary artistic expressions using the overhead projector as they have, for example, been featured at the art of the overhead festival in 2005 and 2009 (Hilfling and Gansing 2005, 2009).

1.1. Background: embodied cognition

The core claim of embodied cognition is that intelligent behavior in biological systems results from real-time dynamics and interaction between nervous system, body and environment (Johnson 1987, Port and van Gelder 1995, Thelen and Smith 1996). While computational approaches to cognition focus on the brain as the central information processing device, the embodied cognition perspective denies this single cause explanation. Historically this paradigmatic shift in the understanding of cognition gained momentum in the 1980s with a focus on explaining the cognitive aspects of movement (Kelso, Schöner 1988, Schöner, Haken and Kelso 1986). Recently the field has moved to higher cognition explaining more complex behaviors such as spatial working memory (Johnson, Spencer and Schöner 2008), object recognition (Faubel and Schöner 2008) or spatial language (Lipinski et al 2006).

A brilliant example for the type of insight this paradigm shift away from single cause explanation offered is the work from Esther Thelen on the development of walking in young infants (Thelen 1984). Newborn babies show a stepping reflex when held upright on a support surface. This stepping reflex disappears after a few months of age only to re-appear when the infant has already learnt to walk. The single cause explanation for this interesting experimental observation was that some neural maturation process in the brain would inhibit this reflex and that later higher level control would allow it to re-appear (McGraw 1943). This explanation was accepted for almost 40 years until it was challenged by Esther Thelen through a simple but insightful experiment. She put babies that had just lost their stepping reflex into a water basin. Relieved from the weight of their heavy legs in the water the stepping reflex re-appeared. Thelen argued that the disappearing of the stepping reflex was not the result of brain maturation but the result of gravity acting on the babies legs. In the early ages of development babies go through an impressive gain of weight, within three month they almost double their weight. Having to move their chubby heavy legs, babies naturally exercise and build up muscles. These muscles are prerequisite for babies to learn to walk (Thelen 1984). Only once they start walking, the stepping reflex re-appears as a result of training their muscles. In order to learn to walk and to make the first voluntary steps, losing the stepping reflex seems to be crucial and part of a developmental and intelligent learning process. Here 'intelligence' is as much to be found in fat legs as in the developing brain.

1.2. A robotic device as philosophical toy

The term philosophical toy was used in the 19th century to designate technical devices that provided scientific insight while at the same time providing amusement and entertainment (Wade 2004). Typically such devices were dealing with perceptual effects, and many are predecessors of today's cinema, such as for example the *Thaumatrope* or the *Phenakistoscope* (see Figure 1).

Fig. 1. The first three images, a *Thaumatrop*: two images, flowers and a vase, are fused into a single image by quickly spinning the disc. The last picture shows a *Phenakistoscope* disc by E. Muybridge that animates a dancing couple when put in rotation and watched through the slits in front of a mirror.

The robotic device I propose relates to philosophical toys in that a real-time animation is created with an overhead projector. The projection shows the shadow of the apparatus, its moving motors and legs (see Figure 2 for an overview of the setup). It does not demonstrate a visual or psychophysical effect. Instead it operates on a more abstract level and makes a theoretic concept comprehensible by using visual and auditive effects. The idea of the rhythm apparatus for the overhead projector is to demonstrate the interdependence of brain, body and environment. Similar to a biological organism there are three subsystems: An analog electronic controller, motors with legs and the environment. The analog electronic controller was developed by Hasslacher and Tilden (1995) and is inspired by simple neural networks that model central pattern generators (Bässler 1986). The minimalist electronic controller uses only 12 basic electronic components. The structure of the motors and legs is equally minimalist, just simple dc-gearbox motors with sticks out of acrylic glass as legs. The design is chosen to render an interesting projection that resembles more a machine than an organism. This is to underline that the device is clearly an abstraction of any living organism and that the apparatus operates on a metaphorical level to make key insights of embodiment accessible.

1.3. Overview

The paper is organized following the key concepts of embodiment that can be demonstrated with the apparatus.

- How structured patterns emerge out of the interaction of simple units.
- That functional modularity fails to account for the interaction of subsystems.
- How everything matters: the nervous system, the body, the environment and their real-time interaction.

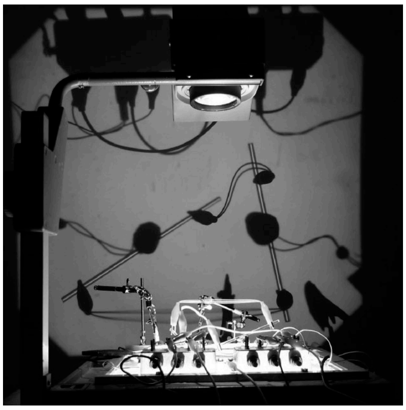

Fig. 2. Overview of the full setup: in the foreground is actual device on the overhead projector. The background shows the image that is produced through the projection.

2. The core circuit – emergence

Emergence signifies the property of a system to produce new structures out of the interplay of its constituents. Importantly the constituents alone cannot produce such structures and the new quality can only result from the interplay. This property can be paraphrased with the whole being greater than the sum of its parts.

In case of the electronic circuit, this new property is a pattern that only appears when the constituents, simple units – resistor-capacitor pairs coupled to an inverter (see Figure 3.a) – are connected into a loop. Each basic unit alone only acts as a change detector for rising activation at its input. Only when there is significant change of the input voltage an output signal is produced and the duration of the output signal is independent of the length of the input signal. The behavior in time of such a basic unit (see Figure 3.b) is similar to a biological neuron with two functional aspects: First a neuron only produces a spiking output when stimulated to a sufficient level (Abbott and Dayan 2001). Second, a neuron adapts to its input: on constant input it stops producing output spikes. The latter property we experience for example when we are exposed to a bad smell: even though the concentration of the molecules producing the odor is constant, after some time we do not smell it anymore (Cometto and Cain 1995). Similarly vision depends on eye movement: we see only because our eyes are in constant movement. We saccade three times a second and make tiny micro-saccades when fixating on an object. If the eye movement is stopped, our vision fades (Martinez et al. 2006).

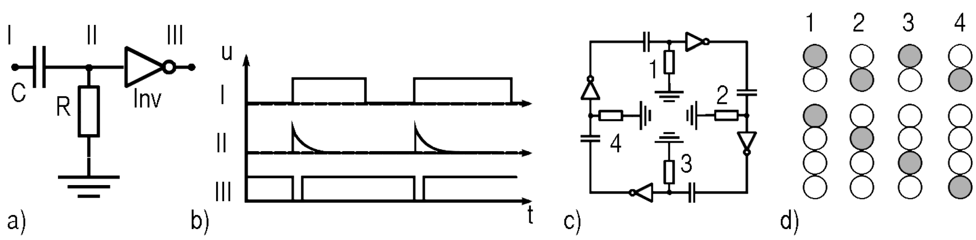

Fig. 3: a) The basic unit: a capacitor (C), a resistor (R) and the inverter (Inv). b) Temporal behavior of a basic unit: given an input signal at point I, the circuit follows the rise of the signal at point II, but then decays back to zero. At point III the output goes to zero at the rise of the input and then switches back when the decay goes below a threshold. A negative pulse is produced for every rising edge of the input. c) The microcore circuit: four basic units are connected into a loop. d) Illustration of the two dynamic patterns: the two top rows show the pattern with two traveling pulses, the four bottom rows the pattern with a single traveling pulse. Each dot represents the off (gray) or on (white) state of the output of a basic unit.

The emergent property is a pattern that appears when two or more of these basic units are connected into a loop. For the rhythm apparatus, I use four basic units (see Figure 3.c). This circuit, called the microcore, has been developed by Marc Tilden as a very simple model of a central pattern generator and was used to drive the leg movement of walking robots (Tilden 1994). The microcore can produce three different stable patterns: one static pattern where all units are off and two dynamic patterns, one with a single traveling pulse and one with two traveling pulses (see Figure 3.d)

2.1. Audiovisual presentation

The electronic circuits are built following a modular design that allows the reconfiguration of the network structure on the fly. Two basic units are assembled into one module, which is housed in a die cast aluminum enclosure with several interface connectors. On top are simple brass sticks that connect to the input and to the output of the basic units (see Figure 4). During a presentation it is possible to reconfigure the circuit using crocodile clips. As the whole setup is put on the overhead projector, the creation of a new connection is directly visible. The brass sticks are also used to connect to a set of strong light emitting diodes that visualize the pattern within the projection. When the overhead projector is dimmed, the light of the LEDs is clearly visible in the projection (see Figure 5).

Fig. 4. Die cast aluminum enclosure with brass sticks as interface connectors. On the front are potentiometers to modify internal parameters of the electronic circuit.

In addition to the brass sticks, a module has mini-jack audio connectors to directly connect to an active speaker or a mixing desk. This way the pattern is made audible in a straightforward way: By directly using the pattern to move the speaker membrane, a beat is created.

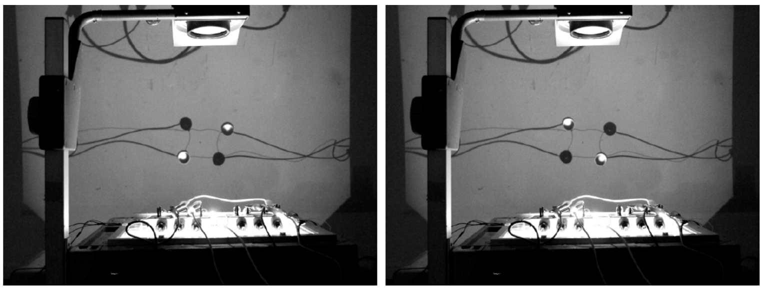

Fig. 5. Displaying the pattern with light emitting diodes on the overhead projector. The two frames show the dynamic activation pattern. In the left frame the outputs number 2 and 4 are active, in the next frame outputs number 1 and 3 are active.

3. Adding motors and legs – no functional modularity

Adding motors to the system illustrates two more important concepts of embodiment. First, to really understand the function of a complex system breaking it down into functional modules can be totally misleading. Attributing modular structures to a system is often tempting because it seems to simplify understanding, but when modules interact with other modules, this can fully alter the way they function. Second, dividing behavior into the chain of sense-plan-act processes is not the best description for behaving organisms. For example the processes of sensing acting and planning may be interdependent and intermingled.

When a motor is connected to the outputs of two neighboring basic units of the microcore, it receives alternating pulses from them. In theory this should produce an alternating movement. The motor should swing from left to right and then back. However this is not what happens when two motors are connected to the outputs of the four basic units. Instead the dynamic pattern disappears and both motors just rotate into a single direction without alternation or pattern.

With a modular perspective one might be tempted to conclude that the modular system is now broken and defunct. But a simple experiment reveals that it has actually gained an important property: it has become sensitive. When one adds legs to the motors, so that it is easy to interact with them with your own fingers, one realizes that if one stops both motors at the same time they will flip direction. The legs seem to feel the performers fingers, the motors behave as sensors.

This raises again the second point from above. If the same device that produces the movement also senses, does it really do it in the order of sense-plan-act? An analysis of the interaction of the motors with the electronics reveals that it is the specific combination of the electronic circuit with the motors that produces a behavior which includes sensing and acting or rather acting and sensing. The pattern disappears because the motors are directly connected to the electronics without an intermediate driver stage. As a matter of fact they directly influence the behavior of the electronic circuit. The inertia of the mechanical parts of the motor produces an opposing force to the current from the electronic circuit. Because every electric motor also functions as a generator, when it moves through an external force, such as inertia, it produces a current. The motors override the pattern of the microcore.

3.1. Audiovisual presentation

The motors are added by simply fixating them with a clay-like material onto the screen of the overhead projector. They are connected to a motor connector on each module. Once connected they immediately begin to rotate, and one sees the shadows of the legs rotating in the projection. The sound changes accordingly, as the motors are connected they become audible and one hears the sound of continuously rotating motors. Moving the finger into the projection to stop the motors causes them to flip direction, which again is audible as a beat. The device becomes an instrument that partly plays on its own.

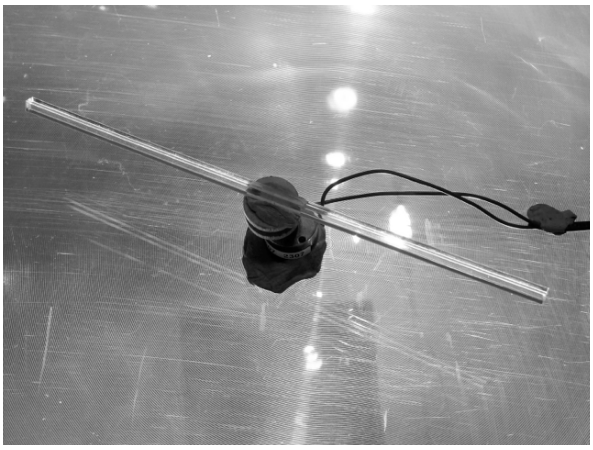

Fig. 6. The dc-gearbox motor with an acrylic glass stick as leg

4. Adding external structure – everything matters

The last lesson showcases how complex patterns result from the real-time dynamics and interaction of a simple controller, a body and the environment.

The environment here is simply created by introducing piezo pickups (Collins 2009) as obstacles for the legs. As the motors 'feel' these obstacles they reverse when touching them. The pattern re-appears as rhythmic movement. The rhythm itself can be modified by changing the positions of the piezo-pickups. When they are placed to constrain the movement the rhythm accelerates, and when there is more space the rhythm slows down. A second physical manipulation consists in adding rubber bands between the legs. Through the rubber band the motors provide mechanical feedback onto each other which stabilizes the rhythmic movement. A third manipulation modifies the internal parameters of the electronic circuit. By reducing the resistance of the resistance-capacitor pair, the timing and thus the rhythm may also be changed. A forth manipulation controls the degree of electrical feedback into the electronic circuit. When the feedback from the motors is reduced, the legs react less to the environment and follow more the internal pattern of the electronics.

4.1. Audiovisual presentation

Introducing the piezo-pickups modifies the behavior of the apparatus, and a regular rhythm re-appears. The pickups act as mechanical barrier but of course they also produce a sound. Using different materials, such as for example felt or paper, they can be tuned to sound lower or higher respectively. Adding the rubber bands introduces a new graphical element to the projection, and the rubber bands appear as thin moving lines in the projection of the overhead. As the rubber bands influence the movement of the motors the sound of the motors changes as well. In order to create more tonal variations a simple analog synthesizer can be connected to the output signals of the core electronic circuit so that it actually behaves as a sequencer.

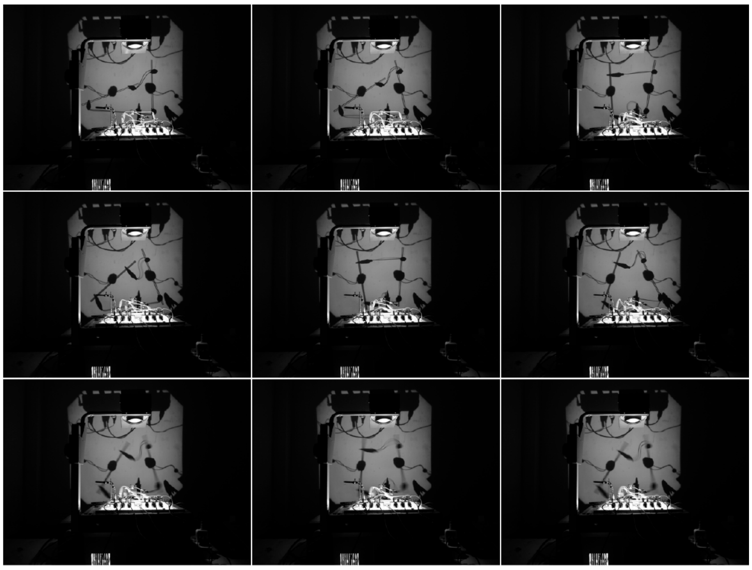

Fig. 7. Key frames of the final demonstration with moving legs, rubber bands between the legs and piezo pick-ups.

With all the parameters that can be modified on the fly, the overall demonstration turns into an audiovisual performance. Its varying beat patterns that are always in sync with the movement of the legs in the projection.

5. Summary and conclusion

Combining the didactic wish to convey a complex scientific topic with a format that may entertain and amuse the audience was once a standard approach in science referred to as philosophical toys. The rhythm apparatus for the overhead projector picks up this tradition to convey a scientific theory. It uses very simple analog electronics to create a behaving system that produces complex movement patterns that are interesting to look at and to hear to. The theory of embodied cognition offers an alternative approach to understanding human and animal cognition. In a step-by-step assembly of the apparatus, core insights about embodiment are conveyed by using the device as a metaphor for biological organisms. The metaphor lies in the fact that, analogous to living organisms, the interactions between subsystems rather than the subsystems themselves create a huge variety of new behaviors. Being far from as complex as any real living organism it however can provide a glimpse of how complex behavior can emerge.

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Between Thinking and Actuation in Video Games

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Keywords: Action, Actuating, Learning, Thinking, Video Games.

Abstract: Action involves thinking and actuating, processes that respectively rely on cognitive and physical effort. When playing a video game, these processes — that may be seen as two stages of player action — do not need to be strictly ordered (thinking–actuating) and they may not even be, in fact, interdependent. This paper explores three types of player action that result from exploring the interdependences of thinking and actuating: from actions that are the consequence of a thought-out plan, to actions that are the result of embodied or mechanized reflexes, and to actions that are visceral responses of the body to external stimuli and internal mental activities or thoughts.
The dialectical relationship that the player and the game system establish is mediated through these actions, undertaken in response to the challenges that the player needs to overcome, through what we may call a *learning process*.

This paper pinpoints a new and still under development approach to game design that aims at recognizing the player as a biological entity, and consequently at identifying the need for the game system to interpret and transcode her biological traits. We believe that multidisciplinary studies in affective computing, psychology, neurosciences, biology, and game design are needed in order to raise a better understanding on how these can affect gameplay.

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1. Introduction

In this paper we focus on the actions of the player and not those of the system. We also regard action as "the means through which the player can make changes to the game state." (Bjork 2005, 20) In other words, actions are the way through which the player operates within the game world.

This paper explores alternate modulations between the interdependences of *conceptualizing* a determinate action and its corresponding *actuation*. These two moments in player action correspond to stages of *preparation* and of *enactment*, respectively. We may say that conceptualization consists in the mental effort involved into ideating or conceiving a determinate action. On the other hand, *actuation* consists in the effort that is employed by the player when she tries to instantiate a certain action. We may say that the first moment consists in the effort that is employed by the player when she forms the model that her actuations will instantiate in the second moment, which is a physical operation capable of sending information to the game system.

In *The Art of Computer Game Design* (1984, 44) Chris Crawford presents a taxonomy of computer games that is organized in two major categories: "skill-and-action ('S&A') games (emphasizing perceptual and motor skills) and strategy games (emphasizing cognitive effort)." We may say that our approach is based on a different perspective on this subject. We believe these two categories are somehow still visible in contemporary computer games, although positioned in different subcategories. Nevertheless, we think that computer games have been discarding the fact that human players are biological beings, with specific biological functions and operations. And a category that may encompass this fact is in order.

So, player's actions can be the result of a conscious choice, of an unconscious reflex, conditioned or trained behavior, or even emerge from the biological functions and operations of her own body. And each of the previously enunciated types is obtained through different modulations between the conceptualization and actuation phases. In this paper we describe three types of action that are based in these premises.

The work presented here is in a certain way related with the work of Donald Norman demonstrated in *Emotional Design: Why we love (or hate) everyday things*, in which he presents three levels of the brain that use alternative thinking processes, requiring different styles of design. "The three levels in part reflect the biological origins of the brain starting with primitive one-celled organisms and slowly evolving to more complex animals, to the vertebrate, the mammals, and finally, apes and humans." (2004, 21) Summarizing, Norman defines the visceral level as prewired, preconscious, pre-thought, focused on the present time, dealing with fixed routines; the behavioral level as unconscious, concerned with use, experience and performance, also focused on the present time, and on routine behavior; and the reflective level as slow, conscious, contemplative, vulnerable to variability through education and culture, and focused on long-term relations. But where Norman is interested on usability and the relationship we establish with everyday objects, we converge our attention to the phenomena of action in the context of video games.

2. Premeditated Actions

We may call *premeditated* those actions that require the player to invest conscious mental effort conceptualizing them. They result from the player's conscious thought and may be planned thoroughly. In other words, the player is aware of what she is going to do, independently of how complex of her plan might be or how long it will take.

These are *deliberate*, *intentional*, *controlled*, and *voluntary* actions. The player takes her time to consciously process information in order to deliberate the preferred course of action.

> (…) the human brain can think about its own operations. This is the home of reflection, of conscious thought, of the learning of new concepts and generalizations about the world. (Norman 2004, 23)

The player resorts to these actions when she has to deal with complex or heavy loads of information. Therefore, they are usually slow, because she has to analyze a given situation, deliberate her course of action, and only then actuate. And the more time is available to her, the further she premeditates her actions. She may even premeditate complete sets of actions instead of one at a time.

It is pretty common for strategy-based games to resort to this type of action due to their orientation on heavy planning. In their case, play may be divided into turns, in which players act alternately. In some of them, turns do not even have a temporal limit in which their actions need to be enacted, rendering real time irrelevant in the overall gameplay. Thus elevating the importance of planning, of the effort in making conscious and rational decisions. *Worms* (Team 17, 1995), *Sid Meier's Civilization* (MicroProse, 1991), *Utopia* (Daglow, 1981) are good examples of strategy games played in turns.

Real time strategy games maintain the overall characteristics of traditional strategy games, but they use time as a gameplay element, providing immediate feedback, pressuring the player into making decisions faster and coordinating several elements (almost) simultaneously. Games like *Populous* (Bullfrog, 1989), *Warcraft: Orcs & Humans* (Blizzard Entertainment, 1994), *Age of Empires* (Ensemble Studios, 1997), *Black & White* (Lionhead Studios, 2001), *Supreme Commander* (Gas Powered Games, 2007), *Starcraft II: Wings of Liberty* (Blizzard Entertainment, 2010) help illustrate this.

This kind of action doesn't need to always be related with strategy games. In many other games, the player has to plan her actions no matter how brief that moment is. Even action games require planning at some point, or some kind of premeditation. But the emphasis on this type of action that is evident in strategy games makes them good examples.

Besides games that have planning at their core, the player may also resort to these actions when in other games she is confronted with an entirely new situation. The fact that she is not familiar with a certain set of circumstances is enough to ignite an analysis process, simply because that is the cautious decision.

Yet another situation that invokes premeditated actions occurs when the player's actions do not produce an expected outcome, as when she is constantly defeated at the same location or by the same opponent, or when she simply fails to achieve her objectives.

At that point she may recognize the need to implement a new and better strategy (no matter how simple or complex the plan may become).

On the other hand, when the player is confronted with familiar situations, she may employ already tested or tried actions to produce expected and preferred outcomes. And because a plan has already been outlined, the ideation stage is bypassed, resulting in speedier response: her actions will be faster. When this process becomes fast enough, resulting in unconscious processes, we discover another type of action.

3. Trained Actions

We may call *trained* to the player's unconscious actions that were learned through instruction and practice. They are automated and sometimes choreographed acts. As António Damásio notes, not all the actions commanded by a brain are deliberated. We can assume that most of the actions happening at a given moment in time are not deliberated at all, and that they constitute simple answers, from which reflex movements are an example: a stimulus transmitted by a neuron that leads another neuron to act. (1994, 128)

For example, an experienced typist doesn't usually think about how her fingers hit the correct keys on the keyboard when typing. Conversely, that usually happens to an individual that has less experience, although with practice she may improve to a point where typing does not require the attention and effort that it previously did. That's what we usually call *experience*. So, the player may refine her actuation, getting better and faster with practice. And as her experience increases, so do the chances of her actions' effectiveness. And as her actions become more and more embodied they require less and less mental effort, becoming *unconscious*, *conditioned* and *automated* processes.

> If I asked you to describe how you got to work in the morning in some detail, you'd list off getting up, stumbling to the bathroom, taking a shower, getting dressed, eating breakfast, leaving the house, and driving to your place of employment. That seems like a good list, until I ask you to walk through exactly how you perform just one of these steps. (...)
>
> Odds are good that you could come to an answer if you thought about it. This is called a morning routine because it is *routine*. You rely on doing these things on autopilot. This whole routine has been "chunked" in your brain, which is why you have to work to recall the individual steps. It's basically a recipe that is burned into your neurons, and you don't "think" about it anymore. (Koster 2005, 20)

These actions may be *voluntarily ignited and terminated* by the player, but they are *not consciously controlled or performed* by her. We may rather say that they are invoked, performed in correspondence to some sort of training the player has undergone.

> The behavior level in human beings is especially valuable for well-learned, routine operations. This is where the skilled performer excels. (Norman 2004, 23)

They can be automated performances as when an experienced driver steers a car. It seems that she does it without thinking, intuitively. They can also be conditioned performances, as when we respond to perilous situations, such as the presence of a dangerous animal or other physical threat.

> Your body reacted in an attenuated replica of a reaction to the real thing, and the emotional response and physical recoil were part of the interpretation of the event. As cognitive scientists have emphasized in recent years, cognition is embodied; you think with your body, not only with your brain. (Kahneman 2011, 51)

Therefore, games where the player must excel through speed or must somehow develop some dexterity, often deal with this kind of action. They usually present increasingly harder challenges, training the player into embodying several combinations of keys, movements, etc.. Games as *Super Mario Bros.* (Nintendo Creative Department, 1985), *Sonic the Hedgehog* (Sonic Team, 1991), *Super Street Fighter II* (Capcom, 1992), *Tekken* (Namco, 1994), *Wipeout* (Psygnosis, 1995) are just some of the many examples that explicitly use these actions.

4. Autonomic Actions

We may call *autonomic* to actions that are the result of *automatic*, *mechanical* or *organic responses* enacted by the player's body, and that occur without her direct control or will. The player's conscious thought is not directly entangled with this kind of actions; they are a direct result of the player's body biology and mechanical operation, regarding its activities and behaviors.

> When you stick your finger in the fire, you snatch it back before your brain has time to think about it (seriously, it's been measured).
>
> Calling this "muscle memory" is a lie. Muscles don't really have memory. They're just big ol' springs that coil and uncoil when you run electrical current through them. It's really all about nerves. There's a very large part of your body that works based on the autonomic nervous system, which is a fancy way of saying that it makes its own decisions. Some of it is stuff you can learn to bring under more conscious control, like your heart rate. Some of it is reflexes, like snatching your fingers out of the fire. And some of it is stuff you train your body to do. (Koster 2005, 28)

These actions may be triggered by actions of the same kind, but also by conscious thought. For example, it is possible that the player's heart rate goes up and her legs may start to shake when she is reminded of a traumatic event she endured in the past. These actions may also be heavily influenced by the mood or emotional state that player may be under. For example, if she is feeling stressed, her heart rate may be higher than normal, or she may be sweating, etc.. As Damásio states, emotion is a collection of changes in the state of the body, that are induced in several organs through the endings of nerve cells under the control of a dedicated cerebral system, that responds to the content of thoughts related with a certain entity or event. Although some of these alterations may only be sensed by the person in whom they are occurring, many can effectively be perceived by others. (1994, 189)

Here her body acts by itself, without her direct control, although some behaviors may be shaped through proper training. "Animals such as lizards operate primarily at the visceral level. This is the level of fixed routines, where the brain analyses the world and responds." (Norman 2004, 23)

The *PainStation* (Morawe and Reiff, 2001) is an interesting example that deals with this type of action. This game is a variation of *Pong* (Atari Inc., 1972) in which the player that looses points is physically punished through electro-shocks, whippings and extreme heat applied to the left hand which, if removed from the game panel, leads the player to loosing the game altogether. Thus, this game tries to measure the player's resistance to pain, and its rules force her to endure punishment in order to continue playing. Here, the reflex of avoiding pain and the conscious decision to continue playing the game are confronted and in constant turmoil.

5. Conclusions and Future Work

Looking back into the history of video games we may notice how extensively they have explored premeditated and trained actions. Since the early days, computer games were divided into two major categories that seem to be close to the two types of action. Video games have also excelled at manipulating the player into transforming premeditated actions into trained ones.

Games force players into optimizing their performance, usually by presenting them with challenges that grow increasingly more complex and harder to solve, requiring them to master their current abilities. Overcoming these challenges unlocks new abilities, restarting the cycle. In most cases, this happens when players succeed in embodying basic essential actions, freeing mental resources, thus allowing them to solve new and usually more complex situations. In other words, throughout the game the player is trained into increasing her skills, either physical or mental.

This increasing difficulty that is usually presented in video games is a good example of how game systems teach their players something that is not necessarily related with narrative or storytelling.

> Games seem on the face of it to be very different from the stories and to offer opposing satisfactions. Stories do not require us to do anything except to pay attention as they are told. Games always involve some kind of activity and are often focused on the mastery of skills, whether the skill involves chess strategy or joystick twitching. Games generally use language only instrumentally ("checkmate", "ball four") rather than to convey subtleties of description or to communicate complex emotions. They offer a schematized and purposely reductive vision of the world. Most of all, games are goal directed and structured around turn taking and keeping score. All of this would seem to have nothing to do with stories. (Murray 1998, 40)

Instead, they teach something intrinsic to their dynamics. And for players to progress in the game they have to keep on learning, and in many games this happens until closure.

> Moreover, the potential uses of video games extend far beyond the playing of games. They could be excellent teaching devices. In playing a game, you have to learn an amazing variety of skills and knowledge. You attend deeply and seriously for hours, weeks, even months. You read books and study the game thoroughly, doing active problem solving and working with other people. These are precisely the activities of an effective learner, so what marvelous learning could be experienced if only we could use this same intensity when interacting with meaningful topics. Thus, game machines have huge potential for everyone, but it has not been systematically addressed. (Norman 2004, 44)

We can even state that this process has been a favored form of learning that players have endured in video games up until now. Perhaps it is because of this learning process — that is very advantageous to games when it comes to their replay potential — that games have been heavily focused on premeditated and trained actions. While the player is capable of transforming the first type of action into the second, we don't think it is possible to transform either of the previous into autonomic actions. We know that unconscious and conscious thought influence them, but there seems to be no direct correlation between the first two and the third. At least, not in the way that we are used to experience between premeditated and trained actions.

Another aspect that as come to our notice is the fact that nowadays few games explore autonomic actions. There is a huge gap here. It is very unusual for the player to be able to influence the game system through autonomic actions. Traditional hardware in which video games run is simply not equipped with the adequate sensors or even software that is able sense and interpret most of these actions. And although the player keeps sending information that derives from them (because it is in her nature), the game system is not capable of receiving and interpret it. It literally goes to waste.

Another aspect that may have contributed to this is the fact that the player is not able to consciously act on the game through these actions because she is not able to directly control them. It is precisely because of that that this unlocks a new approach to game design, an approach that can be closely linked with affective computing, psychology, neurosciences, and biology. An approach that should perhaps start by asking: How can a game be played if the player does not exert direct control over her actions? If the player is a biological entity, how can a game system interpret and transcode her biological traits transforming the outcomes into actions of play? And how can they influence the game system?

Some experiments with brain-computer interface (BCI) devices seem to be focusing on finding alternate ways for the player to send information to the system. Through these devices the system is able to monitor player's autonomic actions related with her brain activity. *Brainball* (Smart Studio, 1999) is an experimental game that aims at inverting conventional approaches to competitive games. Here the winner is the player that is able to achieve the most relaxed mental state, the most passive and calm. Both players wear on their heads a strap that contains biosensors that measure the electrical activity of their brains. Depending on their brains' activity a ball that sits on the table moves back and forward until it reaches one of the player's sides.

BrainBattle (ARS Electronica Futurelab, 2012) is an experiment in which players play a version of *Pong* (Atari Inc., 1972), *Space Invaders* (Taito Corporation, 1978) and *Pac-Man* (Namco, 1980) resorting exclusively to BCI devices. Here players are forced into a higher level of concentration just to move the characters they are controlling with their mind and in most cases success in controlling those characters is hardly guaranteed.

But BCI is not the only way to introduce autonomic actions into games. The spectrum of means through which humans communicate is very wide and diverse. The human body, particularly the face, is highly expressive, and computer vision (CV) devices, for example, can be powerful tools to monitor those expressions. But, most of contemporary video games primarily use CV for motion tracking, granting the player direct control over certain game elements — like the Microsoft Kinect that visually traces the movement of the player's body. *Kinect Star Wars* (Terminal Reality, 2012) can serve as an example here.

Augmented reality has been another focus in CV based games, but, in this context, it just seems to be another variation of the previous. *LevelHead* (Oliver, 2007/2008) or *Invizimals* (Novarama, 2009) are examples of this.

Video games will only be able to include players' autonomic actions into the gameplay when they are capable of sensing and interpreting the modulations of their various states: anxious, excited, relaxed, disoriented, aroused, for example, through bodily responses such as heart rate, skin galvanic response, pupil dilation, facial and body expressions, etc.. We believe that this may uncover an yet unexplored path to exploratory and multidisciplinary studies in computer games, that will not only expand our knowledge on these but also on how our own biology interacts with computational systems and ultimately will allow the development of innovative video games.

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Photography in Video Games: the Artistic Potential of Virtual Worlds

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Keywords: Artists, Graphics, Immersion, Photography, Screenshots, Video Games.

Abstract: Photography has acquired a place and a growing meaning within video games. To this has contributed the abrupt graphic evolution of video games, the spread of a growing number of virtual environments such as Second Life, and the creation of projects that demonstrate the photographic potential of virtual worlds.

In this paper we aim to study the different ways in which photography may exist as an artistic expression of video games. By facing them as imagery mazes containing an undeniable creative potential, we explore the act of photography as gleaning and as a core mechanic that enables gamers and artists to create an original view of their experiences.

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1. Photography and video games: a complex relationship

The relationship between photography and video games is extremely complex due to the strong antagonism evidenced by their natures. Photography's analog nature is characterized by a matrix of sand grains (minimal unit), while video games' digital nature is characterized by a pixel matrix (minimal unit), or binary information. Another issue is the dichotomy of presence/absence of the concept 'photographic referent', introduced by Roland Barthes:

> I call 'photographic referent' not to the *optionally* real thing that refers to an image or a sign, but the real thing that was necessarily placed before the lens without which there would be no picture. (Barthes 2008, 87)

Unlike digital images, in a photograph it is extremely difficult to manipulate its visual information.

> Once recorded, the visual information is irreversible. The image is individual property, is frozen, static. Any movement can only be as much as an illusion. The digital image represents the extreme opposite. Each component of the image is changeable and adjustable. Not only can the image be controlled and manipulated as a whole but also, and more significantly, each individual aspect of it. (Weibel 2000, 29–30)

Still, it is important to consider that the history of photography also shows a significant openness to different techniques, trends and applications. Photography established not only a close proximity to the truth through report photography (Bauret 2010, 33–4) but also, and due to its association with various artistic movements[1], acted as a deceptive illusion (Bauret 2010, 97–8).

1. In the first half of the twentieth century, photography has maintained a privileged relationship with Surrealism, adding different perspectives to those defined by the concept of truth and that the nature of analog photography highlights.

Video games, as creators of digital images, explore the potential that their fantasy allows, introducing a major flexibility regarding their representations. Yet, the representations shown in the majority of video games suggest an increasing proximity regarding their real world referents. These representations distance themselves from the abstract and arbitrary and become closer to the tangible and iconic; a more motivated representation of real, of photography. As such, the distance between video games and photography is becoming increasingly shorter.

For this reason, terms such as 'realism' or 'photorealism' are more associated with video games (McCarthy et al. 2005, 85, 104). In many video games, the creation of three-dimensional virtual worlds is informed by photographs of reality itself. That is the case of *Wheelman*, in which the virtual representation of Barcelona was mainly based on a set of real photographs. Barcelona became the photographic referent and the photographic referent became the digital referent. In such cases, the photographic image as a reality remnant (Aumont 2009, 93) is an instrument that approximates the reality to their virtual recreation. As Tim Shymkus points out, with the growing graphical representation it is possible to achieve a greater 'realism', making it more believable to the eyes of anyone who plays (Morris and Hartas 2004, 24).

2. From analog to digital

Since the first photograph of Joseph Nicéphore Niépce in 1822, there has been a huge evolution of images and photography in particular. The emergence and nurturing of digital photography in the end of the twentieth century, has originated an increased 'democratization' of photography.

> From analog to digital; the great mayhem that affects all forms of message as well as the different treatment processes and communication has obvious repercussions on the world of photography. (Bauret 2010, 21)

Digital photography is a delicate concept. It combines two clearly conflicting opposites (analog photography and digital imaging) and raises a dangerous idea of replacement. Regardless of the analysis of its nature or support, digital photography should be understood as an evolution, as a modern image in the field of photography. This image explores the modernization of the record itself to digital format. Digital photography is the result of hybridization between traditional phenomenology of analog photography and the computerized nature of digital image.

With digital devices increasingly automated and with a quality arguably evolutionary, anyone has the opportunity to 'play' with them. "*The look and spirit of the photographer are now free from any technical constraints*" (Bauret 2010, 21), so there are less constraints on the photographic praxis (Flusser 1998, 74–5). The device is "*a toy and not a tool.* (...) *The man who handles it is not a worker, but a player: it's not* homo faber, *but* homo ludens" (Flusser 1998, 44). Despite the evident automatism, some digital cameras such as the Nikon D40, allow for the photographer to choose manual settings (focus, aperture or shutter speed) before taking a picture. This extends the technical capabilities of the device, as well as the knowledge of the photographer who handles the cameras in order to "*overpower them and trust them with significant accurate and precise function*" (Bauret 2010, 45). However, although it is possible to explore and assimilate a number of applications of phenomenology analog photography in these devices, the indexical character that has always been part of its definition and its analog nature is lost. The captured images assume a digital nature similar to video games' nature (pixel matrix), reinforcing an undeniable proximity. While pressing the shutter button of the device, the image is automatically scanned, converted into information in a JPEG file format and stored on a memory card. In a video game, by pressing the printscreen button, the computer temporarily registers in its memory the image's information captured on that screen. Later, the player can record this log to a file with the JPEG format and save it on the computer disk. This possibility encourages an open field for experimentation, in which players can simulate 'photographic acts'.

3. Imagery mazes

The three-dimensional virtual worlds of today's video games offer light, environment, perspective and depth of field. They offer an aesthetic that invites the player to a closer and attentive look, a deeper contemplation and visual immersion. Its interactive image produces a virtually infinite set of other images, where contemplation is often superimposed to action. As in reality, the majority of the video games' virtual worlds allow for unlimited freedom imagery. 360 degrees simulate what we can visually grasp, not simultaneously but through choices and intentions by the player. "*He is free to look to any part of the image* (*as he is free to look at any part of the reality*)" (Aumont 2009, 163).

Some producers of video games seek to evolve their work in order to emphasize the full potential of gaming visuals, primarily in how they are able to simulate realistic effects in digital aesthetics. In this context, aesthetics must be understood as a reflection of experiences, since the players are invited to increasingly enjoy virtual environments that are capable of stimulating an insatiable sense of contemplation. This idea of contemplation in video games resembles the idea of contemplation of reality. The player will have to make choices and act accordingly, in order to select what he wants to contemplate on the screen. Despite the dynamics associated with the interactivity of video games' images, they can still encourage a mental connection exercise that allows players to 'get into the image' while playing and thus contemplate, 'scrutinize', 'get into' (Barthes 2008, 110–1) the digital matrix and explore its imagery labyrinth much like a photographer explores reality (DuChemin 2009, 2–7). All photographs of the world form a maze (Barthes 2008, 83), and each individual within it explore a path defined by personal readings and interpretations. In video games the same occurs with each player. As he gets into the images, he becomes more immersed in the maze that holds them.

> Immersion does not privilege images more than before; rather, it simply takes images to another level. It is important to remember that immersion is only possible if the immersant *agrees* to participate. (Burnett 2004, 77)

'Sandbox' video games such as *Grand Theft Auto IV* or *Fallout 3*, have mazes conceptually opened to the capture of an endless set of images. The player immerses into these mazes while controlling the character within the virtual world, and contemplates what lies ahead of his eyes. All elements related to the composition of visual images define the depth of the maze, and force the player to stay and explore it, facing a mental and continuous negotiation process. The interest becomes the image as a dimension, as a latent history, and the players, unlike photographers, record these images while immersed in the virtual situation.

> For a photographer gazing through a viewfinder, reality is mediated by the camera. Some describe a distancing sensation, one in which the photographer is disengaged from a situation. (Albor 2010, see also Flusser 1998, 74)

Imagery mazes of most video games support a greater transparency. An observation without camera in a virtual world may, in many cases, comprise several advantages; there is no restriction for the captured image, no fear of approaching possible dangers, or any kind of theatricality by the virtual characters in manufacturing poses or behavior change before the lens (Barthes 2008, 18–9). Such advantages considerably extend the authenticity in virtual worlds that, although from different perspectives, has been exploited both by players and by various photographers and artists. The player actively captures screenshots while involved in the events of the virtual worlds, while photographers and artists prefer to act as observers. The player tries to illustrate his experience while photographers and artists seek to disclose the different experiences (especially multiplayer) that occur in virtual worlds. The interesting aspect is to observe that, although different, they prospects created by both are always the result of their presence in these mazes. Whether the subject is active or passive the captured screenshots show a similar artistic potential, since "*the vision of the photographer is not to see but to be there*" (Barthes 2008, 58). As one can build a reflection from reality, also in video games one can build a reflection from the virtual. This look is the gleaning of images of the virtual in which one is and one's experience, allowing the construction and emergence of a visual *corpus* holding meaning and consequently open to critics.

4. The photographic act as gleaning

This idea is explored by Agnès Varda in her 2000 documentary titled *Les Glaneurs et la Glaneuse*, which refers that "*glean is to catch the debris after harvest*", an ancient custom that is still active today, although in other contexts. Proceeding from Jean-François Millet's painting *Las Glaneuses*, Varda builds a reflection at the persistence of gleaners of contemporary society; those who live of other debris, which "*collects debris in our satiated society*". The author's critic is also a self-critical view of her insatiable desire to show images of a reality that exists but nobody wants to see or take part. The author draws an important analogy as she acknowledges being the main gleaner of her documentary. Her role is to glean the images of the observed reality:

> In gleaning of images, impressions, emotions, there are no laws. Figuratively, gleaning is a mental activity. Glean facts, acts and information. For me, as a person with poor memory, the things I gather are the ones that summarize my travels. (Varda 2000)

Fig. 1. Agnès Varda in *Les Glaneurs et la Glaneuse* (2000)

The same holds true for photographers. The photographic gesture is a gesture that involves gleaning. The photographer is, like Agnès Varda was during the documentary, a gleaner of images from reality, who seeks to establish new circumstances according to the available technical possibilities (Flusser 1998, 51). Currently, perhaps because there is a saturation of pictures of reality and therefore greater difficulty in capturing new images, many photographers and artists seek to create new circumstances in virtual environments. In their projects, the virtual is approached as an environment to be explored for its creative and evolutionary ampleness demonstrated over the years. An environment where people search, read, write, learn, meet, talk and play. In short, an environment where they spend much of their daily time. In the 2006 exhibition *Photographs from the New World* in New York, the English photographer James Deavin presented a series of images captured within the virtual world of *Second Life*.

> *Second Life* is wrongly named. Rather than a pale imitation of "first" or "real" life, *Second Life* is best understood as a new extension of the human senses, and a tool used in different ways by different people for different things. (…) *Second Life* programmers believe that most users don't yet understand the full potential of the environment in which they are currently gaming, chatting, shagging and so forth. (…) This will change over time, one way to understand these photographs is as a piece of *Second Life* history, markers of a time when people were still viewing the new world through the eyes of the old. (Deavin 2006)

Eva and Franco Mattes, known as 0100101110101101.ORG, also presented some projects, such as *Portraits*[2], with several series of images taken in the virtual world of *Second Life*. Their work seeks to represent and explore the relationship between identity and public presentation in virtual worlds regarding the endless possibilities to create and fantasize. They seek to document the existence of a (virtual) society in order to understand their evolution (Bauret 2010, 58–60).

2. 0100101110101101.ORG, Portraits, available at: http://0100101110101101.org//home/portraits/index.html, last accessed on March 18th, 2013.

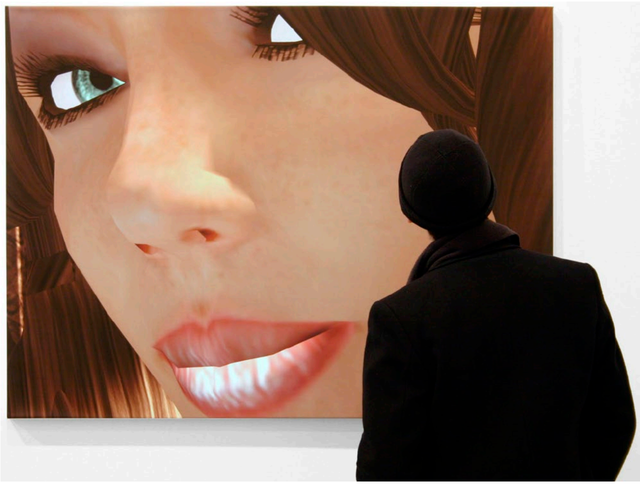

Fig. 2. Portraits, by Eva and Franco Mattes, as known as 0100101110101101.ORG.

Marco Cadioli, known as Marco Manray, is a photographer of virtual worlds. In his website[3] he publishes projects on the images he captures in the virtual world that he discovers and explores, both on the Web and in many video games. Cadioli builds on the theoretical foundations of photography to broaden the discussion on what he considers to be an emerging form of artistic expression.

3. *Marco Cadioli: Projects*, available at: www.marcocadioli.com, last accessed on March 18th, 2013.

> I travel across the net like a Japanese tourist in Europe. I jump from a place to another. I travel across the net like a reporter to tell everything about a place made of information. I take shots at the net.[4]

4. *Marco Cadioli Internet Landscape*, www.marcocadioli.com/ /internet-landscape, last accessed on March 18th, 2013.

In 2005 he published *ARENAE*[5], a black and white report on various war scenarios, summarized in a series of images captured on video games like *Counter-Strike*, *Wolfenstein: Enemy Territory* and *Quake III Arena*. "*Even today, photographers participate in all conflicts that occur on land, at sea and in the air, more or less protected, more or less respected*" (Bauret 2010, 33–4) and Marco Cadioli participated in conflicts that took place in the virtual space. The photographer seeks to discover "*never seen visions and wants to discover them on the inside of the camera*" (Flusser 1998, 52). Likewise, Cadioli sought to uncover insights within the virtual worlds of video games. In *ARENAE*, Marco Cadioli, like Robert Capa, sought mostly action, the dynamics of the event, the conflict in virtual scenarios fueled by players in online experiences. Unlike Robert Capa, Marco Cadioli had the advantage of having a 'security' that only virtual worlds allow by "*providing the psychological experiences of conflict and danger while excluding their physical realizations. In short, a game is a safe way to experience reality*" (Crawford 1997, 14). As Cadioli points out, the images captured in video games are photographs of war, they "*dramatically resemble pictures of a real war, as well as photographs of actual war resemble video games*".

5. *Marco Cadioli Internet Landscape: reportage from the net*, *ARENAE*, available at: www.marcocadioli.com/ /internet-landscape/arenae/ /index.html, last accessed on March 18th, 2013.

> When vision is spoken of in photographic terms, it is not spoken of merely as the things you see but how you see them. Photography is a deeply subjective craft, and the camera, wielded well, tells the stories you want it to. (…) You are central to your photography,and the camera is merely the tool of interpretation — not the other way around. (DuChemin 2009, 11)

Fig. 3. *ARENAE*, screenshots from *Counter-Strike*, by Marco "Manray" Cadioli.

Before pressing the printscreen key, Marco Cadioli had to plan what he wanted to capture. To some extent, what he captured became as important as what he excluded (DuChemin 2009, 14), because it involved a selection and therefore an intention. As a photographer and not a player, Cadioli immerged in the mazes of video games to glean information, experiences, and actions in the form of images. He built a meaningful *corpus*, opened to multiple readings and interpretations, a corpus defined as a documentary record showing the events occurred in these virtual worlds.

The work of these artists and photographers has been important in order to demonstrate that the practice of photographic acts within virtual environments, although simulated and technically limited, can be possible. Video games have evolved to extend these photographic acts to increasingly accessible discoveries, also appreciated and respected by the players. Just as Agnès Varda collects things that summarize her travels, players collect images that summarize their gaming experiences. Many like to exhibit these images at virtual galleries on the Web. Some of these galleries are created for free at sites like Flickr, where players can store and share their screenshots. Building upon Flickr's slogan ("*Share your photos. Explore the world.*"), the players, besides showing virtual worlds of video games, try to show how they see them personally. They invite visitors to explore scenarios, characters, actions and events they experienced. All these galleries result from every player's insights. However, the occurrence of the photographic potential in video games is subjective, as is photography (Barthes 2008, 36–7), to the gameplay that each one experiences.

> Faced with a reality, two photographers do not see the same thing or react the same way, because the act involves their own photographic experience, sensitivity and culture. (Bauret 2010, 47)

For this reason there are a growing number of galleries created on the Web with a substantial set of screenshots captured by several players during their experiences. The website and gallery DeadEndThrills.com, created by Duncan Harris, is a very good example of this. Players, photographers and artists, seek to convey artistic and expressive values in the digital images that they capture. They essentially show what they have gleaned from these virtual worlds.

5. The photographic act as a gameplay core mechanic

Photography is being increasingly explored in several ways. Sport video games, such as the *FIFA* series, let the players watch the replays of various moments, celebrations or even expressions of players. Others like *WipeOut HD* feature a photo shoot mode, allowing the capturing of screenshots of undertaken races. But, most importantly, in many video games, photography has emerged as being a gameplay mechanic. *Dead Rising* or *Afrika* are examples that explore the process of capturing screenshots with the aid of virtual cameras. The characters have at their disposal cameras, which allows players to control a set of techniques (such as zoom, scale, depth of field) to enhance the results of various visual compositions. In these titles, whenever one selects the camera, the perspective changes from third-person to first-person and the player begins to see the virtual world through the viewfinder. The photographer "*is not committed to change the world, but to force the camera to reveal its potential*" (Flusser 1998, 43), and in video games, the player is also not committed to modify the virtual world, but similarly to force the virtual camera to reveal its potential. The diversity of images depends on the diversity of intentions by each photographer. Although simulated, the act of 'taking pictures' as a gameplay mechanic is in itself a sign of the photographic potential that video games possess.

Fig. 4. Frank West, the protagonist and photojournalist in *Dead Rising*.

In *Dead Rising* the player controls Frank West, a freelance photojournalist who, with his camera, documents an invasion of zombies in a shopping center. Despite being free to pick whatever he wants, the player must be aware that all pictures are evaluated according to a scoring system that considers the captured elements, situations and actions. The goal is to cover the entire event and report, through images, a story that is being told through the progression of the game.

In *Afrika*, the character that the player controls is a professional photographer who aims to record various moments of the animal world, in particular virtual scenarios of the African continent.

> The quality of a photograph in *Afrika* depends entirely on how the game's camera operates. Depending on shutter speed, lens type, and positioning of the six axis (which controls the orientation of the camera as though it were the camera itself), an animal in motion may be blurry, off center, or seemingly still. The game world is perceived from within via the camera, not just from outside via the screen. In game cameras immerse players in a unique way. (…) *Afrika* adds depth by rewarding players money based upon the specific goals of a mission, as well as angle, target, distance to the subject, and technique (likely a combination of depth of field, exposure, and camera shake). (Albor 2010)

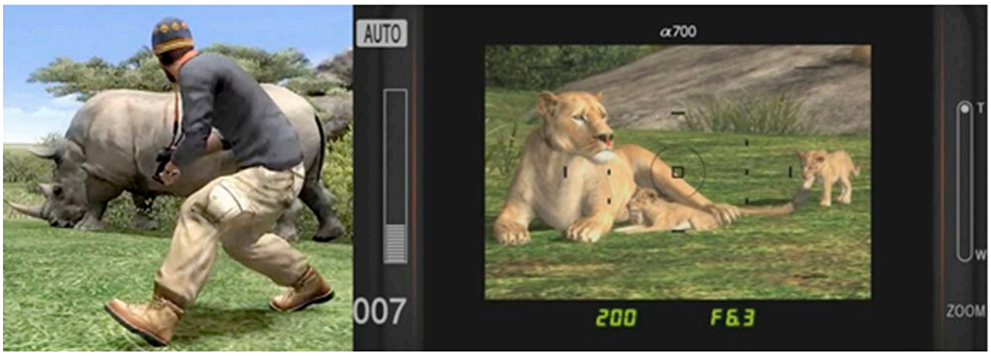

Fig. 5. The photographic act as a gameplay core mechanic in *Afrika*.

The monetary aspect of the game is of special importance as the player needs to purchase new equipment and improve the quality of the captured images. *Afrika* is the video game that greatly incorporates photography. In sum, all the above mentioned titles demonstrate that, albeit simulated, it is possible to perform photographic acts in various virtual environments.

6. Conclusion

The last ten years have been extremely important to reinforce the closeness between photography and video games. As we demonstrated, there is an undeniable photographic and artistic potential that has recently gained greater recognition. This is confirmed by projects of various photographers and artists like James Deavin, Eva and Franco Mattes or Marco Cadioli and the numerous galleries created by players on the Web. Video games such as *Dead Rising* and *Afrika* have explicit core mechanics that include the process of capturing screenshots, enabling and motivating players to capture and share their own experiences.

Even though we have seen a significant improvement on video game graphics, and consequently on their photographic potential, technology evolution and new generations of gaming consoles will certainly bring novelties to the gaming world. It is however essential to understand that this artistic potential will only be noticed and explored within the limits of photographic *praxis*. In essence, more important than technology, video games or graphics evolution is the gamers and artists' ability to recognize and explore photography as an artistic expression of video games. Therefore, future work within this area should focus on the impact of video games evolution on the perception that gamers and artist have of their artistic potential.

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The Design of Horacle: Inducing Serendipity on the Web

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Keywords: Information retrieval, information science, online services, social network services, user interfaces, visualization.

Abstract: Is Serendipity designable? Are we able to induce it or do we end up destroying it in the attempt? Horacle, a prototype hypothesis of a serendipitous system, is an exploration on digital serendipity accomplished through the facilitation of access to new and uncommon content, presented in a way that allows for the occurrence of processes that can be associated with serendipitous discovery. It is our objective, through this system and the analysis of the concept, to help recover the limitless of the Web by breaking through content bubbles and to assist the creation and discovery of insight through access to meaningful information.

1. Introduction

The seemingly infinite amount of content that is accessible on the Web has created the necessity for tools that help to discover relevant and meaningful information. Tools such as search and recommendation engines or social networks attempt to aid the discovery and access to content to the user, and are constantly evolving. This is done through personalization (Montgomery and Smith 2009): learning increasingly more about its users' patterns and habits in an attempt to deliver ever more accurate results that relate with the users interests and tastes.

This personalization of these tools may, however, end up limiting the possibilities of the user, becoming a restrictive enclosure, an echo chamber of perpetuating tastes and content. What Eli Pariser named a "Filter Bubble" (Pariser 2011), which restricts and limits the diversity of content that the users have access to and their capacity to discover new, uncommon and unexpected information from them. In other words: a decrease in the potential for serendipity.

It is with this premise that we have created the *Horacle* prototype: a system that, through the analysis of how serendipity may occur on the web, and its inherent characteristics, may help to induce serendipitous discoveries by allowing access to new and diverse information, in an permissive context.

1.1. Understanding Serendipity

Horace Walpole coined the term *Serendipity* in 1754 (cit), but the process it describes is one that is common through the history of human invention, from Archimedes's famous anecdote to the fortuitous discovery of penicillin by Fleming. It can be described as the accidental discovery of meaningful information, made possible due to the *sagacity* of the observer. This combination between accidental and sagacity is key to any attempt to induce serendipity.

Studies of serendipity can be found associated to various areas of study, but for this study we will focus on those regarding user interaction and information seeking, such as those of Elaine Toms (2000) who observed how users approached a digital newspaper, with hopes of finding serendipitous patterns or methods to trigger serendipity. Users were asked to "find an answer to a set of questions" or to read or browse the newspaper for 20 minutes. Toms then observed that "when the interaction was not guided by an objective, user decisions seemed less definitive and less predictable", however, there is no mention of any serendipitous discoveries.

A small study conducted by André et al. (2009), in an attempt to gather some new insight on the frequency of serendipitous encounters, asked a selection of individuals who considered themselves "serendipitous" to review their search history and report any clicked results not directly related to a task and that lead to any specific discovery. Of the eight participants, only two reported encountering something unexpected and none of them gathered any particular new insight.

This is, of course, an example of the elusive nature of serendipity. Most efforts attempting to observe it in a controlled fashion have been for naught. Only by applying methods that could record the natural occurrence of serendipitous discoveries had a degree of success, such as those of Foster and Ford (2003), who asked users to record serendipitous experiences on a mobile diary, with positive results.

In an explicit attempt to induce serendipity, Max, a software engine developed by José Campos and António Dias de Figueiredo (2001) used information retrieval techniques and heuristic search in order to discover information that is "useful, and not sought for". To do this, Max is informed of websites that are of the users' interest and then submits queries to a search engine as well as randomly chosen words, e-mailing the results to the user. In a two-month evaluation, 100 messages were sent, of which 7 were considered of interest. Its 7% success rate, while seemingly low, it is an encouraging number when considering the fleeting nature of serendipitous experiences.

1.2. Inherent characteristics of Serendipity

In an attempt to discover exactly what can be acted upon when attempting to induce serendipity, we identified four broad characteristics that are intrinsic to the process.

Nature (accidental)

The *accidental* nature of it. For something to be considered as a serendipitous experience, it has to happen in a random and unexpected way. This was one of the defining characteristics since the creation of the term and is key to the whole process. It is also what we may call an *actionable* characteristic, meaning that it can be acted-on in the attempts to design for serendipity.

Context

The context of the user in the time it happens: there are peculiar physical and mental circumstances that are common to serendipitous discoveries to happen. This is also an *actionable* characteristic of serendipity, as we can identify and reproduce the context or processes that are associated with serendipitous discoveries.

Mind

The third characteristic is the capacity to recognize the discovery and its inherent value, what Walpole originally described as sagacity. As this is specific to — and depending of — the one experiencing *serendipity*, it is not an *actionable* characteristic.

Value

If an event isn't in someway valuable to the user, then it's not serendipity. While the value is subjective to the user, we can attempt to increase the odds of a valuable outcome occur, by increasing the relevant content that is made available to the user. The value itself is largely depending of the experiencing user, so it is not *actionable* as well.

2. Theoretical Framework

Not a mere coincidence

Serendipity may be mistaken for coincidence, and it can, indeed, occur due to it, however it does not depend on the (im)probability of an event to happen for it to exist, if we resort to Margaret Boden's definition of coincidence as a "co-ocurrence of events having independent casual histories, where one or more of the events is improbable and their (even less probable) co-occurrence leads directly or indirectly to some other, significant, event" (Boden 2004, 235). It was not only probable, but inevitable that the water level would rise on Archimedes's bath, as such we cannot describe the process to happen as a result of a coincidence, but of the capacity of the user to understand that seemingly unrelated event as an *apropos*, serendipitous one.

Randomness as a creativity tool

Both serendipity and coincidence, however, have inherently a certain degree of randomness. As we have seen, randomness is a prerequisite for serendipity, as per its *accidental* nature. This assumes randomness in the event itself: unsought and uncontrolled. Randomness is a tool well documented on creative practices through history: a method used to overcome creative barriers or to provoke the unexpected, such as Mozart's *Musikalisches Würfelspiel im C K516f*[1], Iannis Xenakis development of his 'stochastic music' or the cut-up techniques employed by dadaist Tristan Tzara.

1. Written in 1787 and published in 1793.

The value of Idle time

One particular aspect associated to serendipitous experiences is the recurring act of changing context. This could be referred as a necessity to wander or, as in many examples, to simply "go for a walk". These common recurring activities, such as, e.g.: gardening, washing dishes or taking a bath, when associated with a creative breakthrough, describe a period of incubation, when active research is halted and the researcher focuses on a completely different activity, normally mechanical in nature. One interesting example of this is of the physicist Hermann von Helmholtz, as reported by Graham Wallas (1926), who said that ideas came to him unexpectedly and without effort and that rather than occurring at his "working table (...) they came particularly readily during the slow ascent of wooden hills on a sunny day".

This concept was explored by Csíkszentmihályi and Sawyer (1995), who interviewed nine individuals, 60 years or older and actively involved in creative work. All of them mentioned the importance of a certain kind of "idle time", crucial to creative insights. Some of their interviewees actually scheduled "a period of solitary idle time" in order to be creative, following a period of hard work.

Serendipitous browsing

Search has dominated our interactions with information seeking on the web. We no longer 'surf the Web', but rather ferry across it, towards our goal and without detours.

To 'surf' the web denoted an underlined exploratory state: to surf is not to dictate our will upon the ocean, but to ride it, let it takes us in its currents, with minimal control on direction, going, wave-like, from website to website.

While we are now much more precise when finding information (click through rates plummet after the first page of Google[2]) there are still services that promote this wandering state. The most prominent are social networks such as Facebook or Twitter, which facilitate an aimless wandering through its content, with easy visualized images and videos. Another example is StumbleUpon, a discovery engine that combines machine learning with human opinions, allowing its users to 'stumble upon' web pages that relate to their previously indicated interests. The user is unaware of what page is going to be shown, although it can fine-tune the possible results by 'thumbing' up or down each page.

2. http://searchenginewatch.com/article/2049695/Top-Google--Result-Gets-36.4-of-Clicks-Study

As per Elaine Toms' (2000) distinctive methods of approaching an online newspaper, this type of wandering browsing opposes the goal-driven conscious browsing one might engage when searching for a particular item. This distinction between purposive and non-purposive browsing reflects the findings of Oscar De Brujin and Robert Spence (2008) of a "serendipitous browsing".

De Bruijn and Spence define "serendipitous browsing" as one which occurs when browsing is done without a particular goal in mind, which may happen in two ways: "Opportunistic Browsing", where the user intentionally looks for content but without a clear notion of what, in a state of seeing "what's there", and an "Involuntary Browsing", goal-less as well but unintentional, when the user's gaze moves naturally from "a series of fixations", and naturally focusing on a specific information item that might lead to a specific, fortuitous insight or the answer to a "longstanding query"(De Brujin and Spence 2008).

This "serendipitous browsing" resulting in a breakthrough denotes a kind of ideation as a result of a question in a state of incubation, akin to the breakthroughs described in the value of idle time. This is in a way reminiscent of the psychoanalytical technique of Free Association, developed by Sigmund Freud. In this technique, patients are encouraged to verbalize their thoughts and feelings, without restriction or fear of embarrass. This was done in the hopes of helping surface repressed thoughts, making the patient aware of them as, then, being able to act upon them.

By considering these various concepts: Randomness, Idle Time and Serendipitous Browsing, we begin to form a pattern of necessities that create a permeable state for serendipity to occur. It is by attempting to reproduce a process that happens during an opportunistic or involuntary browsing, occurring during a period of idle time, and being confronted with new, uncommon and unexpected information, that one might be confronted with a new item that, in turn, could lead to a breakthrough or insight. If we can achieve this we have, indeed, induced serendipity.

3. Designing Horacle

It is our intention to develop *Horacle* as an ever-evolving hypothesis of our study. It reflects our concerns on the increased personalization of the web, and how it limits our access to new information, as well as its purpose and as a method of creativity and discovery.

Being developed concurrently to this ongoing research, it is a reflection of our thoughts and discoveries on the matter and, as such, is constantly evolving. An evolution that will continue as new insights on the matter occur.

3.1. Traits for serendipity

Our analysis of the available literature on Serendipity, as well as an observation of a series of online systems that, intentionally or unintentionally help serendipitous discoveries (Melo and Carvalhais, 2012), have allowed for identifying a series of common traits that are recurrent on serendipitous systems. It is the implementation of these traits that direct the course of the design of a serendipitous system.

Purposelessness

Purposelessness describes an interaction that is deprived of objective, as per De Brujin and Spence's "Serendipitous Browsing". The system should allow for a casual 'wandering' of content, without a defined goal, providing thusly a context that is receptive to the creation of unexpected relationships between data. By allowing a 'wander'-like browsing and exploration of content, we encourage the mind and gaze of the user to freely drift, following a whim. This could lead to the discovery of something unexpected or allow the user to disengage from an active thought on a problem and enter a state of idea incubation. The system, in this case, would serve as the change of context referred by Csíkszentmihályi and Sawyer (1995), and could allow for the uncovering of connections by forming patterns between the sub-conscious processes and the confrontation of these with the visualization of new content.

Immediateness

In order to maintain a state of wandering, purposelessness browsing, the system should necessitate minimum interaction by part of the user. If an user is required to actively interact with content, it engages the mind and removes it from an observing content to one of active interaction.

Diversity

Increasing the diversity of the information available can increase the probability of a discovery or connection between said information being made.

It is, as well, through access to a rich variety of content that we can hope to break through the "filter bubble" and allow the user access to information that can help to broaden their horizons and be truly surprised.

Curiosity and Playfulness

The user needs to be enticed to use a system in order to achieve a state of necessary engagement for a purposeless, unconscious and serendipitous browsing to occur. And since playfulness is recurrently associated to curiosity, creativity and ideation, by applying these principals we encourage the mind to enter a state that is conductive for discovery.

Randomness

We have previously established the accidental nature of serendipity. It is one of the defining characteristics of it. As such, we believe that by introducing a certain degree of randomness into an interactive system, we can increase the probabilities of unexpected and fortuitous events. The advantages of the introduction of randomness have been documented by Leong, Vetere & Howard (2008), on their analysis of the shuffle functionality of music players, noting a more relaxed experience of music by the users, when freed from the "burden" of choice.

Designing decisions

The design of *Horacle* was guided by the attempt of implement the five different traits for serendipity, with the clear intention of providing access to diverse and possibly relevant information that could be accessed in an *overview* state: during idle time, in a state of contemplation or wandering, on a goal-less, non purposive way, all in a playful interface that would entice its users for a continued experience, allowing access to content with minimum direct action by the user. For this, the system should present content fully, when possible, with the capacity to allow for a specific focus on a particular item.

As such, and after other experimentations with other layouts, we decided upon on a fluid, orbital-like layout, that represented three different types of content, as it relates to the user: (1) Content that the user has marked as relevant; (2) Content that is recommended to the user according to their demonstrated interests and (3) Random information for the Web. The first two categories would be representations of the users' tastes and interests while the third would introduce that needed level of randomness for serendipity.

With these three levels of content, we are able to provide the necessary context for the possibility of interesting juxtapositions of information to occur, in an attempt to create unforeseen relationships between them.

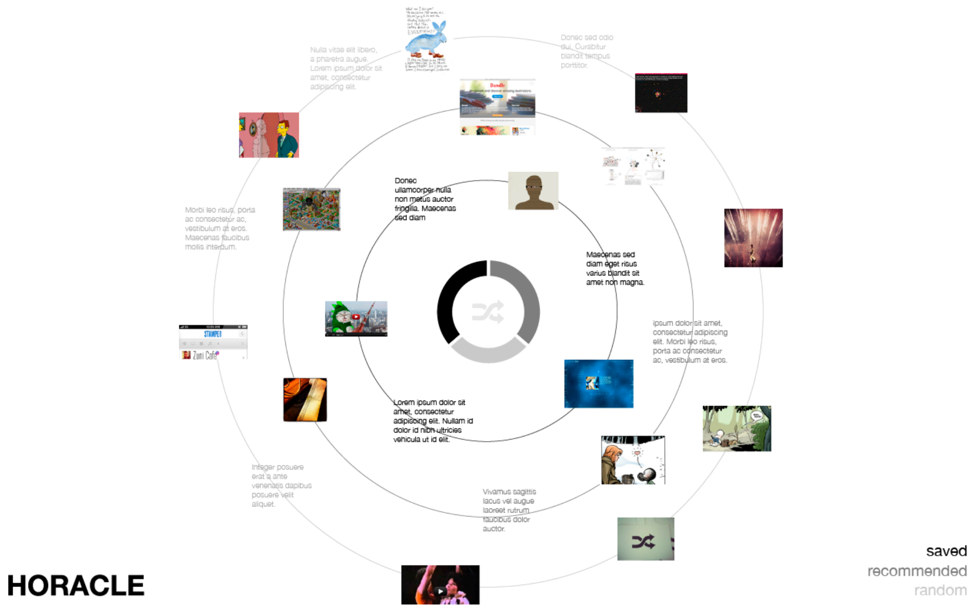

Fig. 1. *Horacle* wireframe with equal distribution of content.

These levels spread from the center, or it's nucleus, in correspondingly degrees of direct relationship to the user: closer to the center we find the saved content and farther out the random content, with recommended in the middle. These levels are also visually distinct from each other, through a color coding.

Initially, the system divides the content, and it's respective levels, into equal amounts, however the user is able to control this, by choosing to increase one particular category (and respectively decreasing the other two). This allows the user to choose between viewing an equal amount of variation, to more of one and less of the other two, as well as being totally dedicated to one of the three variables.

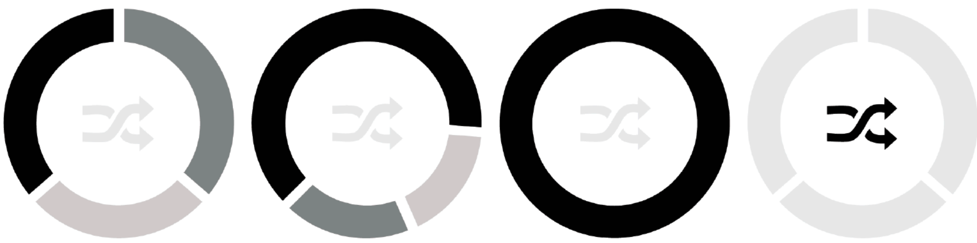

Fig. 2. *Horacle* controller: 1/3, 2/3 and 3/3s, as well as the unstructered mode.

This is done through a controller found in the nucleus of the system, which also incorporates a "shuffle" mode that removes visual indications of types of content as well as randomizing the value for each. This shuffle mode would be an useful method to remove preconceived notions from the user towards the content.

3.2. Conclusion and Future Work

The concept of serendipity and its implications on the web have been subject of a gradually increasing concern as creators of online services and platforms realize its value and implication on information seeking and access to content. Google's executive chairman Eric Schmidt, at the 2010 TechCrunch Disrupt conference, said that their company hoped to "one day tell people things they may want to know as they are walking down the street, without having to type in any search queries" (Krotoski 2011). Schmidt called this a "Serendipity Engine".

The capacity of the web to provide true serendipitous experiences have also been the subject of diverging opinions (Darlin 2009), (Johnson 2011), but regardless of the *current* limitations of the web regarding serendipity, it is our focus to understand how the process of serendipity occurs and how this can inform us in in our design decisions, in order to create better and deeper tools.

Through the review of existing literature on the subject, and particularly on its implications on the web or in digital interactions, we have been able to define a series of identifiable processes and traits that guided our choices for the design of *Horacle* (and other possible serendipitous systems).

Horacle is a work-in-progress in continuing development. Its development mirrors our developments regarding the subject of designing towards serendipity and, as such, its characteristics are in permanent mutation. In this current hypothesis we have attempted to accommodate our five defined traits for serendipity, allowing for constraints of the medium and implementation.

On future work, we will continue the development of *Horacle* as a working hypothesis of a serendipitous system to a fully functional state, as well as conduct some initial user-testing in order to evaluate its true capacity for discovery. We will, as well, continue the examination of the serendipitous process and its implications on the web, information discoverability and creativity.

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Südthüringer-Wald-Institut: Knowledge Sharing for the End of the World

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Keywords: Doomsday, Caves, East Germany, Digital Archives, Cellular Computing, Portable Interfaces, CouchDB, Apocalyptic Knowledge Sharing.

Abstract: Südthüringer-Wald-Institut is an independent, distributed research organization founded in a cave 200m deep below the Southern Thuringian Forest in the former East Germany. Physically positioned as a default site of refuge from the possibly inevitable collapse of the pervasive technological and social infrastructures that scaffold contemporary existence, the conceptual agenda of the Institute is framed by the present luxury of a world where discourse around mitigating unpleasant contingencies is still unhindered by the profound stress of needing to survive them. Embracing the ethos of "hope for the best, expect the worst," the work of the Institute locates the creative potential of technocratic doomsday fetishism within the service of a pragmatic functionalism.

At present, while a resident presence in the cave remains unnecessary, the Institute's member researchers and practitioners throughout Europe, North America and the world collaborate, contribute and share ongoing research through an open, distributed digital architecture, consisting of both an internet-based Archive Platform and a growing number of personal Autonomous Node Devices. Scientific and creative output are maintained online, as well in local archive nodes and replicated to all other members of the institute asynchronously, enabling an organic, cellular propagation of multiple independent archive instances.

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1. The World & The Cave

> If we can't reformulate digital ideals before our appointment with destiny, we will have failed to bring about a better world. Instead we will usher in a dark age in which everything human is devalued. (Lanier, 82)

Let's briefly assume you got up tomorrow and the internet all of a sudden wasn't there. For whatever reason, instantaneous worldwide data exchange as we've come to expect over the last two decades simply has ceased to function, and also as a possibly related side effect, the global supply chain linking an unending stream of modestly-priced offshore-sourced personal technology devices has disappeared into history. Appreciating the irony that the must-have marketing ethos of this season's *last device you'll ever buy* has just become the haunting consumerist epitaph for the last device you'll now ever own, the tendency to reach for this device and share this revelation on your social network of choice is interrupted, as alas, *there is no network*. The device's immediate use value having abruptly vanished, the natural question now becomes what is its exchange value: what else can be done with this sudden technological relic? It is within this hypothetical doomsday that we begin to examine the role of interaction designers in a world where the prevailing maxims of pervasive commodity computing and ubiquitous network connectivity cease to be relevant.

The uncomfortable tendency to link the vanguard of human interaction with the industrial necessity to produce new and ever- obsolescing form factors and product categories has become counter-productive. In the supposed interest of fostering ever deeper and more meaningful connections with others and the world around us, the cybernetic fetish of the new has grown from academic science fiction into a pandemic cultural trope, where actual human interaction is gradually superseded by woefully approximate network-mediated simulacra that grow ever more nebulous with each product-cycle.

> Late 20th-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert. (Haraway, 120)

In the nearly three decades since *A Cyborg Manifesto*, and the birth of what Negroponte affectionately termed the Digital Revolution, these machines continue to grow orders of magnitude livelier, through constantly improving infrastructures for production and networked connectivity, and our interactions with them have become infinitely more complex. We have grown so disturbingly accustomed to this fait accompli that we now generally fail to even notice it:

> Its literal form, the technology, is already beginning to be taken for granted, and its connotation will become tomorrow's commercial and cultural compost for new ideas. Like air and drinking water, being digital will be noticed only by its absence, not its presence. (Negroponte 1998)

This questionable near-sightedness, of course, has not been helped by the flippant normalization promoted by those cheerleading the notion that 'new media is not new any more' (Manovich, 70). As the once unimaginably difficult has become desensitizingly ordinary with the realization of pervasive computing in its contemporary form, it would seem that everything new is already old again. While this is an admirable testament to the prescient capitalist longevity of Moore's Law, it underscores the fundamental breakdown between consistently exponential technological evolution and true innovation:

> I long to be shocked and made obsolete by new generations of digital culture, but instead I am being tortured by repetition and boredom. (Lanier, 121)

In a digital world still smitten with the quaint, if somewhat narrow-minded ideal that anything is possible, we are so enamored of our present and near-term anticipated capabilities that we have become relatively ignorant to the very real limitations inherent to the broader framework that enables them. Our devices become cyclically obsolete, yet our unwavering devotion to the system continually producing and underpinning them remains in stasis. The presently accepted maxim holds that so long as there remains an unending, always-connected stream of newer and faster, innovation will be sure to follow. Unfortunately, in practice the results are somewhat more disappointing:

> Let's suppose that back in the 1980s I had said "In a quarter century, when the digital revolution has made great progress and computer chips are millions of times faster than they are now, humanity will finally win the prize of being able to write a new encyclopedia and a new version of UNIX!" It would have sounded utterly pathetic. (Lanier, 121–2)

The ease and comfort afforded by the methodical certainty of the new has made for a passive culture of complacency. When we choose to be ignorant of systemic limitations, or to deny their existence entirely, innovation is arguably stifled.

There are, in fact, some very tangible limitations to the system. This is evidenced by the lingering, romantic mythologies of a simpler, more altruistic fledgling public internet. Although the widely espoused societal belief has been that the network is an infallibly durable, continuously available and quasi-tolerant bastion of social freedom, these fantasies are now being reconciled against the same industrial and political structures that facilitate the enormous undertaking that is the system's ongoing operation.

> The original Arpanet was designed to withstand the obliteration of a country and remain useful because of its basic architecture. In other words, it was designed to withstand an A-bomb. Over time, the backbones have been taken over by large corporations and streamlined (to maximize profit) in such a way that the backbones themselves are now vulnerable. For the past decade, it has been doubtful that the Net could withstand that A-bomb. (Dvorak, 2009)

Ironically, the spread of ubiquitous connectivity and virtually continuous uptime has come at the expense of the intrinsic architectural qualities that brought about the internet's very existence: the system's availability now directly correlates to its fragility. As has been demonstrated in recent, smaller-scale geopolitical struggles over the past several years, internet traffic can and will be unilaterally suspended at the first sign of unrest. Despite the internet's engineering pedigree as immune to the unpleasantries of mutually assured destruction, the present reality is that it is susceptible to the whims of a prevailing regime at the touch of a button.

In a culture where the concept of disconnection from the network at large is assumed to be nothing more than an aggravating, albeit temporary nuisance, visualizing the complete and unmitigated collapse of the internet remains a critical and theoretical taboo outside of the context of a truly dire doomsday scenario. Any discussion of the need for systems that function even partially independently of the centralized internet requires invoking imagery of total annihilation punctuated by nuclear winter, although in reality, the wheels could come off with substantially less spectacle.

As such, Südthüringer-Wald-Institut is predicated on the End of the World as a heavy-handed starting point for the sorely needed discourse about what our limitations are, and what can be possible outside of the established canon of pervasive commodity computing and ubiquitous network connectivity. Borrowing from a tradition spanning from the dawn of civilization to the last vestiges of Cold War paranoia, the Institute thrives on a preternatural human condition: when the going gets tough, the tough go underground.

Fig. 1. Südthüringer-Wald-Institut Field Expedition Team, June 2012.

2. The Institute

At present, while a resident presence in the cave remains unnecessary, the Institute's member researchers and practitioners throughout Europe, North America and the world collaborate, contribute and share ongoing research through an open, distributed digital architecture, consisting of both an internet-based Archive Platform and a growing number of personal Autonomous Node Devices. Scientific and creative output are maintained online, as well in local archive nodes and replicated to all other members of the institute asynchronously, enabling an organic, cellular propagation of multiple independent archive instances.

Each node functions as a local collections manager and server, semi-public connectivity access point and interconnect for ad-hoc wireless mesh networking between nodes, providing all essential services necessary to function independently, even without the presence of an external internet. Should the need to retreat underground arise, single or multiple instances of the entire digital holdings of the Institute could be easily be brought beneath, establishing a core technical foundation enabling the research activities of the Institute to continue as normal.

Structured around a tribal model that establishes symbiotic relationships between specialists within a micro-community, the design of the Institute embraces the current privilege of global collaboration afforded by our fortunate status as network users, without falling victim to the perverse mentality of the hive mind. Centered on a small core group of collaborators, the Institute is a purpose-built environment not specifically intended for broad public consumption:

> If you grind any information structure up too finely, you can lose the connections of the parts to their local contexts as experienced by the humans who originated them, rendering the structure itself meaningless. (Lanier, 138)

Maintaining an intimate social dynamic intentionally isolated from the relative anonymity of the open internet promotes the implicit operational trust necessary for knowledge exchange to flourish, especially in environments where physical presence must fill the void left by a sudden lack of digital interconnection. As a close-knit transdisciplinary collective, each member can browse and freely copy items from every other member's archive, metering his or her own level of personal engagement while promoting a site for building and sharing dynamic, continually developing libraries of content.

User interaction is guided by a metaphor that blends elements of the Soviet tradition of Samizdat with the distributed computing paradigm of eventual consistency. The active, self-mediating information exchange within the archive serves as a basis for both present-day discourse and future retrospective narrative:

> (…) Tracing the various forms of labor that support that life, we should find that Samizdat constitutes an outstanding modern example of textual system, not only because it originates outside a capitalist economy, but because these texts highlight with special force the text's epistemic ambiguity. What was deemed

> truthful or valuable? How was this determined? The credit of any Samizdat had to be established for each text, and, further, at each phase of the material life of that text. (Komaromi, 4)

As the archive grows and evolves through use, its epistemological relevance advances. In stark contrast to other subterranean archives such as Chauvet, Barbarastollen and the Svalbard Global Seed Vault, which are charged with the task of ensuring the continued existence of a static, historic encapsulation into posterity, Südthüringer-Wald-Institut is actively engaged in the speculation of an uncertain future.

> Enlightened designers leave open the possibility of either metaphysical specialness in humans or in the potential for unforeseen creative processes… (Lanier, 52)

3. Architectural Overview

The infrastructure of the Südthüringer-Wald-Institut is designed as a modular, decentralized architecture that can function both inside and outside environments exhibiting internet connectivity, enabling consistent application functionality and user experience across the widest cross-section of client devices possible. Comprised of both a software layer, the Archive Platform, and a complimentary hardware layer, the Autonomous Node Device (AND), the system ensures the work of the Institute can carry on even in the face of significant topological failure.

In the presence of internet connectivity, member researchers and practitioners can access the Archive Platform through a centralized web-based Archive instance, and by extension, each Autonomous Node Device can directly communicate with this system and directly synchronize content. When internet connectivity is not available, each AND ensures users continued local access to the Archive Platform through a choice of near-range connectivity options, including LAN and ad-hoc wireless. These connections, as well as support for wireless mesh networking, are also employed to establish connections between individual ANDs and allow direct synchronization and replication between devices when possible.

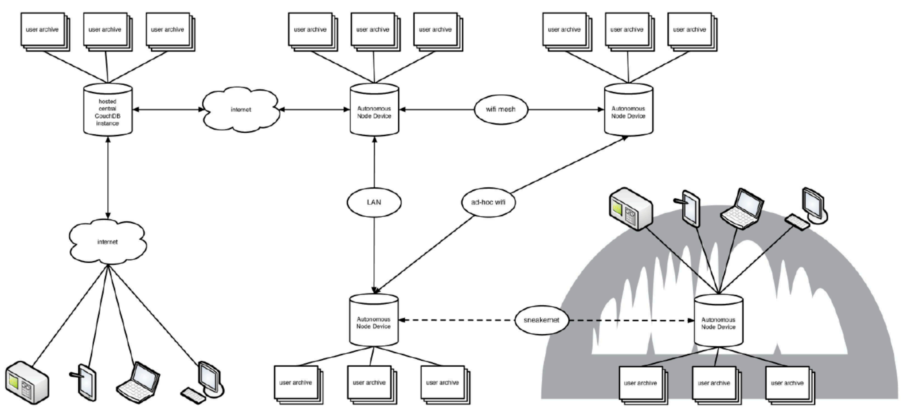

Fig. 2. Architectural Overview: system topology.

4. Archive Platform

The Archive Platform is a browser-based distributed application built on a foundation of open software technologies that allow it to function seamlessly across both the unified online server environment and multiple Autonomous Node Devices, while providing a consistently rich user experience on all supported client devices, from smartphones to conventional PCs.

At the heart of the application stack is Apache CouchDB, a document-based database system authored in Erlang, a fault tolerant programming language and runtime environment originally developed for mission critical telecom equipment. CouchDB is an ideal fit for this project due to its HTTP-based query interface, robust replication, synchronization and version control features. Functioning as both a database and web server, CouchDB has the unique capability of deploying complete web applications from a single server instance combining application logic and storage layers. Additionally, these applications can be easily replicated across multiple server instances and instantly deployed. By design, the system works "with the grain of CouchDB [and] promotes simplicity in ... applications and helps... naturally build scalable, distributed systems." (Anderson et al., 11)

Archive and synchronization management is made possible by the CouchDB application framework developed by the Little Library Project. Originally conceived for sharing content libraries across the cloud and personal devices, the customized Little Library framework is assembled and maintained with the CouchApp toolchain, streamlining application prototyping, modification and deployment.

Additionally, the framework delegates presentation-layer tasks including User Interface rendering and event management to jQuery Mobile. This javascript library provides consistent touch-compatible UI elements and behaviors across all current mobile device platforms and desktop browsers.

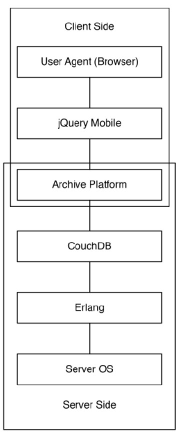

Fig. 3a. Archive Platform: application stack. Fig. 3b. Archive Platform in operation.

5. Autonomous Node Device

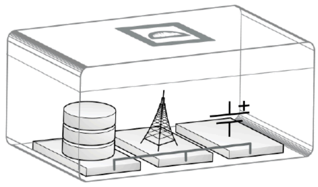

Fig. 4a. Autonomous Node Device: hardware overview. Fig. 4b. AND-FX3a in the field.

Designed as a modular, self-sufficient system, the Autonomous Node Device (AND) provides all fundamental hardware support necessary to operate the Archive Platform independent of the unified online server environment. Anticipating a world of production and distribution scarcities, this architecture functions more as a recipe than a rigid reference design, conceived to be assembled from and maintained with any number of commonplace commodity components. Foregoing esoteric manufacturing procedures, an individual Autonomous Network Device can be easily constructed by someone with basic familiarity with consumer electronics, out of parts and devices likely to be strewn around the wreckage of the average office, studio or living room.

The AND specifications outline the presence and minimum functional compatibility of each module without mandating a vendor- or platform-specific part. Abstracting the individual function sets of each component establishes a rudimentary set of requirements: the power supply module must furnish sufficient electrical power to operate the entire system, the server module must be capable of running an instance of CouchDB, and the network connectivity module must provide some form of basic, local TCP/IP connectivity, either wireless or wired. This approach ensures that the system can utilize the broadest range of hardware combinations possible, from handsets and embedded systems to full-fledged server-class PC hardware.

Early AND prototypes were targeted to fit within a shoebox-sized enclosure, however this form factor presented several issues during the course of development. Originally using repurposed ARM-based hardware running Android, first- and second-generation prototypes simply were not fast enough to reliably support multiple Archive Platform users, and encountered numerous thermal and power management problems. The current third-generation prototype version, AND-FX3A, is roughly the size of a consumer bread machine, and comfortably houses an off-the-shelf lithium-polymer power supply, quad-core application server module and an 802.11g wireless network connectivity module. Production versions derived from the AND-FX3A will begin to be distributed to member researchers and practitioners later in 2013.

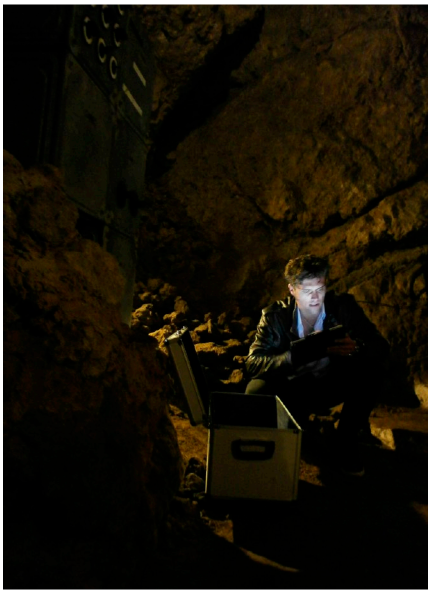

Fig 5. Researcher Heino Weißflog evaluates AND-FX3A.

6. A Journey Beneath

On 23 June 2012, members of the Field Expedition team journeyed to the Südthüringer-Wald-Institut Cave Site as part of the Inaugural Evaluation Expedition. Tasked with gathering advance first-hand geographic, environmental and social data impossible to obtain from the comfort of the lab, the occasion also marked the initial underground field testing of one of the first functional Autonomous Node Device prototypes, AND-FX3A.

Several hundred meters below the forest, the team procured crucial baseline data necessary to the future in situ establishment of the Institute's activity following the End of Days, and prognosticated on the relative stability of the location for the next 50 to 70,000 years.

Furthermore, rigorous testing of the AND-FX3A verified the device's suitability for subterranean installation and operation across a spectrum of usage scenarios and client platforms. Although disconnected from external connectivity to the world above, the Archive Platform remained continually accessible throughout the Cave Site as expected, providing access to the entire holdings of the Institute Archive, as well as serving as a real-time repository for field data.

Despite the overwhelming success of the Inaugural Evaluation Expedition, a litany of other unanswered questions remain. As such, preparations by the Field Expedition Team for future research missions are already underway.

Technical Acknowledgments: Südthüringer-Wald-Institut graciously exists on a hardware and software architecture based on a number of open technologies:

The Little Library Project: Archive management and synchronization platform.
http://github.com/rwadholm/The-Little-Library

Apache CouchDB: Document-based, RESTful database infrastructure.
http://couchdb.apache.org/

CouchApp: Javascript application framework for CouchDB.
http://couchapp.org/

jQuery Mobile: Cross-platform, touch-compatible UI framework.
http://jquerymobile.com/

IrisCouch: Cloud-based CouchDB hosting.
http://www.iriscouch.com/

Mobile Futon: Portable CouchDB installation and administration for Android
http://github.com/daleharvey/Android-MobileFuton

cyanogenmod: Expanded, unencumbered Android hardware support.
http://www.cyanogenmod.com/

OpenWRT: Open Linux-based firmware for wireless hardware.
https://openwrt.org/

OLSR: Wireless mesh networking support.
http://www.olsr.org/

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Making Online Face-to-Face Interaction Easier for Older People with Constructive Design Research

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Keywords: Online Social Interaction, Older People, Constructive Design Research, Research Through Design.

Abstract: This paper reports early findings of employing constructive design research in order to make online social interaction easier for older people. In the western world the majority of computer illiterate people are older people. After investigating which forms of online social interaction present the most obvious benefits for communication, it was decided to focus on making online face-to-face communication more accessible and easier for older people. For this the Teletalker, an installation with two online video kiosks connecting two places audio-visually and where a simple hand sensor operates the sound, was built. Field research was conducted with the Teletalker connecting the communal room of Age UK Barnet, London with London's Middlesex University's entrance hall. Constructive design research allowed making the idea tangible in order to collect feedback, to assess impact on its environment and to generate a discourse on the preferred state.

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1. Introduction

The world has an ageing population. In 2010 in Europe there were around 120 million people over 65 years old, which was 16.2 % of the world population. In the year 2075 an estimated 26% of the European population will be over 65 years old (United Nations 2011). For this research 'older' is defined as 65 years plus since this is how the European Commission defines older people in general (European Commission 2012).

With getting older, a person from the age of 30 experiences an increasing physical decline (Stuart-Hamilton 2006; Fisk et al. 2009; Sharit et al. 2008). For example, one in three people in their 80s experience mild cognitive impairment (Lawton Henry 2007). Having a physical and potentially mental decline and being of an age when peers, friends and family die, it is even more important for older people to maintain social contact for their psychological well being (Lester et al. 2011; Blažun et al. 2012).

The first part of the paper describes the results of reviewing the relevant literature and subsequently constructive design research as a method is introduced. This is followed by a detailed description of the Teletalker installation, together with an account of why this design was selected to be built. Early results of the first round of field research are reported, followed by the proposed next steps for this research.

2. Online connection for social connection

There is controversy in the research literature about whether Internet use increases or decreases social connection between people and about its psychological benefits (Sum, Mathews, Hughes, & Campbell, 2008).

Online communication might be particularly appealing to those individuals who perceive themselves to be low in interpersonal competence and therefore prefer written or mediated forms of interaction (Sum et al. 2008; Young n.d.; Kang 2007). One could argue that online social interaction could have the effect of reducing offline social interaction[1]. Data by the Oxford Internet survey shows that online social interaction does not seem to replace other forms of interaction with the family or friends such as interaction through visits, phone conversations and written communication, but complements it. Interaction through the Internet increased contact between friends and family who live further away. For a quarter of respondents it also increased contact with friends and family who live nearby (Dutton et al. 2009).

1. Personal communication with J. Culling, account manager at Foviance, London UK, in November 2010, who said "I blame google that I talk less with my mum". He gave the example that previously he would have rung his mum to ask a question about cooking for instance, now he simply googles it or poses a question on a discussion forum.

2.1. Online usage by older people

The number of older people who are computer literate is growing (Carpenter & Buday 2007). Approximately 30% of the age group 65–75 years are using the Internet on a regular basis in the UK, but only a quarter of people over 75 years of age have ever used the Internet (Lane Fox 2010; Williams 2010).

The table (see figure 1) by the Office for National Statistics (ONS) illustrates that 90% of all the people that go online send and receive emails and that this figure is the same across all age groups (Williams 2010). In contrast 75% of all 16–24 year old users go online to post messages to chat sites, social networking sites, blogs, but only 8% of all users over 65 years and older do the same.

Table 6: Internet activities by age group, 2010

	16-24	25-44	45-54	55-64	65+	All
Per cent						
Sending/receiving emails	88	90	89	91	87	90
Finding information about goods and services	64	76	80	83	72	75
Using services related to travel and accommodation	50	64	70	72	62	63
Internet banking	45	63	54	53	34	54
Reading or downloading online news, newspapers or magazines	52	53	51	47	40	51
Listening to web radio or watching web television	59	47	45	34	24	45
Posting messages to chat sites, social networking sites, blogs	75	49	31	19	8	43
Playing or downloading games, images, films or music	61	43	32	24	17	40
Seeking health related information	27	42	39	44	36	39
Uploading self created content to any website to be shared	50	43	28	29	22	38
Consulting the Internet with the purpose of learning	47	34	34	30	27	35
Looking for information about education, training or courses	47	36	27	19	7	32
Downloading software (other than games software)	35	34	23	27	18	30
Looking for a job or sending a job application	38	32	23	11	1	26
Telephoning or making video calls (via webcam) over the Internet	30	25	22	17	15	23
Selling goods or services over the Internet	16	28	20	18	9	21
Donating to charities online	10	13	15	13	7	12
Doing an online course	11	8	7	5	3	8

Base: UK adults who accessed the Internet in the last three months

Fig. 1. ONS table of Internet activities by age group (Williams 2010, p13).

Comparing the percentage of users of social media activities across the age groups, it becomes clear that the trend is the younger the person is the greater the use of social media becomes. When we look at "Uploading self-created content to any website to be shared" and "Telephoning or making video calls (via webcam)" the difference in percentage between the age groups is less pronounced. The difference between percentages in the various age groups is even smaller for video-telephony. This could be possibly because of the generation connecting communication flow between grandparents, parents and children.

2.2. The barriers to going online

The most frequently quoted reasons for not being an Internet user are cost, access to the equipment or lack of interest and skills (Lane Fox 2010; Carpenter & Buday 2007). Other reasons that could be more age specific might be related to the attitude towards computers. There is fear (Harwood, 2007) and unpredictability of technology (P. Turner, Turner, & Van De Walle, 2007) felt by older people. Turner collected data on the experience voiced by older people who tried to learn how to use a computer. They commented on the "disconcerting unpredictability of certain features" and on their "frustration at their own inability to remember the necessary sequence" of steps (Turner, 2007 p290). Observations at a Age UK computer class confirmed suspicious attitudes towards computers where participants called the computer a "necessary evil" or the "all-seeing machine that creates neurotic young people".

Barrantes found that the use of the mouse and in particular double-clicking was a major stumbling block, but despite the existence of other input devices older people wanted to use the mouse, so they felt included and not excluded by having to use something designed differently (Barrantes 2009). Other researchers who worked with older people who needed assistive technologies such as a walker or hearing aid also noted the issue of feeling stigmatised (Mullick 2001; McCreadie & Tinker 2005).

Melenhorst et al. studied older adults' motivation for technological adaptation by running 18 focus groups in the US and the Netherlands discussing the use of email and traditional communication methods. The results showed that the perceived benefits are the primary incentive for older peoples' willingness to learn and engage with computer technology (Melenhorst et al., 2006). Or to put it another way: an older person would not take up computer use and go online, even if they are given a computer and lessons free of charge when they don't perceive benefits in using a computer. The older person would prefer spending their time with something they can already do and that they enjoy rather than having to learn something new when their life time is limited (sending an email versus writing a letter for example).

Looking forward 30 years into the future, there may be no need to introduce the benefits of online technologies to older people since half of the people now in their 60s are familiar with the concept of a computer and going online, which means that majority of older people will be computer literate and online (Pollard 2009; Carpenter & Buday 2007). However, as it stands now, it is important to keep older generations connected with the technological advancements for their psychological well-being and self-esteem (Lester et al. 2011; Blažun et al. 2012). Even if presenting the benefits of online Face-to-face communication does not necessarily entice older people to learn the technology by themselves, they will at least know what is possible and can tell their family or friends about the experience. This way they might feel connected to what is going on in society and not feel left out.

3. Constructive design research (CDR) as research method

Employing CDR the Teletalker was built as a tangible artefact to elicit feedback and to further discussion on the role and form of online technologies for older people and its benefits. The Teletalker is an installation of two 'kiosks' connecting two public places using Skype, appearing to work as an online window by constantly displaying the other location. The volume, (which is by default off), is controlled by a simple hand sensor, which has been selected with the older user in mind. The Teletalker will be placed in carefully selected locations, where a large number of older people will have access to, in order to observe usage and reactions. The resulting discussions, further development of the artefact and academic discourse will form part of the knowledge generation.

There are numerous other examples of CDR[2] such as iFloor, the Presence project and Maypole. The common denominator of these projects is that a product, system, space or media takes centre place and becomes key means in constructing knowledge (Koskinen et al. 2011). A constructive design researcher follows the steps similar to those used in Action Research: iteratively planning, acting (i.e. producing a prototype, concept, scenario), observing and reflecting whilst drawing from interdisciplinary knowledge (Koskinen et al. 2011; Basaballe & Halskov 2012).

Examples of CDR derive from a collaboration of various disciplines such as architecture, design, computer science and anthropology to name a few. CDR is particularly helpful when research is dealing with a wicked problem (Buchanan 1995). For design problems that are ill-defined or wicked (as opposed to puzzles which can be solved with one correct solution) analysis can be exhaustive and a correct solution cannot be guaranteed. When dealing with a wicked problem a solutions-focused strategy is preferable over a problem-focused one (Cross 2007).

If theory is developed from CDR it is predominately in the early steps of development i.e. in the formation of nascent theory (J. Zimmerman et al. 2010). There is one strand of

2. Constructive design research has previously been labeled *Research through design* (S. Bardzell et al., 2012).

CDR, which is labelled critical design in contrast to affirmative design. Critical design's role is to challenge pre-existing conceptions and norms that are usually designed into products, systems and spaces (Dunne & Raby 2001), as opposed to affirmative design, which operates within existing design expectations.

With the Teletalker research it is intended to elicit — with help of the artefact — a discussion about the preferred state. The preferred state is the goal the researcher is trying to achieve with the design (personal communication with J. Zimmerman on 11/12/2011). In this case, it is the discussion and subsequent change in thinking by (older) people about online technologies — i.e. that online Face-to-Face communication can be made easy — as well as change in expectations about forms of online technologies and how this can inform further projects and designs.

Older and younger people of the general public, colleagues and academics were able to physically experience the Teletalker and talk about it either with each other or with the researcher. In addition, the Teletalker research was presented at conferences, where other academics and practitioners were invited to discuss.

The design of the Teletalker does not only consist of the physical artefact, but also of the choice of placements and the communications around it. In fact, CDR demands more than producing a 'product', but to reflect and to review the artefact's impact on its environment at the same time.

3.1. Critique of constructive design research (CDR)

CDR has not yet been fully formalised with regards on how to capture design development, decision points and how to assess the artefact and its impact. There have been calls to make the research approach more formalised (Basaballe & Halskov 2012; J. Zimmerman et al. 2010), but also views on keeping the research approach on general terms since the situational 'project' or research context is always different. For example, Gaver calls for a less structured approach and to concentrate only on the main characteristic of CDR such as starting point, documenting the design process, artefact and consequences. Gaver, in particular, advocates the use of annotated portfolio to portray and document the design process (Gaver 2012).

4. The emergence of the Teletalker as a design response

When looking at the question of how to design online social interaction for older people firstly relevant literature was reviewed and then user-centred design methods such as story telling workshops (Schuler & Namioka 1993) were employed to identify the design requirements. The Teletalker research as such was initiated after collecting design requirements for a web solution, after it became obvious that a web solution would have not addressed the majority of older people effectively. It appeared that it would be more useful to design a physical system that allowed older people to experience online technology and its possible benefits directly without having to learn about computer technology. The Teletalker is placed in a public space intentionally, so that older people are invited to come to it, giving them a reason to leave their house. The Teletalker can be experienced in groups, which also nurtures interaction (Vom Lehn & Heath 2002).

4.1. Why was the Teletalker selected over other possible ideas?

The Teletalker idea was selected over other possible design ideas such as designing a website since:

- It was decided to concentrate on online Face-to-Face communication since it appeared to be the closest to offline Face-to-Face communication where immediate feedback during communication is given. (Friendly) Face-to-Face communication can be seen as instantly rewarding in comparison to written online communication[3].
- Findings from interviews with older people emphasised that 'having a reason to get out of the house' such as going shopping was part of older people's social interaction. Therefore it is important for the research to place the Teletalker in public places where people can visit.
- The visual transmission also allows the user to experience the 'atmosphere' of the other place as well as non-verbal communication between people.
- The design of the Teletalker is supposed to evoke curiosity to try it out (Romero et al. 2010). This is expected to generate interaction (Vom Lehn & Heath 2002) and discussion at each location, through the Teletalker and around the Teletalker. The design of the Teletalker might be 'a ticket to talk' in itself[4].
- The Teletalker 'view' is constantly on for immediate use[5] and therefore no need for computer literacy skills such as logging on, using a mouse, switching applications is required. The simple mechanism (a light sensitive hand sensor) to switch the sound on / off (= hand on / hand off) has been chosen with older people' mobility and strength in mind.
- The Teletalker is a tool for connectivity between people of any age, but taking the older person and technological novice as a design requirement. Designing for older people exclusively could either result in specialised accessibility technology or fall into the 'stigmatisation trap' where it might be a useful service / tool / technology, but not accepted by older people since it communicates the message that one is old (McCreadie & Tinker 2005).
- The Teletalker concept asserts acute simplicity in order not to distract from the central aim of interacting socially with each other.

3. Social presence theory ranks the communication medium by the degree to which it conveys the physical presence of the communicating participants (Biocca, Harms, & Burgoon, 2003; Connell, Mendelsohn, & Robins, 2001; Walther, 1992). Social presence would be seen as low when people interact in computer-mediated-communication (CMC) since there is a lack of non-verbal cues.

4. Sokoler and Svenson emphasise how ambiguity should be embraced when designing non-stigmatizing technology for social interaction for older adults. They found that everyday activities such as gardening can provide a 'ticket to talk' with unacquainted older people (Sokoler & Svensson 2007).

5. According to the socio-emotional selectivity theory older adults live more in the present and prefer to do things they get immediate pleasure out of (Carstensen et al. 1999).

4.2. The making of the Teletalker

Due to time constraints and constraints on resources the original designs had to be adapted. However, having researched the designs of Televisions from the 19301950s, the concept of the Teletalker being a piece of furniture similar to the 1936 Baird T5 was followed (as shown in figure 2).

Fig. 2. 1936 Baird T5 picture accessed on 14th April 2012. Shown with courtesy by the TVhistory website.

Two 27inch iMacs, which had cameras and speakers built-in, were used for each kiosk. The Teletalker housing was created with Medium Density Fiberboards (MDF) and painted 'bitter chocolate' brown to match the colour of the Baird T5. The hand sensor[6] consisted of a hole in the shelf, in which the resistor was placed (see figure 3).

6. An ardiuno board with a light sensitive resistor was used to create the hand sensor.

Fig. 3. The Teletalker during field research in the quadrangle of Middlesex University. This photo shows the hole in the body of the Teletalker at the height of 105cm and the light shining out of the hole. The user needs to place their hand into the hole, covering the light-sensitive resistor, in order to activate the volume.

5. Field research June 2012

From 12th June–15th June 2012 field research with the Teletalker prototypes was conducted. One Teletalker kiosk was placed in the quadrangle of Middlesex University, London (see figure 5).

Fig. 4. A group of older people using the Teletalker at Middlesex University speaking to a person at Age UK Barnet.

The second Teletalker was placed in the communal room of Age UK Barnet. The majority of the Age UK Barnet day centre clients are between 70-90 years old, have some form of locomotion restriction and are not computer literate. Between 35–40 clients visit the Age UK Barnet day centre daily. Some have repeated visits during the week. Data was collected through observation and interacting with people through the Teletalker, through individual interviews with people who tried it out as well as with staff from the day centre. The Teletalker did not record the video transmission. With people's consent some video was filmed of people interacting through the Teletalker.

In total 27 conversations through the Teletalker have been noted down. The majority took place between members of the researcher's team and with a daycentre visitor. Eight conversations took place between students and daycentre visitors.

Fig. 5: An edited video clip showing the use of the Teletalker. (http://www.youtube.com/watch?v=Ucoy6pm3wyI)

5.1. Early results of the field research

Analysis of the data is still in progress, but here are early results.

- As expected the Teletalker generated interaction and communication between younger and older people as well as between the people at each location.
- The Teletalker seemed to have worked well as a window, giving each side a feeling of what is happening at the other location.
- The Teletalker introduced older people without computer literacy skills to online Face-to-Face communication.
- Tuesday's and Thursday's group at Age UK seemed to receive the Teletalker positively. Several day centre visitors went up to the Teletalker, tried it out and spoke to students and Middlesex staff. Older people suggested practical applications for the Teletalker such as serving as an information point in a major shop or for travel information.
- Wednesday's group at the Age UK felt that their privacy was invaded. In particular one person felt upset about not having been asked whether this research could take place near 'her' seat. (Note: the Age UK day centre management has re-assured that they will take extra care to inform everybody about future research in the day centre.)
- It was observed that younger students were more curious to try out the Teletalker by themselves. At the university's location A-level students from the college across the road were coming in in order to see the "cool machine", which fellow students had told them about.
- The hand sensor was very easy to use, although older people still needed guidance as to where to place their hand exactly. Once this was understood, older people did not have a problem using it.

5.2. Immediate lessons learnt from the first round of research

Signage is needed

It wasn't obvious without any signs, what the Teletalker was, why it was there and or what a person needed to do to experience it.

Physical placement

The physical placement of the Teletalker was crucial in order for people to come up it or to stop when walking past. When it was placed directly next to the main exit, lots of students stopped to have a look, but they did not stop when it was placed under the staircase. At the day centre the Teletalker was placed in the communal room, which worked well to give people at the Middlesex location an idea of what older people do in a day centre such as playing cards.

A person always present at one location

The Teletalker was more effective when there was always a person present at one Teletalker. Ideally, the Teletalker was supposed to initiate random conversation between people walking past. However, in hindsight it was unlikely that two random people approached the Teletalker at the same time and then started talking.

Technical issues

Technical issues did get in the way with enjoying the experience of the Teletalker. The Wifi connection was not very stable at times, which meant the Teletalker disconnected several times. The sound and picture quality was not always adequate (most likely due to limited bandwith connection). In one instance Skype lost its volume functionality.

5.3. Preparing for the next round(s) of field research and discourse

Currently, modifications to the Teletalker have been made such as adding extra speakers and improving the programming, so that the audio connection between the two places is more immediate. The next location for the second round of field research has been chosen. On 18th December 2012 the Teletalker connected two communal rooms between two Age UK day centres, which effectively meant connecting older people with older people. However, due to technical problems the Teletalker volume was not working properly. This round of field research will be repeated and the results will be compared with the previous results, where students and older people were connected. Subsequent planned field research, such as connecting two care homes, will add to the findings and provide a more complete picture of how successful the Teletalker was in introducing older people to online face-to-face interaction and what benefits it may bring. In discussion with the care home manager the Teletalker will be adapted to cater for the residents' requirements and become a Telewalker. This means that the Teletalker will be placed on a trolley and include a bell to ring for people's attention at other location. However, the main outcome of the constructive design research is not to propose the Teletalker or Telewalker as a commercially viable product, but to generate discourse around the role technology can play to connect older people and which physical forms it may take. This will be achieved by holding a small symposium in July 2013 where representatives working with older people, researchers focussing on older people, designers and some older people themselves will take part. The Teletalker and Telewalker will be there to give participants a tangible experience, results from the field research will be reported and participants are invited to contribute to the imagined future uses and forms of the Teletalker. This symposium will be filmed and results of the discussion will be reported.

6. Conclusion

This paper presented results of reviewing relevant literature in regards to older people and their use of online technologies in the UK. It argued why it is useful to have older people connected with online technologies. Further, it introduced the method with which the Teletalker research is being conducted. Constructive Design Research (CDR) is particularly helpful when dealing with wicked problems and where a solutions-focussed design strategy is more applicable since analysis can be exhaustive and there might be several possible design solutions. By building a physical artifact research goals can be externalised and provide people with a tangible experience to give feedback on.

The Teletalker design response has been selected based on knowledge gained through literature and from direct data collection. The main idea is to present a window where online face-to-face interaction can be carried out in a very simple form (such as waving), and so that the use of the technology becomes instantly rewarding.

The making of the Teletalker was described and early findings of the field research reported. Analysis of the full results is still in progress, but preparations for further rounds of field research are being made. With a future round of field research the Teletalker will be transformed into a Telewalker to addres the target audience needs. This is a major transition of the teletalker from a general research tool (which could be placed anywhere the researcher decides in order to connect older people) to a specific research tool (connecting two care homes). This transition highlights the difference between 'research for design' (Frankel & Racine 2010) and constructive design research in as much as the Teletalker has been built to externalise the researchers' knowledge rather than being based on a real application need. In order to achieve a meaningful discourse in the research community about the role and form of online social interaction technologies a symposium will be held. In the symposium with selected stakeholders, such as representatives of organisations working with older people, the artifacts will be presented, field research findings reported and a discussion generated on the of future forms and applications of the Teletalker. It needs to be emphasised that not only the physical artefact, in this case the Teletalker, is part of CDR, but also the data collection, the choice of placement, direct and indirect feedback from the people who tried it and from the research community. Generalisable knowledge can be reported on once the Teletalker / Telewalker has been placed into the field for at least three times, if not more, and when the researcher has been able to reflect on the experiences including the use of CDR.

With this paper other researchers are invited to comment on the Teletalker research in order to stimulate the discourse on the role of online social interaction technology for older people and which physical forms it may take in the future.

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Innovation, Collaboration, Education: Histories and Perspectives on Living Labs

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Abstract: This paper suggests a genealogy of Living Laboratories (LL) by comparing similarities in their development with media labs and experimental art schools. These histories all share an interest in concepts of innovation, collaboration, interdisciplinarity, and in the subversion of traditional forms of governance and knowledge production. Originally conceived as a research environment in the field of computer science, and subsequently applied as a curatorial strategy for exhibiting and evaluating interactive art, the idea of the LL can be expanded and enriched with new potential. Looking at the models of media lab and the educational turn in contemporary art can not only add a chapter in media histories, but can also indicate a possible trajectory for LL towards the establishment of temporary communities engaged in forms of knowledge exchange. By ascribing new responsibilities to the public and addressing issues relevant to them, this can bring new perspectives on audience development and offer a context more suitable for the presentation of digital media projects.

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1. Introduction

There is an increasing inclination in the art world towards a transition from spectatorship to active participation. Minimalism, happenings, public art, community specific art, interactivity, discursive practices, all contributed to a tendency which experienced an incredible acceleration with the rise of the Web 2.0 and its possibilities in terms of sharing, crowdsourcing and networking. The dream of a democratisation of art merged with the development of new curatorial strategies and the creation of platforms for online collaborative curating or to facilitate the collective production of artworks (Paul 2006). The idea of a user-centred approach is rooted in business studies, particularly around the concept of lead user developed by Eric von Hippel: according to his theories, innovation is largely generated by end-users rather than manufacturers (1986) whose role is mainly to respond and implement new needs identified in the marketplace. Subsequently, disciplines such as computer science, psychology and interaction design were informed by the principle of an open, distributed innovation[1], with the setup of dynamic environments to test user experience in a collaborative dimension closer to everyday life and

> engage all stakeholders such as end-users, researchers, industrialists, policy makers, and so on at the earlier stage of the innovation process in order to experiment breakthrough concepts and potential value for both the society (citizens) and users that will lead to breakthrough innovations. (Pallot 2006)

One of these platforms for innovation and experimentation took the name of LL and inspired a redefinition of exhibiting strategies for interactive art. Beta_Space, launched in 2004 at the Powerhouse Museum, Sydney, is an exhibiting space where interactive artworks are showed at different stages, from early prototype to product, and where the audience is involved in the evaluation process (Muller and Edmonds 2006). What is crucial at Beta_Space is that the audience is

> expected to provide feedback to assist the research happening in the same space. This action, this participation becomes the median by which the work is measured. (ibid.)

LLs provide a framework to address the ongoing question of how artistic practice is reshaped to suit the adoption of digital technology and scientific procedures. However, this paper takes as a starting point the contention that the application of the LL as a curatorial strategy contains a strong political potential which has not been fully explored yet. Pallot considers the potential of LLs in terms of citizen-government partnership and mentions a series of examples[2] at the level of local authorities where it has been applied as a model for regional development to facilitate the citizens understanding of various issues in their environment and test possible solutions (2006). Given the value of LLs as a means of participatory co-planning, territorial self-governance and citizen ownership, even though still at an experimental stage, a richer perspective can be envisioned also for contemporary art. Therefore its application should not be limited to the evaluation of interactive art but extended to a wider area of interest. One of the most problematic aspects

1. This approach informs for instance ideas of Cooperative Design (Greenbaum and Kyng 1991) and Emotional Design (Norman 2004).

2. For a detailed survey of LLs in the public sector see www.openlivinglabs.eu

in translating the user-centred model in innovation into artistic practice is the difficult coupling of user and audience. For this reason, LLs will be put in relation to creative platforms such as experimental art schools and media labs, especially in association with their contribution to the free culture and open source movement. We will show how this can provide a fertile model for future applications and will allow us to put an emphasis on learning as vector for creativity, social interaction and collaboration.

2. Media lab histories, free culture and innovation

By suggesting a collective-action model in innovation, Von Hippel's theories had an impact on the free/open source software (FLOSS) and Free Culture (Lessig 2004) movements. He directly addressed the question of open source software as a mixed private-collaborative strategy (von Hippel and von Krogh 2003). In *Democratizing Innovation* he explained how technology enabled users to initiate communities of innovators and why it is profitable to share intellectual commons freely (von Hippel 2005). Furthermore, open source software is an easier platform for those customisation, reinterpretation and adjustments which are typical of creative production, rather than tools protected by intellectual property (National Research Council 2003, 4). Innovation is in fact one of the key arguments adopted in Lessig advocacy of a free distribution of cultural content (2004, 184). Criticisms to this position however do not only come from copyright advocates, but also by those concerned with the dangers of free and anonymous labor: in his book *You Are Not A Gadget* (2010), Jaron Lanier warns that free culture may lead to the exploitation, rather than the empowerment, of small producers. What is also relevant is FLOSS's major role in promoting free and broad access to knowledge and enhancing peer led models for production and education.[3] This collaborative approach has proved essential for the growth of media labs across Europe. In a recent article commissioned by the Arts Council Charlotte Frost stresses their contribution to Open Source culture and also provides a basic definition of media labs, described as

> spaces — mostly physical but sometimes also virtual — for sharing technological resources like computers, software and even perhaps highly expensive 3D printers; offering training; and supporting the types of collaborative research that do not easily reside elsewhere (2012).

This definition is helpful to understand certain continuities between media labs and LLs: the idea of artist as innovator or lead user (not just applying existing technologies to creative purposes, but developing media and applications in close collaboration with scientists and technologists) is an essential premise with which to speculate on the role of the audience itself as innovator. However, it is interesting to notice how Frost's definition does not envisage a program explicitly open to the 'general' public. In media labs there is no audience: all participants are users and tend to form communities clustered around specific projects, rather than opening doors to occasional visitors. Frost (ibid) outlines a succinct account of media labs in the UK from the Nineties onwards culminating in their recent incarnation of the hacklab. However, the history of the productive synthesis of practices, resources and methodologies between science, art and technology is a more

3. The debate about free access to academic publishing is particularly relevant here to show how research can be affected by a limited availability of publications.

complex and long-lived one. Michael Century (1999) provides a compelling insight into this matter adopting the definition of studio-lab, which significantly emphasises the merging of artistic and scientific research spaces. Century's report describes the gradually intensified communication between the scientific and humanistic sectors leading to hybrid institutions "*where media technologies are designed and developed in co-evolution with their creative application*" (ibid). Century traces back the roots of this development in the early 20th Century avant-gardes and especially the Bauhaus, characterised by

> a strongly applied socio-technical project to shape the quality of mass reproduced designs with all the imaginative resources of the contemporary creative spectrum (ibid).

Subsequently, Century identifies the following three phases in the historical evolution towards the studio-lab. 1) Art centres created during the 1960s and 1970s to support the artistic experimentation of emerging technologies. For instance: E.A.T. (Experiments in Art and Technology), IRCAM (Institut de Recherche et Coordination en Acoustique et Musique) and the Centre for Advanced Visual Studies at MIT. 2) Media centres interested in research but also in engaging the public with festivals and exhibitions, appeared in the 1980s and 1990s (ZKM and NTTInterCommunication Centre). 3) Studio-labs created in the 1990s and based on strong partnerships with the industry or higher education. Examples are the MIT Media Laboratory, Xerox Parc PAIR artist in residence program, and the Banff Centre. This history demonstrates how the relationship between engineers and artists goes far beyond that of provider and consumer of technology, to become a "*flexible and thoughtful collaboration in which the roles of software designer and user are not rigidly distinguished*" (National Research Council 2002, 3). Studio-labs have been informed by hacker culture and its preference for the open source ethos, and have a strong tendency towards teamwork and interdisciplinarity. Not only does innovation become embedded in cooperative practices, but it precisely aims to address social needs (Frost 2012). What appears crucially reinforced in the last generation of media labs is the effort to engage a larger community outside their peer circle, and especially marginalised groups, not with an exhibiting program but with an open door approach, involving all participants in the maintenance of the space and its resources, offering opportunities for inclusion and learning-by-making, community-oriented projects, internet access, tuitions on software packages and professional training for unemployed people. Learning tends to happen in informal ways, often through direct application to creative production: "*once a media lab participant has learnt how to do something, they should pass this knowledge on.*" (Frost 2012). To illustrate this emphasis on social empowerment Frost provides the example of the Zero Dollar Laptop project (a collaboration between Access Space and Furtherfield 2009): a series of workshops to teach homeless people how to build and maintain a laptop created using recycled, donated hardware and open source software. This preference for recycled technology is not just a money-saving solution, but a way to disseminate the potential of creativity in re-using things and the importance of accessibility. Frost goes on stressing the importance of media labs in addressing the special needs of digital art, which often does not find an ideal context in traditional gallery spaces. The difficulties in exhibiting digital art have been widely debated (Dietz 2003, Paul 2008, Graham and Cook

2010) and lie, in part, in its process-oriented nature. Paul identifies a number of issues inherent to the display of digital art, including the requirement of a certain familiarity with the interface, an extended viewing period, a strong dependency on the context and participatory and non-linear qualities. She also tries to outline what an ideal setting would be:

> New media art seems to call for a distributed, "living" information space that is open to artistic interference — a space for exchange, collaborative creation, and presentation that is transparent and flexible (Paul 2006, 85).

Media labs offer the artists a platform to work, test, develop a process but do not require them to show a final product. This also made the role of media labs complementary to that of the gallery, sometimes resulting in fruitful collaborations between the world of contemporary art and that of digital media[4]. If we take the blurring of boundaries between production and exhibiting site as a defining feature of the LL, we see how strong its continuity with the media labs is. However, media labs partnerships are not limited to art organisations, as they are frequently affiliated, supported or hosted by educational institutions or universities. To sum up, what LLs can draw from the experience of media labs could be in the first instance a more concrete idea of its public. LLs need to address and nurture communities around specific projects. Community is defined here as any temporary collectivity built around a shared site of co-creation and common interests. Media labs also suggest a range of structural solutions: partnerships with the University and art organisations, networks of labs, online and offline presence, are all viable possibilities for the LL to pursue. Finally, rather than limiting the involvement of the public in the evaluation process, workshops and training activities introduce participants to the use of tools which can trigger further creative production and dissemination, and that suggests a shifting aesthetic paradigm. Open-ended pieces, subject to further modifications would be preferred to static artifacts. For instance, the possibilities offered by code (live coding, web scrapers, data visualization, rapid prototyping) tend to engender further re-writings and enable production by others, turning these creative languages into living organisms.

4. Frost gives the example of Folly's collaboration with the Harris Museum and Art Gallery in a project involving the exhibition and acquisition of digital artworks. This is happening despite a certain historic antagonism between new media and mainstream contemporary art, a question recently tackled by Claire Bishop in an article on Arforum (2012).

3. Experimental Art Schools

The emphasis that the Bauhaus put on the potential of creativity to encourage social change explains its influential role in shaping the imagination around the idea of the art school. It was mentioned earlier how Century considered the Bauhaus as a source of inspiration for the development of studio-labs. The institution founded by Walter Gropius is also claimed as model for a number of experimental art schools that contributed to what became popular since the mid-Nineties under the name of the 'educational turn' in contemporary art (O'Neill and Wilson 2010). This definition has worked as an umbrella term to classify a series of heterogeneous experiences associated with the adoption of formats and methodologies typical of educational infrastructure (seminars, classes, courses, research trips, workshops, lectures) within curatorial or artistic practice. This turned the exhibiting space into a site for discourse, but also expanded curatorial practice to alternative sites, outside the traditional gallery. The School of Missing Studies (n.d.), for instance has a specific focus on architecture and urban studies, and its most famous project was the Lost Highway Expedition in 2006, located literally on the road:

> A multitude of individuals, groups and institutions will form a massive intelligent swarm that would move roughly along the unfinished "Highway of Brotherhood and Unity" in the former Yugoslavia. The road was made in [the] Sixties in the massive voluntary campaign of the peoples of all nationalities that constituted Yugoslavia. The expedition is meant to generate new projects, new art works, new networks, new architecture and new politics based on experience and knowledge found along the highway.

Expanded academia, artist as researcher, seminar as exhibition, the interpretation of the educational turn vacillates between two poles. On one side it could be considered as a further declination of the wider trend of 'art as encounter', (Dave Beech 2010, 48), that refers to a repertoire including relational and dialogical practices curtailing the role of the public as viewer and turning it into a user. On the other side, it can be cast in a more specific light as a reaction against the educational institution, which, with the introduction of the Bologna Accords of 1999, has been criticised for standardising and corporatising the entire Higher Education system within the European Union. More recently, the Arts Against Cuts movement reinvigorated similar antagonisms in the UK. This criticism is also addressed at the hierarchies traditionally informing the passing of a pre-determined set of knowledge on to coming generations. Experimental schools were conceived as a way to undermine an idea of pedagogy as discipline and encourage instead an educational practice driven by emancipatory and liberative forces (Freire 1972; Rancière 1991). The association between knowledge and power is a well-established one that acquired new complexity with the rise of the so-called knowledge economy. The question of immaterial labour (Lazzarato 1996) is having a deep and multifaceted impact on the art world which would take too long to analyse here. We can however say that the financialisation of intellectual practices nurtured a desire for opportunities of knowledge production outside the logic of profit. A case in point is the Copenhagen Free University. The house of its founders Henriette Heise and Jakob Jakobsen became a public space in which one could research archival material, take part in debates, present artworks or screen films. The following excerpt from the project website suggests how crucial the idea of performing education in a living environment is:

> Seeing how education and research were being subsumed into an industry structured by a corporate way of thinking, we intended to bring the idea of the university back to life. By life, we mean the messy life people live within the contradictions of capitalism. We wanted to reconnect knowledge production, learning and skill sharing to the everyday within a self-organised institutional framework of a free university. (Heise and Jakobsen 2007)

Further motivations for artists and curators to explore the dimension of learning are to be found in what we could define as the 'biennial fatigue'. As Anton Vidokle[5] points out, the exhibition might not necessarily be the most effective way to deliver an art

5. Invited to curate Manifesta 6, Vidokle envisioned it as an art school in Nicosia, Cyprus. The project failed due to the political contrasts between the Greek and Turkish population but it was successively realised in Berlin under the name of Unitednationsplaza (www.unitednationsplaza.org/).

aiming to engage and transform society, rather than simply present itself as a symbolic gesture. Large scale international exhibitions have become a trite reiteration of the same standardised formula, very often showing the same pieces by the same artists (2010). Additionally, Vidokle's fundamental belief[6] that art schools do not primarily teach but create the precondition for creative work (Vidokle 2006), raises questions about the self-reliance of contexts. Jan Verwoert warns about the risk of thinking that creating a platform is a self-sufficient strategy, without much concern for the content, reduced to a "*semi-disposable filling for the format*" (Verwoert 2010, 26). The idea of adopting education as a medium implies troublesome questions. How to balance the needs of learners with aesthetical requisites? How to avoid forms of exploitation (towards the students) for the sake of art? Piero Golia, co-founder in 2005 with Eric Wesley of The Mountain School of Art, operated out of a bar in Los Angeles, radicalises this point:

> I don't think a school is part of an art practice, I think that's where the confusion is. I think some people misunderstood and wanted to play education as a medium because they noticed it was successful for others. But education is not a media, it's education. It's just for the students and not for educators/artist's personal research. (Golia 2010)

6. After Walter Gropius famous claim that art cannot be taught (1919).

We can consider under this rather functional perspective also The University of Openness, founded by Saul Albert as an experiment in the self-provision of a collaborative research infrastructure (Albert n.d.). This is a case in point to trace back to our discourse on media labs, free culture and open source and to demonstrate how the idea of collaborative learning is productively intertwined with the creative applications of media technologies. Or, to slightly rephrase it, this clarifies the importance of digital and networking technologies in facilitating alternative and independent forms of education. The University of Openness was devoted to researchers interested in the possibilities offered by Unix to art production. It was structured in weekly sessions at Limehouse Town Hall but the community grew significantly when resources were made available and shared through those platforms emerging as the favoured sites for collaborative work for geeks and media practitioners: wikis, mailing lists, blogs, IRC. Despite such a heterogeneous collage of experiences, some commonalities among experimental art schools prove useful in understanding where LLs can go. The idea of learning as a structure for inclusion and access is combined with a rethinking of the dialectic between exhibiting space and sites for dialogical practices. By removing the gap between production and discussion, and encouraging questioning rather than aiming at the achievement of an expertise, these models of education empower the community by transferring responsibility to all participants of carrying out the project and filling the platform with content. LLs can be envisioned as self-organising systems where the transmission and production of knowledge are intertwined and not dramatically separated as in traditional schools. Even though we can only consider labs in a complementary role in the broad educational system, they are indicators of deep transformations in the way we tend to organise knowledge. The relationship between humanistic and scientific areas of research, developed in relation to digital culture, is in fact a symptom of the inadequacy of the traditional discipline-based educational practices, and calls for a rethinking of the system towards a project-based approach. This obviously demands a great amount of time and commitment, but it pays back with a sense of shared ownership towards the outcomes of the projects itself. This is also made possible by subverting the traditional separation between artist, curator and audience: a certain degree of criticism towards the institution, its hierarchies and power structures is ascribable to most of the experience we took into account. The emergence of new curatorial strategies, new institutional configurations and new models of representation comes together with a new conception of art and its public. Curator Simon Sheikh talks about a fundamentally fragmented public sphere and investigates how to construct participatory models of spectatorship as opposed to modernist generalised ones. The erosion of nation states and the process of globalisation played an important role in this shift, since the public realm can no longer be associated with a location, but rather with networks, groups or subgroups (Sheikh 2004). A plurality of more or less specialised publics means not only that the traditional divide between cultural providers and cultural receivers is less and less substantial, but also that curators should stop treating the audience as endowed with an equal, neutral background. Rather, everyone can bring their own specific knowledge and share it with the participants in a given project. This has important consequences in terms of the sustainability of the LL, suggesting forms of gift economy and exchange whereas large financial resources would have been otherwise indispensable.

Additionally, the performed character of most experimental art schools indicates a drive towards liveness, conceived as both the re-creation of a context mimicking everyday life situations and concerns, and the live dimension of the presented projects, experienced in their own making. An interesting perspective for LL would be to set up a situation that works on the double level of real life and symbol, assembly and performance, specific setting and archetype. From a curatorial perspective, liveness also establishes a new autonomy for art practice, by avoiding the usual displacement of the artwork in the space and time of the exhibition (and letting it inhabit, instead, the space and time of its own creation).

4. Conclusions

This study addressed a range of issues involving media labs, experimental educational practices and the FLOSS movement. The latter contributed to the delivery of forms of self-education and to the digitalisation of educational resources into open-source packages available to everyone (Roush 2011). One of the key arguments to support FLOSS is that of innovation (the free circulation of cultural content is not an impairing force in the market but rather a propulsive one). We have discussed the relationship between innovation and user-centred approaches first in business research, then in computer science and finally as applied to curatorial and artistic practice. We have also emphasised the role of digital technologies in facilitating a democratisation of innovation by enabling more and more people to access resources and skills to creatively reuse those already in circulation. This culture of sharing and collaborative co-creation is typical of media labs. By tracing a history of the different incarnations of media lab we identified relevant commonalities with the still open-ended concept of LL and key features of its possible future trajectories: a) there is no such thing as a general audience, but rather temporary project-oriented communities (with a potential in terms of sustainability); b) partnerships with research or art organisations can contribute at different levels (including financial support, participation in large research projects, outreach); c) the program is focused on workshops and other activities encouraging an exchange of knowledge and skills that can trigger further creative production, able to enter into an active life beyond its initial implementation (for instance coding). Experimental art schools are also imbricated in the FLOSS movement as models for collaboration and self-regulation (Roush 2011). They developed as a response to a series of crises: of the audience, the public, the exhibition, the educational institution (and against the monetarisation of knowledge typical of the new economies). The attempt to reintegrate the putative inclusive role of education is enhanced by the effort to disrupt a set of hierarchies and power relationships traditionally associated with a top down transmission of knowledge where expertise is intended as authority. LLs emerge from this discussion as possible sites for the transfer of responsibilities from the usual cultural gatekeepers to the public. This leads us to consider creative practice as a space where people can think about how to fit in society and arises questions for possible future research around the role of the LL as an environment in which to experiment with new forms of governance and production. If involvement in creative projects can be an emancipatory force, supported by the feeling of giving a contribution to the collectivity, how can it be put in relation with ideas of DIY and gift economies, equality, autonomy and self-governance? How can we bypass the spasmodic utopian flavor of community ethos which might be applicable, after all, only on the small scale? The risks embedded in this approach lies precisely in making the public interest as a guiding principle. The point will be to understand where the shift between merely gathering people together around some digitally-enabled bricolage and actually engage them, take place. In the context of LLs, liveness invokes responsibility and choice, but also performance and representation: an effort towards the synthesis of the contingency of a specific situation and the staging of the symbolic.

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On the Notion of Code Convergence in Vilém Flusser's Work

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Keywords: Technical Images, Photography, Computer, Re/Translation, Einbildungskraft, Gesamtkunstwerk.

Abstract: In the course of the 1970s and 1980s Vilém Flusser formulated the theoretical vision of a general convergence of different diverging aspects of modern society. According to him, this was made possible thanks to the latest technological developments: the invention of technical images, through photography and film, as well as the creation of new calculated digital images emerging from computer monitors. This notion of a final fusion is based on Flusser's own daily translation and retranslation practice and the theoretical vision he associated with this.

Ah love! Could thou and I with fate conspire,
to grasp this sorry scheme of things entire,
would not we shatter it to bits — and then,
remold it nearer to the heart's desire?
Edward Fitzgerald, *The Rutalyat of Omar Khayyam*

In my talk I would like to focus on the notion of code convergence in Vilém Flusser's work. Even if he used the terms medium and mediation throughout his oeuvre he never developed a media theory proper, probably also to distance himself from the likes of Marshall McLuhan. Instead of media, Flusser speaks of discursive and dialogical communication structures — theaters, pyramids, trees, amphitheaters, circles and nets — and of codes, images, texts and technical images. His vision of a final fusion in the digitally calculated technical sounding images, as he developed it in *Into the Universe of Technical Images* first published in German in 1985 can, therefore, strictly speaking, not be described in terms of multimediality only: a significant theoretical difference that would have to be explored further.

The idea of a final fusion, a synthesis of the different codes, the senses associated with them and the body parts that go with this is slowly developed in a series of texts in the course of the 1980s. Already in *Mutation in Human Relations?* however, written between 1977 and 1978, Flusser develops a loose narrative moving from one communication structure to another and envisaging a sort of final convergence which he calls synchronization. Each step is motivated by a structural weakness which the following structure is supposed to do away with, creating, however, a new problem calling for further changes. This dialectics of mediation is also at work in the code progression described in the works of the 1980s. The move from theater to pyramid to tree to amphitheatre, furthermore, adumbrates the later passage from image to text to technical image described in *Towards a Philosophy of Photography*.

A first version of the notion of final synthesis can be found in *Towards a Philosophy of Photography* first published in German in 1983, but subsequently translated into English and republished in 1984. In this text Flusser develops a history of media based on a series of processes of translation and retranslation. Flusser defines three interconnected codes each defining a specific universe — images, texts and technical images — and develops a history of media evolution based on a series of processes of translation and retranslation. In a *Lexicon of basic concepts* at the end of the book, translating is defined as a "move from code to code", a "jump from one universe into another." (Flusser, 1984:61) The first step in this evolutionary process based on an alternation of images and texts consists in the creation of significant surfaces whose function is to make the world imaginable by abstracting it. These surfaces were meant to be mediations between man and world, but tended to hide the world by slowly absorbing and substituting it. "The world becomes image-like (…). This reversal of the function of images may be called 'idolatry' (…)." (Flusser, 1984:7) To counteract this tendency, texts were invented. Their aim was to break up the hallucinatory relationship of man to image and to criticize imagination by recalling its original intention.

> "Some men (...) attempted to destroy the screen in order to open the way to the world again. Their method was to tear the image elements out from the surface and to align them. They invented linear writing. In doing so, they transcoded the circular time of magic into the linear time of history." (Flusser, 1984:7)

History, thus, can be defined as the "progressive translation of ideas into concepts" (Flusser, 1984:60), of images into texts.

The dialectics of mediation at work in the passage from the first to the second step of evolution, however, leads to a second impasse.

> "The purpose of writing is to mediate between man and his images, to explain them. In doing so, texts interpose themselves between man and image: they hide the world from man instead of making it transparent for him. (...) Texts grow unimaginable, and man lives as a function of his texts. A 'textolatry' occurs, which is just as hallucinatory as idolatry." (Flusser, 1984:9)

The same way the pre–historic phase of images was overtaken by a historical phase of texts, post–history takes over from history and by inventing technical images attempts to make texts imaginable again. By doing this, post–history bends the progressive linear development of translation from images into texts back to its origins and beyond. Flusser describes it as a "re-translation of concepts into ideas" (Flusser, 1984: 61), that is, of texts into technical images. Technical images differ from traditional images in that the two are the results of dissimilar processes of translation. Traditional images have real situations as their source; technical images, on the other hand, start out from texts, which in turn have been written in order to break up images through translation.

Flusser's history of media evolution as translation and retranslation has its origin in his vision of translation which he developed in the 1960s. Flusser's writing practice consisted in translating each text into another language rather than just rewriting it in the same language. This text was in turn translated into another language. Flusser used four different languages altogether: German, Portuguese, English and French. These processes of multiple successive translations were generally ended by retranslating the last version into the language of first text, thus turning a straight line into a circle. This final text, a palimpsest of sorts, in a way, contained all other previous texts the same way that the technical image contains texts containing images. The following description of a translation process holds true also for the code progression described above. When we translate an English text into a French one, or an image into a text, one code feeds on the other: the French text, the meta-code, or the target language, swallows the English one, the object-code, or the source text.

> "In the case of retranslation the original relationship of the two codes is reversed: the object-code becomes now a meta-code. In other words: after the French code has swallowed part of the (...) English one, he is in turn swallowed by the English code, (...) so to speak with the English in his belly." (Flusser, 1996:343)

Technical images are transcodings of texts that have ingested images. This is the first aspect of Flusser's idea of code convergence. But there is more to it.

In *Into the Universe of technical Images* — first published in German in 1985 as *Ins Universum der technischen Bilder* — Flusser amplifies his early concept of code convergence by adding numbers and sounds. In the chapter *Chamber Music* Flusser uses "to compose" and "to compute" as synonyms, bringing the world of music, mathematics and technical images together.

> "The world of music is a composed universe. (…) We don't need to wait for electronic music to recognize this quality about music. The universe of music is as calculated and computed as that of technical images." (Flusser 2011:164)

Contrary to music, the universe of technical images is a two-dimensional universe of surfaces, but like the musical universe and contrary to that of traditional images

> "It is a pure universe, free of any semantic dimension. Technical images are pure art in the same sense that music alone once was. (…) Since the beginning of computing, technical images have rushed spontaneously to sound, and from sound spontaneously to images, binding them." (Flusser 2011: 164–5)

Flusser does not explain the reason for this reciprocal tendency of images and sounds to fuse into one, but defines this inclination as a characteristic of both pretechnical images and pretechnical music. The technical image is "the first instance of music becoming an image and an image becoming music." (Flusser 2011: 165)

This synthesizing fusion, however, is not to be understood as a simple juxtaposition of the visual and the acoustic. What Flusser intends is a complete reciprocal penetration and fusion of the two codes creating something radically new, unheard-of and unseen so far. This is made possible by computing which breaks down sound and sight into small bits and reassembles them again into a new coherent form.

An example that aptly sums up Flusser's position — but unfortunately without the acoustic dimension — can be found in the work of Nancy Burson to whom Flusser dedicated a short essay published in 1987. Flusser starts out with one of his favorite quotations, two verses from the *Rubaijat* of the Persian poet Omar-i-Chajjam: "We shatter it to bits, and then remold it nearer to the heart's desire." (Flusser 1998:146) "Expressed in less poetic terms", continues Flusser, "we calculate the world in order to compute it." (Flusser 1998:146) [my translation RG] Flusser uses the English word 'bits' in a double sense: in the general sense of bits and pieces and in the more restricted sense of binary digit, the basic units of information theory. We shatter the world to bits in order to recreate it according to our own wishes. We project new composite realities. Nancy Burson does the same. She creates chimeras through photography. Her chimeras, however, are not like the traditional ones from Greek mythology: a lion with the head of a goat arising from its back and a tail ending in a snake's head. Her pictures are not assembled like a collage, through simple juxtaposition. The mythical chimera was composed from different heterogeneous elements. If Bellerophon instead of fighting it, so again Flusser, would have kicked it up its backside the lion's head would have tumbled on the right and the snake tail on the left. This would not be possible with Burson's chimeras. Her portraits of politicians — combining Hitler, Stalin and Mussolini into a single face –, and her ironical composite female beauties — a cocktail mixed out of Audrey Hepburn, Bette Davis, Grace Kelly, Sophia Loren and Marilyn Monroe — are based on computer programs that work according to a specific algorithm. "These new 'authentic' chimeras", writes Flusser, "are self-contained independent phenomena." (Flusser 1998:146) [my translation RG]

Neither the concept of the audio-visual nor the existence of *electronic intermixers* that translate images into sounds nor sounds into images, correspond to the new level of integration that has become possible with the invention of calculated technical images.

> "In a sounding image, the image does not mix with music; rather both are raised to a new level (…) Contemporary approaches to making music pictorial and pictures musical have had a long preparation. They can be seen, for example, in so-called abstract painting and in the scores of newer musical compositions. (…) so-called computer art is moving toward sounding images and visible sound." (Flusser 2011:165–6)

As Flusser points out, this trend can be detected in all synthetic images "even those that present themselves as scientific or political documents rather than art." (Flusser 2011:166) This anticipates the third and last aspect of the notion of convergence I am discussing here. I will come to it shortly.

The technical images finally manage to get rid of their earlier representative character of images and to become pure art, the same way music always was: immaterial and with-out an object to refer to.

> "But only synthesized images are really conceived musically and made musical with visualizing power. It will be pointless to try to distinguish between music and so-called visual arts because everyone will be a composer, will make images. The universe of technical images can be seen as a universe of musical vision. (…) Once they have both become electronic, visual and acoustic technologies will no longer be separable." (Flusser 2011:165)

Unfortunately the English translation does not quite reproduce the idea Flusser is trying to express here. For 'conceive' and 'vision' Flusser uses 'einbilden' and 'Einbildungskraft', linking thus the word image, 'Bild' to the new technical possibility of computation, 'Einbildung', and calling this new form of technical imagination 'Einbildungskraft' in order to separate it from earlier forms of imagination. In the German original, stressing the two-way thrust of his argumentation, moving from image to sound and back, he writes: "erst bei synthetischen Bildern wird tatsächlich *musikalisch eingebildet* und mit *Einbildungskraft musiziert*." Another play on words takes place with the use of 'synthesis', 'synthetic', 'synthesize' and 'synthesized', in German 'Synthese' 'synthetisch' 'synthetisieren' and 'synthetisiert', linking the early vision of a final synthesis through multiple translation to the new vision of synthetic sounding technical images.

Flusser ends his description with a reference to German Romanticism, however, with a rationalist twist. The new general convergence is not about mysticism, but the collective projection of a world that is completely man-made and therefore concrete: an utterly fictitious world in which to live with complete self-consciousness.

> "I think this new aspect can be grasped at its tip in the dreamlike quality of the emerging image world. It is a dream world in which the dreamers seem exceptionally alert, however, for to press the buttons that produce pictures, the dreamer needs to calculate and compute clear and distinct concepts. It is a dream world, then, that does not lie below waking consciousness but above it, conscious and consciously constructed, a hyperconscious dream world. It will therefore be pointless to try to interpret dreams: they will mean nothing beyond themselves, and they will be tangible — a world of pure art, of play for its own sake. '*Ludus imaginis*' (…) as *ludus tonalis* (…) and the emerging consciousness of the power to imagine as that of *homo ludens*." (Flusser 2011:166)

The same way that music does not refer to any specific object, technical images are concrete dreams that do not refer to any reality but to themselves. I would now like to conclude with the third aspect of the notion of convergence.

In *The Photograph as Post-Industrial Object: An Essay on the Ontological Standing of Photographs* published in Leonardo in 1986 Flusser sums up his idea of an encompassing cultural convergence directly stemming from technological evolution: the meeting and fusion of the natural sciences and the humanities, art and science, imagination and precision. In the following passage Flusser, furthermore, links this evolution to the work of Leonardo da Vinci and the notion of *Gesamtkunstwerk* as it appears in the music of Richard Wagner.

> "Ever since the fifteenth century occidental civilization has suffered from the divorce into two cultures: science and its techniques — the 'true' and the 'good for something' — on the one hand; the arts — beauty — on the other. This is a pernicious distinction. Every scientific proposition and every technical gadget has an aesthetic quality, just as every work of art has an epistemological and political quality. More significantly, there is no basic distinction between scientific and artistic research: both are fictions in the quest of truth (scientific hypotheses being fictions). Electromagnetized images do away with this divorce because they are the result of science and are at the service of the imagination. They are what Leonardo da Vinci used to call 'fantasia essata.' A synthetic image of a fractal equation is both a work of art and a model for knowledge. Thus the new photo not only does away with the traditional classification of the various arts (it is painting, music, literature, dance and theatre all rolled into one), but it also does away with the distinction between the 'two cultures' (it is both art and science). It renders possible a total art Wagner never dreamt of." (Flusser 1986:331)

To sum it up: The global encompassing convergence Flusser is envisaging is a synthesis of several diverging aspects. Not only mathematics and music merge, also the West and the East, art and science — that were separated in the Renaissance — are joined again, science, art and politics — that were divided in the course of a more and more positivistic and factual 19th century — finally join hands again, the senses and the codes come together, the eye, the ear and the fingertips, the visual, the acoustic and the tactile creating a multilingual, multi-mediatic and multi-discursive *Gesamtkunstwerk*. All borders disappear, all simple dualisms are abolished: the border between dream and reality, the separation between the artist and his audience, as well as that between art and life.

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Short Papers

Transients: a Transit Visualization

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Keywords: Data Visualization, Generative Art, Transit.

Abstract: *Transients* is a series of generative animations inspired by the notions of flow, ephemerality and transitory states. The underlying structure of these animations is a database created using GPS data from the Toronto public transit system. The data, available on the web through the Toronto Open Data portal, includes the location, routes and stops of every bus and streetcar in the system, as well as the arrival times of trains within underground subway stations. Custom software created by the artist establishes an aesthetic framework for the data to unfold within, balancing artistic and algorithmic decisions alongside existing patterns within the data.

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1. Context

This work was curated by Sharon Switzer and was developed as a specially commissioned, site-specific installation for Pattison Onestop and Art for Commuters, in the context of Scotiabank Nuit Blanche, an all-night contemporary art festival. *Transients* was exhibited on over 300 information screens operated by Pattison on subway platforms across the Toronto transit system. The work was presented without interruption, replacing the news and advertisements otherwise typically shown on these screens. The animations generated for this work had a total runtime of 12 hours, in order to coincide with the duration of the event.

Fig. 1. The work running on an information screen.

2. Artist Statement

The motivation behind *Transients* is to look at the mundane, everyday nature of transit activity within the city, and present this information from a different perspective than what is typically experienced by commuters. Through animations generated by custom software, motion patterns are slowly revealed using colorful ribbons unfolding according to the paths taken by vehicles. The work provides an opportunity for the audience to become aware of the behavior of the network, as well as to reflect on how they become a part of this larger system by riding transit.

The software alters the scale of the representation over time, going from a bird's eye view to extreme close-ups on individual routes, shifting the focus between the network as a whole (Fig 1) and the seemingly meandering motion of a single vehicle (Fig 2).

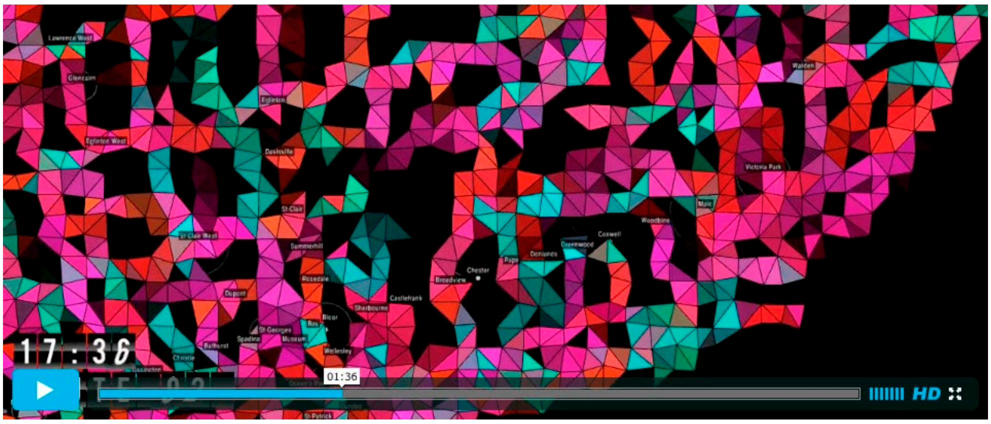

Fig. 1. A video excerpt showing motion patterns across the network (http://vimeo.com/57697210).

By definition, the term *transient* refers to the commuters; the people in motion, the temporary guests, who are the primary audience for this work. However, the title also implies the notion of ephemerality. Like an improvised performance, the motion patterns of hundreds vehicles across the city generates an intricate composition. The movement is not rehearsed, yet it follows a specific structure dictated by the routes and timetables. This dance of the trajectories exists in the moment, and as such can only be perceived when captured and represented by a system such as *Transients*.

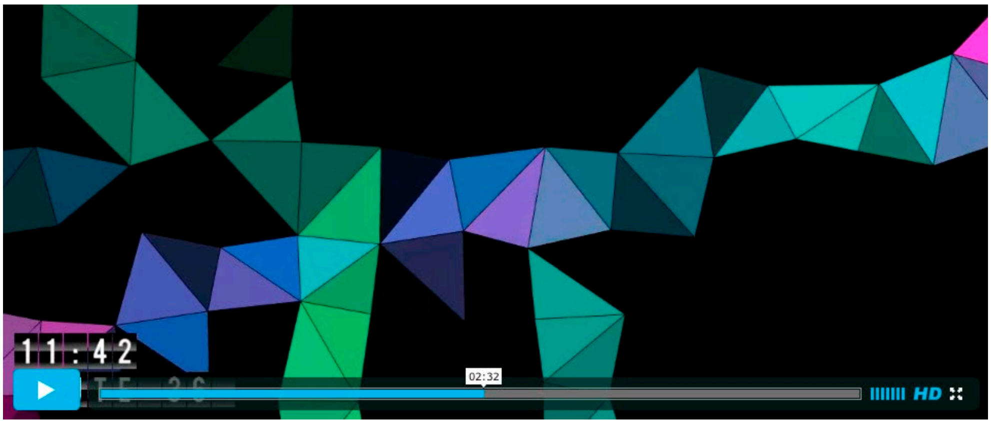

Fig. 2. An example of a close-up, shifting the focus on the motion of individual vehicles (http://www.vimeo.com/57697214).

This work is positioned as a form of artistic data visualization. (Viegas/Watternberg, 2007) While it is based on actual data, its aim is not to analyze or represent, but rather to evoke a particular emotion using the underlying data as a driving force. The map metaphor is used as a starting point, but is transformed (particularly at the extreme close-up scale) to the point of not always being recognizable as such.

Another major preoccupation behind this work is an exploration of generative methods within the creative process. *Generative* is sometimes a contested term, but broadly speaking can be defined as following rule-based or mathematical structures, operating in real-time and created with an emphasis on critical concerns for the process of production. (Cox 2002) In the case of *Transients*, the rules are not purely mathematical in nature, yet the data, which informs the work, is unpredictable and subject to infinite random variations introduced by the real world.

The approach used in creating the work (a real-time software program, as opposed to a static rendering of the data) ensures that the work has some degree of autonomy, introduced by variations within the external data as well as occasional elements of randomness in the rules established to interpret the data. As such, it is a reflection on the notions of artistic control and authorship. (Galanter 2003) The software establishes an aesthetic framework for the data to unfold within; but ultimately the outcome represents the careful balance of thoughtful algorithmic decisions alongside existing patterns within the data itself over which the artist has no control.

3. Process

The initial step for the realization of this work was to collect and process the GPS vehicle data offered by the city's public feed. An automated system was put in place to query and collect the information for individual vehicles over time. The data was then compared against known route topology to filter errors and outliers. The software also performed interpolation between GPS updates in order to generate fluid animations and motions paths.

A real-time visualization engine was then developed to explore, verify, and understand how the data behaved over time. The engine included basic features such as zoom, pan, time controls and vehicle lock-on (the latter eventually became one of the main mechanisms of the final piece).

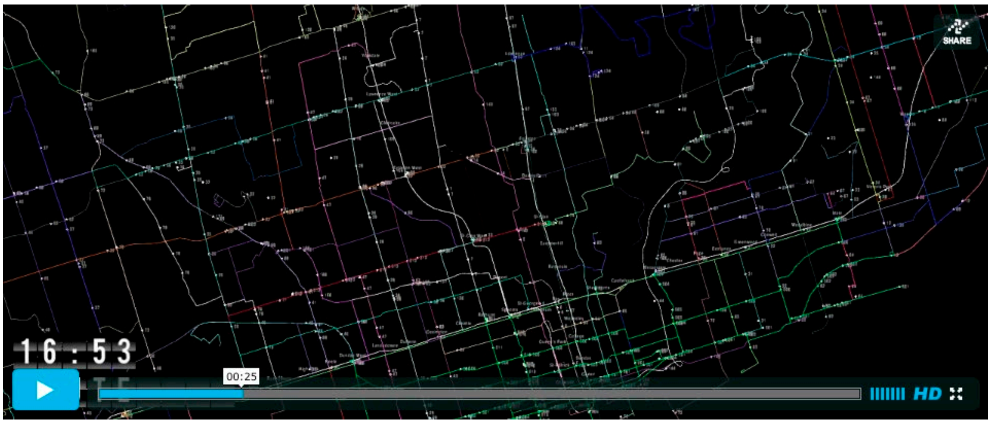

Fig. 3. The transit map, viewed within the development engine (http://vimeo.com/57697208).

After experimenting with the engine, variables were selected to vary within the final work: route number, time of day, speed factor, map scale and route color. The map itself was removed and replaced by a randomly generated triangle mesh. Initially invisible, triangles are revealed and tinted when touched by the path of a vehicle. The result is a series of intertwined ribbon-like shapes, which unfold according to the vehicle's motion. The camera follows selects a route to follow at random, and occasionally jumps from one route to another when two the path of vehicles intersect.

The structure and impression of the transit map remains, albeit in a more abstract form. In order to provide context to the audience, the names of subway stations were left in their original locations as landmarks, hinting at the actual geography represented by the ribbons. The route number currently being the tracked by the engine, as well as the time of day being represented were also included as overlays.

While the engine was capable of generating the visuals in real-time, constraints of the display platform for the exhibition required animations to be pre-rendered and at most 5 minutes long. As such, a script was used to create a playlist of unique short clips, each seeded with randomized starting conditions.

Additional video excerpts from the work are available online on the project's website at http://www.onestopallnight.com/12.

Acknowledgements: This work was made possible in part by funding from the Toronto Arts Council.

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Exploring Open Hardware in the Image Field

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Keywords: Electronics, Hardware, Image, Open Source, Physical Computation, Tools.

Abstract: The project documented in this article, developed under the Image Design master degree program at the University of Porto, aims to explore the production and transformation of imagery through the use of open platforms for electronic prototyping and physical computing. This field for exploration encompasses the construction, hacking and deconstruction of electronic, analog and digital devices, both as a means for creative research and a quest for alternatives to work processes established as de facto standards. Practical development is focused on modifying, designing and building devices to generate and manipulate imagery with analog and digital components. This study is framed by the relevance of open source technologies, shared creativity and produsage models, as well as the promotion of hardware literacy.

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1. Introduction

Images are increasingly contaminated by technology, in aspects well beyond a merely functional role (Bolter and Grusin 2000, 45–50). How a certain image reaches us, how intimate is the channel through which we view it, can be as determining to its perception as the visual matter itself. However, technological literacy remains focused mainly on promoting software packages and training end users. While plural in their use, devices are increasingly averse to being modified or repurposed by users, be it through physical properties or legal restrictions. In view of this setting, we seek to retrieve technological matter as part of an open creative process, as opposed to a set of defaults. A pliable tool instead of a workplace.

In liberating oneself from predefinitions found in most media-capable devices, strategies such as hardware deconstruction, repurposing and hacking can provide stimulating paths in a search for alternatives to established workflows, framed by the relevance of computational technologies, open source standards, shared models for creative productivity and the promotion of hardware literacy.

In this frame of mind, we set out on a practical exploration of open hardware and electronic prototyping platforms, ultimately geared towards developing operational devices for the production and manipulation of images and sound. Developments and results are freely available as a contribution to further work in this field and retribution to those that have generously contributed with their knowledge and experience. As this project required a good amount of learning about electricity, electronics, prototyping, building, testing and debugging, it offered an opportunity to assess both its feasibility for the average layman and its applicability to learning programs focused on visual communication. This learning process also seeks to point out the benefits of *libre* and open-source resources, particularly their uncompromising flexibility and adequacy to shared creativity models. Finally, the critical reading of experiments, processes and results is an opportunity to reflect on convergence points between images and their technology.

This convergence has deep historical roots, such as Thaddeus Cahill's Telharmonium, which gathers a set of features that make it relevant to this day. Patented in 1898,[1] predating both the Theremin and the Ondes Martenot, it is the first widely known instrument to synthesize polyphonic sounds from electricity, breaking the record-playback loop of contemporary inventions like Edison's Phonograph and rooting the idea of device-generated media. Incidentally, it also preluded streaming, as it was Cahill's intention to broadcast music to public spaces and private homes via telephone wires, on a subscription basis. Sadly, the massive infrastructure required by this invention was the main cause of its early demise.

In what Marshall McLuhan called an era of illumination (2008, 353), more recent technologies like video, personal computing and digital photography were rapidly embraced by a thriving consumer's market and a notably disruptive artistic community. The growing ubiquity of technology-based media marked a turning point in art and design practice, urging a more widespread thought on media and our connections to (and through) it. The *Experiments in Art and Technology*, started by Robert Rauschenberg and Billy Klüver in 1966, remain especially relevant to this topic, as they so memorably achieved the goal of "*developing an effective collaborative relationship between artists and*

1. Patent document available at the United States Patent and Trademark Office website (http://patimg1.uspto.gov/.piw?docid=00580035).

engineers" (Klüver et al. 1980). These experiments reverberate far and wide, from intersections with Nam June Paik (Wardrip-Fruin 2003, 227) to works such as Bruce Nauman's *Live-Taped Video Corridor* (Shanken 2009, 31) or even Roy Ascott's admonition on how dazzling effects achieved through skillfuly crafted technology can replace the creation of meaning (2008, 358). More recent works, such as *Hektor*[2] by Jürg Lehni and Uli Franke, or Zimoun's reduced technological structures,[3] denote how researching technology for its expressive potential has kept a continued interest. This is also evidenced by well-known academic laboratories dedicated to this area of research yielding influential results, such as the Processing IDE.[4] Here we narrow our focus on the cultural influence of makers and users in technological developments, as well as the technological origins of that influence (Lister et al. 2009, 320), for if some devices or technologies cater to a perceived need or want, others are ultimately shaped by unforeseen usage.

2. Documented at http://hektor.ch/

3. Documented at http://www.zimoun.net/

4. http://processing.org/

2. In the lab

A good number of electronics prototyping platforms are now widely available, allowing one to assemble devices useful to this study with reasonable speed and economy. Arduino,[5] now a staple in the maker's tool chest, was selected for its strict conformity to industry standards and open hardware definitions. Its extensive documentation and massive popularity also provide a fertile ground for exchanging knowledge and practical applications.

5. http://arduino.cc

For a practical exploration of translations between sound and image, a working base permeable to different formulations is needed. To serve this purpose, two complementary devices were planned: one to produce images from captured sound, the other to reverse this flow by generating sound from captured images. This configuration allows the devices to operate together and independently, accepting both mutual and external stimulus. The sound component externalizes part of the machine translation process and increases susceptibility to interference.

In a most simple description, the audio input stage uses amplified electret microphones, while the output is performed by salvaged speakers. Video capture uses inexpensive micro cameras and image output is fed to small LCD screens. These choices were biased toward the development of portable devices, easier to carry and use in any location, with low production costs. Composite analog video was used, as it is less taxing on limited microprocessors and more widely compatible with equipment salvaged from obsolescence. Also, the use of only black and white furthers the economy of processing resources, reinforces an aesthetic penchant for deprecated media and provides a more focused canvas, one less prone to diversion maneuvers. Programming on Arduino microcontrollers brings this flow together, managing analog to digital to analog conversions and affording computational control over response, variability and operational autonomy.

A project of this nature requires a small laboratory with a few specialized tools and basic knowledge of how to use them, such as a multimeter or a soldering iron. Also, while many tutorials and instructional documents are readily available online, reference literature in electronics is strongly advised. Obtaining such resources and knowledge is quite painless and inexpensive, especially when aided by a community of enthusiasts and open laboratories, as was the case in this endeavor. Organizing development in stages, defining tasks and intermediate goals, proved critical to progress through incremental gratification.

The first device generates imagery based on data collected from a microphone. Sound is routed through an operational amplifier, in order to achieve adequate current values for the Arduino, where an RMS[6] algorithm is applied to the sampled data. This averaging method enables fluctuations to more closely resemble a human perception of the sound environment, favoring a more obvious correlation between cause and effect in sound and image relations. Images are generated through the TVout library[7] and output to a 3.5 inch LCD screen, usually sold as a monitor for aftermarket car reversing cameras. Designed to operate on the 12 V standard automobile power, the screen was modified to work on 5 V by performing a bypass on a voltage regulator. This enabled the entire device to be powered from USB or a 9 V battery, thus allowing its assembly on a small reused plastic box. Once a stable build was achieved, with a fully functional bridge between sound input and image output, experimentation turned to the programming of various graphic visualizations of the captured audio data sets. While not an initial requirement, this process occurs in as close to real time as the technology in use allows, with negligible[8] delay. The initial purpose of testing and verifying sound-to-image correlations was progressively skewed towards exploring possibilities afforded by the images' aesthetic properties and the device's physical features. All programs resort to strict black and white on a grid of 128 by 96 pixels and each frame reflects, in some way, the averaged volume of the sampled sound.

6. Root mean square, i.e. the square root of the mean of the squares of a set of values.

7. Code library for the Arduino IDE by Myles Metzler, available on Google Code (http://code.google.com/p/arduino-tvout/).

8. Close to the minimum of 0.1 milliseconds, the time required by the Atmel 328p microprocessor to perform a reading on an input.

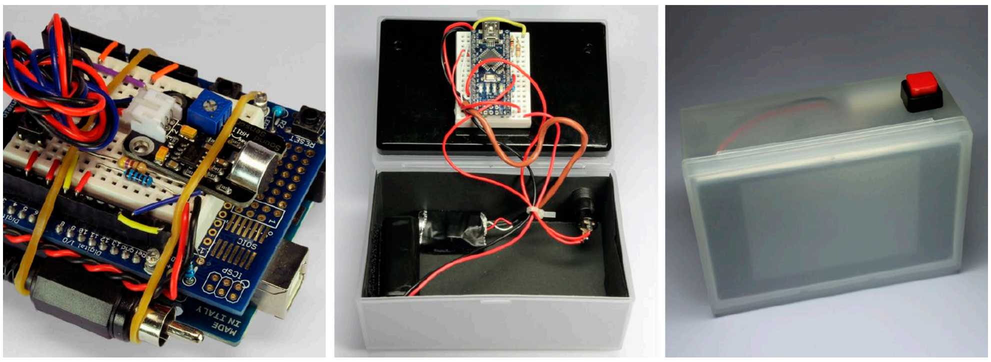

Fig. 1. Prototyping and building device 1.

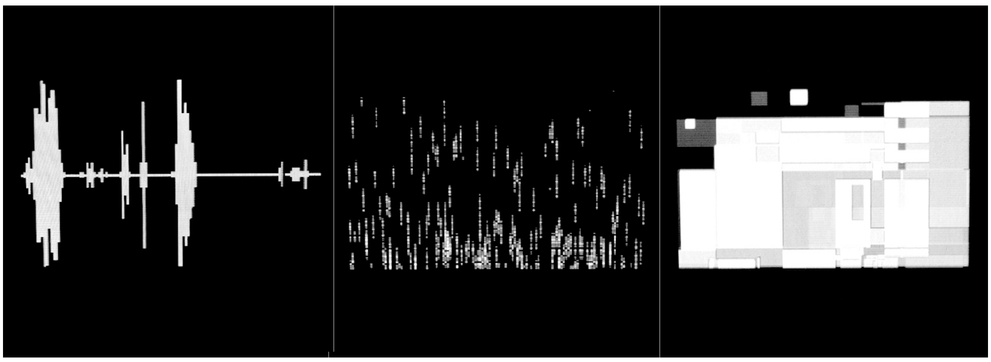

Fig. 2. Three examples of images produced by device 1.

In the second device, captured images are used to generate sound. The core of this device pairs an Arduino with a Video Experimenter Shield,[9] where a LM1881 integrated circuit generates 1 bit images from video frames supplied by a miniature surveillance camera. A potentiometer attached to this circuit allows the luminosity threshold to be calibrated according to the surrounding environment. A simple 8 Ohm shielded speaker with standard protection resistors, salvaged from a broken television set, completes the device. On the Arduino side, the largest continuous bright area in each frame is detected, with a minimum of 4 by 4 pixels defined for reduced response to noise and faster scanning by skipping pixels in the image analysis stage. The center coordinates of this area's bounding rectangle are then used as a basis for tone generation. Using pulse width modulation on an Arduino output pin, monophonic tones between 8 and 1024 Hz are fed to the speaker, corresponding to the 128 pixel horizontal dimension of the captured images. When the bounding rectangle fills the screen's width, the vertical coordinate is used instead. Finally, if the bounding rectangle remains centered, spanning the entire screen, the tone's frequency slopes down to 8 Hz, at which point the sound is muted for as long as the captured image remains unchanged.

9. Arduino shield designed by Michael Krumpus and distributed by Nootropic Design (http://nootropicdesign.com/).

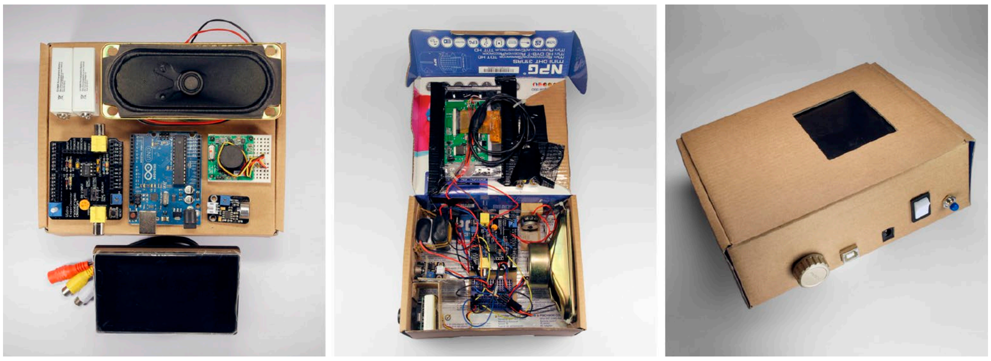

Fig. 3. Building device 2.

3. In the wild

Having reached a stable version of both devices with essential programming in place, a round of tests with a diverse group of ten subjects in different locations was carried out, where the devices' behavior and material properties were submitted to varying approaches and interpretations. The following is a brief account of these experiences, focused on the effects of audiovisual products, of the artifacts' physical configuration and of their computational affordances.

The first device is more widely perceived as indicative of its purpose, leading subjects to prefer visualizations that add to what is seen as functional. Its shape, size and layout also immediately offer clues as to how it may operate. In particular, the appearance of a rudimentary digital camera induces a corresponding approach and expectation. The scale of the artifact favors an introspective experience, in which the subjects interpret the device's response as taking part in the dialogue they lead. Ambient sounds are usually the first trigger in outdoor settings. When indoors, speaking, tapping the device and snapping fingers are the most common first interactions, comparing the results of deliberate actions with those caused by the surroundings. Most subjects direct their actions at the screen in an engaged dialogue that surpasses the screen's natural magnetism, much as if it were able to accept input. This happens even after knowing the microphone's location on the device. The production of sound during the process of interaction is subjected to the visual dynamics afforded by the visualization programs, the most popular being those that offer longer resistance to predictability.

The second device imposes upon the user a more exploratory approach, as it instills a sense of doubt and uncertainty, more evident in subjects less acquainted with experimental devices and technology in general. Curiously enough, most subjects felt motivated by this challenge and were keen to decipher the device. Neither its purpose nor the causality of its operation are self-explanatory, and the inclusion of a screen for monitoring the image being captured proved very helpful to this understanding. Once the screen is activated, the image to sound correlation is more evident and the device becomes an instrument, allowing a more analytical experience. The expressive potential triggered by this mutation sometimes borders on the performative, with subjects moving spontaneously and 'reading' surfaces with the device. The limited tone range encourages a search for patterns and rhythms, as subjects try to master the machine's behavior. In many instances the generated sound becomes somewhat separate from the device itself as it is more closely linked to what the camera sees, thus turning the device into a prosthetic mediator, unnoticed until interest is exhausted.

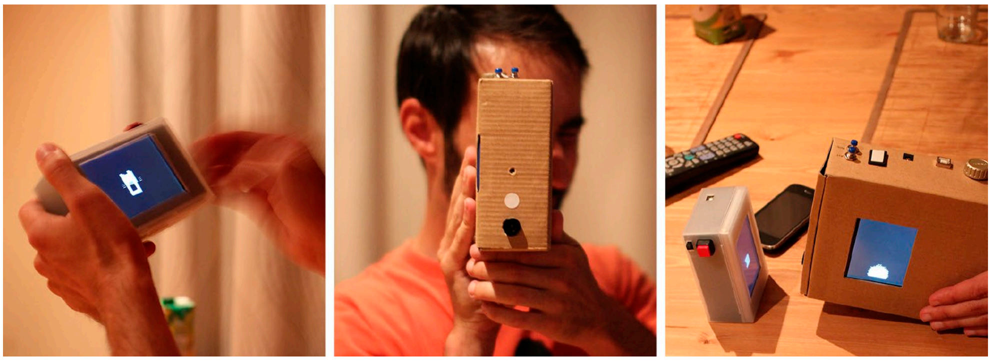

Fig. 4. Devices under exploratory usage testing.

Mutual interference between devices was the last stage of each experience, in which subjects restarted the process of improvising activities, exploring features and evaluating response to expectations (Ribas 2011, 226). Where previously the visual components were the primary focus for the majority of subjects, sound production became the main point of interest when using devices together. With few exceptions, subjects mostly held the first device as a trigger for the second, as if sliding a bow on a string, exploring the potential of the first device's visualizations as output to the second device's input. Naturally, the opposite would take place simultaneously, but that part of the process was overcome by the inversion of the first device's usage: now the subjects pointed the screen away from them, it was no longer an intimate collocutor but a playful proxy.

4. Considerations

These brief observations summarize the expressive potential observed in improvised experimentations, so long as devices were able to provide a path from cluelessness to instrumental mastery, a balance of predictability and surprise, and a graceful incorporation of glitches.[10] It became clear that physical properties afford the artifacts expressive qualities even before their use, adding layers of complexity to the interpretation of their experiences and results, while raising additional questions as to what might change with each possible reconfiguration. Computational properties are particularly relevant to this analysis, as devices with procedural behavior clearly benefit more deeply engaging experiences, thus enabling an active role in social contexts. This possibility of mediating or even generating dialogue through interaction, involving one's surroundings, reinforces the possible impact effected by this mediation, harkening back to what Ivan Illich designated as convivial tools (2001).

Current computational technologies lend themselves quite aptly to experimentation and sharing activities. As makers and designers working with media technology, participatory action in accordance with open source standards adds a sense of accountability, by reclaiming and rethinking one's role in shaping the tools one uses and defining the nature of their benefits. It is important that this intervention be guided by long-term benign goals, as it inevitably contributes to reshaping the technological and cultural fabric of our time in history. In this spirit, most of the materials and components used were recycled or repurposed, and full documentation is available on a public wiki in http://mdi.takio.net, under a Creative Commons Share-Alike license, without commercial restrictions.

As this project hopes to demonstrate, open hardware is, both in its spirit and current state of development, a primed playground for what Janet Murray described as a sandbox for the development of computational systems and procedures through experimental exploration (2011, 339). Not just for end users of well-intentioned black boxes, but for an emerging breed of produsage[11] agents. The expressive potential of the devices built and used over the course of this research is not apparently crippled by lack of processing power, as was observed when they were experimented with by test subjects. Rather, their often unexpected configuration details and physical properties added to the perceived richness and complexity of interaction experiences. As curiosity was piqued by the unconventional nature and hand-made appearance of the devices, bridges were found to the development of a deeper hardware literacy, as many subjects felt they too could acquire the skills needed for similar projects, taking one step further from consumers to creators, actively engaged in generating value beyond wealth (Bauwens 2006). In retrospective, it is gratifying to observe the results achieved by using humble means and obsolete technologies, in a time where product life cycles end long before significant technological leaps.

The devices here described are by no means considered final, and further variations are under consideration, especially regarding their programming, physical layout, scale and connectivity. Also of interest is the research of computational and procedural abilities in the most rudimentary possible build, for the accessibility and educational potential of such a device.

It is our humble hope that this project and its documentation may contribute to a deeper collective hardware literacy and a more distributed control over the tools we use to define our world and ourselves.

10. Intentionally or by serendipity, as discussed by Miguel Carvalhais (2010) regarding Peter Kubelka's short film *Arnulf Rainer* (1960).

11. As described by Axel Bruns in *Produsage: Towards a Broader Framework for User-Led Content Creation* (2007).

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Nevermore: Pretext Machine

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Keywords: Computation, Graphical Algorithm, Data Visualization, Generative Design, Drawing, Poetry, X.

Abstract: Our proposal is to make a graphic representation of the sound syntax and the syllabic structure enclosed in *The Raven*, published in 1845 by Edgar Allan Poe, using a script that works simultaneously as reading-text-machine, a drawing-machine and a synthesis-text-machine.

The script translates the poem structure into an abstract grid, generating a drawing. The geometric definition of the poem is then constrained by the characters and their correspondent location to the sound code: the word nevermore and the textual reverberation it produces. A synthesis of the poem is achieved by a recursive selection of syllables, resulting in a graphical and textual configuration towards a rewritten final stanza.

The process is repeated with the Portuguese translation of the poem, made by Fernando Pessoa in 1924. Although it follows the same initial structure and algorithms the change of idiom introduces different geometries and sound reverberations.

1. Introduction

Originally published in February 1845 by Edgar Allan Poe *The Raven*, widely translated and illustrated since then, was analysed in *Philosophy of Composition* (1846) to demonstrate Poe's writing method—a recurrent rhythmic combinatory procedure to emphasize the mathematic and mechanical structure of the text.

Our proposal is to make a graphic representation of the sound syntax and the syllabic structure enclosed in *The Raven*, using a script that works simultaneously as reading-text-machine, a drawing-machine and a synthesis-text-machine.

The poem is conceived as a pretext to use the sounds contained in the single word of the refrain. The script defines a set of combinatory rules that move and elapse the text ac-cording to it's basic sound code: the word nevermore and the textual reverberation it produces. Like Poe refers, "*considerations inevitably led me to the long* ***o*** *as the most sonorous vowel in connection with* ***r*** *as the most producible consonant*" (Poe, 1846).

2. Script

Made "*with the precision and rigid consequence of a mathematical problem*" (Poe, 1846), it is possible to describe and deduce an algorithm and represent it in a graphic grid. This grid gives visibility to the transformations that occur along the script iterations:

a) Reading text *machine*: The computational model we present, starts by defining a grid of points that interpret the structure of the poem: stanzas (18), verses (108) and syllables (1512). Each point of the grid as a correspondence to a character, which as a value assigned by the script: a geometrical representation of variable length;

b) Drawing *machine*: in each iteration a repulsive reaction is applied to the geometries from the points of resonance (nevermore, o–r);

c) Synthesis text *machine*: A process of natural selection is undertaken each iteration. The strongest syllable in an equivalent position between two stanzas remains, the other is obliterated. The elected syllables generate a final stanza. The result is a graphical and textual synthesis where the poem is rewritten.

The script, developed with the purpose of reading the English version of the poem, can also read other translations, and in this case running the Portuguese translation made by Fernando Pessoa in 1924. There were only two parameters that had to be changed: the number of syllables per verse — from 18 to 22; and the points of resonance (textual elements –**ais** and –**ro**).

The script is made in Grasshopper 0.9 (a graphical algorithm editor integrated in Rhino modelling software) complemented by some functions written in Pynthon Script.

The script allows the user to read/draw/synthesize other poems by changing the pa-rameters variables on the grasshopper interface, such as: the number of stanzas, verses and syllables and by defining the strongest rhymes along the poem.

Future advances in this demo will contemplate an interface developed in Processing in order to the user control of the parameters values.

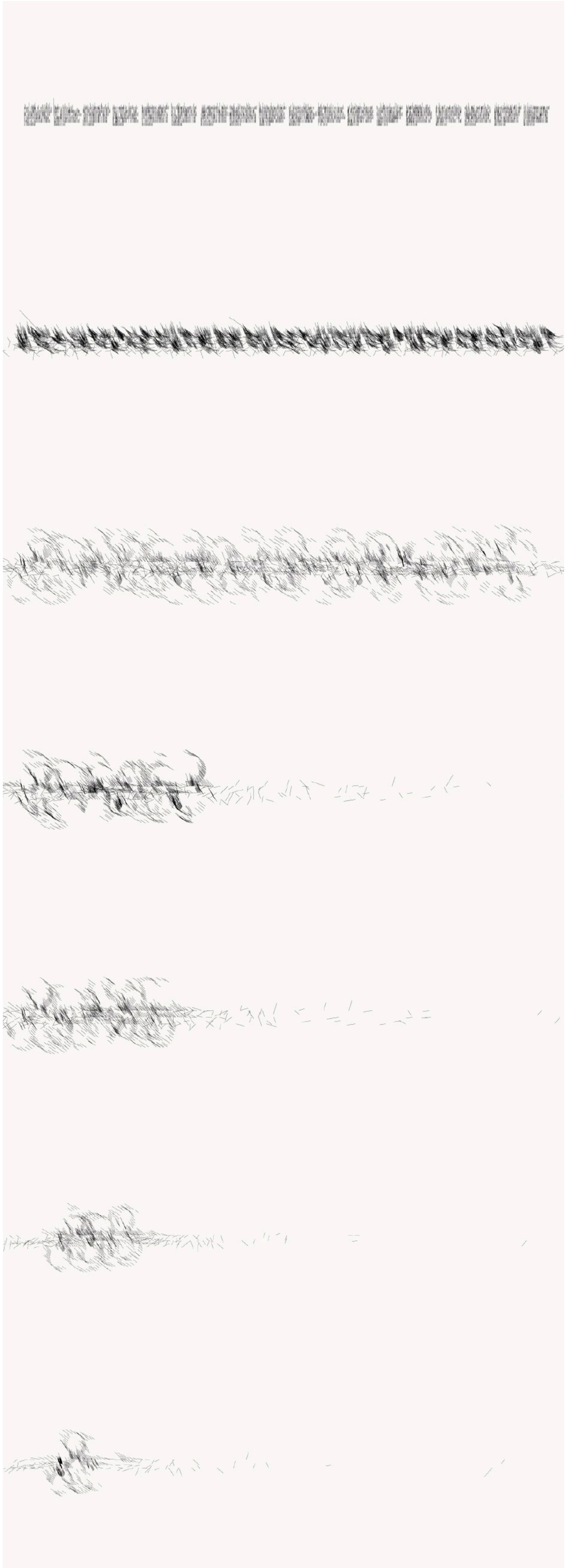

Fig. 1–7. Pretext drawings generated by reading *The Raven* original version, #1–7 iterations.

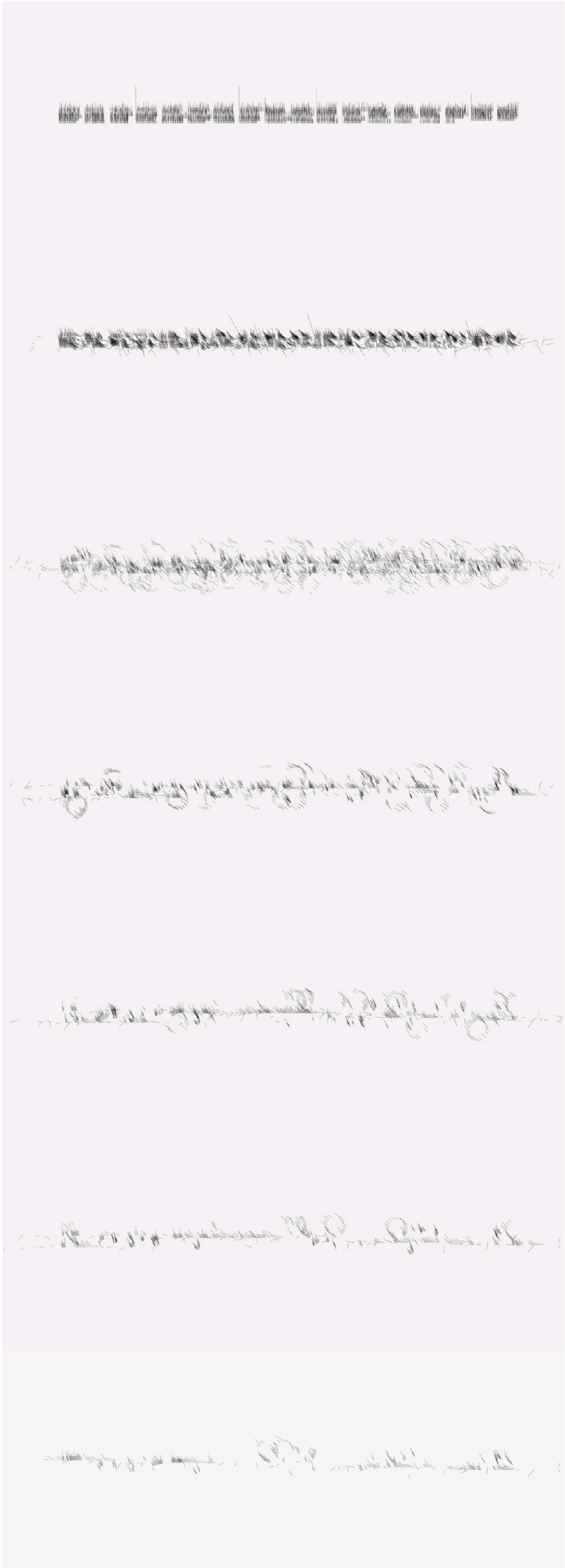

Fig. 8–14. Pretext drawings generated by reading *The Raven* Portuguese translation, #1–7 iterations.

proph thought that thing night denser tling there course press straight ting still fiend shriek start ing
there tempt whose dreams quaint wheth falls burned wrought saint stock both floor fore wretch this night's shore black
plume shorn sance daunt thee with these feath stood sought aidenn thee ter ed shall scarce demon's leave light stream
throws saint cient ping trance friends gloat flown shore bore clasp there dirges there shad floor that heart
still tured gaunt trance night's flown name plore shall press said noth from floor shall more
more more that

Fig. 15. New stanza generated on the pretext drawing # 7 iteration, *The Raven* original version.

que mais cor gri dis noi mais gres frou quan quei chei ain dum zen dis tris par mar gu
ra tor trou dia tais fron qual quem nhan nhos quem mos trou guem vras trais guais brais brais nais
tens pren lhar mais mim que man nha tris gre guem por mui nio que ses nha vros tra vi gre
do que nha luz lan guem lhe res tris gou nha som bra meus bras brais brais guais ais trais quem
ais trais num ber tar qual que nun meu mais quo fran tes som meus ses brais seus brais guais trais
dis cli nar cor nun nun mais mais

Fig. 16. New stanza generated on the pretext drawing # 7 iteration, The Raven Portuguese translation.

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Profilography

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Keywords: Drawing, History of Art, History of Technology, Albrecht Dürer, Eadweard Muybridge, Pre-Cinema, 3D Printing, Investment Casting, Digital Fabrication, Computational Art.

Abstract: This art project exploits digital modeling and fabrication techniques to reexamine historical images. Using a process I call Profilography — tracing and extruding a series of sequential contours or profiles — I transform serial or morphological images from art history into contemporary works of digital art. The goal of project is to connect proto-digital art — analog in craft yet 'digital' in conception — to the software and hardware of today. This both expands the reach of historical art into today's computational environment and creates a rich historical context for digital art.

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1. Introduction

What would artists from the distant past do with a computer? At a glance, it seems that it would be a strange device to their analog sensibilities. From today's vantage point, some artists could be considered 'digital', even though it would be generations before computational technology would transform the art world. Artists using technology to automate processes, or making images through logical, serial, and analytical thinking predate computers, but their methodologies are quite familiar to digital artists today. One way to explore the 'digital' nature of work from centuries ago is to apply digital technologies to historical works.

For this art project, I selected two artists — Albrecht Dürer and Eadweard Muybridge — to reconsider. Centuries apart, each artist-explored techniques that, using a computer, would be welcome in today's digital paradigm. In Four Books on *Human Proportion* (1528), Dürer presents an exhaustive morphological study of human form. Ostensibly a guide for artists drawing the human figure, from today's digital viewpoint, the book reads like computer code applied to produce theme and variation from an initial figure. This parametric distortion is easy with a computer. Dürer worked by hand, meticulously using rulers and arithmetic to produce his treatise.

Muybridge was a 19th century photographer most famous for his serial imagery of animals in motion. By setting up twelve cameras in regular physical intervals, he captured time and movement in a series of stills. Compiling these images into a flipbook, zoetrope, or other animation device transforms the twelve still photographs into moving pictures. His published volume of work, *Animal Locomotion* (1887), was vital in sparking the invention of cinema, undertaken simultaneously by notable inventors like Thomas Edison in the US and the Lumière Brothers in France.

Using a process I call Profilography — tracing and extruding a series of sequential contours or profiles — I extract new data from the historical data sets provided by Dürer and Muybridge. Computation affords new geometric possibilities unavailable to artists of the past. Transforming Dürer's facial profiles or Muybridge's side views of running animals into contiguous extrusions yields physical 'morphing' forms. Slicing through the form at any point produces new frames from the interstitial spaces between the originals. For Muybridge, it means an animation with a potentially infinite frame rate. For Dürer, profilography expands his morphological study into thousands of new human forms.

2. Artworks

2.1. Profilography (after Muybridge)

Eadweard Muybridge's 19th century photographic studies of animal locomotion marked the beginning of cinema. What began as a way to settle a wager (does a galloping horse ever fully leave the ground?) evolved into a proof of concept: sequential photographs of action can be assembled to realistically present life in motion. Or, as we know it today: a movie. To capture the action, Muybridge used twelve still cameras at regular intervals to capture one cycle of a horse's gallop. By cinema standards, this is quite sparse. There is a lot of data missing between each frame in comparison to the 30 frames per second of contemporary video.

Muybridge produced hundreds of studies of animals in motion. Plate 624 — a running horse — is the basis for this project. Using Profilography, the twelve photographs become a continuous profile. Slicing through the extrusion yields new frames, derived from Muybridge but absent from his original sequence. Since the model is contiguous, there are an infinite number of frames that can be generated from the original twelve.

After 3D printing the digital model, each print is prepared for investment (lost-wax) casting. In traditional metal casting, a form must first be molded and cast in a series of steps to produce a wax version. That wax version is then slowly covered in a ceramic shell. The wax inside is burned away, leaving a void for the molten bronze. In this project, the 3D prints are directly cast in the ceramic shell and melt away when flash-burned. Since the parts can be made on demand by a 3D printer, this process obviates the need for intensive manual sculpting. The final piece is a 3D manifestation of 2D images originally made to represent 4D (temporal) action, exploring artistic methods across time: millennia of bronze casting, the 19th century (early cinema and photography), and the 21st century (computers and 3D printing).

2.2. Profilography (after Dürer)

In *Vier Bücher von Menschlicher Proportion (Four Books on Human Proportion)* (1528), Albrecht Dürer exhaustively examines variations of human form. Not as Vitruvius' depiction of ideal human measurements, but as a full range of proportional possibilities. This physiognomic treatise establishes the basic parameters for drawing the human face and figure, such as relationships between the eye, nose, mouth, and chin. Over dozens of pages, Dürer shows an incredible variety of male and female figures and facial profiles, drawn by hand but made with a precise mechanical approach to geometric variation.

The six facial profiles Dürer presents early in the treatise are the basis for this machine. Using Profilography, the six faces become a continuous facial profile. Slicing through the extrusion yields new faces, derived from Dürer but absent from his analog treatise. After making the form into a closed loop, I 3D printed the form and mounted it onto a motor-driven spindle. As the piece spins, a light casting a shadow along the profile edge animates the transforming faces. Dürer's early experiment into parametric transformations arrives at its 21st century digitally-produced conclusion.

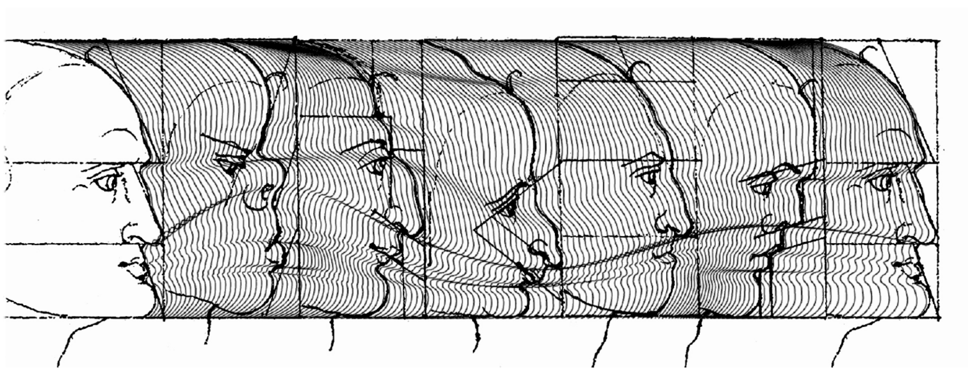

Fig. 1. *Profilograph (after Dürer).* Dürer's six profiles in *Four Books on Human Proportion* (1528) connected through digital extrusion.

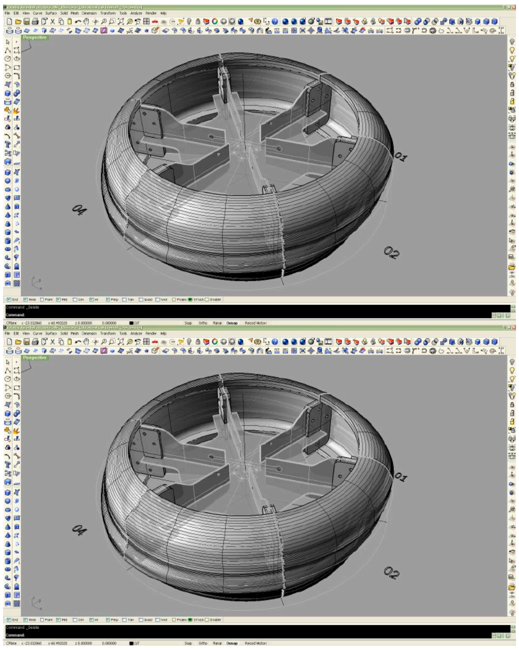

Fig. 2. *Profilograph (after Dürer).* The facial extrusions are wrapped into a closed loop and fabricated with laser-cut aluminum and 3D printed parts. The form is mounted to a motorized spindle.

Fig. 3. *Profilograph (after Dürer).* As the form spins, Dürer's original profiles morph between the six original faces.

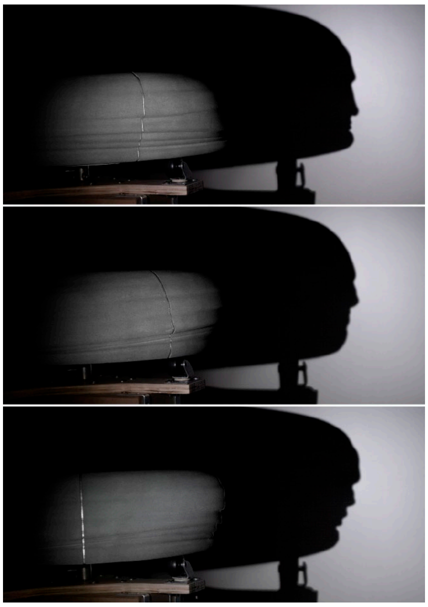

Fig. 4. *Profilograph (after Dürer).* The installed machine includes a light casting a shadow of the profile edge. The shadow is a 2-dimensional morphing of Dürer's original faces.

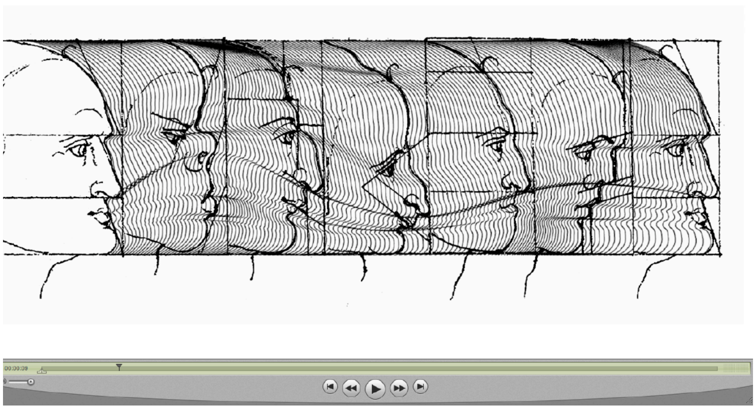

Fig. 5. *Profilograph (after Dürer)* — Video. URL: http://bit.ly/145wDNV.

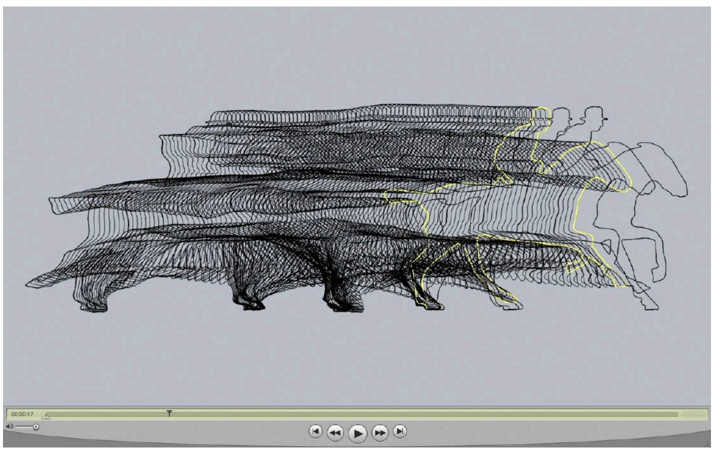

Fig. 6. *Profilograph (after Muybridge)* — Video. URL: http://bit.ly/Weumxw.

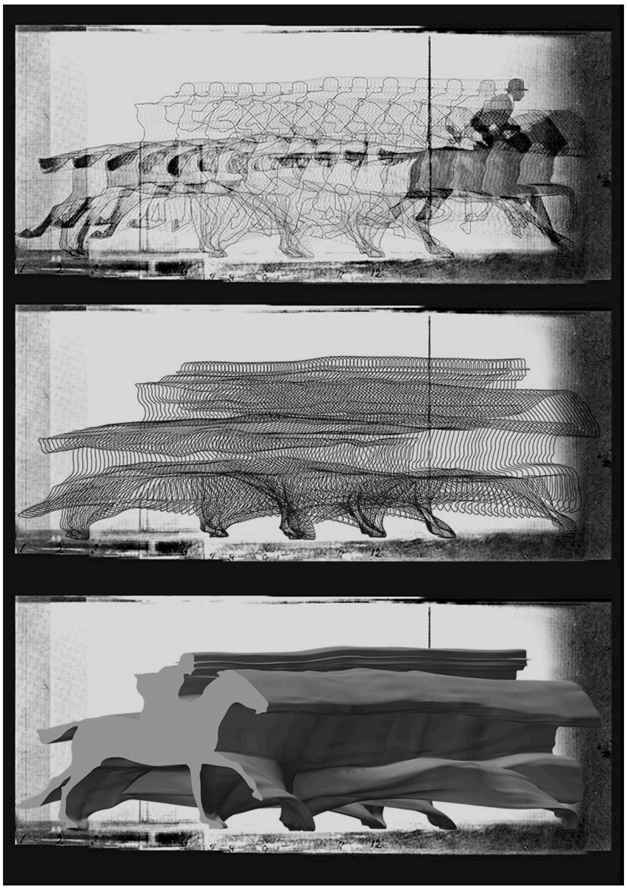

Fig. 7. Profilograph (after Muybridge). Muybridge's original photographic series is first compiled, then transformed through Profilography into a solid.

Fig. 8. Profilograph (after Muybridge). The digital model becomes 3D prints used directly in bronze investment casting. The bronze parts are welded together into a single form.

Fig. 9. *Profilograph (after Muybridge).* Finished bronze sculpture.

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Heimlichkeit des Berührens: Exploring the Correlation of Perception and Intimacy

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Keywords: Sound Installation, Intimacy, Skin-Based Interfaces, Haptic Interfaces.

Abstract: *Heimlichkeit des Berührens* is a sound installation that invites visitors to experience the intimacy of touch. A space is split into four separate areas, each of which is accessible to visitors in a way that seeing each other is inhibited, whereas in a centered invisible shared area touching is the only enabled form to communicate. The exploration, the contact and movements of touches, are captured by a specifically designed sound instrument (Müller-Rakow 2012). Below we briefly present the concept behind the practical work and outline setup and interaction methods of the installation.

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1. Introduction

Mostly it is the conscious model of human behavior that underlies the development and design of embodied interfaces to control (social) interaction. The diversity of expressions in human social interaction includes all human senses and always is conducted by unconscious actions.

In their introduction to the work *Room#81*, d'Alessandro et al. refer to the unconscious parts of communication e.g. small gestures as the "foundation for emotional commitment" (d'Alessandro et al. 2011). With *Heimlichkeit des Berührens* we firstly turn our and the visitor's attention to the sense of touch due to that fact that the sense (and act) of touch — in western philosophy — is the most intimate and exclusive perception in human interaction (Benthien 2002). On the other hand we address the sense of hearing with an individually assigned role for manipulating the sound in order to provoke and encourage the act of touch and additionally the experimentation with the correlations of intimacy, touch and sound.

With this interactive exhibit we seek to bridge the gap between the practice-based research in the field of interaction design for everyday life communication technologies, and arts with its potential for provocation, reflection and experimentation in order to excite personal intimate exploration.

The technical setup of the installation was presented before (Müller-Rakow 2012) and tries to be in line with outstanding works that advanced the development of skin-based instruments and installations (e.g. by Waisvisz 2004; Jaimovich 2011; Brinkmann[1]). However, the concept of the installation marks a new approach in our research bringing the exhibition context, the composition and its mapping into main focus.

1. http://www.daanbrinkmann.com (accessed 05-Jan-2013).

2. Concept

The installation consists of four perpendicularly arranged walls that split a room into four areas. Visitors can only access in a way that seeing each other is inhibited, whereas skin contact esthablishes the unique form to communicate in between each other in a common space that connects the four areas. Visitors — becoming participants — make nonverbal contact with each other and begin a tactile communication that redraws the line of interpersonal intimacy and privacy. How may one touch an unknown and invisible person, to what extend does the interaction feel pleasant to oneself, and how does the soundscape react to the manipulations of the electronically enhanced bodies?

Occurring within the shared space, contacted movements and gestures are captured by a specifically designed device that measures electrical resistance on the participant's skin. Their bodies act as a constituent of a specific electrical circuit. In doing so each affiliated participant assumes a specific role in the joint (invisible) performance. The action of one touching another, influences the sound synthesis by varying in intensity, the duration of contact and the movement speed.

The measured values are sent to a PC where the mapping and sound synthesis proceeds using MAX/MSP.

Fig. 1. A shared but invisible space for collaborative skin-based sound control.

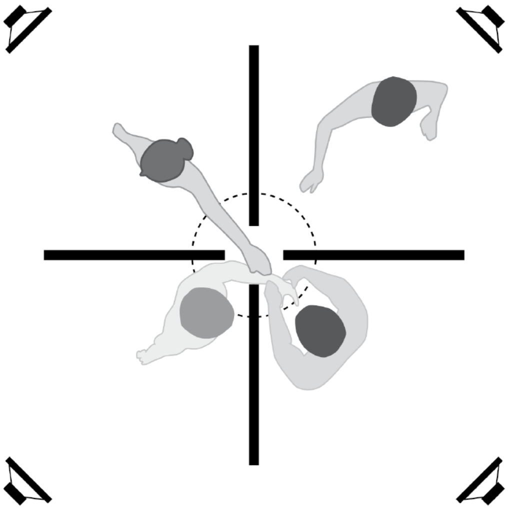

Fig. 2. Sketch of setup.

3. Equipment

The installation requires the following equipment: 4 walls (size 3 x 2 meter), 4 tripods, 4 loudspeakers and the central box, accessible from each of the 4 aereas, where the touching takes place. We would like to ask conference organizers to provide us with a separate, dark room, the tripods and the loudspeakers. Material, arrangement and alignment of the walls will be discussed individually.

4. Video Demonstration

Testing the mode of operation with a first prototype at XX: http://www.vimeo.com/37367946.

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Null By Morse: Performing Optical Communication with Smart Phones

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Keywords: Mobile Art, Morse, Optical Communication.

Abstract: *Null By Morse* is an installation artwork incorporating a military signaling lamp and smart phones. A number of Morse messages are transmitted automatically by the signal lamp. A custom app for iPhone and Android uses the phone camera to identify the changing light levels of the lamp and the associated timings. The app decodes the Morse and displays the message on the screen on top of the camera image. The messages are taken from the 19th C development and testing of Morse code and its subsequent use in the military and in transport. I discuss theoretical implications of the work by locating it in a rich, material history of optical and telegraphic communication.

1. Introduction

The use of signaling lamps marks only one installment in the varied material history of optical communication. This history is tightly bound with the development of strategic military coordination. The development of the optical telegraph for instance allowed Napoleon's army to manage logistical resources across the expanding French military conquests (Standage 1998). Meanwhile, the birth of Morse code is imbricated with both art history and American Civil War as Samuel Morse's failed ambitions as a salon painter re-diverted his career into that of an inventor at a time when the rumblings of war between the North and South encouraged financial support of his new communication medium (Standage 1998, Gere 2006).

Fig. 1. NBM Documentation, (http://www.flickr.com/photos/92328727@N03/sets/72157632547712877/).

2. Performing Historicity

Morse code as been employed in a variety of situations which have gone on to fame and notoriety. The invocation of the Old Testament in Samuel Morse's early public transmission 'What hath God wrought' dramatically foreshadowed later uses where Morse succeeded or failed to save lives. Its history is closely entwined with the cataclysmic failure of technologies. The infamous broadcast from the Titanic 'We have struck an iceberg, sinking' is perhaps the cardinal example where Morse code is employed as call to rescue after technological hubris helped to cause disaster.

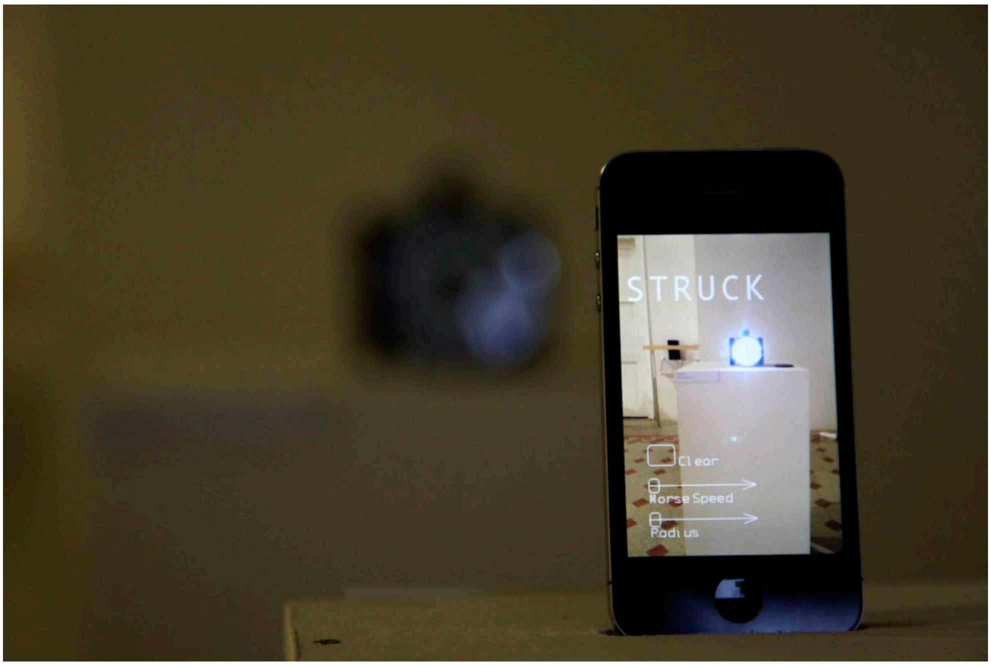

Fig. 2. The Null by Morse interface.

3. Dumb Phones

Morse code maintains an unusual and pervasive presence in civil and military histories. Its principle strength is that it can be transmitted in a variety of media (sound, light, radio, telegraph) and this lead to its early adoption in radio, which in turn allowed it to be transmitted to aircraft. The versatility which allows Morse to exist alongside more complex communication devices provokes questions as to what other 'side effect' technologies are being produced alongside mainstream products such as smart phones. Null By Morse reduces the wide array of interaction possibilities of smart phones to a 'dumb' minimum. By doing so it critiques the futurism implied by such high-tech devices and locates them in a rich material history of communication.

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The Lonely Tail

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Keywords: Internet, Aesthetics, Embodiment, Performance, Animation, Video Art, Cross-Discipline.

Abstract: *The Lonely Tail* is a four channel video installation that investigateshuman-computer interaction through experimental combinations of abject and glitch aesthetics. Each channel contains an animated digital collage and sound composition sourced from the user-generated content of specific web sites. Performative actions by the artist are then superimposed on the animation using chromakey. *The Lonely Tail* is an experiment in the performance of vicarious engagements that are experienced by Internet users who are frequently privy to other users documented experience of embodiment.

1. Introduction

Campbelltown Arts Centre in Sydney commissioned *The Lonely Tail* for the exhibition *There's a Hole in The Sky* in 2012, which examined themes of anxiety in daily life. *The Lonely Tail* was the result of an investigation into unease about the experience and representation of embodiment in an age of ubiquitous computer connectivity.

2. The Lonely Tail Methodology

Displayed originally as a four channel video installation, each screen depicted an animated digital collage and sound composition containing media sourced from the user-generated content of specific online communities dedicated to a particular physical experience that has been displaced into a cyberspatial context. Channel 1 (figure 1) examines dermal grooming and extractions with content sourced primarily from popthatzit.com and reddit.com/r/popping/. Channel 2 (figure 2) examines the popular body-building and exercise culture typified by /fit/ (a board of 4chan.org), Channel 3 (figure 3) is concerned with the proliferation of 'amateur' pornography and Channel 4 (figure 4) contains images and sound sourced from various food blogging sites. This content was chosen because it relates to the abject described by Julia Kristeva, as "*food loathing… a wound with blood and pus, or the sickly, acrid smell of sweat… these body fluids, this defilement, this shit…*" (Kristeva 1982, 2–3)

Each channel presents an image of superimposed performance actions by the artist that are related to the content of the animation. Using chromakey effects, the artist's body is replaced by a digital animation comprised of mediated and distorted images sourced from the online sites and communities mentioned above. The chromakey is done ineptly, so that evidence of a chromakey green costume and pixilation can be clearly seen. This misregistration is intended to make visible the media utilised and to prompt viewer distaste at a degraded style as much as revulsion towards the visibly abject content. This union between the abject and electronic glitch proposes the possibility of engaging with such Internet content as an immaterial "*ritual of defilement*" (Kristeva 63–64).

The notion of an immaterial ritual of defilement is significant because *The Lonely Tail* attempts to illustrate the kind of vicarious sensation that all notional bodies experience when transgressing physical, categorical distinctions between the viewer of the artwork, the online user, and the digital body depicted. Such ambiguous relations to the body in cyberspace challenge the assumption of the Internet as a disembodied environment. The union of the body as a pictorial depiction and process of embodiment as vicarious experience allies *The Lonely Tail* with Feminist criticism of conventional representation of the female body in cyberspace, most notably the work of N. Katheryn Hales (1999).

Fig. 1. Channel 1 Video Still (full video available: http://www.youtube.com/watch?v=x5nD51rkVrA)

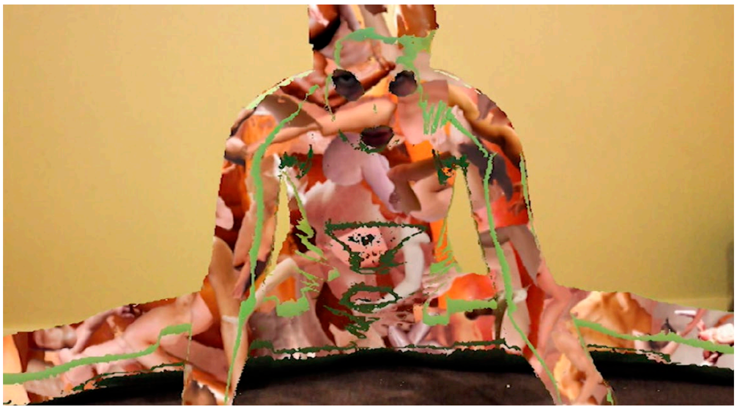

Fig. 2. Channel 2 Video Still (full video available: http://www.youtube.com/watch?v=jXvjCReHPQE)

Fig. 3. Channel 3 Video Still (full video available: http://www.youtube.com/watch?v=a0ERkC5ezYs)

Fig. 4. Channel 4 Video Still (full video available: http://www.youtube.com/watch?v=4pcMyftm3QY)

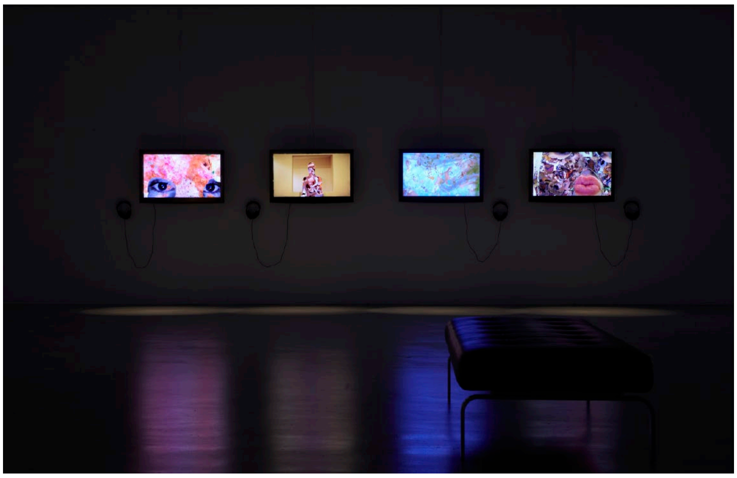

Fig. 5. The Lonely Tail installation documentation.

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Funkschatten: a Creative Collaboration Experience

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Keywords: Kazoosh!, Collaborative, Art, Installation, Sound, Visuals, Interactive, Urban, Landscapes.

Abstract: Creating a piece of art is a deeply personal process inspired by your surroundings, society and environment. However, collaborating with over 15 people from different backgrounds and only five days of preparation for an installation turned out to be a new challenge for most of us. In this report, we cover our approach from techniques for the creative process to organizing a workgroup.

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1. Introduction

In November 2012 the 16th annual CynetArt Festival was hosted in Dresden, Germany. The INTERNATIONAL FESTIVAL FOR COMPUTER BASED ART is a “recognised platform of digital culture” (CynetArt2012) and is funded by the Saxon State Ministry of Science and Art. For the first time, the CynetArt was organized to take place in different locations (i.e. festival halls, bars, clubs and on the streets) around the city of Dresden all at the same time. The KAZOOSH!–Team took the opportunity to participate for the second time in a row in this event. KAZOOSH! is a community of like-minded people with a drive to create awe inspiring installations, its members coming from very different backgrounds and thus bringing various kinds of expertise to the projects. Members of KAZOOSH! studied the fine arts, computer science or electronics, however the unique nature of this group is more complex and will be covered in depth in a future paper.

In this paper we describe the process, difficulties and the overall experience of designing an installation. First, we briefly explain the motivation behind KAZOOSH! and the installation. Second, we illustrate the circumstances and limitations of the location, the timeframe and our resources. The third section covers the process of creating the installation. The outcome is presented in the fourth chapter. We conclude with the results of the week, questions that were raised and the influence on our future work.

2. Impulse

2.1. Motivation

In November 2012 the KAZOOSH! group was given the opportunity to be a part of the CynetArt by realizing a completely new project in under one week. The main topic: *Funkschatten*, meaning the shadow area where radio transmissions are impossible, set our minds for the installation. Bringing together fine arts and new media in an installation in which the imperfections of the technical surroundings and the beauty of urban life would connect. The KAZOOSH! team was fascinated by the contrast of the digital and real world and wanted to blend these two worlds with their expertise in computer -based art, sound-installations and sculpturing. The creation process took place at the exhibition’s location, which made it possible for us to work out a spatial concept for the *Club64* (Club2012), a small bar in Dresden. The connection between a specific space, the different fields of expertise and the interdisciplinary context made it possible to create a world, which mixed up real and imaginary urban landscapes. The bizarre and subtle break between daily life and a possible second world behind that reality was displayed with different media. Electrical and mechanical systems met sensual materials, such as transparent paper. Cables and light seemed to blend into organic structures, contrasted by the geometrical forms of polygons (Fig. 1). Images and situations of everyday life were mixed with sounds to create a multisensory experience that lived on the verge of familiarity and strangeness.

2.2. Time

These ideas and the motivation behind them were dampened by the dense timeframe of less than a week. Starting the work on November, 10th and opening the installation to the public on the 15th of November overshadowed almost every part of the creation process. The short two day period of showcasing and cleaning out the location till the 17th was also part of the tight schedule. During this time not all of the KAZOOSH! members were able to take vacation days at work, which sometimes resulted in only a few attending hours per day. In addition to the temporal factor, the creative process of the group was further restricted by various limitations.

Fig. 1. Polygon structures.

Fig. 2. The rooms during construction.

2.3. Limitations

The "Club64" is a small bar with a worn down interior and a low ceiling. The team was given two of the three rooms to work with (Fig. 2). Throughout the exhibition the bartender would still serve drinks which had to be taken into consideration. The owner of the bar was cooperative but had strict rules about construction and prohibited any kind of drilling, gluing or bolting to the walls.

Further difficulties were materials and funding, yet through various channels the team raised a total of 450€. Most parts of the structures were built with recycled wood from previous installations and the CynetArt organizers provided additional lumber. Since the KAZOOSH! Team has currently neither storage space nor a permanent workspace, most materials especially wood were returned afterwards or donated to friends, artists and the WERK.STADT.LADEN (WSL2012). Overall, the few resources and limited timeframe liberated the creative power of the team and were considered a challenge, not a burden.

3. Process

The week started with a meeting to set up the organizational structure for the upcoming days. Keeping track of a group of 10 to 15 people, everybody with different assignments and personal schedules, is the key factor for a successful cooperation. Exchanging telephone numbers, scheduling a rough timetable or clarifying transportation can be time-consuming at first but enhances efficiency during the project week. Furthermore, voting for a contact person and/or spokesman on behalf of the entire group is often needed and makes communication with other teams or, in our case, the administration of the CynetArt easier. Actual work started on the second day, with a session in which every member of the team pitched in three ideas for the installation. This way, we gathered everything from technologies and materials to feelings and moods, we wanted to convey with the installation. Based on these various topics, we established five working-groups of two to four people. The groups were called: 'sounds&mechanics', 'projection', 'origami', 'sculpturing&construction' and 'video' and consisted mostly of members with a lot of expertise in that field. In contrast to the usual goal of a workshop, where participants are introduced to a concept to broaden their skills or mindset, this project facilitated personal growth for every member of the team by leveraging their abilities. Within each group, we brainstormed (Fig. 3) for more detailed concepts on how to combine hardware, interaction concepts and new media to illustrate the gap between the digital and urban world.

Fig. 3. Brainstorming.

Fig. 4. Group meeting.

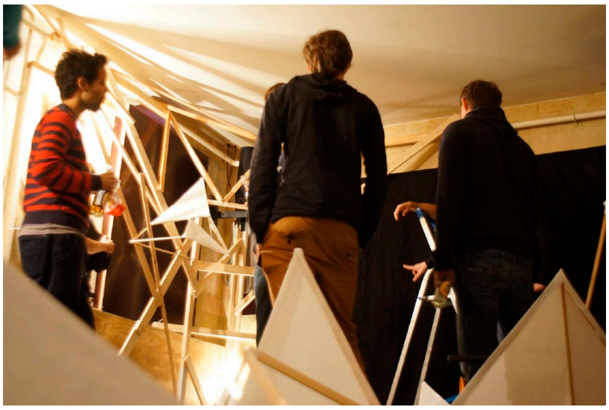

Fig. 5. Final construction.

To make sure the final installation would still be a coherent concept, we set up two 1-hour meetings (Fig.4) and a few presentations, bringing together the working results of all the groups. Every meeting was attended by at least one representative from each group to facilitate meaningful decisions while still allowing for flexible scheduling. Naturally, some groups were more connected from the beginning, and needed to work closely together throughout the entire week. For example, the construction and the projection group had to find a material which was easy to sculpt and could still be used as a projection screen, while being illuminated from behind. Such material tests and early prototypes began during the third and fourth day. The last days of the process were surprisingly well organized due to the compartmentalization of tasks, as responsibilities were distributed among every member of the team (Fig. 5). All this previous planning, continuous feedback and every meeting throughout the week helped to finalize the installation in the end.

4. Final Stage

The resulting installation consisted of two worlds and the question about the foreign in between the usual. We tried to connect reality and fiction in our concept inside the *Club64* by working with new media as well as custom software and hardware solutions: The room, which was used as a bar during the exhibition, was the border between the well-known and the subtlety of the alien within. The video above the bar showed feet of passengers in everyday live with the difference that these feet walked on the height of the visitors' heads. Additionally, we transformed reality into something foreign as the sounds of the city resonated quietly from the seats. Small piezo-discs transmitted the sound waves to the wood of the seats. The visitors sitting there had the chance to individually hear that sound. A sound, which is so common and omnipresent in our lives, that we usually would not notice it.

The interactive polygon (Fig. 6) in a sidearm of this room was one of many paper-shaped sculptures. As it was touched an alarm activated a projection where digital life forms fled from the sculpture as if they were flushed out of their nest.

Fig. 6. Interactive polygon.

Fig. 7. Large sculpture.

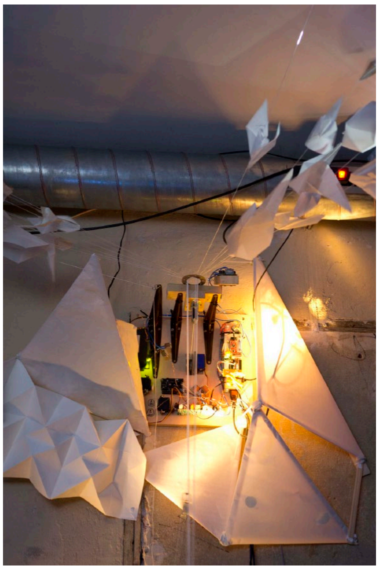

Fig. 8. Visible electronics.

Fig. 9. Moving origami structures.

The second room was one coherent installation. A large polygon structure grew from the edges into the room (Fig. 7). The construction of wooden slats was covered by different types of paper, which formed the background of a multisensory projection reacting to the audiences' movements. The forms of the sculptures represented abstract cities and were lit from inside, referring to the luminance of real cities. Furthermore, this installation combined movements of mechanical objects and virtual projection. Paper, changing LED-lights and the analog sounds caused by electric motors formed a hybrid atmosphere. The aim was not to hide the technical background but to make it part of the final product (Fig. 8). Cables, motors and pulleys were noticeable inside the polygons and added their sound to the digitally produced atmospheric tunes. The electronics moved the origami-structures throughout the room creating an impression of living processes (Fig. 9). Artificial sounds coupled with the movement and the semi-technical appearance caused associations with natural organisms.

5. On our way

During the week the process of working as a team (Fig. 10) of different people was a central aspect of the installation. Structures within the group, decision making and communication are as important as the final product. The symbiosis of analog and digital ideas and media are the common ground of the exhibition and the principles of KAZOOSH!. Different people, broad interests and a specific location define the way we work. The installation as such was finished within one week but the outcome for KAZOOSH! were the experiences and inspirations we took home. We think of this piece of art as one step of a developing process which sparked new ideas and fields of interest in each member of the group.

Fig. 10. Final installation with several members of the KAZOOSH!-Team.

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The Robot Quartet: a Drawing Installation

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Keywords: Robots, Generative Art, Drawing Machines.

Abstract: The Robot Quartet — a group of four robots receive identical instructions and jointly draw a repetitive pattern. This project investigates the relation between an abstract idea and its physical manifestation, and explores the poetry of this divide — an aesthetic space that lies beyond human control over machine.

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1. Introduction

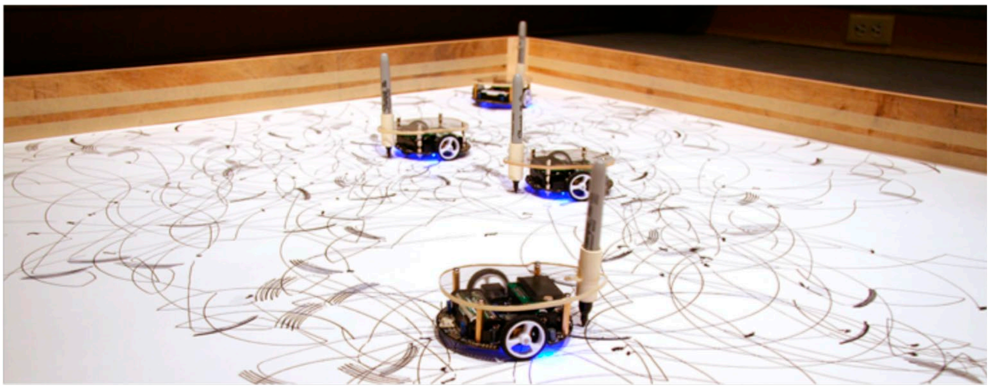

Fig. 1. The Robot Quartet at work.

The robot quartet — four drawing robots, equipped with identical repetitive instructions, start with symmetrical motions. Their drawing gets increasingly distorted by mechanical imperfections. The project is situated between Kinetic- and Generative Computer Art (Galanter); inspirations go back to Jean Tinguely's drawing machines (Tinguely). Being a reflection on properties of a mechanic system as a form-giving principle, the piece embraces imperfections, rather than eliminating them. Repetitive software patterns, as well as seemingly organic traces of mechanic deviations, generate an aesthetic between analog and digital.

The author hopes to argue for a beneficial role of inaccuracies in robotics. While technology may become increasingly precise, the work hopes to trigger reflections on how to embrace imprecision.

2. Description of the system

Four slightly adapted, identical Pololu 3pi robots steer freely in all directions with two independent motors. Initially synchronized, with inexact motions they follow an exactly timed choreography. As physical machines, they do not only move back and forth, but draw from a repertoire of straight and curvy lines, scribbles and zigzag-shapes, and perform rattling and wiggling motions, thus balancing considerations between visual output and dynamics of the robots.

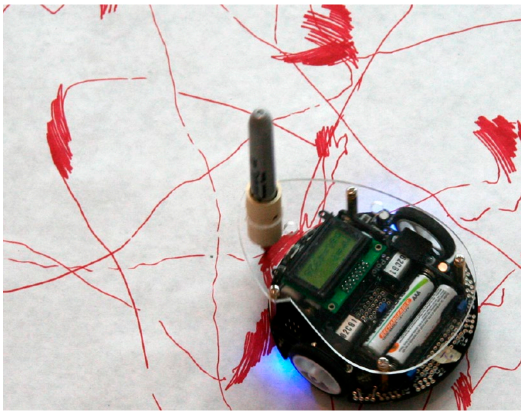

Fig. 2. Repetitive vs. organic lines.

Fig. 3. Detail: composition.

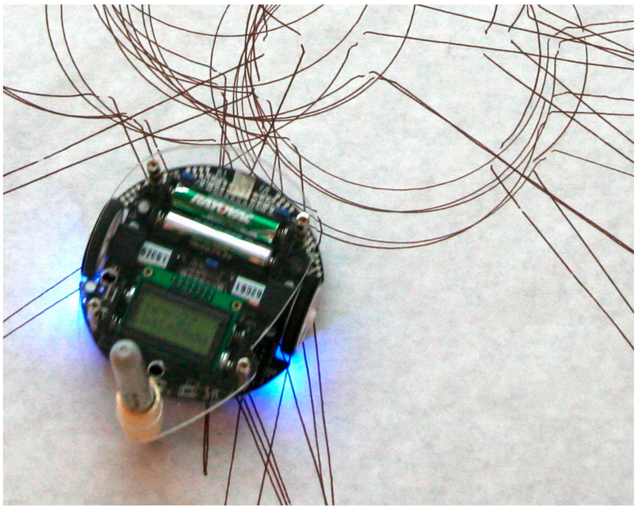

Fig. 4. Replicating the same figure.

3. Documentation

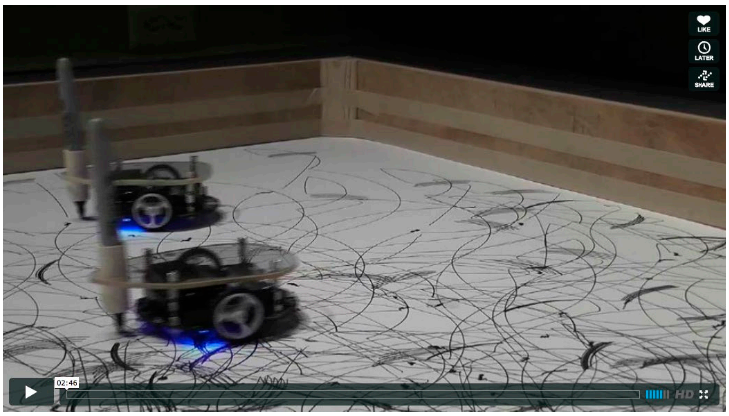

Fig 5. Documentation Video on http://vimeo.com/55805990.

Fig 6. Robot Drawing *Farewell to Canada*. Patterns of different line-qualities can be read as dancing figures, heart-shapes or falling leaves

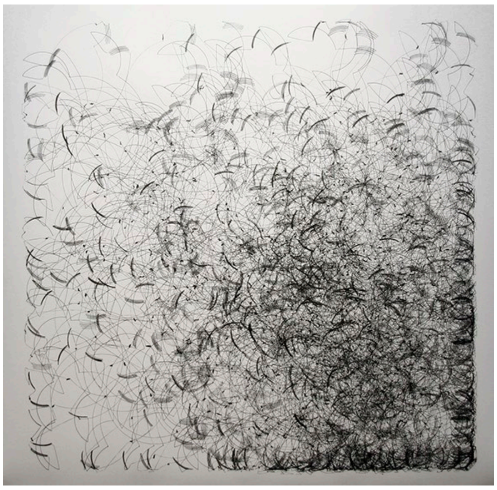

Fig 7. This drawing, *Composition 1.1* consists of different curves. The irregular density emerged independently of the algorithm.

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Geometries of Flight

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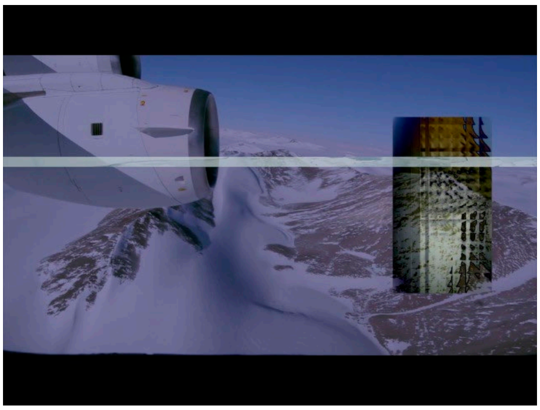
Keywords: Audio-Visual, Remix, Hybridity, Nodalism, Video, Visual Music.

Abstract: *Geometries of Flight* is an audiovisual work created by the authors in 2013. Adkins was commissioned by Tobias Fischer to contribute to a publication centred on the work of Kenneth Kirschner. The brief for the project was to use any of Kirschner's compositions as the starting point for a remix. All of the sound artists commissioned were given free reign to use his work in any way with no restriction on length or media. The resulting audio piece *For Kenneth Kirschner* utilizes five short samples taken from Kirschner's *10 July, 2012*. In response to the composition and its concept of remixing/sampling, d'Escriván created a video utilizing found footage. The intention was to concentrate on form and the reshaping of materials — drawing out the epic, frozen qualities of the harmonic and gestural content. The authors propose that their use of these materials goes beyond the accepted notion of the 'remix' and is an example of nodal practice. In *Geometries of Flight* it is the 'process' and reframing of the original material that is the most important factor in determining the identity of the new work rather than the embedding of 'samples' as referential units. In such works, material, concepts, and ideas are assimilated into the very fabric of the new work rather than merely weaving quotations into the surface level of the work.

Video: Julio d'Escriván
Sound: Monty Adkins
2013, 21′14″



A Bridge From Nowhere (8'44")

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Keywords: Electroacoustic Music, John Cage, Clarinet, Quadraphonic, Use of Space, MaxMSP.

Abstract: *A bridge from nowhere* is an electroacoustic work written for clarinet and quadraphonic electronics. It is a tribute to John Cage's music and philosophy.

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1. Introduction

John Cage is a revolutionary figure for music of all time.

A bridge from nowhere is inspired by his masterpiece *Lecture on nothing*, a brilliant musical prose composed in the '50s. It is written with the same rhythmic structure used in his compositions, such as, for example, Sonatas and Interludes.

The basic idea is that

> a structure is like a bridge from nowhere to nowhere and anyone may go on it: noises or tones, corn or wheat. Does it matter which? (...) We really do need a structure, so we can see we are nowhere. (J. Cage, *Lecture on nothing*, 1959)

The structure of the piece evokes the text of Cage in its division into five sections. This is made clear from the stolid fragment that, as in the prose, is repeated at the beginning of each section and also from the apparent 'randomness' of every musical gesture. The central section is *the bridge* that brings together the whole composition, which ends with a new beginning, like *a bridge to nowhere*.

The composition is quadraphonic, and the acoustic sounds of the clarinet are opposing the electronic noises, sometimes reworking of monodic characteristic timbre of the instrument, sometimes totally synthetic.

2. Algorithms and strategies

Most of the sounds are coming from clarinet and are acquired ad hoc on the basis of the composition's purposes.

Each sound is subjected to various editing processes, especially warping, shuffling, convolutions, delays. All the processes I've used are related to my idea of composition: I'd like to have an apparently random content into a defined structure, given by the prose.

I formed complex sounds without any harmonic relationship. Changing the envelope of each sound, I meant that synthetic sounds have a typical profile of the sampled clarinet sound and clarinet loses its shape to conquer another one.

Many of the sound events are severely distorted, or deprived of their transitional attack, to create events more or less prolonged with an attack transient artificially slow. On some of these I applied a new transitional character, quick and impulsive, using the spectrum of the resonance area, commonly less rich in harmonics.

I used other editing processes to create events for which the original material is used as a modulating vocoding algorithm of spectra as rich as square waves and triangular ones, to enrich the sonic palette of timbres and the synthesis possibilities.

The continuous bands that characterize the central section are constructed from pink noise, with an excess of power for the low frequencies, molded with the convolution of other waveforms, especially clarinet events.

I used a delay in multiple sections, also with feedback, with the possibility to modulate or maintain constant the delay time.

Clarinet and electroacoustic scores took place simultaneously, evaluating new performance practice for the clarinet, while respecting the structural features of this instrument. Every gesture of the clarinet is a *bridge* between the traditional writing and a new form of sound.

2.1. Space

Space is not mainly focusing on the forward axis, but tends rather to a wide distribution of the composition, also with moments of prevalence of exclusive zone or with obvious sudden contrasts.

I used MaxMSP to create an algorithm that allows me to manage the mapping of each sound event by creating random trajectories and rotations.

The space of the live clarinet, instead, is limited to the front stereo external to quadraphonic.

2.1.1. Spatial description/Diagram for the performance

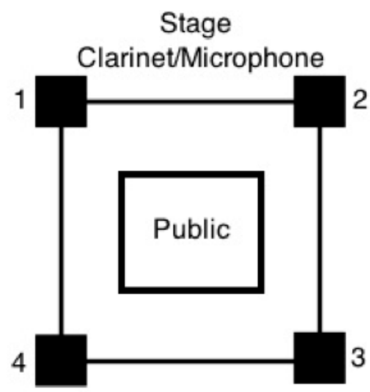

Fig. 1. Diagram for the performance (1, 2, 3, 4 speakers).

Impetus Cascading Chaos

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Keywords: Iteration, Intuition.

Abstract: When working with computer generated sound I have the past couple of years been very interested in exploring waveforms created through iteration of mathematical algorithms such as it is done within chaos and fractals.

Chaos has over the past century become a vast topic within mathematics, so I will in this context simplify the notion of chaos to a time function system with orbits which has a sensitive dependence on the initial condition and when mapped to waveforms produce waveforms of a very high or infinite period.

Till now I have just looked at a few things within that field. Iterating a 'simple' transcendental function like e.g. k*sin(x) already has chaotic properties for most values of k. I looked at several maps which in some ways are extensions of this fact — Standard/Chirikov — Henon — Ikeda — CurlicueFractal. There will be an almost endless possibility to design new algorithms out of this basis.

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1. Impetus

The particular work, which will be presented at xCoAx2013, is based on an algorithm twisting the Standard map to something surely different, and then cascading versions of it to look for something one could call 'harmonically related chaotic and high-period orbits… ' Also the notion of cascading chaotic systems has many aspects to it and offer of course many diverse possibilities to be explored further in the future. This particular work is done in MaxMsp.

My concept for including voice alongside with these autonomous and happily unpredictable algorithms has been to use the intuition of the voice, the physical action which comes before thought. After all the human body, being nature in some sense, is acting as the most sophisticated calculator and possibly beyond that. Very importantly the intuitive possibilities of the human mind-body has always been a central topic for me, and from I first started working with computer-music the relation between mind-intuition and computer has been a root question. Recently I listened to an interview with physicist Russell Targ who has been a part of the US military program for 'remote viewing'. An espionage program which aimed at a systematic development of extrasensory perception, ESP. Targ has recently written an iPhone application with which one can train ESP. The idea is that the mind can be trained to fathom the outcome of the pseudo random algorithm in an instant. Targ very much expressed some possibilities which are of great interest to me when working with chaotic algorithms…

Back to Impetus — in order to make the details of the piece unpredictable for the rational mind the interaction between calculation-flow and human is done by letting the person decide on the moments of change from one phase of the piece to the next. Since we are in a realm of 'sensitive dependence of initial condition' it will create different paths to initiate this change just 1 sample sooner or later.

Along the way I have as well looked at a few algebraic algorithms like the Mandelbrot set and the wide notion of Möbius transformations which with suitable parameters can produce chaotic orbits. Here I have till now spent most time with the Mandelbrot set. (MaxMSP-patch can be found at http://antidelusionmechanism.org/vilbjorg.html) — spending days on end slowly scrolling towards to boundary in many different places has been an universal sound- and space-travel in the infinitesimal. When arriving from the 'outside' one gets an almost physical feel for what number precision means. When approaching 'the boundary' it takes still more iterations before the point escapes/blows up. It can sound periodic but then suddenly after ever so many million iterations the point escapes and proves that the waveform produced never was completely periodic — it seems like the boundary itself is wrapped in infinity — that is the fractal one must agree.

How much chaos can a computer in theory generate from a chaotic map? — here is one simple way to look at it: due to finite bit-rate the period will be finite, but the period might be longer than the concert, even much longer than your life. One could think about an algorithm that in continuous form would produce *absolute chaos* = infinite period if dealing with some ideal infinite number-precision. When iterating at every sample by 44.1 kHz sample rate and working in 64 bits then the maximum possible period (with maximum rounding luck) could simply be considered to be 2^64 samples (if you return to exactly same number-value you start over) which is about = 1.84467441e19 which very roughly corresponds to 1.16e10 hours or 1.3 million years. My computer and I will most likely not be there at the end that 'ultimate' period… And I mostly do not iterate at every sample, so that I can hear whats going on, I do a minimum iteration-period of 2 samples and often much larger to fully enjoy the waveforms — in 32 bits the same calculation goes to roughly 27 hours, quite a difference! — in 128 bits the time-span goes somewhat beyond my imagination.

Something which looks to me to be standing central today — when working with algorithms and computers — is the interplay between the mathematical idea on the one side and the computation on the other. I keep remembering Benoit Mandelbrot telling about the moments (1980) when he and a programmer from IBM saw the first prints of the Mandelbrot set. They thought something had gone very wrong, they just did not believe what they saw. No one had ever been able (or had the time in one life) to do those calculations and no one had previously seen those rich — one could be lured to say non-linear — consequences of mathematics. I believe this is a true paradigm shift — the more I look into the various fields of mathematics the more it becomes clear that centuries of excellent mathematical ideas still need to be explored in computational arts. Most is at this moment undone. Out of such material we will perhaps see a bridge being enforced between artistic and scientific practices.

Improvising With Self-Observing Systems: a Duet For Cellist and Adaptive Delay Network

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Keywords: Adaptive Systems, Live Algorithms, Computational Creativity, Feedback.

Abstract: Feedback is a fundamental organising principle of living systems, adaptive systems and creative activity. This is an obvious point of fact, but a rich and inspiring point of departure for activity at the intersection of computation, communication and aesthetics. The proposed performance is an improvisation for cellist and an adaptive circular delay network coupled via acoustic feedback in the concert hall environment.

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1. Introduction

I am interested in the cross-talk between analogue and digital sound in live performance and the mediation of this conversation with adaptive systems. Systems theory taught us to think above and beyond the specifics of any particular media and highlights certain organisational principles which can be observed in biology and instantiated in silico. From this systemic perspective, the design of Live Algorithms (Blackwell et al, 2012) for musical improvisation — software capable of sustaining a responsive and inspiring live conversation — starts from the conception of the human performer and performance software as two adaptive systems coupled via a shared acoustic environment (cf Di Scipio's 'composing interactions', Di Scipio, 2003).

2. Improvisation for cello and adaptive feedback circuits

ISOS (Improvising with Self-Observing Systems) is an ongoing project exploring the performance possibilities for a human improviser and self-observing digital systems. The performance system builds upon some earlier experiments with self-controlling feedback circuits[1]. These experiments were driven by an interest in eco-systemic principles (McCormack et al, 2009) as powerful metaphors for the design of generative and interactive systems.

The system is based on a circular network of delay lines as shown in Fig.1. A similar set up has been explored previously (e.g. Burns, 2003). In this case however, the delay units are adaptive: rather than peak limiting via compression or even non-linear waveshaping (ibid), each unit contains a watt-governor style spring model which alters the length of the delay line if the input amplitude exceeds a pre-specified limit. This creates a basic homeostatic mechanism (Ashby, 1952) whereby the positive feedback created by the Larsen effect is stabilised by the adaptive delay mechanism.

1. http://www.ecila.org/ecila_files/content/academic_files/project_files/selfdirectingFeedback.html

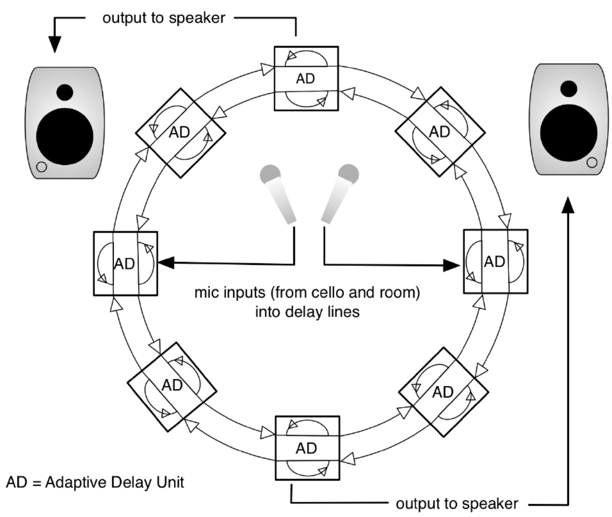

Fig. 1. Schematic of the performance software: Eight digital delay lines are connected in a bi-directional circular fashion and fed by two microphones. Two outputs are fed to a stereo PA. The network induces a Larsen effect which is fed and perturbed by the performer. The circular set up of delay lines and adaption of delay times creates an unpredictable yet coherent response and reinterpretation of the cellists' input.

The sonic complexities arising from the circular delay network and the adaptive behaviour of the self-observing delay modules create a dynamic environment which at once reacts to and provokes the human improvisor, creating a beguiling digital-analogue coupling between human and machine.

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Drive Mind

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Keywords: Media Art, Sound Art, Electro Acoustic, Sound Sculpture, Sonification, Tangible Interface, Max/MSP/Jitter, Noise, LED, Performance, Refraction of Light.

Abstract: *Drive Mind* is a unique electro acoustic system that provides audiences with a new sonic experience produced by the refraction of light. The main feature of *Drive Mind* is to visualize abstract figures of sound by a ray of LED light, and to manipulate sound by the refraction of this light. To ease recognition and understanding by the audience, the performer manipulates the acrylic objects physically, and the system produces the sound with this manipulation data, which was generated through well-understood physical phenomena. In this way, an audience will have a full sonic and visual experience filtered through their own imaginations.

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1. Introduction

Advances in computing have led to achievements in complex virtualization. Also, with the development of peripheral devices, such as touch panel screens and remote controllers, it has become easy for anyone to have a 'virtual experience'. These tools are actively utilized in the field of media art.

2. Aim

Advances in virtualization have not been able to eliminate the incongruity of one's tactile experience. For example, when a user is using gestures while performing an operation with motion graphics, ideally the user should feel the weight of the operation, not only the air resistance. Also, most of the data for the operation is in reality invisible. Therefore, the user would be unaware of the method working 'behind the scenes'. Because of these problems, an audience has difficulty empathizing with the performer or system and does not have a full experience expanded by the audience's own imaginations. To overcome these difficulties I have developed an electro-acoustic system named *Drive Mind*.

3. Approach and Implementation

A ray of LED light visualizes the manipulation data. This ray of light is a metaphor for a stream of sound. The system is manipulated physically through acrylic objects. The ray of light is projected onto a panel and the camera shoots an image onto that panel. The input to this system is an image taken with a Web camera. When the acrylic objects move, the ray of light gets refracted; in effect, the position of the light on the panel changes. The moving light on the panel is tracked by an application called *Max/MSP/Jitter* and produces positional information. This positional information is converted to MIDI information, which is used to produce a variety of sounds generated by a software synthesizer called Reason.

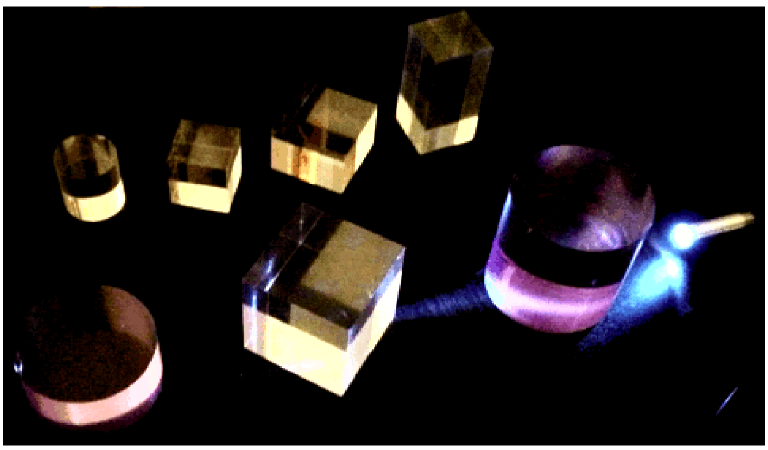

Fig. 1. An LED light and acrylic objects.

4. Media Assets

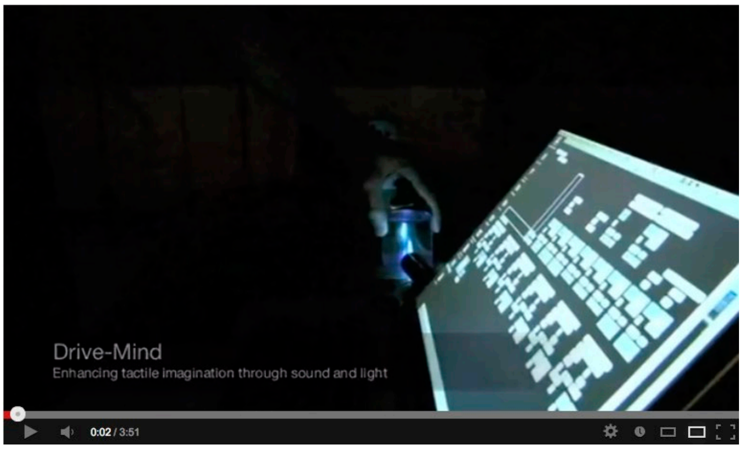

Fig. 2. A video asset (http://www.youtube.com/watch?v=iyS3WUbAQD8).

Acknowledgements: I would like to give special thanks to Dr. Yuta Uozumi and Tomoko Nakai for their creative advice. I would also like to thank Paul Brocklebank and Dr. Akemi Iida for proofreading this paper.

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Decomposing Electric Brain Potentials for Audification on a Matrix of Speakers

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Keywords: Audification, Electric Brain Potentials, Independent Component Analysis.

Abstract: Audifications of electric brain potentials suffer from the fact that each scalp electrode records a mixture of signals from all neural generators plus muscle artifacts resulting in a opaque and noisy rendition. We apply a recently developed computational technique to separate source signals from the recorded mixtures. These sources are then edited individually and spatialized in a matrix of speakers. The result is a clearer and more transparent audification of electric brain activity.

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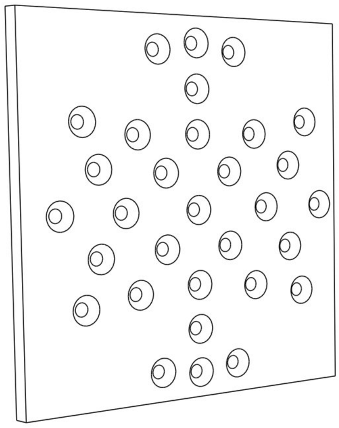
For at least a half century, musicians and sound designers have used audifications of electric brain potentials to perceptualize the functioning of the human brain (e.g., Lucier, 1965; Klein, 2001, 2004; Dean, White, Worall, 2004). However, presenting brain signals in a transparent and appealing manner has proven to be a challenge. One factor contributing to this is the volume conduction in neural tissue, cerebral spinal fluid, the skull, and skin: signals of the various neural generators are transmitted to all electrodes on the scalp such that each electrode records a mixture of all source signals. This poses various problems for audifications: Since the source signals are not separated, it is not possible to edit them individually and to spatialize them freely. The result is an obscured rendition of the signal in which potentially interesting components mask each other. Parameter mapping sonification circumvents this problem by extracting features from the raw signal that are used to control parameters of a sound generator. While this approach produces intriguing results (e.g., Monro, 2004; Potard, Schiemer, 2004; Rangel, 2012), it forgoes the authenticity and immediacy sought by audifications. The present work addresses this problem using a computational technique that has recently been introduced in neuroscience: independent component analysis (ICA) identifies source signals in mixtures heuristically by assuming certain statistical properties of the sources: minimal mutual information (Bell & Sejnowski, 1995) or non-Gaussianity (Hyvärinen & Oja, 2000). In previous work, ICA has successfully been used to separate muscle artifacts such as those generated by eye movements from brain signals (Jung et al., 2000). In the present work, we use ICA to separate source signals from the mixtures recorded at 30 scalp electrodes. The 30 sources obtained from this procedures are individually edited for clarity and presented using a multi-speaker audio system. The result is a transparent and revealing, yet faithful rendition of the recorded brain signals.

Methods and Materials

The EEG signals were acquired in a psycholinguistic experiment that studied human language processing (von der Malsburg et al., 2013). In each recording session, a participant read 360 sentences with varying grammatical structures. The signals were recorded in a shielded chamber at 30 scalp sites following an extension of the 10-20 electrode layout. The sampling rate was 512 Hz. The recording sessions lasted about an hour. BrainVision Analyzer 2 (Brain Products GmbH, Munich) was used to band-pass filter the raw data and to conduct independent component analysis. The source signals recovered by ICA were then further edited using the Soundhack software by Tom Erbe.

Sound projection

Our demo will be presented using a custom made 120cm x 120cm sound module on which 30 speakers are arranged in the layout of the electrodes on the scalp (see figure). Each source signal will be assigned to the position where it was most active. The spatial arrangement of the sources will therefore resemble their distribution during the experiment while preserving a clear separability of the signals. Audio samples can be found here: http://sinuous.de/soundpanel.html.



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Câmara Neuronal: a Neuro/Visual/Audio Performance

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Keywords: Digital Performance, Brain, EEG, Music, Digital Art, Body.

Abstract: *Câmara Neuronal* is a neuro, audio-visual performance. In this project the movement/physical interpretation, as well as mental and sensory interpretation of the performer, are translated, in real time, into sound and visual compositions within an immersive projection environment.

1. Introduction

Câmara Neuronal is a neuro, audio, visual performance unfolding around the character of the Adolfo Luxúria Canibal, a Portuguese poet and performing artist. In this piece, the movement and physical interpretation, as well as mental state of the performer, are translated into sound and visual compositions within an immersive projection environment, in real time.

Fig. 1. Public presentation of *Câmara Neuronal* at Guimarães European Capital of Culture 2012.

One of the most innovative aspects explored in this project is the close link between the narrative and emotional aspects of the performer, achieved through a neural-physiological signal recording device, Electroencephalogram (EEG) in synchronization with the visual and sound aesthetics. The EEG helmet, from Emotiv Inc, adorned with cables that connect to the ceiling evoke a “brain connection” to the system. The helmet signals are transmitted via wireless to a software trained specifically to the mental states of the artist Adolfo Lúxuria Canibal. The heartbeat of the performer is also acquired in real-time during the performance.

2. Project Development and Performance

The performance, with the duration of 45 minutes, involves a single character on the stage, with his body connected to the visual and audio system. The connections include one EEG helmet, from Emotiv Inc with 16 electrodes and 1 Polar Inc device for heart rate measurement. The body movement is captured through a Microsoft Kinect 3D depth camera. The heat rate is transformed into image and sound by beat detection and transmitted through open sound control protocol. The EEG Emotive system provides a neural network software to train the detection of specific mental states. Through a set of rehearsals the EEG Emotive neural network was trained to respond to a set of mental states of the performer.

3. Challenges behind physiological performances

Through out the piece, there are several moments where the visuals react to the intensity of the neural recordings. While the piece was created and adjusted through a series of approximations and trials conducted during rehearsal, in a real performance the readings from the EEG are necessarily different, as many factors, including the levels of anxiety, stress, concentration, focus, contribute to changes of the performer's mental state and the EEG readings. The graphical and sound design that was done for a set of signal intensity might work differently from what was originally intended when the intensity of those readings change. So that might cause a change in respect to the aesthetics of the piece and add an "unknown" variable to what the public will see as a final outcome.

Ways that we dealt with that was to rehearse with the performer just a few minutes before the show started, for one.

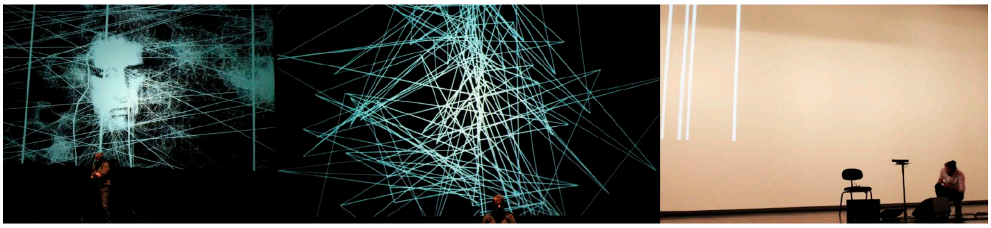
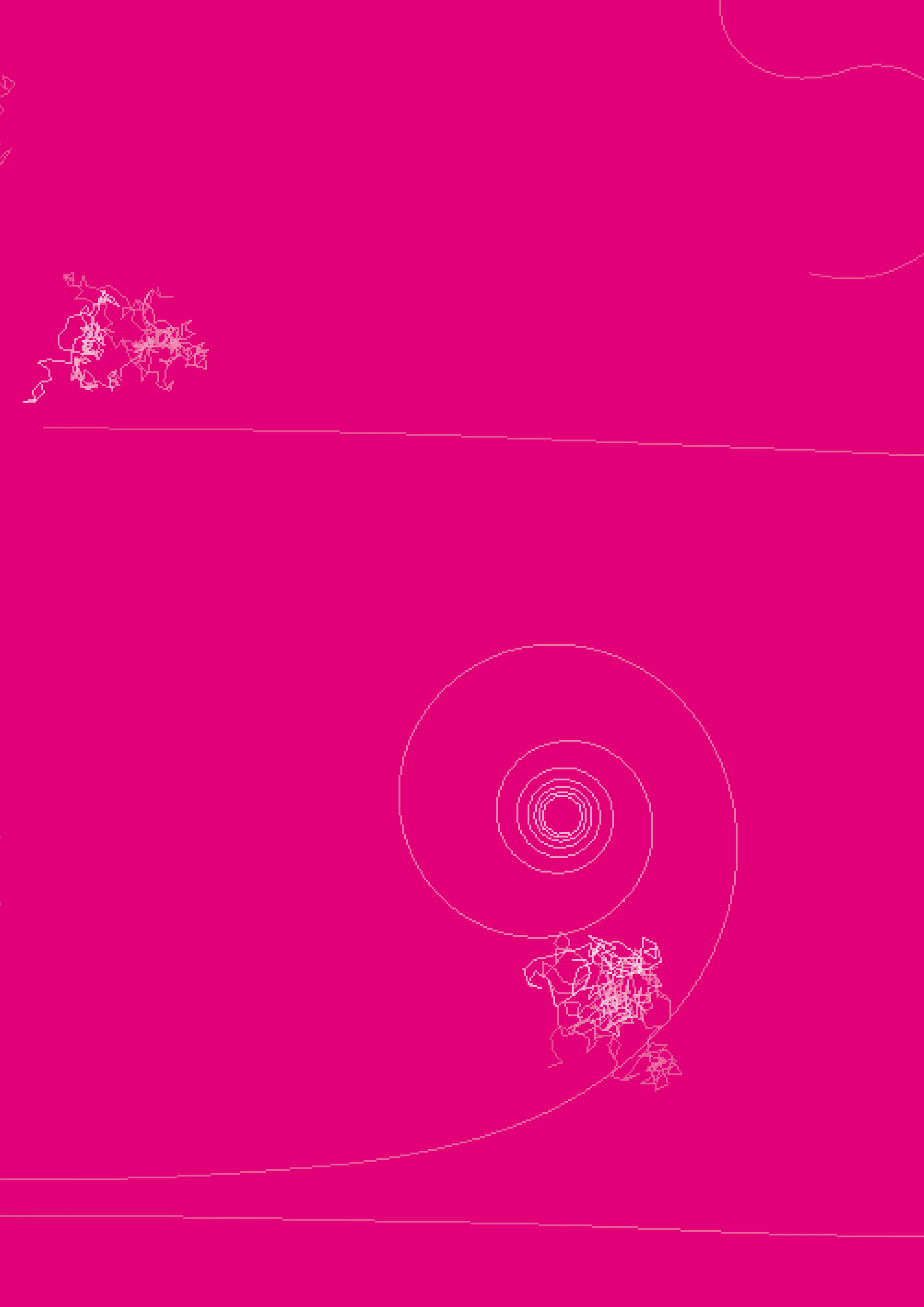


Fig. 2. Presentation and stage tests of *Câmara Neuronal* at Theatro Circo, Braga, 2013.

4. Relevant media assets

Access to relevant media assets about this artwork at:
http://camara-neuronal.jmartinho.net

Acknowledgements: Centro de Computação Gráfica, Guimarães European Capital of Culture 2012, Rádio Universitária do Minho.



Keynote

Post Digital Publishing, Hybrid and Processual Objects in Print

Alessandro Ludovico
Neural / Academy of Art Carrara

The influence of digital on publishing has reached a preponderant level, questioning the very core of the practice. But more than speeding up a much touted "definitive transition" from traditional to fully digital publishing (still to be accomplished on mass) there are various practices which are pervading the timeless stoicism of the printed page with calculated processes, transforming it into something new. This had lead to the creation of "hybrids" which can be considered as new types of publications with the potential for having both physical and digital qualities, and which are helping to pave the way towards more complex and less predictable transitions.

1. How a medium becomes digital (and how publishing did)

For every major medium we can recognize at least three stages in the transition from analogue to digital, in both production and consumption of content.

The first stage concerns the digitalization of production. It is characterized by software beginning to replace analogue and chemical/mechanical processes. These processes are first abstracted, then simulated, and then restructured to work using purely digital coordinates and means of production. They become sublimated into the new digital landscape. This started to happen with print at the end of seventies with the first experiments with computers and networks and continued into the eighties with so-called "Desktop Publishing", which used hardware and software to digitalize the print production (the "pre-press"), a system perfected in the early nineties.

The second stage involves the establishment of standards for the digital version of a medium and the creation of purely digital products. Code becomes standardized, encapsulating content in autonomous structures, which are universally interpreted across operating systems, devices and platforms. This is a definitive evolution of the standards meant for production purposes (consider Postscript, for example) into standalone standards (here the PDF is an appropriate example, enabling digital "printed-like" products), that can be defined as a sub-medium, intended to delivering content within certain specific digital constraints.

The third stage is the creation of an economy around the newly created standards, including digital devices and digital stores. One of the very first attempts to do this came from Sony in 1991, who tried to market the Sony Data Discman as an "Electronic Book Player" [1] — unfortunately using closed coding which failed to become broadly accepted. Nowadays the mass production of devices like the Amazon Kindle, the Nook, the Kobo, and the iPad — and the flourishing of their respective online stores — has clearly accomplished this task. These online stores are selling thousands of e-book titles, confirming that we have already entered this stage.

2. The processual print as the industry perceives it (entertainment)

Not only are digitalization processes yet to kill off traditional print, but they have also initiated a redefinition of its role in the mediascape. If print increasingly becomes a valuable or collectable commodity and digital publishing also continues to grow as expected, the two may more frequently find themselves crossing paths, with the potential for the generation of new hybrid forms. Currently, one of the main constraints on the mass-scale development of hybrids is the publishing industry's focus on entertainment.

Let's take a look at what is happening specifically in the newspaper industry: on one hand we see up-to-date printable PDF files to be carried and read while commuting back home in the evening, and on the other hand we have online news aggregators (such as Flipboard and Pulse) which gather various sources within one application with a slick unified interface and layout. These are not really hybrids, but merely the products of 'industrial' customisation — the consumer product 'choice' of combining existing features and extras, where the actual customising is almost irrelevant.

Even worse, the industry's best effort at coming to terms with post-digital print is currently the QR code — those black-and-white pixelated square images which, when read with the proper mobile phone app, allow the reader access to content (almost always a video or web page). This kind of technology could be used much more creatively, as a means of enriching the process of content generation. For example, since they use networks to retrieve the displayed content, printed books and magazines could include QR codes as a means of providing new updates each time they are scanned – and these updates could in turn be made printable or otherwise preservable. Digital publications might then send customised updates to personal printers, using information from different sources closely related to the publication's content. This could potentially open up new cultural pathways and create unexpected juxtapositions. [2]

3. Printing out the web

Many possibilities emerge from the combination of digital and print, especially when networks (and therefore infinite supplies of content that can be reprogrammed or recontextualized at will) become involved. A number of different strategies have been employed to assemble information harvested online in an acceptable form for use in a plausible print publication.

One of the most popular renders large quantities of Twitter posts (usually spanning a few years) into fictitious diaries. "My Life in Tweets" by James Bridle is an early example, realized in 2009 [3], which collected all of the author's posts over a two-year period, forming a sort of intimate travelogue. The immediacy of tweeting is recorded in a very classic graphical layout, as if the events were annotated in a diary. Furthermore, various online services have started to sell services appealing to the vanity of Twitter micro-bloggers, for example Bookapp's Tweetbook (book-printing your tweets) or Tweetghetto (a poster version).

Another very popular "web sampling" strategy focuses on collecting amateur photographs with or without curatorial criteria. Here we have an arbitrary narrative employing a specific aesthetic in order to create a visual unity that is universally recognizable due to the ubiquitousness of online life in general and especially the continuous and unstoppable uploading of personal pictures to Facebook.

A specific sub-genre makes use of pictures from Google Street View, reinforcing the feeling that the picture is real and has been reproduced with no retouches, while also reflecting on the accidental nature of the picture itself. Michael Wolf's book "a series of unfortunate events" [4], points to our very evident and irresistible fascination with "objets trouvé", a desire that can be instantly and repeatedly gratified online.

Finally there's also the illusion of instant-curation of a subject, which climaxes in the realization of a printed object. Looking at seemingly endless pictures in quick succession online can completely mislead us about their real value. Once a picture is fixed in the space and time of a printed page, our judgements can often be very different.

Such forms of "accidental art" obtained from a "big data" paradigm, can lead to instant artist publications such as Sean Raspet's "2GFR24SMEZZ2XMCVI5... A Novel", which is a long sequence of insignificant captcha texts, crowdsourced and presented as an inexplicable novel in an alien language [5].

There are traces of all the above examples in Kenneth Goldsmith's performance "Printing Out The Internet" [6]. Goldsmith invited people to print out whatever part of the web they desired and bring it to the gallery LABOR art space in Mexico City, where it was exhibited for a month (which incidentally also generated a number of naive responses from environmentally concerned people). The work was inspired by Aaron Swartz and his brave and dangerous liberation of copyrighted scientific content from the JSTOR online archive [7].

It's what artist Paul Soulellis calls "publishing performing the Internet" [8].

All this said, the examples mentioned above are yet to challenge the paradigm of publishing — maybe the opposite. What they are enabling is a "transduction" between two media. They take a sequential, or reductive part of the web and mould it into traditional publishing guidelines. They tend to compensate for the feeling of being powerless over the elusive and monstrous amount of information available online (at our fingertips), which we cannot comprehensively visualize in our mind.

If print is quintessential of the web, such practices sometimes indulge in something like a "miscalculation" of the web itself — the negotiation of this transduction is reducing the web to a finite printable dimension, denaturalizing it. According to Publishers Launch Conferences' co-founder Mike Shatzkin, in the next stage "publishing will become a function... not a capability reserved to an industry..." [9]

4. Hybrids, calculated content is shaped and printed out

This "functional" aspect of publishing can, at its highest level, imply the production of content that is not merely transferred from one source to another, but instead produced through a calculated process in which content is manipulated before being delivered. A few good examples can be found in pre-web avant-garde movements and experimental literature in which content was unpredictably "generated" by software-like processes. Dada poems, for example, as described by Tristan Tzara, are based on the generation of text, arbitrarily created out of cut-up text from other works. [10] One of the members of the avant-garde literature movement Oulipo created a similar concept later: Raymond Queneau's "Cent Mille Milliards de Poèmes" [11] is a book in which each page is cut into horizontal strips that can be turned independently, allowing the reader to assemble an almost infinite quantity of poems, with an estimated 200 million years needed to read all the possible combinations. That an Oulipo member created this was no accident - the movement often played with the imaginary of a machinic generation of literature in powerful and unpredictable ways.

Contemporary experiments are moving things a bit further, exploiting the combination of hardware and software to produce printed content that also embeds results from networked processes and thus getting closer to a true form.

Martin Fuchs and Peter Bichsel's book "Written Images" [12] is an example of the first 'baby steps' of such a hybrid post-digital print publishing strategy. Though it's still a traditional book, each copy is individually computer-generated, thus disrupting the fixed 'serial' nature of print. Furthermore, the project was financed through a networked model (using Kickstarter, the very successful 'crowdfunding' platform), speculating on the enthusiasm of its future customers (and in this case, collectors). The book is a comprehensive example of post-digital print, through the combination of several elements: print as a limited-edition object; networked crowdfunding; computer-processed information; hybridisation of print and digital — all residing in a single object — a traditional book. This hybrid is still limited in several respects, however: its process is complete as soon as it is acquired by the reader; there is no further community process or networked activity involved; once purchased, it will forever remain a traditional book on a shelf.

A related experiment has been undertaken by Gregory Chatonsky with the artwork "Capture" [13]. Capture is a prolific rock band, generating new songs based on lyrics retrieved from the net and performing live concerts of its own generated music lasting an average of eight hours each. Furthermore the band is very active on social media, often posting new content and comments. But we are talking here about a completely invented band. Several books have been written about them, including a biography, compiled by retrieving pictures and texts from the Internet and carefully (automatically) assembling them and printing them out. These printed biographies are simultaneously ordinary and artistic books, becoming a component of a more complex artwork. They plausibly describe a band and all its activities, while playing with the plausibility of skilful automatic assembly of content.

Another example of an early hybrid is "American Psycho" by Mimi Cabell and Jason Huff [14]. It was created by sending the entirety of Bret Easton Ellis' violent, masochistic and gratuitous novel "American Psycho" through Gmail, one page at a time. They collected the ads that appeared next to each email and used them to annotate the original text, page by page. In printing it as a perfect bound book, they erased the body of Ellis' text and left only chapter titles and constellations of their added footnotes. What remains is American Psycho, told through its chapter titles and annotated relational Google ads only. Luc Gross, the publisher, goes even further in predicting a more pervasive future: "Until now, books were the last advertisement-free refuge. We will see how it turns out, but one could think about inline ads, like product placements in movies etc. Those mechanisms could change literary content itself and not only their containers. So that's just one turnover."

Finally, why can't a hybrid art book be a proper catalogue of artworks? Les Liens Invisibles, an Italian collective of net artists have assembled their own, called "Unhappening, not here not now" [15]. It contains pictures and essential descriptions of 100 artworks completely invented but consistently assembled through images, generated titles and short descriptions, including years and techniques for every "artwork". Here a whole genre (the art catalogue or artist monography) is brought into question, showing how a working machine, properly instructed, can potentially confuse a lot of what we consider "reality". The catalogue, indeed, looks and feels plausible enough, and only those who read it very carefully can have doubts about its authenticity.

5. Conclusions

Categorising these publications under a single conceptual umbrella is quite difficult and even if they are not yet as dynamic as the processes they incorporate, it's not trivial to define any of them as either a 'print publication' or a 'digital publication' (or a print publication with some digital enhancements). They are the result of guided processes and are printed as a very original (if not unique) static repository, more akin to an archive of calculated elements (produced in limited or even single copies), than to a classic book, so confirming their particular status. The dynamic nature of publishing can be less and less extensively defined in terms of the classically produced static printed page. And this computational characteristic may well lead to new types of publications, embedded at the proper level. It can help hybrid publications function as both: maintaining their own role as publications as well as eventually being able to be the most updated static picture of a phenomenon in a single or a few copies, like a tangible limited edition. And since there is still plenty of room for exploration in developing these kind of processes, it's quite likely that computational elements will extensively produce new typologies of printed artefact, and in turn, new attitudes and publishing structures. Under those terms it will be possible for the final definitive digitalization of print to produce very original and still partially unpredictable results.

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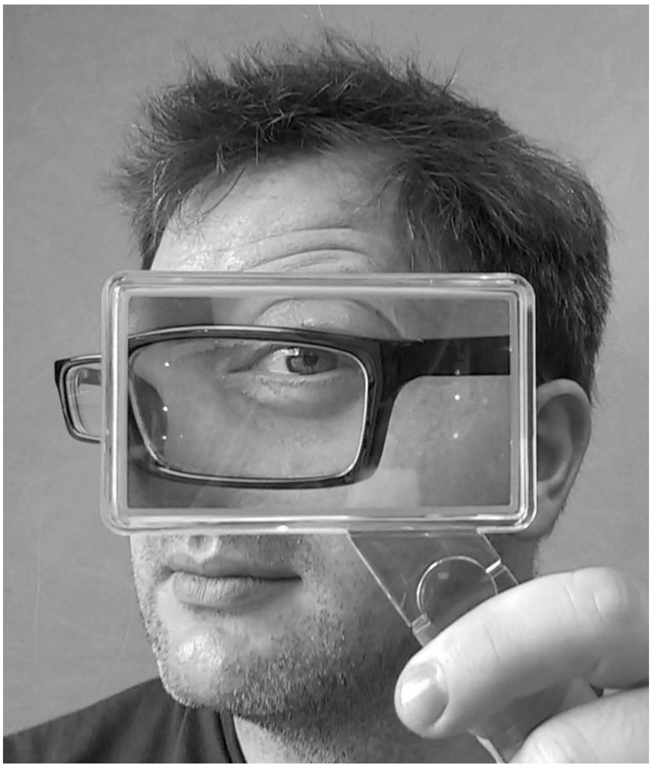
Biographies

Monty Adkins



Monty Adkins is a composer, performer and professor of experimental electronic music. His work is characterised by slow shifting organic textures often derived from processed instrumental sounds. Inhabiting a post-acousmatic sensibility, his work draws together elements from ambient, acousmatic and microsound music. Adkins has worked collaboratively on a number of audio-visual projects, including *Four Shibusa* with the painter Pip Dickens and most recently with composer/digital artist Julio d'Escriván. Adkins has been commissioned by the BBC, Radio 3, IRCAM and INA-GRM amongst others. His most recent albums are published by Audiobulb.

Gabriella Arrigoni

Gabriella Arrigoni is a PhD candidate in Digital Media at Newcastle University. Her research interests lie at the intersection of collaborative practices, connectivity, urban and innovation studies. Former editor in chief of undo.net, she has curated a number of exhibitions and talks and published articles and essay across Europe, with a special focus on public art and the relationship between art and the socio-economical context. Her current research explores the concept of Living Lab as a curatorial strategy where practitioners work in a public setting to enhance the audience understanding of the artistic, technological and scientific dimensions of the work.

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Álvaro Barbosa

Álvaro Barbosa (Angola, 1970) is an Associate Professor, Dean of the Creative Industries Faculty at University of Saint Joseph (USJ) in Macau SAR-China and a Researcher at the Centre for Research in Science and Technology of the Arts (CITAR). He was the acting director of the Sound and Image Department at the School of Arts from the Portuguese Catholic University (UCP-Porto) until September 2012. In 1995 He was awarded with a Graduate Degree in Electronics and Telecommunications Engineering from the University of Aveiro, in 2006 a PhD in Computer Science and Digital Communication by the University Pompeu Fabra in Barcelona and in 2011 he concluded a Post-Doc at Stanford University in the USA.

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Stephen Barrass

Stephen Barrass is an Associate Professor in Digital Design and Media Arts at the University of Canberra. He holds a Ph.D. in Information Technology from the Australian National University 1997, a Bachelor of Electrical Engineering from the University of NSW in 1986, and a Graduate Certificate in Higher Education from the University of Canberra in 2010.

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Alba Francesca Battista

Alba Francesca Battista (1987) graduated in Musica Elettronica with the highest possible marks at *D. Cimarosa* Conservatoire of Avellino, Italy, with M° Damiano Meacci.

Her compositions are selected for many international contests (Biennale di Venezia 2013, Eclettica 2012, ...). Her electroacoustic work Eusebius is among the winners of the Internation Competion *PianoForteMix2012* by VoxNovus of New York.

She graduated in Piano and in Physics, specialized in Acoustic and Nanotechnologies. She is the author of *Elementi di Acustica Fisica e sistemi di diffusione sonora*. She works as Electronics Professor for the Master Degree in Sound Engineering at *D. Cimarosa* Conservatoire.

Ruth Beer

Ruth Beer is a Vancouver-based artist whose artistic practice includes sculpture, video, photography and interactive projections. She is interested in interdisciplinary approaches to artistic, collaborative and pedagogical practices. Her artwork has been shown in national and international exhibitions, she is a member of the RCA of Canada and has been awarded several public art commissions. Her recent projects address social history and geological / marine conditions focused on the Pacific northwest region.

She is a Professor of Visual Art in the Faculty of Visual Art and Material Practice at Emily Carr University of Art and Design.

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Sara Bergamaschi

Sara Bergamaschi earned a bachelor degree in Industrial Design at the Politecnico di Milano in February 2011.

In December 2012, she graduated in Design & Engineering. She developed her master thesis in collaboration with the Design Department at Politecnico di Milano, that is entitled *Changing face. Le possibilità comunicative dei prodotti industriali* (Changing face. The communicative possibilities of industrial products). In her thesis she explored the theme of dynamic communication.

Today, she performs collaborative activities at Politecnico di Milano.

David Bouchard

David is an omnivorous New Media artist, technologist and educator. His work explores the expressive potential of computation, both in software and hardware forms. His research interests include generative art, interactive and responsive environments, digital fabrication, display technology for public spaces, electronic music interfaces and wireless sensor networks to name a few. He is currently an Assistant Professor of New Media within the RTA School of Media at Ryerson University. He holds a Bachelor of Computer Science from Concordia University and a Masters of Media Arts & Sciences from MIT.

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Pedro Branco

Pedro Branco is Assistant Professor at the Department of Information Systems, University of Minho where he is currently the director of the master program in Technology and Digital Art. He is working on several funded research projects focusing on diverse aspects of human-computer interaction, ranging from physical computational interfaces, to systems that are aware of users' non-verbal language. Within the master program in Technology and Digital Art he works closely with students from a wide range of backgrounds developing interactive systems that explore a synergy of technology and aesthetics, exploring future directions for our interaction with technology.

Vilbjørg Broch

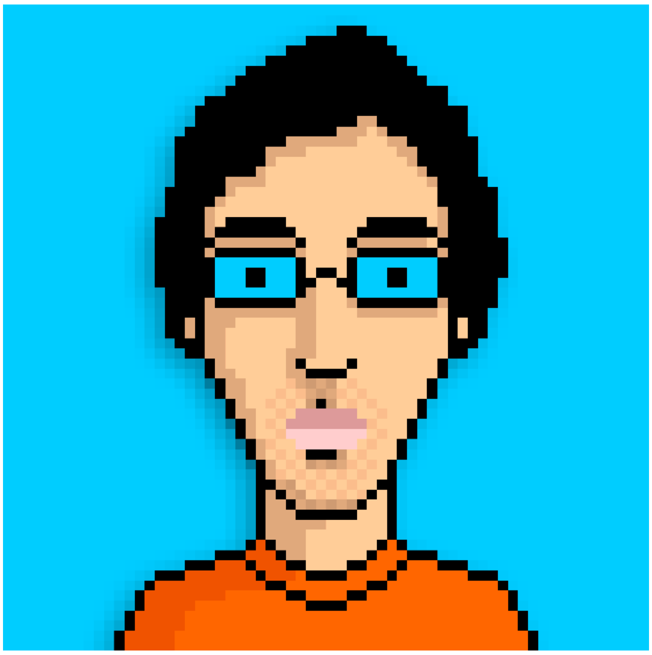
I grew up in Denmark and in the early 90s I went to Amsterdam to study dance. Three very important teachers have been: Katie Duck, improvisation and dance; Enrique Pardo (Roy Hart Theatre), text in performance and coloratura soprano Marianne Blok by whom I have studied traditional voice for more than a decade. I have worked solo as well as in large collaborative performance, theatre and music projects as a vocalist and dancer during the past 20 years. It had a huge impact on me when I , only around 6 years ago, got acquainted with the work of people like John Bedini, Tom Bearden and first of all Nikola Tesla. This, in very short, complete critic or reinterpretation of the 2nd law of thermodynamics, profoundly changed my view on the future for humanity on this planet. It became clear for me that our retarded utilization of destructive energy sources such as fossil fuels and uranium not is due to technological impossibility but rather is caused by financial dominance and centralization. Since this realization I have picked up a self-study of mathematics. This is still a process which I at the moment am applying to music / algorithmic composition.

http://antidelusionmechanism.org

Adolfo Luxúria Canibal

Adolfo Luxúria Canibal is the artistic pseudonym of Adolfo Morais de Macedo. Graduated in Law from the Lisbon University, he practiced law in this city and is a legal advisor. He was the founder of the rock group *Mão Morta*, where he is vocalist and lyricist, has created several performances of spoken word in his own name, and joined the French collective of electronic music *Mécanosphère*. Participated as an actor in the television series *The Smoke Dragon* and some short films. He was also an author and broadcaster of radio programs. He is the author of dispersed texts in newspapers and magazines and published, among others, the books of poetry *Rock & Roll and Shards*. In 2003 he was considered one of the fifty most important living persons of the Portuguese culture.

Pedro Cardoso



Pedro Cardoso is a communication designer, researcher, professor and a PhD student at the University of Porto pursuing studies in video games in the context of new media and interaction design, and developing experimental work in this scope.

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André Carita

Born in Oporto (Portugal) in 1984, André Carita has a Ph.D in Fine Arts at Universidad Politécnica de Valencia (Spain) where he developed a thesis on Videogame studies, design, art and culture as the main focus. Currently, André is an assistant professor at Universidade Lusófona de Humanidades e Tecnologias in Lisbon and coordinator / professor of a post graduation in Game Design at Alquimia da Cor in Oporto. He has also collaborated in several videogame magazines such as *Mega Score*, *Hype!* and *GameCultura*. In a small team, he helped planning and designing the iOS videogame *Poproids: Suicide Mission!*.

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Miguel Carvalhais

Miguel Carvalhais is a designer and musician. He holds a Ph.D. in art and design by the University of Porto, Portugal, where he currently is an assistant professor at the Faculty of Fine Arts. His practice and research have been focusing on digital media and on computational design and art practices. He collaborates with Pedro Tudela in the @c project since 2000 and he helped to start the Crónica media label, a platform for experimental music and media art, which he has been running since 2003.

carvalhais.org
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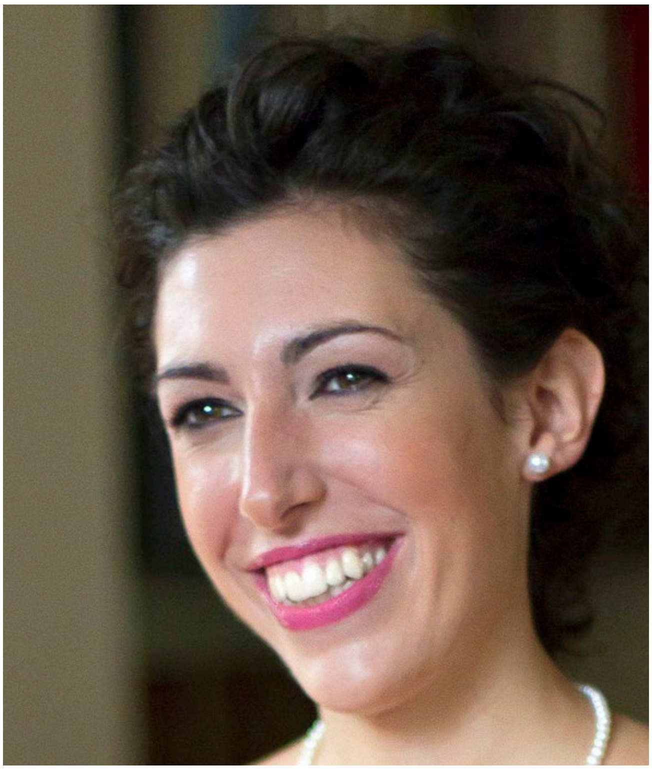
Sara Colombo



Sara Colombo has a background in Product Design with a Master degree in Design&Engineering. She has been working on her PhD in Design at Politecnico di Milano since 2011. She has spent some months in Sweden cooperating with the Interactive Institute research group as visiting PhD student. Her research interests deal with the user sensory experience within the Human-Product Interaction, focusing on how products can communicate information through physical sensations instead of virtual interfaces. The aim is to explore all the sensory modalities, to design emotional and meaningful experiences.

Arne Eigenfeldt

Arne Eigenfeldt is a composer of live electroacoustic music, and a researcher into intelligent real-time music systems. His music has been performed around the world and his collaborations range from Persian Tar masters to contemporary dance companies to musical robots. His research has been presented at conferences such as ICMC, NIME, GECCO, SEAMUS, ISMIR, EMS and SMC. He is an associate professor of music and technology at Vancouver's Simon Fraser University (Canada) and is the co-director of the MetaCreation research group, which aims to endow computers with creative behaviour.

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Hideyuki Endo

Born in Yokohama City, Kanagawa Prefecture, Japan. Currently a doctoral student studying sound art, with a particular research interest in the sonification of natural phenomenon.

http://on.fb.me/Y1UDvQ [Evoke the source]

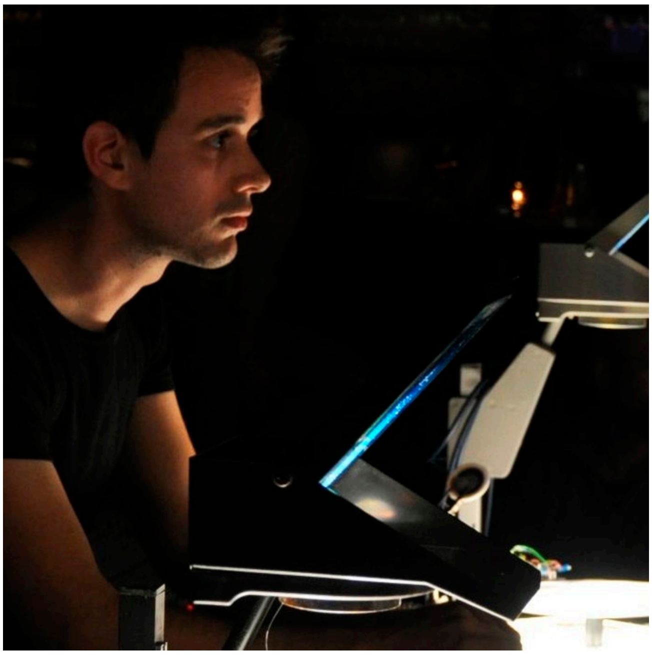
Julio d'Escriván

Julio d'Escriván is a composer and audio-visual artist working in creative technologies and moving image through laptop comprovisation. Julio is active as a laptop and video artist in the UK and abroad with performances this year in Brazil, Spain and the UK. His work combines, live coding and visual loop remixing along with found-objects amplification. Julio's recent written work includes the Music Technology book from the Cambridge Introductions to Music series published in early 2012 by Cambridge University Press. He is also coeditor of the Cambridge Companion to Electronic Music (C.U.P.) and co-author of the chapter on Composing with SuperCollider for The SuperCollider Book (MIT Press). At present he is Senior Lecturer at the Music Department of the University of Huddersfield in the United Kingdom.

Luis Eustáquio

Born in Oporto in 1974. Attended the Faculdade de Belas-Artes da Universidade do Porto, where he graduated in Communication Design and completed his MA thesis in Image Design. Currently employed in a web and mobile development house, has spanned his activity throughout various areas in just over two decades, including active politics, graphic design, illustration, visual coding, VJ'ing, teaching, sound works and parenting.

Christian Faubel



Christian Faubel works at the lab3 — the laboratory for experimental computer science at the Academy of Media Arts Cologne. Till 2012 he worked at the Institute for Neural Computation in Bochum, where he received his PhD in electrical engineering in 2009.

In his work he is interested what it is that enables autonomous behavior? How complex autonomous behavior may result from the interaction of very simple units and from the dynamics of interaction between such units. He explores the assembly of simple units into systems and the emergence of autonomous behavior both in artistic and in scientific research.

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Bruno Figueiredo

Bruno Figueiredo (Porto, 1977).
PhD Candidate of Architecture at Escola de Arquitectura da Universidade do Minho (EAUM), Guimarães, since 2010.
Master of Contemporary and Modern Architecture Culture at Faculdade de Arquitectura da Faculdade Técnica de Lisboa, with the dissertation *Design, Computation and Fabrication — the integration of digital technologies in Architecture*, in 2009.
Graduate on Architecture by Faculdade de Arquitectura, Universidade do Porto, Porto, in 2000.
Visiting student at the Design and Computation Group, MIT, Cambridge, in 2012.
Lecturer at EAUM (Guimarães) since 2005.
Research Member at Centro de Estudos Sociais (Coimbra).

Sofia Figueiredo

Sofia Figueiredo was born in Oporto, Portugal, and lives in Viseu, Portugal.

She currently lectures in several subjects art-related at ESEV–IPV, while pursuing doctoral research at Universidade de Coimbra. Her research seeks to explore the rich fields of interactivity, animation and autobiography, as they intertwine in her artistic production.

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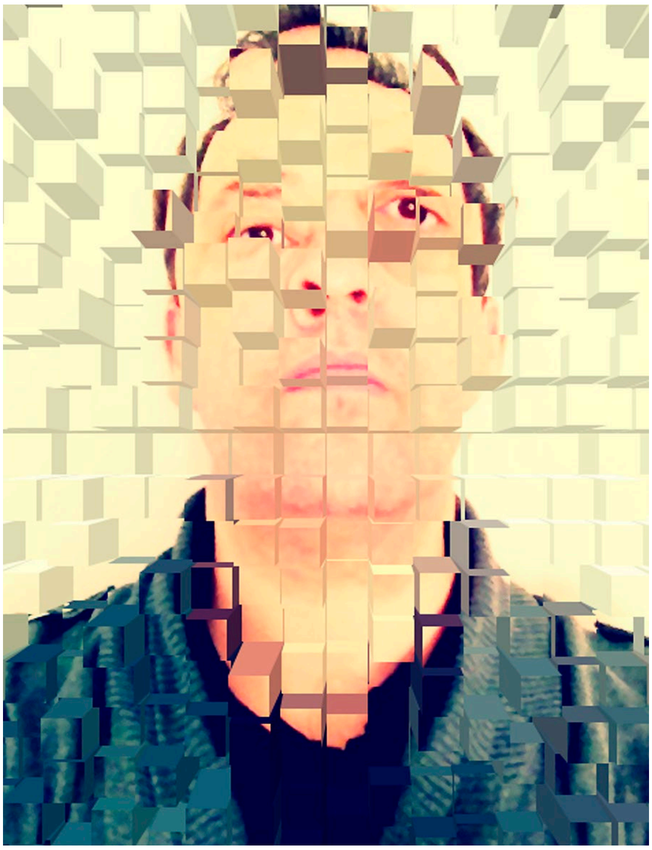
http://www.esev.ipv.pt

Pablo Garcia

Pablo Garcia is an Assistant Professor in the Department of Contemporary Practices at the School of the Art Institute of Chicago. Previously he served as the Lucian and Rita Caste Chair in Architecture and Assistant Professor at Carnegie Mellon University from 2008–2012 and the 2007–2008 Muschenheim Fellow at the University of Michigan Taubman College of Architecture + Urban Planning. From 2004–2007 he worked as an architect and designer for Diller Scofidio + Renfro. Garcia has also taught media and representation technologies at Parsons The New School for Design and Princeton University. He holds architecture degrees from Cornell and Princeton Universities.

http://www.pablogarcia.org

Miguel Pedro Guimarães



Miguel Pedro is a Portuguese composer, multi-instrumentalist, born in Braga. Founded the band *Mão Morta*, *Mundo Cão*, *Palmer Eldritch*, among others, having already recorded and produced over 50 works (among vinyls, CDs and DVDs). He was the author of soundtracks for movies, plays, ballets and is one of the responsibles for programming the Semibreve Festival, dedicated to electronic music and digital arts.

Rainer Guldin

Rainer Guldin is lecturer for German Language and Culture at the Faculties of Communication and Economic Sciences at the Università della Svizzera Italiana in Lugano (Switzerland). He studied English and German Literature at the University of Zurich and at Ashton University in Birmingham (England). His diploma was dedicated to the work of the American writer H. P. Lovecraft, and his Ph.D. thesis focused on the work of the German writer Hubert Fichte. He is Editor-in-Chief of the peer-reviewed multilingual open access e-journal Flusser Studies: http://www.flusserstudies.net/. Rainer Guldin taught courses at the Universidade do Estado do Rio de Janeiro (UERJ) in Brazil, the Bauhaus Universität in Weimar (Germany) and the Centre for Translation and Intercultural Studies of the University of Manchester (England). He was also visiting professor (Cathedra IEAT/Fundep) at the Universidade Federal de Minas Gerais in Belo Horizonte (UFMG), Brazil.

http://www.com.usi.ch/en/personal-info?id=323

Jingyin He

Jingyin He (1986, Singapore) is an experimental composer/ performer, researcher, sound artist, and multimedia installation artist. Working within a hybridized culture of technology and the arts, the style of his work evolves with time through investigating, experimenting and formalizing new creative processes in contemporary sonic arts and visual arts practices.

Jingyin completed his Bachelor of Arts in Music Technology at LASALLE College of the Arts (Singapore) in 2010. In 2011, he was invited to STEIM (Amsterdam, NL) for a workshop residency to discuss and explore matters relating to instrument design for electronic music performance. Jingyin has recently completed his Masters of Fine Arts in both Music Technology: Interaction, Intelligence and Design, and Integrated Media at California Institute of the Arts (California, USA), and will be pursuing his PhD in Sonic Arts at Victoria University of Wellington (New Zealand).

Christoph Illing

Christoph Illing (1969). An artist, programmer and composer of electronic music, he is based in Berlin, Germany. Runs Studio Sinuous — Sound & Code. After beginning as sound artist with publications in electronic music, studies in philosophy and informatics, a Master's degree in Sound Studies at the University of the Arts in Berlin resulted in his plunge into the combination of sound and philosophical concepts. In collaboration with Ulrike Sowodniok composition relating to the sound of the voice and its meaning. He has participated in numerous sound art exhibitions and performances including Notations 21 (US), Erbil Theater Festival (IQ), Raumstimme (DE).

http://www.sinuous.de/

Vitor Joaquim

Vitor Joaquim (Portugal 1963) laptop experimentalist, sound and visual artist, graduated in sound and film directing. He started performing improvised music by the mid 80's and has created extensively for contemporary dance, theatre, installations and cross media platforms. He has five solo releases, several collaborations and a long list of compilations and remixes.

He has worked as curator and advisor in several festivals and events. In 2000 he started EME, a festival dedicated to experimental arts and non-standard music. He has been teaching and coordinating audio-visuals in art schools since the 90's, working now as a researcher at CITAR/UCP, Porto, where he is also teaching.

www.vitorjoaquim.pt

Ajay Kapur

Ajay Kapur is currently the Director of the Music Technology program (MTIID) at the California Institute of the Arts, as well as the Associate Dean for Research and Development in Digital Arts. He is also a Senior Lecturer of Sonic Arts Engineering at the New Zealand School of Music at Victoria University of Wellington. He received an Interdisciplinary Ph.D. in 2007 from University of Victoria combining computer science, electrical engineering, mechanical engineering, music and psychology with a focus on intelligent music systems and media technology. Ajay graduated with a Bachelor of Science in Engineering and Computer Science from Princeton University in 2002.

Kapur has published over 80 technical papers and presented lectures across the world on music technology, human computer interface for artists, robotics for making sound, and modern digital orchestras. His book *Digitizing North Indian Music*, discusses how sensors, machine learning and robotics are used to extend and preserve traditional techniques of Indian Classical music.

Ricardo Lafuente

Ricardo Lafuente spent the better part of his recent years oscillating between the roles of designer, hacker, teacher and artist. He lives and works from the beautiful city of Porto, forming one half of the design studio Manufactura Independente, and teaches as a guest assistant teacher at the Faculty of Fine Arts of the University of Porto.

http://manufacturaindependente.org

Titus von der Malsburg

Titus von der Malsburg (1977) is a postdoctoral researcher in the research group for mind and brain dynamics at the University of Potsdam, Germany, where he investigates language processing in the human brain. For this research he uses techniques such as eye tracking and the recording of electrical brain potentials. Alongside his studies in computational linguistics and mathematics, he worked as a freelance software developer and consultant. Earlier, he founded a company that produced 3D visualizations for customers in industry and science. During that time, he also operated a recording studio for electronic music.

http://www.ling.uni-potsdam.de/~malsburg/

Marianne Markowski

Marianne Markowski is in her third year fulltime Ph.D. studies at Middlesex University, Art & Design Research Institute, London. Her research is on the design of online social interaction for older people. For this she has designed a physical research tool — the Teletalker — that facilitates online face-to-face interaction for older people.

Prior to returning to academia Marianne has been working in user research for over 8 years. She has evaluated a wide range of software and platforms starting from kiosk, desktop, interactive television to mobile applications and handsets. She led and worked on UX projects B2C and B2B in the retail, banking, education, mobile and government sectors.

www.teletalker.org

Susana Lourenço Marques

Susana Lourenço Marques (Caldas da Rainha, 1975).

PhD Candidate of Communication Sciences at the Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa (FCSH.UNL), since 2010.

Master on Contemporary Culture and New Technologies at FCSH.UNL, with the dissertation *Copy and appropriation in art after 1839*, in 2007.

Graduate on Communication Design by Faculdade de Belas Artes, Universidade do Porto, in 1999.

Recherches Doctorales Libres at École des Hautes Études en Sciences Sociales (EHESS), Paris, in 2010/2011.

Lecturer of Photography and History of Photography at Intermedia — Fine Arts Department, FBA.UP since 2004.

http://88dots.tumblr.com

Jon McCormack

Jon McCormack is an Australian-based electronic media artist and researcher in computing. He holds an Honours degree in Applied Mathematics and Computer Science, a Graduate Diploma of Art (Film and Television) and a Ph.D. in Computer Science. He is currently Associate Professor in Computer Science, an ARC Australian Research Fellow and director of the Centre for Electronic Media Art (CEMA) at Monash University in Melbourne, Australia. Since the late 1980s McCormack has worked with computer code as a medium for creative expression. His work is concerned with electronic "after natures" — alternate forms of artificial life that may one day replace the biological nature lost through human progress and development. His artworks have been widely exhibited at leading galleries, museums and symposia, and have received numerous awards for new media art and computing research. He is co-editor (with Mark d'Inverno) of the book *Computers and Creativity*, published in 2012.

http://jonmccormack.info

Alex McLean

Alex McLean is a Research Fellow in Human/Technology Interaction working from the Interdisciplinary Centre for Scientific Research in Music. As a live coding musician, he performs with Adrian Ward and Dave Griffiths as the live coding band Slub (http://slub.org/), getting people to dance to code including at the Sonar (Barcelona), Transmediale (Berlin), Ars Electronica (Linz), STRP (Eindhoven), Sonic Acts (Amsterdam), Lambda (Antwerp), Make Art (Poitiers), Piksel (Bergen) and /* vivo */ (Mexico City) festivals. He also collaborates with Jake Harries in the spam-pop band Silicone Bake (http://siliconebake.lurk.org/). Alex is active across the digital arts, for example as organiser of algoraves (http://algorave.com/), of regular dorkbot events in Sheffield and London. He also chaired the first International Conference on Live Interfaces in 2012 (http://lipam.lurk.org).

Ricardo Melo

Ricardo Melo is a Portuguese designer, writer, researcher and comic book aficionado. He has a B.A. in Communication Design from the Faculty of Fine Arts of the University of Porto and since 2008 works as a graphic and interface designer at the Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions, where he collaborates in academic and industrial R&D projects in the field of Ambient Assisted Living and Human-Computer Interaction.

In 2012 he completed his M.Sc. in Multimedia at the Faculty of Engineering of the University of Porto with the thesis entitled: “Call to Adventure: Designing for Online Serendipity”.

João Martinho Moura

João Martinho Moura, Digital Artist. His interests are focused in intelligent interfaces, digital art, digital music and computational aesthetics. João Martinho Moura has a special interest in the development of interfaces between human behaviors and digital artifacts. Guest lecturer in the Master of Digital Art and Technology at the University of Minho, he is the author of several publications in the area of digital art, computer interaction and aesthetics, and has presented his artwork in several countries and conferences, such as Ars Electronica in 2012 in Linz, the OFFF festival in Lisbon, Artech International, Guimarães European Capital of Culture or Chemins Numériques in the Centre Culturel Saint-Exupéry in France.

Alexander Müller-Rakow

Alexander Müller, born 1982, Germany. He works as research scientist and PhD Candidate at the Design Research Labs Berlin, where he investigates the relation between bodily movements, interfaces and situational meaning. His project-grounded research is strongly influenced by his interest in experimental and embodied interfaces, new instruments for musical expression and sound reactive performance. In addition to his research he was working as lecturer, e.g. at Hochschule für Kunste Bremen, University of Applied Sciences Magdeburg and Berlin University of the Arts.

www.design-research-lab.org

Michael Pogorzhelskiy

Michael Pogorzhelskiy is a product and interaction designer living in Berlin. He is interested in social and behavioural consequences of design decisions and the aesthetics of physical computing.

Lucia Rampino

Lucia Rampino, PhD, is an assistant professor at the Politecnico di Milano, Design Department. Her theoretical and applied research focuses mainly on the role of design in new product development processes aimed at innovation. She has participated in a number of European and nationally funded research projects. Since January 2009, she has been a member of the faculty of the Doctoral Program in Design at the Politecnico di Milano Doctoral School.

Jason Reizner

Jason Reizner is a dyslexic hypochondriac originally from Chicago. After stints in film, print and interactive, he works now as a researcher in Interaction and Experience Design on the Faculty of Computer Science and Languages at Anhalt University of Applied Sciences in Köthen (Anhalt), Germany. He holds a Bachelor's in Film, Video & Integrated Media from Emily Carr Institute of Art & Design in Vancouver, Canada and a Master's in Media Art and Design from Bauhaus–Universität Weimar.

http://reizner.org

Luísa Ribas

Luísa Ribas holds a PhD in Art & Design (2012), a Master in Multimedia Art (2002) and a Degree in Communication Design (1996) from FBAUP (Faculty of Fine Arts, University of Porto). She is a member of ID+ (Research Institute for Design, Media and Culture), researching sound-image relations and audiovisuality in digital interactive systems. As a professor at FBAUL (Faculty of Fine-Arts, University of Lisbon) she teaches Communication Design, Editorial Design and New Media, and Sound and Image. She contributes to events and publications with articles on digital art and design.

http://lmlr.wordpress.com
lribas@fba.ul.pt

Oscar Palou Ribó

Oscar Palou studied Electronic arts and Digital Design in Barcelona. Considered himself as a pilgrim of sound, his activity holds on the acoustic sensibility as a way to achieve communicational, ecological and aesthetical purposes. His current interests root in computational solutions for sound generation and installation.

www.manglart.es

Theresa Schnell

Theresa Schnell is a student of Fine Arts in Dresden, Germany. In her second year of university she is interested in social progresses and how it is possible to transform them. Currently she is in the class of Christian Sery. In 2012 she joined *KAZOOSH!* and took part in the actual working-processes. The different backgrounds of the group (such as computer sciences, electronics, fine arts etc.) try to find one expression through their creative work. The process of trying, researching and finaly forming something is highly interesting, especially because of the fact that *KAZOOSH!* often works project-based in a very limited period of time.

www.kazoosh.com

Tom Schofield

Tom Schofield is an artist, researcher and Ph.D. candidate. He studies and teaches at Culture Lab, Newcastle, UK (http://culturelab.ncl.ac.uk). His research interests and art practice centre around the use of data as a material for artists. Recent self initiated projects include Neurotic Armageddon Indicator, a wall clock for the end of the world (http://tomschofieldart.com/Neurotic-Armageddon-Indicator), 'null by morse', an installation with vintage military equipment and iPhones (tomschofieldart.com/null-by-morse), and Burj Babil (with Guy Schofield http://fieldventures.org/burj_babil.html) a video installation which warps computer models using the Google translate api.

www.tomschofieldart.com

Giselle Stanborough

Giselle Stanborough is an emerging intermedia artist whose practice often addresses online user generated media and the way in which such technologies encourage us to identify and perform notions of self. She graduated from the College of Fine Art in Sydney in 2010 with the University Medal and since then has exhibited in galleries around NSW and in Melbourne. Her work has been shown online in The Washington Post's *Pictures of The Day* and in Hennessy Youngman's *Art Thoughtz*.

http://gisellestanboroughart.blogspot.com.au/

Michael Tränkner

Michael Tränkner graduated in computer sciences at the University of Applied Sciences Dresden (Germany), specializing in multimedia programming. He is currently employed at the research and development division in the computer graphics department, working on natural user interfaces and creating software for unique museum experiences. In 2011 he joined *KAZOOSH!*, a group of analog makers, digital tinkerers and creative hobbyist, who want to utilize the expertise of their members from backgrounds such as the fine arts, computer sciences and electronics to build public installations on the verge of art and technology. Taking part in *KAZOOSH!*'s mission to develop skills, spread knowledge and broaden the mindset of its members and the community.

www.kazoosh.com

Andres Wanner

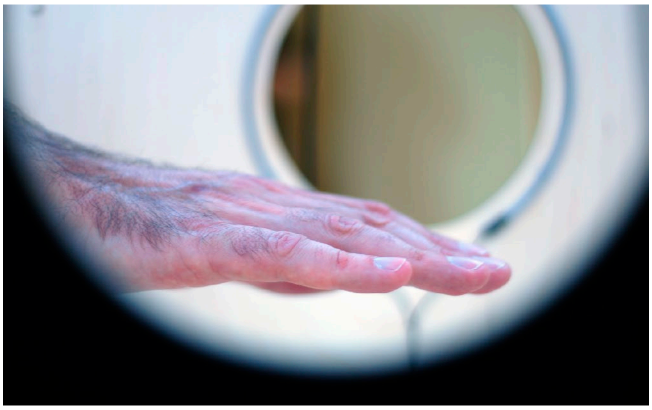
Andres Wanner is a Swiss-Canadian artist, interaction designer and educator.

His interdisciplinary practice investigates generative systems — machines and computer programs producing pictures. He likes to tinker, invent and to play.

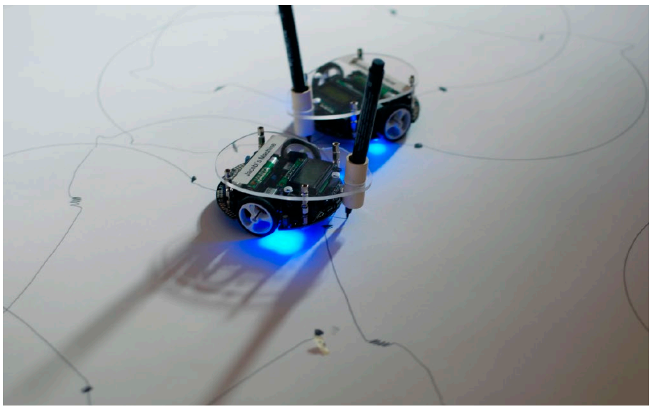
He has taught internationally and is an Adjunct Professor at Simon Fraser University, Vancouver, Canada. He has worked as a designer and programmer and holds an MSc in Physics and a BA in Visual Communications.

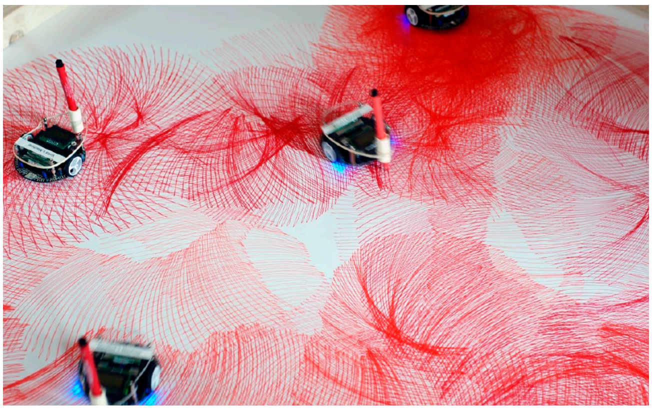
His work has been exhibited in major exhibitions such as SIGGRAPH, IDEAS 10, New Forms Festival, Re-new Festival, Hyperkult and other international venues. He has chaired the arts track of the Computational Aesthetics conference 2011.

www.pixelstorm.ch

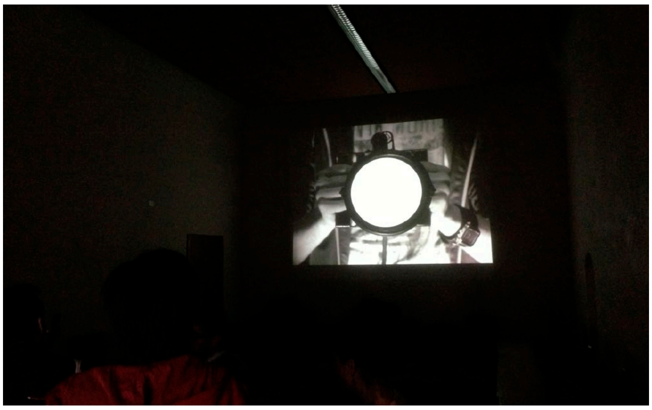


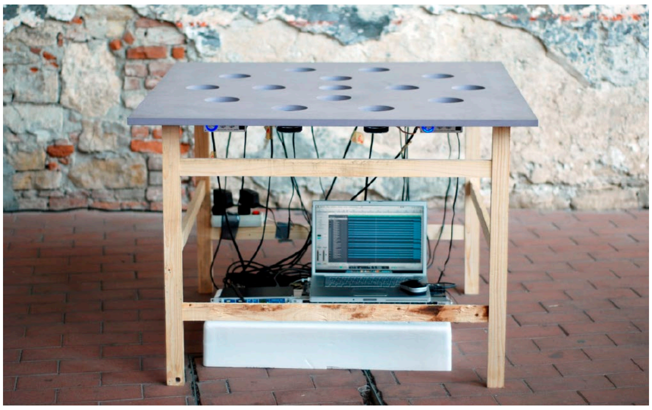
Heimlichkeit des Berührens: Exploring the Correlation of Perception and Intimacy—Installation by Alexander Müller-Rakow, Oscar Palou Ribó & Michael Pogorzhelskiy.





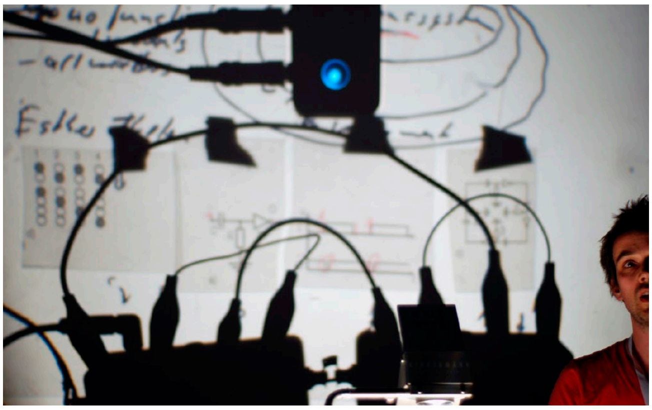
The Robot Quartet: a Generative Robotic Drawing Installation—Installation by Andres Wanner.

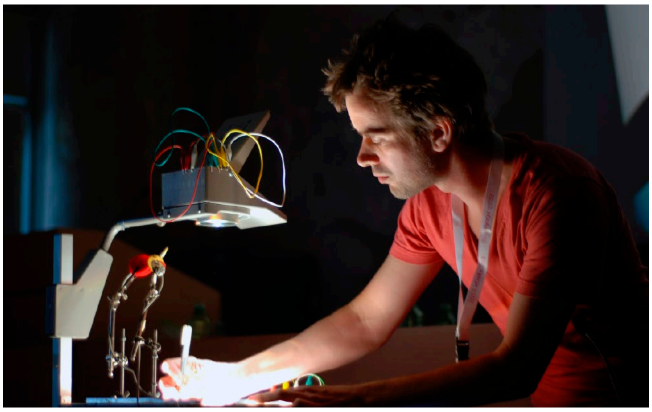




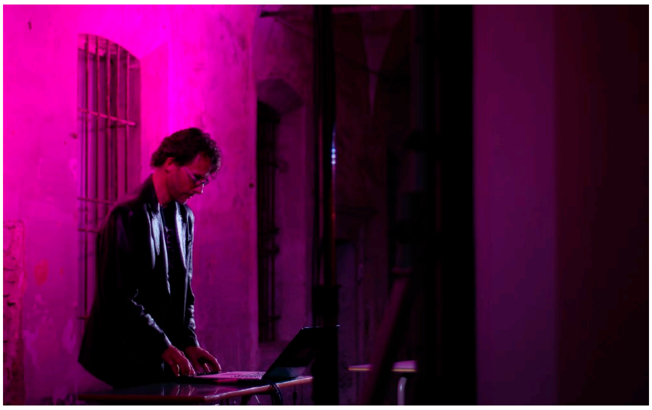
Null By Morse: Performing Optical Communication with Smart Phones—Installation by Tom Schofield.

Decomposing Electric Brain Potentials for Audification on a Matrix of Speakers—Installation by Titus von der Malsburg & Christoph Illing.



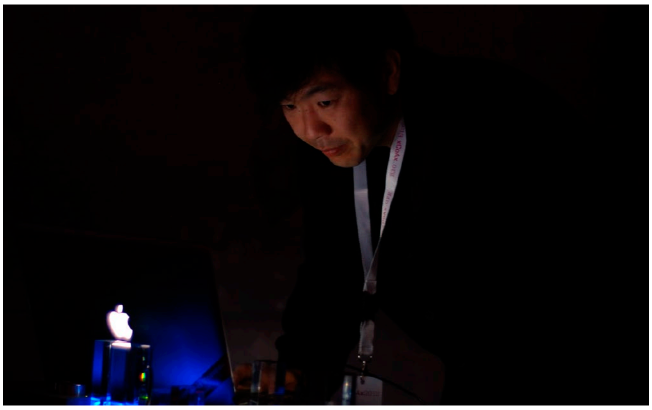


Rhythm Apparatus For the Overhead Projector: a Metaphorical Device—Presentation by Christian Faubel.

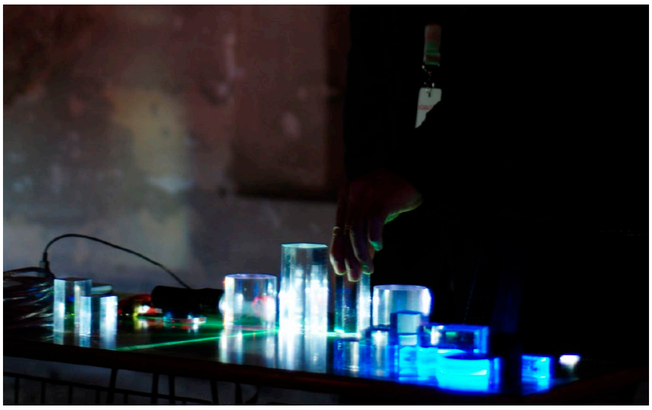


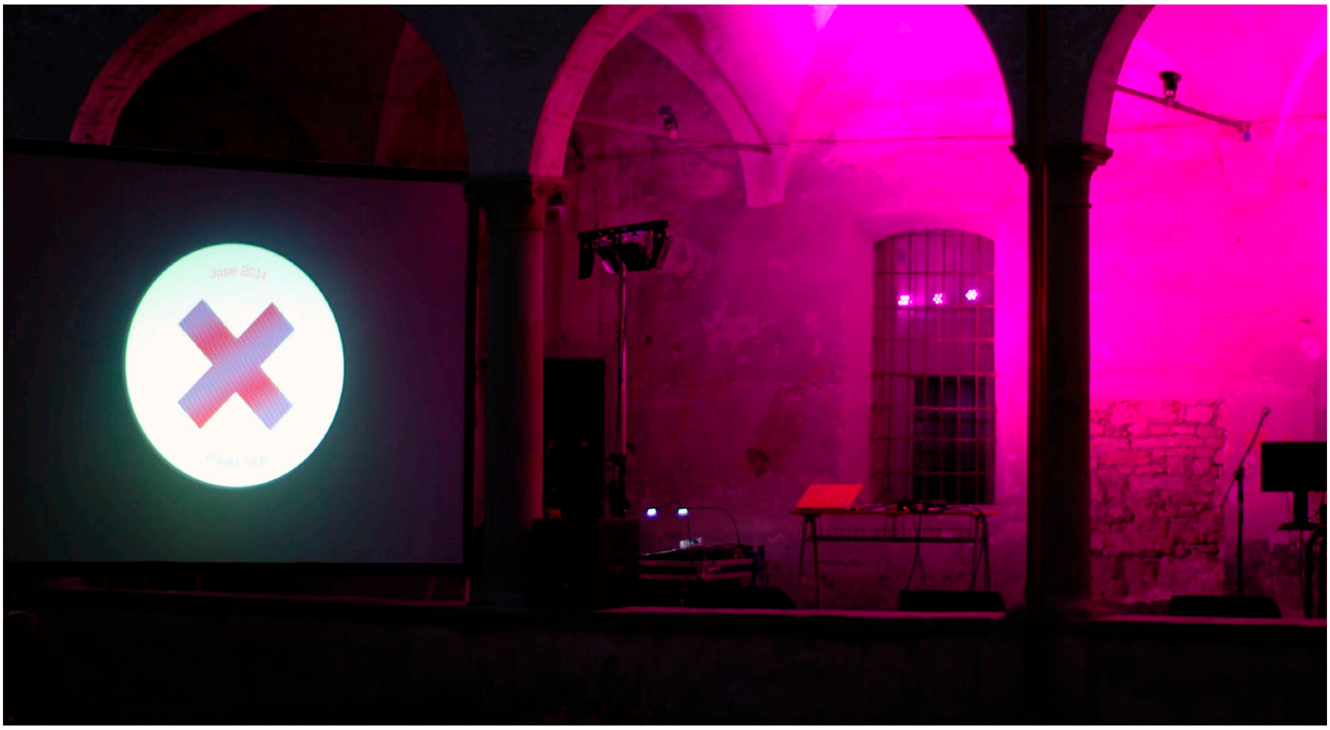
Performance by Arne Eigenfeldt.

Performance by Alba Francesca Battista & Michele Brogna.



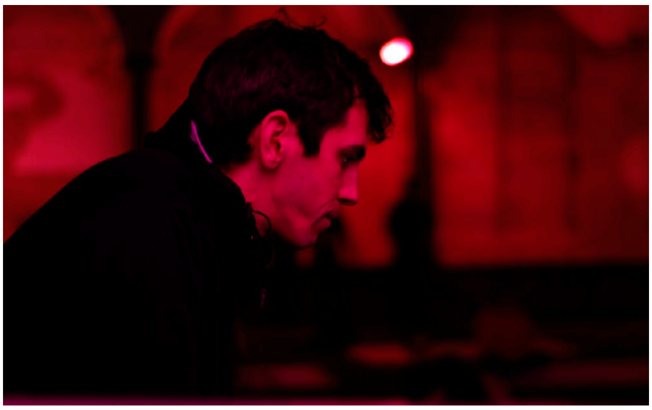
Performance by Hideyuki Endo.

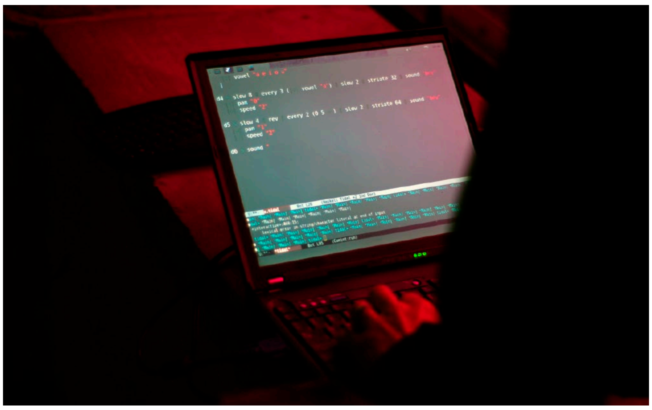




Performance by Vilbjørg Broch.

Performance by Monty Adkins, Julio D'Escrivan & Iñigo Ibaibarriaga.





Performance by Alex McLean.

This project is partially funded by FEDER through the Operational Competitiveness Program — COMPETE — and by national funds through the Foundation for Science and Technology — FCT — in the scope of project PEst-C/EAT/UI4057/2011 (FCOMP-Ol-0124-FEDER-D22700);