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FOREWORD

Welcome to the proceedings of the second edition of xCoAx, the International Conference on Computation, Communication, Aesthetics and X.

xCoAx's inaugural edition in Bergamo gathered artists, musicians, scientists, researchers and educators in an event aimed to explore computation, communication and aesthetics but also, and perhaps chiefly, the X – standing for the unknown, the impossibility, but also intersection and convergence.

Indeed xCoAx started with the serendipitous convergence of its founding group and the gradual accretion of a larger number of people who, sharing an interest in the project, formed its Scientific Committee. This led to an overwhelming response to the call for papers and to the gathering of a great number of participants from ten different countries.

The second edition of xCoAx aimed firstly to live up to the previous year. Our intention was to grow avoiding the risk of a sophomore slump, trying, as we did, to look back and to improve on Bergamo, to refine the conference model, to invest in a nascent community and in the outcomes of the conference. We maintained the plenary conference sessions, the keynote, the poster session, the performances and the social events, and added to the program a larger exhibition and an algorave, as well as a parallel X Factor futures workshop organized by the European project Future Fabulators (co-ordinated by Time's Up, with FoAM, M-ITI and AltArt). This program brought together over 130 participants from 19 countries.

Opening this volume of the proceedings of xCoAx 2014, we must start by thanking all the authors that submitted proposals and the panel of reviewers from the scientific committee that painstakingly reviewed them. We also need to acknowledge and thank the entities that supported a conference that, without their help and resources, wouldn't have been possible: the University of Porto (in particular the Faculty of Fine Arts and the Rectory), the Regional Center of Porto of the Portuguese Catholic University, ID+, i2ADS, CITAR, the University of Bergamo, the City Hall of Porto and Porto Cultura, the National Theatre of São João, the Foundation for Science and Technology, Luz e Som, and Passos Manuel. Truly indispensable was the wonderful group of more than twenty volunteers that helped set up and run the events, some of whom got involved many months ahead of schedule.

Let us proceed!

PAPERS

VENTRILOQUISM IN CODE-BASED PARTICIPATORY ARTWORKS

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Keywords: Code, Speech, Ventriloquism, Participation, Artist-Programmer, Translation, Voice, Performativity

This paper uses an analogy of ventriloquism to reflect on the roles of code, coding artist, and visitor in participatory new media artworks. Ways in which theorists and practitioners have viewed code and speech are considered while two of the author's artworks, *Toast and Ventriloquisms for Fun and Profit*, are used as case studies. Here, the projects are described and insights that emerged from their implementation are proposed as results. Throughout the text, ventriloquism diagrams are used to illustrate possibilities for directional transmission of speech that occur in the artworks being discussed.

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1. INTRODUCTION

> **DUM:** *Hey, what's goin' on here? What's the idea of wearing the white coat?*
> **VENT:** *Well, you see, you are the patient, and I am the dentist.*
> **DUM:** *(Calmly) Oh, I see … (Suddenly leaps up) WHATTT? (Winchell 1954)*

A ventriloquism analogy can be used as a model to consider the roles of coding artist, code, and participant in a new media artwork. A general model for a code-based participatory artwork looks like this:

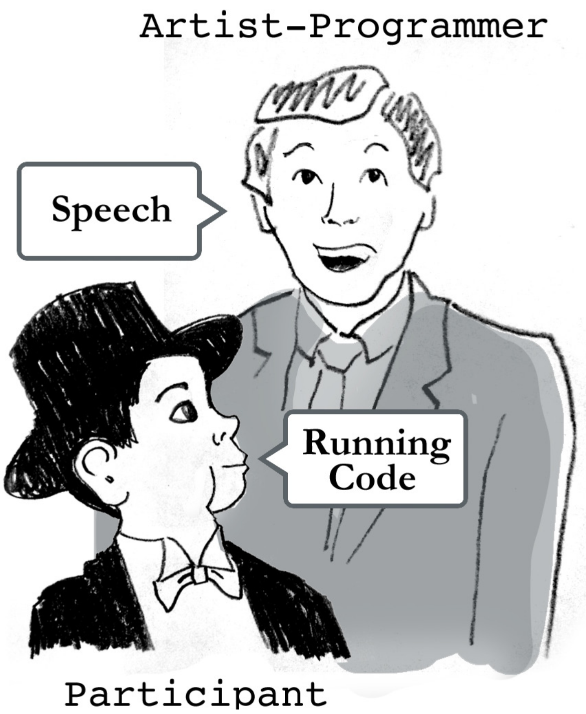


Fig. 1 General ventriloquism diagram for code-based participatory artworks

Computer code is written, compiles, and then runs through an end user. In the act of ventriloquism, the voice is thrown so as to appear to be coming from somewhere other than the original source. A study of ventriloquism in relation to new media art considers the origin of voice (code), the phenomenon of one entity speaking through another, and potentialities of control in computational systems. This paper examines ways in which new media artists and theorists have previously discussed ventriloquism while using the analogy of ventriloquism to reconsider the roles of code, coding artist, and visitor/participant in two of my new media artworks: *Toast*, which explores translation and *Ventriloquisms for Fun and*

Profit, a performance with audience involvement. Ventriloquism diagrams are used to simplify complex scenarios. They are intended as a tool to discover the types of entities that emerge when code is run and interpreted.

A ventriloquist is responsible for both sides of a conversation while dummies offer the illusion of autonomy (Clair 2007). A dummy appears to be a sovereign being while the audience knows that he is an extension of the ventriloquist. Thus, a doubling occurs and a loop is established:

```
{Ventriloquist → Dummy → Ventriloquist →}
is equivalent to (==)
{Ventriloquist → Ventriloquist → Ventriloquist →}
```

Alexander Galloway (2004) writes about the importance of language to communication. He defines language as shared protocol. For two nodes on a distributed network to communicate, they must speak the same language. Galloway states that "Code is the only language that is executable" and "[code] is a machine for converting meaning into action."

In *Interaction/Participation: Disembodied Performance in New Media Art*, *Dead History*, *Live Art?* Beryl Graham states:

> *Conversation is a highly elaborate skill involving exchange, evolution, creativity, interpretation, empathy and ambiguous language. Computer logic may just about be able to manage the first two factors, but beyond that it needs firm rules and predictable structures. (Graham, 2007)*

Languages, both coded and spoken, provide the power to communicate. Code is a language that acts, but as Graham states, it is not capable of carrying out complex conversation. In our technology-dependent culture, code mediates and controls conversation between humans. Just as audiences watching a ventriloquism performance ignore the objecthood of the dummy in order to be entertained, users similarly ignore the coded infrastructure beneath computational devices. This reinforces the power of the person, company, or government that writes or owns the code, while those using the technology are locked out of adjusting it or accessing its inner-workings.[1]

1 The experience of technology, for the majority of people, does not include the creative act of writing code, but only the consumption of a final interface with no entry into its inner workings. This is especially true in the case of tablets and smartphones.

2. VENTRILOQUISM IN A NEW MEDIA ART CONTEXT

When an artist writes lines of code for a work that invites participation, the code (the voice of the artist) is speaking (is thrown) through the visitor's actions. But what role does this visitor take when interacting with the code? Is he simply a dummy, acting as a medium for the coder's voice? Curt Cloninger (2010) states that "computers don't execute code in a transcendent, metaphysical vacuum… Code is run on physical hardware in lived and present (albeit massively accelerated) time." In order to come into being, code "has to be read by and run on something – a person or a computer." During this performative moment, the code is united with both the hardware on which it runs and with the person who interprets the result of this running. If this is true, then each time a program runs, a unique organism emerges.

When asked in an interview about the word "ventriloquism" in relation to his work, Jonah Brucker-Cohen stated that it is relevant "if you are making work that allows the user to be heard through some other object - ie. not themselves." (Brucker-Cohen 2012) In this description, the participant's voice, rather than the artist's, is being thrown through an object:

Fig. 2 Diagram with participant and object

The ability or privilege to speak grants power because the voice can be used to direct others to take certain actions, to persuade, or to assert oneself as an individual in the world. Geoff Cox and Alex McLean's book *Speaking Code* begins with a quote by Theodor W. Adorno from "Institute for Deaf-Mutes" that contextualises ventriloquism within social power structures:

> *While the schools drill human beings in speech…, the pupils become increasingly mute… In the all-embracing system conversation becomes ventriloquism. (Adorno in Cox, 2013)*

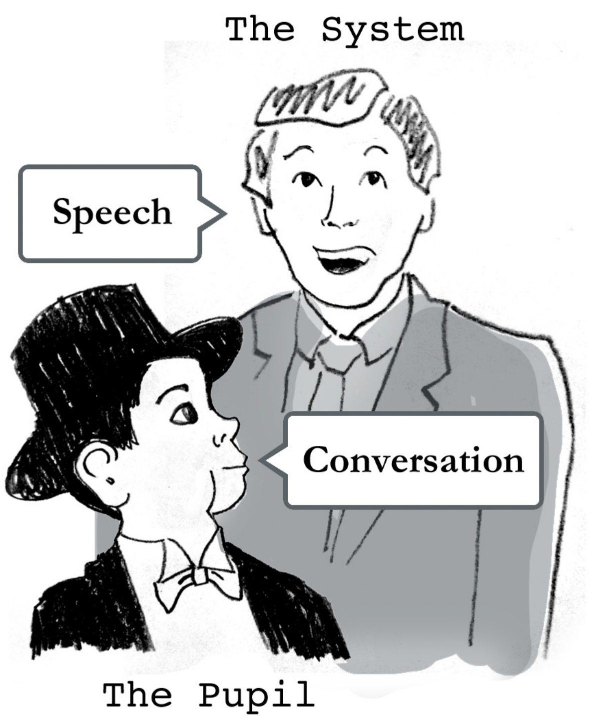


Fig. 3 Diagram for system-pupil relationship

In Figure 3, the pupils' mouths speak someone else's words. Like a ventriloquist's dummy, the pupil does not have the autonomy to articulate his own thoughts with his body and voice.

In Yvonne Rainer's *Carriage Discreteness*, part of *9 Evenings of Art and Engineering* (1966), Rainer stood offstage, choosing the actions and placement of people and objects from a pre-determined list of possibilities, then communicating these as instructions to her performers via walkie-talkie (Morris and Bardiot 2006). Choreographer and new media artist Kate Sicchio (2013) takes Rainer's idea into a contemporary context in her *Hacking Choreography* body of work.

In December 2013, Sicchio described *Hacking Choreography* at an *Into Practice*-run *Datarama* event at *Pixel Palace* in Newcastle, UK. In this presentation, she commented that her dancers don't always conform to her code as they can choose to either follow or disobey the given commands. In Rainer and Sicchio's works, the choreographer assumes the role of the ventriloquist while the dancers assume the role of the end-user/dummy. In both cases, however, the dummy has autonomy to act outside of the programmer's intent.

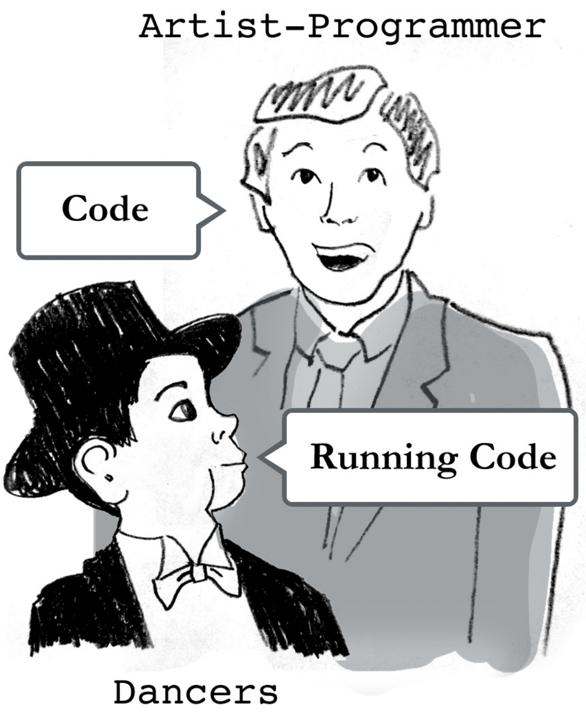


Fig. 4 Diagram for *Carriage Discreteness* and *Hacking Choreography*

Figures 1 through 4 illustrate directional transmissions of speech. Figure 1 shows an artist-programmer as the ventriloquist and the code running through the participant as a dummy. In Figure 2, the participant is the ventriloquist whose speech moves through an object. Figure 3 illustrates systems of power and social control as the system as ventriloquist dictates the speech of pupils. Finally, Figure 4 shows an artist-programmer articulating code that runs through the bodies of dancers who become dummies with an option of autonomy.

A ventriloquism analogy has been considered in two ways. First, the dummy as a powerless object who simply channels the voice of the ventriloquist through his mouth. Second, the dummy as a double of the ventriloquist, the same voice appearing to emerge from another body. These models can allow us to consider the roles of participant and artist in new media artworks and whether the participant has autonomy in an interactive scenario. Through their interaction with the code, are they simply a channel for the artist-coder's voice or do they beome one entity with the artist and the code?

Brian Masummi (2002) considers code to be strictly protocol while bodies are analog and continuous. Thus, code can "potentialize, but only indirectly, through the experiential relays the reception of its outcomes sets in motion…Whatever inventiveness comes about, it is a result not of the coding itself but of its detour into the analog." This means that the body is that which translates the strictly pre-determined code into the analog.

The following two case studies discuss my own practical projects that were created to investigate the roles of a coding artist and a participating audience. Here we will consider channels of ventriloquism present in the works.

3. TOAST

Toast uses a coded translation device to mediate the speech of a performing participant. The project was initiated in 2011 while I was living in China with Mandarin language ability that limited me to only simple utterances. Although I could speak enough to purchase food at a local market, to relay basic directions to a taxi driver, or to tell someone my occupation and nationality, the attempts at discussion that ensued after these basic exchanges discouraged further conversation. In Beijing, I quickly became interested in making a translation device that would allow me to take conversation to a more complex level while highlighting the ridiculousness of using a machine to communicate rather than taking the proper steps to learn a language.

Work began by moving directly into the code using translation in a Processing[2] sketch, drawing on libraries to handle the speech-to-text functionality and the Google Translate integration.[3] Next, I began to search for agents of performativity that were already present in Chinese culture that could help participants to overcome potential shyness of speaking into the device.

During the initial stages of project research, I was attending various functions in and around Beijing and Shanghai including gallery openings, private dinners,

2 Processing is a Java-based programming language created at MIT Media Lab by Casey Raes and Benjamin Fry primarily used by artists and designers to create animations, generative images, or interactive artworks.

3 Florian Schulz's 2011 STT Library was used for speech to text (*http://www.getflourish.com*) and the Google Translate API (*https://developers.google.com/translate/*) for Google Translate integration.

and banquets. It occurred to me during these occasions that there was something special going on in the performance of a toast. In a landscape where public expression is not widely encouraged, the toast provided a forum for a person to express his views and emotions about the occasion at hand and his gratitude to guests or hosts.[4] I decided to draw upon the social code of the toast in my emerging project, as it was a performative gesture with cultural precedent.

Iteration, a property inherent to media artworks because of code's flexibility, was important to *Toast* because the project resulted in a series of tests rather than a single work. These tests included an audience-performer format at Barcamp Shanghai, a series of one-on-one experiments at Shanghai's Xinchejian Makerspace, and an installation prototype at the *Feijiacun Shangri-La Art Community Open Studio Exhibition* on December 1, 2012. This final iteration is described below.

Fig. 5 Feijiacun, Beijing iteration of *Toast*, Open Studio Exhibition curated by Filipa Reis (2012)

The Feijiacun *Toast* installation included instructions for visitors that were posted on the wall in both English and Mandarin. The text asked a participant to address his toast to an adjacent photograph of a common restaurant table, set with empty chairs in the round. This table image served as a blank canvas on which the visitor could imagine people seated for a meal.

The participant approached the computer, read the instructions, picked up the microphone in one hand (and optionally an empty wine glass in the other), and then spoke a toast to his fantastical companions at the dining table. His words were sent through the Processing sketch. Here, speech was turned into text in the spoken language. This text was sent to Google Translate where it

4 In Britain, a prominent part of a wedding ceremony is the series of toasts traditionally made by men in the wedding party (the best man, groom, and father of the bride). This proclivity of men to make toasts over women, in both Chinese and British culture, situates the toast as an official forum in which expressing emotion and sentiment is made socially acceptable by the formality of the performative act.

was translated it into the "opposite" language (English <> Mandarin), and then it was sent back to be displayed on the screen. Throughout the interaction, a web cam picked up a live-feed of the speaker's face, which was situated next to a speech bubble containing the final result of the translation.

In *Toast*, the translations returned by the code were almost always inaccurate and not a representation of what the speaker had actually said. This defeated the initial purpose of the project: to help a non-native speaker to be better understood. Instead, it highlighted the ineffectiveness and humour of machine translation and created an instance in which the code *does not* act as an Austinian performative,[5] saying what it does and doing what it says.

The following excerpt of code is activated if there is a button-press by a user, at which time the code "hears" the spoken language, turns it into a string, sends the string to be translated, then returns the result to be displayed:

```
println(utterance);
result = utterance;

if (buttonCaller == 1){

  String translatedText=Translate.
  DEFAULT.execute(result, Language.
  ENGLISH, Language.CHINESE_SIMPLIFIED);
  println(translatedText);
  result = translatedText;
  }
```

In this code snippet, the variable *result* initially represents *utterance*, or the words spoken by the participant. Inside of the if statement, *result* becomes equivalent to the translation (*translatedText*). While the translation algorithm considers the original utterance and the result of the translation to be equivalent, the human participant knows that the final translation is often quite distant from what was actually said.

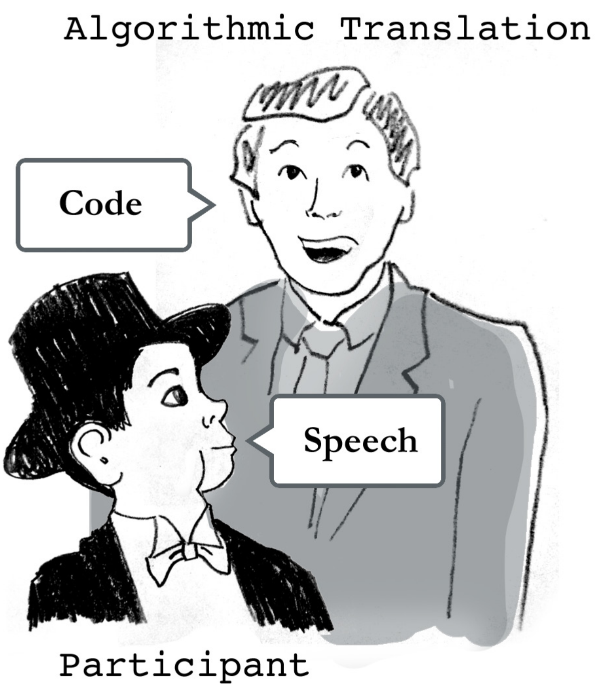
Although the code imposed translations on the *Toast* participants, they were free to interpret the text and image, drawing additional meaning or humour from the juxtapositions provided. Because most of the people attending the Feijiacun exhibition could speak some English and some Mandarin, among other languages, the

5 In *How to Do Things with Words*, J.L Austin defines the linguistic performative, saying it "refers to a class of expressions that are not descriptive and have no truth value, but rather in their very utterance, do something (I bet, I promise…)." (Austin, 1962)

participants were aware of these missed translations. This understanding led to them becoming actively engaged with the piece, gathering in groups, and creating a playful performative atmosphere around the spoken utterances, the doubling of a participant's likeness onscreen, and the floating speech-bubble translations.

A ventriloquism diagram for *Toast* looks like this:

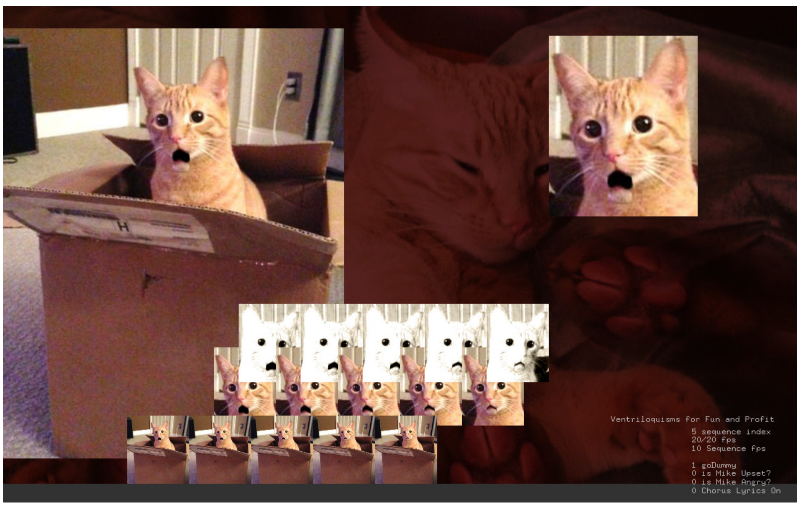
Fig. 6 Diagram for *Toast*



In Figure 6, the ventriloquist embodies the translation. This translation is dictated by an algorithm, which sends speech back through the mouth of the participant.

4. VENTRILOQUISMS FOR FUN AND PROFIT

Fig. 7 *Ventriloquisms for Fun and Profit*, audio asset: *http://blurringartandlife.com/vb/ventriloquisms.html (2013)*



In *Ventriloquisms for Fun and Profit*, I took the role of coder and performer as an audience was invited to participate. My voice was thrown through a self-coded puppet, while a call and response song made both performer and audience into dummies. In this performance, the dummy was a puppet of a cat, coded in openFrameworks rather than built with wood, strings, and glue.

The performance took place on April 26, 2013 at Datarama, Pixel Palace, Newcastle, UK. The piece began by engaging the audience in a song by instructing them to repeat the phrase “Oh Mona” after each artist-led line of verse. Between verses, they sang along with a chorus, “Oh Mona you shall be free…”. The text to be sung was displayed onscreen. When written in pseudo code, these instructions to the audience create an if-else-statement:

```
if (line of verse is complete){
Sing "Oh Mona";
};

else if(entire verse is compete){
Sing chorus;
};
```

At Datarama, the audience willingly participated, singing along and “joining in” or following the instructions. When everyone in the room was singing, social codes enforced individual participation. This call and response established the following loop between the audience, the artist, and the running code:

Artist → Code → participatingAudience → Code →

To begin the performance, I changed a Boolean value in the code from false to true in order to get the dummy “working” (See Figure 8). This moment of live coding referenced a common act in which a ventriloquist takes apart his dummy’s head and tinkers with it using a spanner, pretending to get a non-functioning part, such as the mouth, moving again.[6]

When I changed the value of makeDummy from false to true, the dummy appeared to have suddenly gained the ability to move his mouth (the change doesn’t actually serve a functional purpose within the running code, but acts as a visual gag for the audience). The code-saavy Datarama audience laughed at this moment.

Fig. 8 The “Make Dummy” code

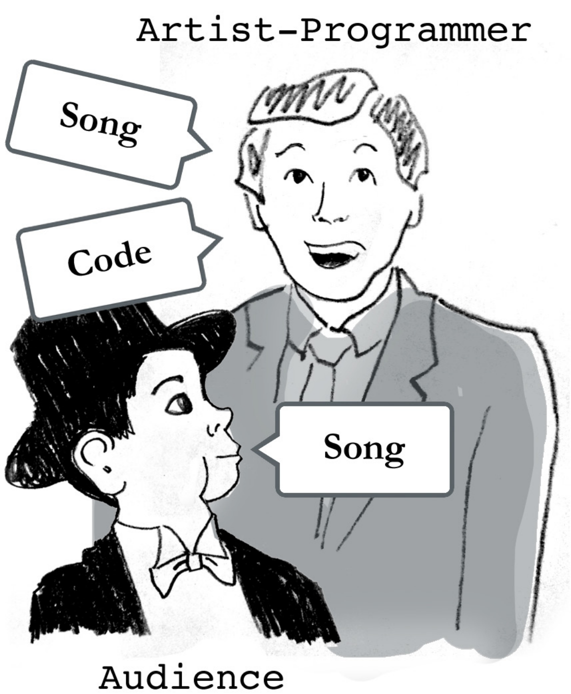
```
//makeDummy
makeDummy = true;
```

After the song, I performed a ventriloquist act, *At the Dentist* from an instruction manual for aspiring ventriloquists titled *Ventriloquism for Fun and Profit* (Winchell 1954). Winchell's *At the Dentist* sketch follows a common trope of ventriloquist performances that create humour through violence between the ventriloquist and the dummy.

At the beginning of *At the Dentist*, the dummy discovers that he is a patient at a dentist office and the ventriloquist is the dentist (see the quote at the beginning of this paper). The humour here lies in the fact that the dummy is surprised to find out that he is going to be subjected to a potentially painful procedure. This threat of violence between versions of the self is analogous to our interactions with code through an avatar which allows us to embody violent actions that we would not enact in our everyday lives. There is also an underlying power structure between a dentist and a patient similar to the pupil/system dichotomy seen in Figure 3. In these relationships, the dummy, patient and pupil are at the bottom rung of the power structure, subject to the speech of the ventriloquist, dentist, or a system of authority.

A *Ventriloquisms for Fun and Profit* diagram might look like this:

Fig. 9 Diagram for *Ventriloquisms for Fun and Profit*



6 My grandfather, Burke Bradbury, an amateur ventriloquist, often performed this trick with his dummy Oscar, who would continue to speak and protest throughout the "operation".

In Figure 9, the ventriloquist is equivalent to the artist-programmer while the dummy represents the audience as they sing the chorus of “Oh Mona”.

5. REFLECTION

During the March 2014 CRUMB discussion on the topic of *The Performativity of Code*,[7] new media artist Jack Stenner (2014) stated that humans are “the “neuronal” support for technology.” Stenner wrote that “By “othering” technology we can absolve ourselves and shift responsibility. It’s an unnecessary binarization of a more complex relationship.” Stenner sees our selves and technology (code) as one and the same. This union of code and body is reflected in the analogies of participation and ventriloquism described in the above case studies.

In *Toast*, while participants speak through a translation device that doesn’t translate accurately, the code becomes the ventriloquist, imposing meaning on the speaker’s image. The code places words in the mouth of the participant who is left to interpret the translation as it hovers beside his face-image (a doubling of the self). While code is the ventriloquist, the participant is the dummy with a sense of interpretive autonomy.

The Ventriloquisms for Fun and Profit performance situates the artist and audience as performers within a system dictated by artist-written code in which underlying social codes influence audience members’ participation. While the audience is the dummy in Figure 9, the artist is also a dummy during the performance, as both parties are controlled by the code and the code (as ventriloquist) speaks through them.

6. CONCLUSIONS

In a conversation, words are spoken by one party, then heard, considered, and responded to by another. This exchange continues in a loop. In a toast, one person speaks to a group in a performative moment. An audience hears this speech and clinks their glasses, initiating a consecration of the words. In a call and response song, one person holding the power of performance sings a line and a group responds with a pre-established, repetitive phrase. In ventriloquism, the ventriloquist speaks as himself, but simultaneously and in another voice, channels his speech through the dummy.

7 CRUMB (*http://crumbweb.org/*) run a new media curating discussion list that proposes month-long discussion topics with list members and invited participants. The March 2014 topic was *The Performativity of Code* and was mediated by CRUMB researchers Victoria Bradbury and Suzy O’Hara with 17 invited respondents. The full discussion may be found on the CRUMB online archives.

In viewing a ventriloquist performance and while interacting with code, an audience or participant often accepts and ignores the workings behind the scenes in order to accept the illusion. In ventriloquism, the trick is obvious, but with code, layers of obfuscation, translation, and compilation hide the source, making it unclear exactly how the programme controls the participants' actions.

In each of the analogies of ventriloquism described in this paper, code is not the other, but is equivalent to the author and participant as it runs through all of the entities within the system. Bodies and voices are not separate from code.

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MECHANICAL DRAWING MACHINES AND THE GLITCH – VISUALIZING TECHNOLOGY THROUGH ITS FAILURES

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A glitch is an unpremeditated result of a digital protocol, making visible technology by its failures. Both practitioners and scholars have explored this phenomenon creatively and theoretically.

This paper provides an overview on glitch literature and examines definitions and motivations for glitch art, grounded in a more established discourse on the role of the error in art. The Artificial Intelligence notion of emergence will be consulted, to offer a model for phenomena arising without being prescribed.

The paper applies these concepts from literature to a practical line of inquiry, describing two mechanical drawing machines of the author, which draw their aesthetics from imperfection. Peirce's semiotics is consulted to establish a distinctive framework situating both the mechanical patterns and digital glitches.

1. CONTEXT: THE GLITCH

1.1. THE ERROR AS A PRODUCTIVE FORCE IN ART

The glitch discourse relies on more general reflections on errors and accidents. In *The Original Accident*, Paul Virilio frames the accident as inherent in any product, highlighting its "accidental potential": "To invent the sailing ship […] is to invent the shipwreck. To invent the train is to invent […] derailment." (Virilio 2007, 2)

While accidents have held an appeal for introducing an unpredictable quantity into art making since a long time, only recently this idea has stepped over to digital culture. The electronic musician Kim Cascone writes

> *Indeed, 'failure' has become a prominent aesthetic in many of the arts in the late 20th century, reminding us that our control of technology is an illusion, and revealing digital tools to be only as perfect, precise, and efficient as the humans who build them. (Cascone 2000, 13)*

Accidents, failure and imprecision have played a role in art since a long time. With the glitch, they have also become a topic of interest in the digital realm.

1.2. THE GLITCH

After an initial gold rush, in which many artists have playfully explored the phenomenon of the glitch, some of these have also engaged in theorizing it and discussing its cultural implications. Rosa Menkman is one of the leading figures in this discourse; she has established some canonical references for discussing the glitch. She defines the glitch as "an unexpected occurrence, unintended result, or break or disruption in a system," (Menkman 2010, 26) or as a "break from (one of) the protocolized data flows within a technological system." (Menkman 2010, 26)

Iman Moradi is another main contributor to the discourse. In his initial Bachelor's thesis on the glitch, he calls the (pure) glitch "an unpremeditated digital artefact, which may or may not have its own aesthetic merits." (Moradi 2004, 10) The aspect of aesthetic discovery that he points out here seems to be a powerful driver of glitch culture. In a later definition, this aesthetic element is less prevalent, when he specifies glitches to be "short-lived disturbances that populate our digital landscapes." (Moradi 2009, cover text)

A glitch seems to be a transient, ephemeral phenomenon arising out of digital cultures. This limitation to the digital is not shared among all writers: The scholar of screen studies Hugh S. Manon and the glitch artist Daniel Temkin hold that framing the glitch as a purely digital phenomenon is not enough: "Glitch is an intersection of analog and digital modes of (re)production." (Manon and Temkin 2011, 4)

They emphasize that hybridity and intersection between analog and digital lead to the glitch. This hybrid interplay is often described as the "materiality" of the glitch:

> *Despite the seeming immateriality of digital representation, it would be difficult to deny that some glitch experimentation has a materialist bent: […] when broken, a JPEG looks very different from a BMP. (Manon and Temkin 2011, 9)*

The term "material glitch" is used to describe how the glitch reveals "material" properties of a digital file format. The relation between digital and material is also the topic of a much earlier essay *Einmaliges und Beliebiges / Künstliche Kunst im Strom der Zeit* by computer art pioneer Frieder Nake:

> *The artist as programmer looks for the resistance he has lost materially. […] The artist as programmer finds a resisting material. This material a priori is of a semiotic nature. ("Der Künstler als Programmierer sucht die Widerständigkeit, die ihm stofflich ja abhanden gekommen ist […] Der Künstler als Programmierer findet ein widerständiges Material. Dieses ist von vornherein semiotischer Art.") (Nake 1995, n. pag.)*

Reflecting on the resistance a digital material offers to the creator, he contrasts this semiotic resistance with the physical realm, in which the resistance is manifest and embodied. Material is understood as something offering resistance that is worth exploring. A similar point of view is entertained by critic and curator Ed Halter, who uses the term "digital materialism" to say that glitch art's goal is to make visible technology by its failures and to "see the material through disruption." (Halter 2010, n. pag.) The glitch artist and researcher Theodore Davis illustrates this way of seeing, comparing a digital file format to a window, in which the glitch introduces a crack: “the window transfers from a transparent or unnoticed medium to an opaque one.” (Davis 2011, 212)

Also Menkman holds that the glitch “reflects critically on a medium.” (Menkmann 2010, 2) She identifies the rejection of the “continuing search for a noiseless channel” as a motivation for glitch art. (Menkmann 2009/10, 2) Her motivations are post-structuralist: they serve the purpose of deconstructing media and revealing inherent properties, thus bringing to the discussion our use of media itself. In *Glitch Studies Manifesto*, she appeals to glitch artists for disputing the “the operating templates of creative practice; fight genres and expectations!” and thus using the glitch as an “exoskeleton of progress.” (Menkmann 2009/10, 5)

To compile the literature into a workable definition for this paper, let us summarize that a glitch is an unexpected, unpremeditated result of a protocol. This result is used to reflect critically on the medium and making visible technology by its failures and disruptions.

The digital seems to be a legitimate and viable territory for such reflections – but it is easy to argue that glitch art could also be looking for disturbances outside of “digital landscapes.” As a glitch aficionado, the author argues that glitch art may be complemented with inquiries beyond the digital, and thus a similar perspective can be applied for exploring analog and digital technology.

1.3. EMERGENCE

Unexpected or unpremeditated – glitch effects emerge indirectly from its causes. The concept of emergence is also used in the field of Artificial Intelligence, where the Australian roboticist Rodney Brooks has coined the term of subsumption architecture: the behavior of a system is understood as determined by the interaction with its physical environment – it is not prescribed explicitly through an algorithm. Brooks introduces several “subsumption layers”: instructions on a lower algorithmic layer lead to patterns on an overarching superior level, which cannot be predicted algorithmically. (Brooks 1991)

Christian Faubel, a researcher at the *Academy of Media Arts Cologne*, has demonstrated impressive examples of emergent phenomena, creating fascinating kinetic sculptures out of very simple electro mechanic circuits. He states: “The interactions between subsystems rather than the subsystems themselves create a huge variety of new behaviors.” (Faubel 2013, 160)

In Brooks' terms: the interactions between subsystems constitute a behavioral layer that was not explicit in the design of the system: the emergent pattern only appears when "basic units are connected into a loop." (Faubel 2013, 156) Faubel defines emergence as "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." (Faubel 2013, 156)

The concept of emergence applies to glitches as well – they are unpremeditated high-level patterns that are not explicit in their protocolized code. But emergence particularly occurs in the physical world: here, algorithms collide with material conditions such as friction, vibration, or mechanical wear. The precise effect of such conditions is never completely predictable, which opens a poetic space for emergent phenomena. This is also why it became interesting for the author to shift his attention from purely digital systems to mechanic drawing machines. Some of these will be presented in the next chapter, together with their images.

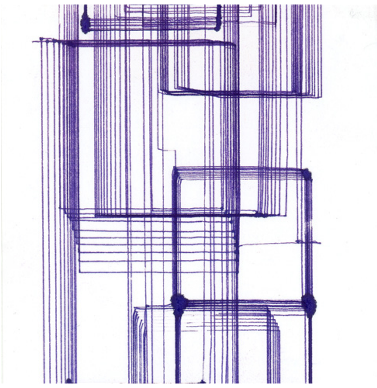
2. EXPERIMENTAL SETUP AND RESULTS

2.1. THE PLOTTER

In an earlier paper, the author has described drawings resulting from mechanic imperfections of a Lego-built drawing machine: *The Plotter* produces a generative line drawing, with resulting images caused by the interference of "instructions" with "mechanical friction." As characteristic elements, the author identifies "near congruent forms" – the slightly shifted multiple squares visible in figure 1, and "negative space compositions" – segments of different shapes and proportions into which the white space is divided. (Wanner 2010, 7) These emergent patterns lead to an aesthetic composition as an emergent result which is unpremeditated by the underlying code, and makes visible the specifics of the mechanic process.

This drawing machine is an "analogital"[1] hybrid: digital program code is interacting with an analog mechanic system. As the digital algorithm played only a minor role anyway, the consequential next step was a similar investigation of purely analog, non-programmed machines, discussed in the following subsection.

Fig. 1 Plotter drawing, featuring near congruent forms and negative space compositions



1 *Analogital!* was the title of a recent workshop at the interfiction XX festival 2013 in Kassel, Germany. In their call for participation, the organizers argue that analog and digital belong together, rather than being opposites. *Analogital* describes objects finding their way from digital culture back to material concreteness ("... Objekte, die ihren Weg aus der digitalen Kultur zurück in die materielle Gegenständlichkeit finden.") (Kuni 2013, n. pag.)

2.2 MACHINIC TRAJECTORIES

Machinic Trajectories is a series of household devices appropriated as drawing machines. Their mechanic motions are traced on paper surfaces; the machines are minimally altered and their respective drawing utensils are attached to one of the moving parts. Other than that, no electronic or mechanic changes are made to the machines, to allow direct observation of their original mechanisms.

The Mixer is one of the appropriated household devices of this series. A black technical pen – connotated with precise recording – attached to one of the whisks leaves lines on a paper attached to the underlying support disk. Simultaneously, the pen causes the plate to rotate and moves the paper: the drawing results in a kind of spiral.

Fig. 2 The Mixer, 2011. Drawing machine

Fig. 3 Mixer drawing Nr. 2, parallel circles

Searching for aesthetic visual figures, the author came across emergent patterns reminiscent of the near-congruent forms observed in the Plotter drawings mentioned in the previous subsection.

Figure 3 shows the emergent pattern of a spiral consisting of dense parallel circles. This spiral shift is not a designed feature of the machine, but results from inaccuracies of the whisk movement propagating the support plate. The pattern is caused by mechanic irregularities and mechanic frictions, but also of a subtle unevenness in the flat surface. Higher density patterns result from temporary stagnations of the disk, and pressure fluctuations of the pen cause light intermissions between the circles.

Figure 4 illustrates another unpremeditated result – a defective pen splattering around ink-blobs when rotated at the given high rotational speed of the machine.

Fig. 4 Mixer drawing Nr. 9

Figure 5 illustrates the variety of expression achieved with different places and angles of attaching the pen, and different paper surfaces leading to frictional variations. The drawing features variations resulting in a rhythmic play between denser and more openly articulated circles. The intrigue of the image lies in this pattern of varying densities, the variation from the regular repetition.

Fig. 5 Mixer drawing Nr. 11

Altogether these irregularities render the drawings their aesthetic appeal –unpremeditated breaks from the repetitive geometric regularity of a functional process. Similar to investigations of corrupted digital file formats, technology is made visible through its imperfections, turning these documents of repetition into multifaceted compositions. A more extensive description of this project is provided in the author's Master's thesis. (Wanner 2013)

2.3. DIGITAL GLITCHES, MECHANIC PATTERNS AND A SEMIOTIC DIFFERENCE

The glitch reflects critically on a medium by making visible digital protocols – often the encoding conventions of a digital file format. As pointed out earlier, Nake spoke of program code as a semiotic material, resisting the form-giving intention of the artist-programmer. With Peirce's distinction between semiotic signs icon, index and symbol,[2] digital code can be framed as a symbolic sign – its reference to the world is determined by convention. The digital glitch acts on a symbolic level, revealing the arbitrary nature of digital coding conventions: minimal alterations in the code do not continuously translate into subtle visual differences, but may result in gross distortions. This lies at the heart of the surprising aesthetic discoveries the glitch offers: aesthetic artifacts seemingly appear out of the blue, small changes can lead to drastic effects. Manon and Temkin observe a "glitch paradox": "the individual glitchwork does not respond well to gradual refinement." Seemingly closely related sequences of code may result in very different aesthetic and visual output: as easy it is to make a surprising find, as hard it is to tweak this discovery just a little bit: "to attempt to refine a glitch even slightly would be to render it unreadable." (Manon and Temkin 2011, 3)

In contrast, the traces of mechanic imperfections discussed above are indexical signs (indices): the drawings document the machinic mechanisms in a way that "physically connects" the two. The deviations in *The Plotter* and *The Mixer* are a continuous result from a shift caused by mechanical frictions. The emergent patterns evidence a mechanical principle. This physical connection is continuous and more predictable than the codified symbolic relation between a digital file format and the world. In other words: small distortions lead to

2 Charles S. Peirce introduced the distinction between "icons" representing things "by imitating them", "indices" which are "physically connected" with the things they represent (e.g. resulting from a cause and effect relation), and thirdly "symbols" "associated with their meanings by usage" – symbolic meanings are arbitrary and rely on convention. (Peirce 1998, 5) small visual effects. This lends itself better for gradual refinement, but still responds to the agenda of glitch art: reflecting critically by making visible technology, deconstructing our use of it, emphasizing noise over signal, and – through all of this – potentially acting as a vehicle for progress.

3. OUTLOOK

Based on an overview of glitch literature, the paper has outlined a widely entertained notion of the glitch and listed motivations for glitch art. Aesthetic explorations of mechanic imperfections were framed according to glitch criteria. Reoccurring formal properties were demonstrated in images exploiting inaccuracies of mechanical drawing machines. These emergent patterns were then paralleled to digital glitches by the way they make visible the technological mechanisms at their origin.

Digital and analog technology may share more connections than we usually assume. Investigating errors and inaccuracies beyond digital data compression may allow a wider view on technology and technological "failure" more specifically.

3D printing and smart materials are current technological developments that may dissolve the clean boundary between analog and digital – we may see a revival of mechanic technologies. Generalizing digital phenomena to analog or analogital environments will allow a wider perspective, and may be useful for entertaining an ongoing critical contention with technology surrounding us. To conclude with words of Paul Virilio: "In my view, the accident is positive […] because it reveals something important that we would not otherwise be able to perceive. In this respect, it is a profane miracle." (Lotringer and Virilio 2005, 63)

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A SURVEY OF PROGRAMMERS' PRACTICES FOR HANDLING COMPLEXITY IN CREATIVE CODING

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Creative coding has goals, methods and tools that distinguish it from other forms of programming practice. A number of creative coding practitioners regularly engage with complex systems in creative applications, such as neural networks, genetic evolution, ecosystems and reaction-diffusion equations. Such systems are conceptually opaque and hard to manipulate, but we know little about the ways in which creative coders handle them. In this paper we present findings from a survey of creative coders regarding how they deal with complexity in their work. We discuss four issues of interest: time-demands of specific activities; sources of knowledge and approaches to problem solving; approaches to exploration; and information-seeking versus intuitive styles of working. Our results provide an initial characterisation of creative coding strategies and suggest how tools could be better adapted to their needs.

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1. INTRODUCTION

Creative coding or creative computing has begun to emerge as a field that can be distinguished from other types of computer programming, based on the nature of the practice, the tools used and the methods employed in its production (McLean and Wiggins, 2010; Turkle and Papert, 1990; Mitchell and Bown, 2013). Researchers are beginning to focus on these areas in order to understand how creative coders can get the most out of what they do, either through new tools or new forms of practice.

As an example, the idea of merging code and GUI elements has been explored in many contexts, leading to a more flexible integration between writing code and exploring its parameter-space: in visual programming languages, such as MaxMSP and Pure Data, GUI elements sit within the visual programming paradigm; in hybrids, such as Field, GUI elements can be inserted into blocks of code; in web-based environments, such as Khan's Code Academy, variables such as numbers and colours in the code can be interacted with to change their values; and in add-ons to regular IDEs, such as the Processing environment optional add-on, Tweak Mode, the same effect is achieved working directly on the Java code. The utility of such tools are easily inferred from their popularity, but more detailed studies of what transformative effects they have on creative coding practice are also required (see Mitchell and Bown, 2013 for some recent analysis).

2. BACKGROUND

In previous work examining the potential to apply complex dynamics from models of nature to creative goals (McCormack and Bown 2009, Bown and McCormack 2010), a key observation was that, whilst rich biological models – such as those of ecosystems evolution – had creative value, the biggest obstacle to their successful use was the difficulty of working with their unwieldy complexity. Our autobiographical accounts of programming such systems showed that we often didn't have good enough information about what the system was doing to be able to make clear informed creative choices about what steps to take next.

All software programmers must take steps to discover things about their running programs that they cannot tell from the code alone. This often involves gleaning information that is additional to the output itself. Thus a programmer animating a flock may already have the flock to look at on their screen, but they may add print statements to reveal other data – in the form of text – to the screen or to a console output, view variables in a debugger, draw additional layers on the animation, such as velocity vectors or the flock's centroid, or use other data visualisation methods such as histograms or scatterplots. Some tools exist for these purposes, such as debuggers and convenient libraries for visualising data. Other forms of data discovery need to be added by the programmer. For example, typically the programmer would draw visual layers such as velocity vectors themselves, but they could equally use a third-party physics library that provides visualisation layers for them.

As well as gleaning information about their programs, creative coders regularly iterate through a number of designs in search of specific outcomes. An additional form of information acquisition therefore comes in the form of partial automation of their search process. The flock programmer may have a number of real-valued variables that they wish to explore in order to find the system's best settings. In that case they may explore this parameter space using one of the interactive methods described above. Alternatively, they could perform a *parameter sweep*, in which a large number of parameter values are input in order to produce many different possible animations (perhaps generated overnight while the programmer sleeps), which can be quickly examined. A more advanced approach would be to conduct some kind of automated search for preferred parameters, but this requires the flock programmer to define in the program what is being sought. Whilst all of these approaches are feasible, they require increasing levels of input to achieve desirable results, sometimes involving significant design challenges in their own right.

Finally, information about the workings of a program comes not only from isolated inspection of the program itself but by learning from other people: the flock programmer has likely discovered the classical flocking algorithms through books or lectures or discussions with colleagues, and may also find out the precise implementation and specific parameter values that way. If a programmer's code produces unexpected results, they may be able to understand why through discussion and comparison with others' results. This form of knowledge acquisition is evidently ubiquitous throughout programming practice: we would not even know of the existence and applications of cellular automata, reaction-diffusion equations or neural networks without learning about them from others. It is rare that someone makes an original discovery as significant as one of these canonical forms.

In this paper we present the initial findings from a study that sets out to understand how practitioners approach knowledge acquisition and manage their understanding of their code when interacting with software objects. Our focus is on the more complex end of topics that creative coders work with: concepts from computer science such as genetic algorithms, reaction-diffusion systems and self-organising behaviour. For the purpose of this discussion we loosely refer to this set of elements as 'complex systems' (although note that 'complex systems science' refers to an overlapping but distinct set of systems).

Complex systems have in common that certain aspects of their behaviour are opaque to the user. Although this could be said of computer programs in general, complex systems push the cognitive capacities of the programmer to the point where it is not viable to maintain a mental model of what the system is doing at all levels of scale, whereas for many acts of programming the programmer is able to maintain a clear understanding of the macroscopic effects of specific programmed behaviours. With complex systems, the system changes and interacts in ways that are not clearly predictable or transparent. For example, in artificial evolution the structure of a computational component, the genotype, is modified by a process of selection and random mutation, and its outcome may not be easily predicted from the design of the process. In this way, surprising designs come about, such as those of Sims' famous evolved virtual creatures (Sims, 1994). Complex systems are, as their name implies, hard to work with.

3. STUDY

For all of the strategies mentioned above, there is little information on the extent to which creative coders use them, how they enhance creative search, and where and when they are most effective. Through this study we set out to begin to understand what aspects of the programming process support or hinder creative development using these systems.

The study was run as an online survey.[1] Participants were asked to respond to the survey only if they worked with complex systems, a list of examples of which were provided at the start of the survey. Participants were asked a number of background questions regarding their training, experience, the tools they use, and the application areas they work in. They were then presented with a number of statements with Likert-scale response options (strongly disagree, disagree, neutral, agree, strongly agree) on a range of issues from their approach to debugging, to their experience of surprise. All questions had the option of adding additional comments.

As a provisional look at practice, the questions covered a broad range of topics and were designed to give clues as to where to look in further more detailed research. Our aim was to use the current survey results to identify compelling areas of further study.

4. RESULTS

Participants were contacted via special interest mailing lists catering for communities working creatively with code (with which we include visual programming environments such as MaxMSP), such as the Processing forum and the Computer Arts Society mailing list. 110 respondents started the survey and 39 completed it entirely. All questions were optional and no responses were discarded. The average age of respondents was 41.1 years. Of those who chose to respond, 53 were male and 7 were female, confirming a strong and widely recognised gender imbalance in creative electronic arts.

We divide results into four distinct areas: time-demands of specific activities; sources of knowledge and approaches to problem-solving; approaches to exploration; and information-seeking versus intuitive styles of working. We present results in each of these areas interspersed with some discussion.

4.1. TIME DEMANDS OF SPECIFIC ACTIVITIES

One of the sets of questions with the most unanimity concerned the time-burden of different parts of the programming process. Most participants (40.5% SA, 40.5% A)[2] reported that along with the coding of the system itself, “a significant proportion of time was spent exploring spaces of possibilities (e.g., parameter spaces) of the system”. Likewise, a moderate number of participants

1 The full survey, with fully anonymised numerical only results, can be found at: *http://2014.xcoax.org/files/070.zip*

2 For reporting statistics we give the percentage of respondents stating Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD).

(13% SA, 25% A 22%N) reported that it was hard to find the system's 'sweet-spots', whilst the vast majority (60% SA, 15% A) reported that they had experiences of finding surprising behaviour. A moderate number of participants (19% SA, 17% A, 19% N) also reported spending significant time on writing unit tests. Two participant's comments suggest that the central challenge of their work lay outside of the domain of programming *per se*:

> *"The system was 'easy' to implement in the sense that there were no new technical breakthroughs required in order to make it work. However, figuring out how to make it work aesthetically was complex and time consuming." (Respondent 50)*

> *"I definitely understood the low-level behaviors, but was continuously amazed by higher-level emergent behaviors." (Respondent 56)*

This suggests that it may make sense to distinguish aesthetic search and/or design from the act of programming in creative coding. But another participant's remarks related to the difficulty of setting debugging issues apart from design in this context:

> *"I did not understand what was going on due to complex bugs in my code" (Respondent 43)*

Finally, most respondents reported satisfaction with the high-level libraries available to them (49% SA, 25% A), i.e., they did not feel that a lack of high-level libraries was a hindrance to progress.

We may ask then whether existing tools are catering sufficiently for the time-demands of creative programmers, given that significant time is spent in an exploratory state. For example, it may be that tools that allow breaking out of a programming mode of activity and into a design mode of activity would be useful. Further study into this area, could involve prototyping and user-testing such a tool to understand its efficacy.

4.2. SOURCES OF KNOWLEDGE AND APPROACHES TO PROBLEM SOLVING

We asked respondents about the different ways in which they inspected their own programs, considering graphs and statistics, abstract visualisations and indirect quantitative measures such as entropy. The dominant approach identified in responses was abstract visualisation (49% SA, 15% A) (the example we give above of abstract visualisation is the visualisation of mechanical properties such as velocity vectors, although we did not offer specific examples to respondents), which the majority of respondents used, though all methods received above neutral average responses. We also looked at how people used personal communication and other knowledge resources to better understand their systems. We found a greater tendency to solve problems alone (47% SA, 39%A), e.g., using deduction or trial and error, rather than seeking help directly (34% SD, 16% D) or on forums (56% SD, 21% D).

We do not have data on regular programming practice to compare this to. Logically, individual problem solving must be more common than consulting forums, since it is necessary to try and solve a problem before asking for help. However, the lack of use of forums may be related to the idiosyncrasy of systems, and the loosely-defined nature of problems in this context, that would make it harder for others to get involved. As above, there is also a distinction to be made, as well as an overlap, between programming problems and design problems. Respondents generally agreed that the idiosyncrasy of their systems limited the value in seeking help. A study of creative coding forums could be used to reveal more information about the level at which individual design issues are raised.

4.3. APPROACHES EXPLORATION

Artistic creativity is often described as exploratory, and a number of personal accounts of creativity in the digital arts known to the authors emphasise search as a core process. One comment from a respondent expresses a common scenario for creative coders familiar to the authors:

> *"I was hoping to get sequences that were on the 'borderline' of randomness and predictability. In fact, the series almost always ended up too random."* (Respondent 7)

Anecdotally, we have noticed in our own work that it is common to have expectations of specific phenomena that do not materialise easily in practice. It may then be common to have a mismatch between expectation and outcome. It would be reasonable to guess that the expectation was too great. But it could also be that in such cases the programmer is actually close to achieving their goals but without the required tools or methods to ultimately find the desired solutions.

Other approaches are more pragmatic in that there is no search for an ultimate configuration, only for good candidates, which can be integrated simply by switching between states:

> *"I actually ended up using several different permutations of the flocking system in the one work." (Respondent 43)*

A large proportion of participants (66% SA, 24% A) reported that one motivation for using their chosen complex system was that it was a good generator of variation. The sentiment may therefore be common to a wide-range of creative computing objectives, typical in the practice of 'generative art'. Techniques for rapidly generating variation, and doing so for a wide range of aesthetic objects, may therefore be the most *currently* useful tools in the creative programmer's toolkit. Finally, respondents tended to agree that batch processing in their search for solutions was within their capacity (59% SA, 19% A), and a moderate number reported a willingness to use batch processing (43% SA, with an even distribution across the rest of the scale).

4.4. TYPES OF CREATIVE CODER

Based on our own experience we hypothesised that a distinction may exist between two prototype styles: an information-seeking approach which emphasised the need to manage the complexity of the system through analysis, valued tools that supported this, and sought additional knowledge about systems; and an explorative approach which emphasised an intuitive iterative creative cycle with a focus on visualisation. This latter type may correspond to the archetype of the creative, 'bricoleur' programmer (McLean and Wiggins 2010), and closer resemble the artistic practice of a painter, sculptor or composer, who is engaged in a *tight coupling* of action and response with their artistic material. This is suggested in a comment by one such practitioner:

"I regard the creation of algorithms as similar to a traditional compositional activity… understanding can be intuitive and 'musical'. " (Respondent 96)

The former type resembles a more traditional view of an engineering approach, but could be more exploratory than software development in non-creative domains, distinguished by an openness to the final outcome.

The same participant also stated:

"I don't always know exactly how the system will work when finished; and I prefer not to aim for a preconceived goal." (Respondent 96)

This may be distinctive of an exploratory approach, but we suspect that it is not actually the distinguishing feature between approaches – both approaches could accommodate an open-mindedness towards the final outcome.

In fact, the numerical results did now reveal clear-cut distinctions between types of practice, but they did show a wide range of responses, as well as significant correlations between sets of responses to those questions that asked whether better tools were needed to enhance creative search. According to these correlations, participants' level of contentment with their development environment was not specific to any particular improvements, but rather generic. However, there was no correlation, positive or negative, between how advanced people's use of analysis tools was and their recognition of a need for better analysis tools or methods.

These results suggest that there is no neat distinction between information-seeking and intuitive approaches, but do support the idea that some programmers are content with methods for discovering information whilst others desire improved support tools. This may include different information-seeking needs. We therefore suggest that there is good reason to seek innovative and diverse ways to support creative coders with information about the systems they are coding. We also propose that further research should continue to try to identify distinct strategies for handling complexity, given our wide-range of responses, and to further understand how practitioners define goals and go about arriving at outcomes with respect to those goals.

5. CONCLUSION

This study takes a first detailed look at the way creative coders manage complexity in their practice. Our results provide pointers for how to think about categorising and understanding creative coding practice, indicating a range of approaches to handling complexity. We have summarised four areas where we feel further research could be carried out into how creative coders work and what tool designs would support them. We have briefly discussed further questions, and possible implications for future creative coding tools.

The following conjectures are not conclusive given the current results but are at least supported by them and worthy of further study: exploratory search is a major component in creative coding which could be better supported by allowing it to take place in a non-programming design phase; additional and varied forms of feedback may provide one way to enhance the search process, and a range of distinct information-seeking strategies should be considered; the generation of variation is currently a key motivator for creating with code, and is perhaps a greater focus for creative practitioners than discovering sweet-spot states, possibly because the latter is harder to achieve.

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DIGITAL COMPUTATIONAL SYSTEMS AS AESTHETIC ARTIFACTS: PRACTICES, SYSTEMS, PROCESSES AND PERSPECTIVES

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This paper addresses the study of digital computational systems as aesthetic artifacts seeking to provide instruments for their analysis and critical understanding. Implied in this view, is the need to combine complementary perspectives considering both their specificity as digital computational (software-driven) systems and their different aesthetic intents and experiences. This approach also entails articulating the viewpoint of their creation or poetics with the viewpoint of their experience or aesthetics. To this end, this paper discusses concepts and frameworks that not only argue on the distinctive processual nature of these systems, but also stress the interdependency of views on their principles, mechanics and experience.

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1. INTRODUCTION

This paper was motivated by a previous study of aesthetic artifacts that explore the possibilities of software as a creative medium and propose audiovisual interactive experiences. However the question that immediately emerges while confronting perspectives on the subject is that before addressing their audiovisual and interactivity specificity, a deeper understanding of digital computational systems as aesthetic artifacts is needed (Ribas 2012). Therefore, rather than focusing on their surface audiovisual modes of expression, this study is oriented towards understanding the dynamics of these systems. And rather than focusing on the specifics of audience interaction, it frames interaction as one of the dimensions of the variable dynamic behavior of these systems.

We begin by discussing complementary perspectives on the principles that motivate and drive the creation of these systems (framing practices), on their specific nature as digital computational systems (framing systems), and on their processual nature (framing processes). These views emphasize processuality as a distinctive aspect of these systems, tied to procedural creation and to the performative dimension of their experience, therefore assuming that beyond surface representations we need to focus on their procedural modes of expression and dynamics. Finally, we discuss interdependent and causally linked views (framing perspectives) on their creation, enactment and experience.

2. FRAMING PRACTICES: DIGITAL COMPUTATIONAL SYSTEMS AS AESTHETIC ARTIFACTS

In order to frame the diversity of creative practices that use software as their medium, and are concerned with, or articulated through sound and image, Golan Levin proposes to consider the *principles* that motivate the creation of audiovisual software art. They comprise sound visualization and notation, the transmutability of digital data, interactive performativity and generative autonomy. They correspond to the use of sound or music "to generate aesthetic or analytic visualizations", to works that "map 'real-world' data signals to graphics and sound", or works that "use human performances to govern the synthesis of animation and music", and also to "generative artworks [that] produce animations and/or sound autonomously – from their own intrinsic rule-sets" (Levin 2010, 271-7).

The premise that any information (once digitized) can be algorithmically sonified or visualized, as expressed by the transmutability of digital data, can ultimately be considered as tied to all visualization and sonification practices. Interactive performativity involves user and system in an interactive feedback-loop, while in turn, generative autonomy implies rules as "recipes for autonomous processes" (Galanter 2006) that potentially lead to unforeseeable results, which are not completely predictable neither by artist or user (Boden and Edmonds 2009, 24).

These principles correspond to different ways of exploring the mapping of a given input data or source information into visual and auditory form (tied to visualization and sonification practices linked to transmutability), and to the possibility of devising dynamic audiovisual behaviors and responses to interaction (expressed through generative autonomy and interactive performativity).

As such, they address creative possibilities of a medium where "data and processes are the major site of authoring" (Wardrip-Fruin 2006, 381).[1] The notion of transmutability (including visualization and sonification) therefore puts an emphasis on data as information or content, its mode of representation and perception, and on the mediating transformational process. In turn, generative autonomy and interactivity accent processes, as observable activities performed by the work, defining its surface and supporting interaction.

As Wardrip-Fruin states, "authoring new processes" is a significant means of expression for authors, as a creative opportunity for "defining new computational behaviors" (2012, 7). This view highlights the procedures or operations performed by the work, suggesting that sound and image acquire meaning only as the products of processes, performed with or without the participation of the user. Therefore, the subject matter of these works is not merely tied to surface (audio, visual) manifestations, but by exploring the possibilities of software they propose dynamic, and potentially unique, audiovisual configurations; however, not as an end in itself but as the result and expression of processes. Our attention turns towards the dynamic processes of which the audiovisual surface is a consequence and expression.

The relevance of these principles – understood and used artistically as aesthetic concepts and methods – is that they draw attention to both the digital computation-

1 While data are the "non-process" element of a work, processes are the "procedures or operation carried out by the work", such as those that "respond to interaction, arrange data, and so on", that can be "selected from a set of available options in an authoring system" or "newly-created for the work" (Wardrip-Fruin 2006, 10).

al specificity of these systems and to their diversified nature as aesthetic artifacts. They express what they share, as self-referential works that are speculative and prospective in exploring the possibilities of software as their medium, and also, how they diverge in the subjective discourses and intents they entail as aesthetic artifacts.

3. FRAMING SYSTEMS: AESTHETIC ARTIFACTS AS DIGITAL COMPUTATIONAL SYSTEMS

By framing creative practices and aesthetic artifacts, while emphasizing data and processes as their significant themes, the mentioned principles call for a deeper understanding of the role of digital computation. This refers to work that uses computers for computation and not only as storage and transmission media. It requires computation not only for its authoring but also during its experience, and "in a manner that defines the work". Rather than "fixed" (or containing nothing within their process definitions that leads to variation), this is "reconfigurable and process-oriented work; it "explicitly includes processes of digital computation in its definition" in order to be itself (Wardrip-Fruin 2006, 19).[2]

Consequently, and as Manovich asserts, "instead of fixed documents whose contents and meaning could be fully determined by examining their structure… we now interact with dynamic 'software performances'"; being that *performance* refers to the fact that "what we are experiencing is constructed by software in real time… as the dynamic outputs of a real-time computation" (2008, 15). What we experience, even as static displays, are the results of ongoing computations, which give us not objects but instances or occasions for experience.

According to the author, what better characterizes these works are the "software operations" that shape them and structure their experience, given that "encoded in algorithms… operations exist independently from the media data to which they can be applied" (Manovich 2001, 121).[3] So these artifacts may produce (audio, visual) artifacts, but are also aesthetic artifacts in themselves, as works that occur while running.[4]

As programmed works they are designed to run – running is their "*raison d'être*"– and one can think of each occurrence of the work as a unique performance (Bootz 2005). This performance may vary in each occurrence according to "internally-defined procedures" that allow the

2 This is works that is "explicitly designed for its surfaces to be experienced in a context employing digital computation" performed by any computational device (Wardrip-Fruin 2006, 19).

3 According to this idea, Manovich questions the limits of the terms 'digital' and 'media' to define what is specific about computational works. The author avoids the term 'digital' emphasizing computation, which defines the 'new' logic behind media, and questions the limitations of the term medium to encompass this logic (cf. Manovich 2001; 2008). Cramer similarly proposes to focus on 'software' rather than 'media', since computers are not just 'media' but "are capable of writing and reading, interpreting and composing messages within the limitations of the rule sets inscribed into them" (Cramer 2002). In accordance with this, rather than using the term media, we consider artifact, work or system (or even work-as-system), whose nature is digital but whose specificity is computational, as suggested by Wardrip-Fruin (2006, 9).

4 As suggested by Dorin *et al*., their "outcomes may be artefacts (visual, sonic, musical, literary, sculptural, etc.), including static or time-based forms", however these systems, as process creations, are also aesthetic artifacts in themselves (Dorin, *et al*. 2012, 244-7).

work to respond, recombine its elements and reconfigure (Wardrip-Fruin 2006, 2). The focus shifts from the outcomes of processes to the process elements of the work, or the ways in which they operate.

For better understanding this idea it is useful to consider the "forms and roles" of computation that distinguish the ways in which these works operate, according to their computational variability, interaction and source of interaction (Wardrip-Fruin 2006). These are computationally variable works in which "processes are defined in a manner that varies the work's behavior (randomly or otherwise)", that is, either "without input from outside the work's material", with input from external data or processes, or with human input; the latter being specifically "from humans aware of the work", as audience interactive (2006, 397-400). Naturally, these factors of variation (intrinsic rules, or external data or process) may either be exclusive or combined within the work.

These aspects are tied to the principles previously mentioned that stress how these factors, pertaining to variability, become a significant theme or feature of the work: either as its potential autonomy, or being driven by (and exploring) external data, namely human input or performances. This point of view is then conforming to the dynamic nature of works *driven by processes as dynamic systems*.

4. FRAMING PROCESSES: FROM POSSIBILITIES TO AESTHETIC QUALITIES

This framing of systems goes beyond their surface by stressing dynamic behavior as their distinctive quality. It also resumes the principles that are in fact Levin's rephrasing of the main "aesthetic possibilities" inherent to the digital computational medium, namely: interactivity, processuality (tied to generativity) and transmediality (tied to transmutability) (Levin 2003; 2007).[5] These terms again highlight digital data's mutably or "susceptibility to transformation", to be mapped into any tangible (visual or auditory) form (Whitelaw 2008), emphasizing the translation processes performed on non-process elements of the work. Interactivity and processuality again bring to the fore dynamic processes that define the surface and support interaction. In this sense, what they stress is not only a "unique aspect of software as a medium", the fact that "it enables response", but also other

5 In his words, they 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 (the character of the feedback loop established with a user; creative flow, play, cybernetic feedback); processuality (the character of algorithmic processes; generativity); transmediality (the way the senses are addressed in simultaneity; tangibility, audiovisuality, environment) (Levin 2003; 2007).

"fundamental expressions of software" that may include "dynamic form, gesture, behavior, simulation, self-organization, and adaptation" (Reas 2003, 175).

4.1. PROCESS AND PERFORMANCE

The terms process and processuality are not without ambiguity, since they evoke the algorithmic structuring of processes (defined within the work and carried out automatically by digital computation), as well as the idea of the work as a process, or an activity performed in time as a unique performance. According to Levin (2007), processuality is a concept that connects concerns with "building machines that develop processes" and "conceptual descriptions of processes"; an artistic application to processes, their design (as a logical score, a conceptual notation) and execution (Cramer 2002). Processuality then relates to code "as something 'generative'; that is always in progress, and on execution produces unpredictable and contradictory outcomes… in a continuous state of 'becoming'" (Cox, *et al.* 2001, 167).

According to Jaschko (2010) processuality highlights what rule-based processes may generate as forms and behaviors, as processes in "development, flux and change"; however, as both generative and interactive artworks, since "live processes… generate unique configurations and dynamics" performed either by system or by system and user. This view of processes refers to a time-based evolution of sequences of events as results of continuous computations. The notion of process then conflates with that of performance which designates the "quality of a technological artifact in operation" (an execution) and the "live dimension" of its presentation. As Broeckmann (2005) argues, processuality and performativity are 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". This is another way of emphasizing processes (and performance), as a distinctive expression of these systems, beyond their surface modes of expression.

A more strict view of processes defines them as "the mechanisms of change" that occur within a system, as Dorin et al. establish when considering generative systems. As the authors assert, processes may or may not be directly apparent to the viewer of a work, since they involve "hierarchical relationships where a global or macroscopic process is composed of many micro processes" (Dorin, *et al.* 2012, 245). Therefore, not all processes are immediately perceptible as observable activities, but more importantly, "not all processes contribute equally to the experience and meaning of digital works", as Wardrip-Fruin asserts (2006, 81). For this reason, he uses the concept of "expressive processing" to "talk about what processes express in their design", which may not be visible to audiences but is central to understanding computational media processes, in their "potential numerousness, repetition and complexity" (Wardrip-Fruin 2012, 7-9).

The concept of "expressive processes" also critically questions what processes operate significantly "as part of the work's expression", questioning the value of considering their "intensity",[6] for relevance is not in process intensity as such, but rather in the intensity of expressive processes; or those that clearly contribute for the work to be itself and more evidently define its meaning and experience (Wardrip-Fruin 2006, 80-1). In addition to this, the author suggests that processes that are designed specifically for the work are easier to identify as contributing to the work's expression (whether by algorithmically generating images or sounds, governing the behavior of the surface, or supporting interaction).

However, a deeper understanding of processes entails distinguishing "implemented processes", as concrete realizations of "abstract processes", which support an "operational logics", i.e. embody an appropriate behavior of that system towards a particular end (Wardrip-Fruin 2006, 214). Furthermore, it entails considering the interplay between the activities "carried out by process defined within the work itself", from those performed by its audience as interactions (139), both seen as agents determining the work's outcomes. This implies that *agency*, as an ability to take action leading to meaningful results – much in the sense described by Murray as "exerting power over enticing and plastic materials" (1997, 153) – can be attributed to both system and user (through the system's reactive agency).

From the perspective of audience interaction this emphasis on expressive processes supports the idea that action and processes leading to observable results, rather than the outcomes of processes – "or actions and process-

6 *Process intensity* is the degree to which a program emphasizes processes instead of data. When a work of digital literature emphasizes the presentation of pre-created words, images, and sounds, those are all data. When it emphasizes algorithms and calculations, those are processes (Crawford, 1987 qtd. in Wardrip-Fruin 2006, 65).

es, as opposed to (re)presentations" – are the core of the aesthetic experience of interactive works (Kwastek 2013).

4.2. PROCESSES AND MODES OF EXPRESSION

These different views emphasize processuality and performativity as fundamental qualities, and concepts, to understanding digital computational systems as aesthetic artifacts. As Jaschko underlines, beyond the "regime of the display" or "visual appearance of a work" the essential aesthetic dimension of processual artworks is that of performativity, which is relative to the 'acts' from which form and meaning arise (Jaschko 2010, 134). These aesthetic qualities are tied to both their generative and interactive potential, and, at the same time, highlight the double status of these works as artifacts and as ephemeral moments for experience.

In this manner, these views underline procedurality as the "principal value" of the computer in relation to other media, as its "defining ability" to execute rules that model the way things behave (Murray 1997, 71). Therefore, understanding these systems as aesthetic artifacts entails moving beyond a "rhetoric of the surface" (Bootz 2005) towards an aesthetic level that is tied to their "procedural rhetoric" or "the practice of using processes expressively" (Bogost 2008, 122–24). This means focusing not only their surface representations or modes of expression, but also on their procedural modes of expression, tied to their behavior.[7] The focus moves beyond the surface towards the dynamics of these systems, or their variable behavior, in each occurrence and in response to interaction. As Simon Penny (2008) asserts, we are experiencing systems that "exhibit dynamic real time behavior, or responsiveness to their environment", thus demanding a new aesthetic category: "aesthetics of behavior".

5. FRAMING PERSPECTIVES: SYSTEMS AS AESTHETIC ARTIFACTS

In other words, these works' content "is their behavior" and not merely the output that streams out, as argued by Hunicke, LeBlanc and Zubek (2004). Supporting this view, is the framework proposed by the authors as a formal approach to understanding computational systems "where the interaction between coded subsystems creates complex, dynamic (and often unpredictable) behavior". These are "designed artifacts that build behavior" via interac-

7 In line with these views, procedurality becomes relevant as a "conceptual grounding and aesthetic focus in artistic creation and appreciation, as an aesthetic pleasure in itself", as suggested by (Carvalhais 2010), and for which he proposes a new "analytical model".

tions, and that can be seen in terms of the "causally linked" perspectives of *Mechanics*, *Dynamics*, *Aesthetics*.[8] From a bottom-up (MDA) perspective, "the mechanics give rise to dynamic system behavior, which in turn leads to particular aesthetic experiences", while from the top-down (ADM) user's perspective, "aesthetics set the tone, which is born out in observable dynamics and eventually, operable mechanics" (Hunicke, *et al.* 2004, 2).

The relevance of this framework is that it makes evident the *interdependency* between these "views, or lens" over systems – separate but inseparable – and at the same time supports an ADM top-down approach. In accordance with this idea, Bogost defends, rather than a "bottom-up, code literacy" approach, we can assume a top-down approach that involves "learning to read processes", namely by interacting with a procedural system "with an eye toward identifying and interpreting the rules that drive that system", its *operational logic*, its modes of operation and action (qtd. in Wardrip-Fruin 2006, 48). Similarly, Wardrip-Fruin argues that our "fundamental challenge is to begin to understand dynamic media systems", focusing "on what code is used to express and construct: the operations of systems". The concept of *operational logics* addresses this idea (by inference and deduction of modes of operation). The author adds that this approach, rather than replace, can expand audience-focused understandings, while "moving beyond frameworks developed for fixed media" (2006, 7).[9]

Complementing this view, Dorin *et al.* discuss existing frameworks focused on processes, asserting that they are often more focused on "medium through which processes are enacted" or "on the means by which the form is achieved" than on the processes that create them. The authors argue the need for a "broadly applicable framework" suited to the description and analysis of "dynamic processes", that can also be "intuitive and flexible" (Dorin, *et al.* 2012, 239).[10] To this end, they favor an "analytical descriptive rather than critical framework" that does not privilege technology. Importantly, they also acknowledge the need to complement this view, not leaving silent the artistic motivations behind these works.

These considerations support the strategy outlined in this paper, which aims at articulating distinct, but also (and more importantly) *interdependent* perspectives on digital computational systems as aesthetic artifacts; per-

8 Mechanics refers to "the rules and concepts that formally specify the [work]-as-system", i.e., its components "at the level of data representation and algorithms". Dynamics describes the "run-time behavior of the [work]-as-system". When considering interaction, it pertains to the "run-time behavior of the mechanics acting on player inputs and each others' outputs over time". Aesthetics designates the "desirable emotional responses evoked by the game dynamics", when confronting or interacting with the work (Hunicke, *et al.* 2004, 2).

9 To this end the author proposes a model suited to consider the operations of digital systems according to the interplay between their constituent elements: data, processes, surface, interaction, author, and audience (Wardrip-Fruin 2006, 9).

10 The authors propose a descriptive framework for generative art composed of four primary elements: entities; processes; environmental interactions; and sensory outcomes (Dorin, *et al.* 2012, 239).

spectives suited to consider both their "poiesis (construction)" and "aisthesis (perception)" (Cramer 2002), while probing into their enacted processes.

The principles, models and frameworks discussed in this paper, in their complementarity, provide a way to actually consider digital *computational* systems, not only as systems but also as aesthetic artifacts. This implies articulating separate but interdependent views, considering: their *conceptual dimension* (regarding their motivations, principles or themes, or what they address as subject matter, as suggested by Levin); to address these aspects as they are computationally implemented (as their *mechanics*, data and processes); and to address the elements of their *experience* – concerning not only their *surface* but also their *dynamics*, or the variable behavior tied to their processual and performative qualities. By articulating such views, we can develop instruments for the analysis and critical understanding of these systems, while tackling deeper on the questions that their conceptualization, actualization and experience raise.

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THE REAL IN AUGMENTED REALITY

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What is augmented in Augmented Reality (AR)? This fundamental question has received surprisingly little attention in AR research. In this paper, we review existing views and show how little consensus there is on the topic. Subsequently, we approach the question from a theoretical and technology-independent perspective that focuses on the relationships between the virtual and the real. We consider both spatial as well as content-based augmentations and distinguish between augmented environments, augmented objects, augmented humans, augmented content and augmented perception. We discuss our findings and suggest possible future directions, such as research into multimodal and crossmodal AR.

1. INTRODUCTION

In Augmented Reality (AR), virtual and real content are combined in a real, physical environment. AR has been emerging as an academic field since the late 1990s. So far, research has mainly focused on technologies and techniques that enable or support the integration of virtual visual objects in our view of the real physical world, such as tracking or calibration techniques (cf. Zhou, Duh, and Billinghurst 2008). We, however, propose to interpret AR as a more general concept that potentially includes all modalities and not necessarily requires advanced computational technologies.

In this paper, we explore the conceptual characteristics and possibilities of AR. We ask “What is augmented in Augmented Reality?” and “What forms of augmentation do exist?”. This paper addresses these questions from a creative, theoretical and technology-independent perspective. We approach augmentation by looking at the relationships between virtual and real elements. We distinguish between augmentations that are based on a spatial relationship between the virtual and real and augmentations where the virtual and the real are related content-wise. The paper illustrates how such spatial and content-based relationships can result in augmented environments, augmented objects, augmented humans and augmented content.

Our research is driven by our personal interest in better understanding the qualities and potential manifestations of AR. We are especially interested in non-visual (for instance, sound-based) and multimodal forms of AR. Our work aims to provide a theoretical foundation and foster reflection, experimentation, artworks and exchange rather than final results.

The paper is divided into four sections. Section 2 gives a short overview of existing views on the topic. Subsequently (3), we present our own understanding of augmentation and consider augmented environments, augmented objects, augmented humans, augmented content and augmented perception. We conclude the paper (4) with a discussion of our findings and suggestions for future research.

2. WHAT IS AUGMENTED IN AR?

The term itself – Augmented Reality – indicates that reality is augmented. Hugues, Fuchs and Nannipieri (2011, 2) have argued the impossibility of this suggestion: “If reality is by definition everything that exists, then strictly speaking reality cannot be augmented since it is already everything. So what is augmented?”

In existing AR literature, we can find different views on the matter. Many argue that it is not reality but the *perception* of reality that is augmented. For example, Normand *et al.* (2012, 1) point out: “Reality can not be increased but its perceptions can. We will however keep the term ‘Augmented Reality’ even if we understand it as an ‘increased perception of reality’.” Similarly, Ross (2005, 32) refers to AR as that “what should be called augmented perception of time and space.” Also the widespread survey of AR by Azuma (1997, 3) claims that AR enhances a user’s perception of and interaction with the real world. Hugues, Fuchs and Nannipieri (2011) have explicitly addressed the question as part of their AR taxonomy and distinguish between AR environments that augment the perception of reality and environments that aim at immersing users in an artificial environment.

Furthermore, there is the notion that in AR, our *real physical environment* is augmented. This has for example been stated by Milgram and Kishino (1994, 1322): “As an operational definition of Augmented Reality, we take the term to refer to any case in which an otherwise real environment is ‘augmented’ by means of virtual (computer graphic) objects [...]”. (Unfortunately, the authors are not completely consistent and also refer to the augmentation of the *display* of an otherwise real environment.)

Besides the idea of an augmented environment, we also find the notion of augmented *space*. The media theorist Manovich (2006) introduces this more general concept and describes it as “physical space overlaid with dynamically changing information, multimedia in form and localized for each user” (p. 219). Manovich lists AR as one of the technologies, that already create such augmented spaces.

Looking at Wikipedia’s current definition of AR (“Augmented reality”), we again find a different opinion on what is augmented in AR. As of April 15, 2014, AR is described as “a live, copy, view of a physical, real-world environment whose *elements* are augmented [...]” (italics added by the authors).

Yet another approach is suggested by Mackay (1996). The author considers the carrier of the physical equipment as augmented (e.g., the user is augmented when he/she carries a helmet and an object is augmented when sensors are embedded in it) and consequently distinguishes between an augmentation of the *user*, an augmentation of the *physical object* and an augmentation of the *environment* surrounding the user/object.

Considering popular views on AR, such as Milgram *et al.*'s (1994) Reality-Virtuality continuum[1] and Azuma's (1997) widespread survey on AR,[2] we can identify general agreement among researchers that in AR, virtual content is overlaid, projected onto, or otherwise added to (our perception of) a real environment. However, as the reviewed literature illustrates, there is little consensus on what is actually augmented by this virtual content. We think this has two main reasons: Firstly, there has been little said about what constitutes augmentation in an AR context. Secondly, there is not one right answer to this question.

In our previous research, we have proposed an understanding of AR that can shed light on the problem (Schraffenberger and van der Heide 2013). We consider AR the result of the relationships between the virtual and the real. As a preliminary answer, we claim that the augmentation does not necessarily have a target. Rather, there is a real component and a virtual component to the augmentation. Their relationship constitutes the augmentation.[3] Unfortunately, this view is conflicting with the language associated with AR. Even the term "Augmented Reality" implies that something (Reality) is augmented.

We believe that there are two different forms of augmentation, corresponding to two different forms of relationships between the virtual and the real. The relationship can be either spatial (as is the case when virtual objects are integrated into a real 3D environment) and/or content-based (as is for example the case when AR applications present us with information about a specific place or object).[4]

We propose to replace the question "What is augmented in AR?" with the questions "To what does the virtual content relate?; What is the real component in the augmentation?; What is the real in AR?". In lack of better alternatives, we will continue using the already accepted terms and language.

1 The Reality-Virtuality continuum describes environments where real objects and virtual objects are presented together within a single display. It ranges from purely virtual environments to entirely real environments. AR is placed within this continuum and describes an otherwise real environment that is augmented by virtual objects.

2 In this survey, Azuma (1997, 2) summarizes AR as a field that "allows the user to see the real world, with virtual objects superimposed upon or composited with the real world."

3 If we look at an AR scenario, we usually perceive both the virtual and real at the same time – relating, complementing and adding to each other. It hence appears just as accurate to claim that the real augments the virtual as to claim that the virtual augments the real.

4 Various other relationships between the virtual and real (e.g., interaction between virtual and real objects) are possible (Schraffenberger and van der Heide 2013). However, we believe that all of them are based on underlying spatial or content-based relationships.

3. THE REAL IN AR

In the following, we group, illustrate and extend the ideas collected in section 2 and discuss them in the context of our proposed understanding of augmentation. We consider augmented environments, augmented objects, augmented humans, augmented content and augmented perception.

3.1. AUGMENTED ENVIRONMENTS/SPACE

In an augmented environment, there is a relationship between virtual content and its real surroundings. As pointed out, this relationship can be spatial and/or content-based. A spatial relationship is common in cases where virtual visual objects are integrated in a real 3D space. When, for example, a virtual chair is added to a real desk (cf. Azuma 1997) there is a spatial relationship between the real environment and the virtual chair: the chair is part of/integrated in the real space.

Content-based relationships between the environments and virtual content are also common. For example, the mobile app *Layar* (*http://www.layar.com*) shows site-specific information such as nearby restaurants, metro stops and ATMs and overlays this data onto the real world using a mobile phone's screen.

It is important to note that the virtual content does not have to be presented visually. We can find various examples of sound-based augmented environments: Cilia Erens' sound walks are designed for a certain walking route and mainly use unprocessed binaural recordings of everyday-sounds (Erens; cf. Schraffenberger and van der Heide 2013).[5] When the participant navigates the environment and listens to the composition on headphones, the recorded sounds merge with the sounds present in the existing environment and invite the participant to make connections between the added sound and the existing environment.

Another example of an audio-based augmented environment is Edwin van der Heide's (2000-) *Radioscape* (van der Heide 2000-; Schraffenberger and van der Heide 2013). The installation makes use of multiple radio transmitters that are distributed over a part of a city, each transmitting one layer of a meta-composition. By navigating through the city with a custom-made receiver (see Fig. 1), a listener can pick up several signals at a time. The volume of the single layers depends on one's distance to the corre-

5 See, for instance, *Hollands Doorzicht* (2006), *http://www.cilia-erens.nl/portfolio-2/hollands-doorzicht-berlijn-2006/*. This sound walk is made of sounds that were recorded in the Netherlands and took place close to the Dutch embassy in Berlin, 2006.

sponding transmitters. For the participant, there is a clear relation between the content and environment. What one hears depends on one's own location, the position/placement of the transmitters and the shape of the city. Small movements of the receiver lead to repeatable changes that happen in the space around the listener. Besides experiencing the city in a new way, the participant discovers and experiences the relationships between sound and space.

Fig. 1 A participant is experiencing *Radioscape* as part of the Electromagnetic Bodies exhibition in Rotterdam, 2006. Image courtesy Studio Edwin van der Heide.

It is crucial that linking virtual content to specific locations alone isn't enough to result in the experience of a spatial augmentation. This can be concluded from *Wormhole Dordrecht*, another concept by Edwin van der Heide, which was realized in 2008. For this project, ten artists were invited to each make a sound environment existing of multiple sound files, linked with GPS coordinates to locations in the center of the city Dordrecht. The Wormhole environment was experienced with a custom developed iPhone application, which used GPS coordinates to start, stop, fade and mix the sound files. In *Radioscape*, the surrounding buildings work as resonators and reflectors for the transmitted radio waves, resulting in detailed changes that relate to the environment. However, in *Wormhole* the individual sounds are only linked to GPS coordinates and there is no further influence between the sounds and the spatial environments within the city. Although the resulting soundscapes depended on the participant's position in the city and although it was clear that sound files were triggered and mixed depending on the listener's location, there was no experienced tangible relation to the physical space. This, however, does not mean that there was no augmentation. An augmentation could also take place on a content level (for instance, when narratives relate to the space) and thereby still result in an AR experience.

3.2. AUGMENTED OBJECTS

The fact that virtual content *exists* in a real environment does not necessarily mean that the virtual content also *relates* to this environment. There are cases where the virtual relates to, or becomes part of, a particular physical element/object. This is, for example, the case in the context of projection mapping. Here digital images are projected on physical models. One example of an augmented object is the augmented zebrafish by Gómez-Maureira *et al*. (2014). In this project, the zebrafish's skin is projected on a physical bigger-than-life zebrafish (see Fig. 2). The audience can look inside the fish and reveal additional information (for instance, an X-ray visualization and a basic anatomical schematic) by stepping in front of the projector and moving their shadow over the fish's surface. This is realized using a kinect sensor, which detects the shadows, and a secondary projector that fills in the shadows with the additional content. Here the virtual content primarily relates to (and becomes part of) the fish, rather than to the general surrounding space. Both components - the virtual and the real - are designed in a way that deliberately leaves out certain characteristics. These 'missing' aspects are filled in by the other component, resulting in one hybrid virtual-real model (cf. Schraffenberger and van der Heide 2013).

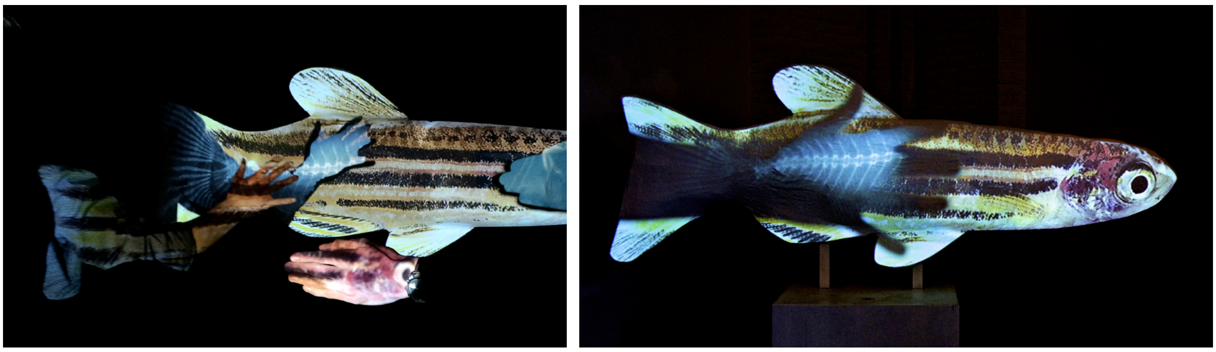

Fig. 2 The augmented zebrafish (length approximately 1,75 m). The fish's skin is projected on a physical model. The shadows of the viewers reveal the inside of the fish (X-ray view).

A distinction between augmented environments and augmented objects is especially relevant when we consider the user or audience. Although viewers are part of the environment, they are usually not part of an augmented object. While environments usually invite the audience to navigate through them, augmented objects might facilitate interaction with the objects. Apart from that, a clear distinction between augmented objects and augmented environments is not always possible.

3.3. AUGMENTED HUMANS

Just like there can be relationships between real objects and virtual content, there can be relationships between humans and the virtual. For example, the art installation *Cloud Mirror* temporarily merges the online identities of visitor's with their physical selves (Gradman 2010). It accesses Internet web services to identify visitors by name and find photographs of and facts (dirt) about them. When visitors approach the digital mirror, the found data is superimposed in an on-screen comic book-like thought bubble that follows the visitor's motion. The virtual content relates to the human both spatially and content-wise.

While in *Cloud Mirror* visitors have no influence on what data is displayed, we can also imagine scenarios where AR allows us to modify our own appearance. An early example of this is the AR-tattoo (Archer 2010) that displays an animated 3D tattoo above a marker, which is physically tattooed onto someone's arm.

A more serious example is the Skinput interface (Harrison, Tan, and Morris 2010). This technology allows the skin to be used as an input surface. In a proof-of-concept, a numeric keypad was projected upon on a user's palm and allowed the user to tap on the palm to dial a phone number (see Fig. 3).

From a technological perspective, augmented humans do not differ much from augmented objects. However, as the human's role changes drastically, it makes sense to treat this as a separate conceptual category.

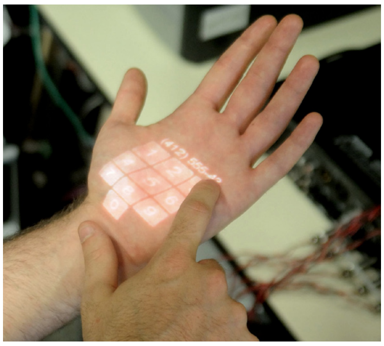

Fig. 3 Skinput turns the user's palm into an input surface. Image courtesy of Chris Harrison.

3.4. AUGMENTED CONTENT/INFORMATION

We have shown that virtual information/content can relate to the real. Next to this, information/content can also be the real component in the virtual-real relationship. For example, information in a book might be supplemented with interactive 3D illustrations, a soundscape or relating smells. The software *Layar* allows publishers of print media to add digital content such as links, videos or polls to analogue print content. Another example is The MagicBook project by Billinghurst, Kato and Poupyrev (2001). Here, virtual sceneries pop up when the pages of the children book are viewed through a handheld display.

The augmentation of content is not restricted to visual content. For example, virtual musical improvisers can improvise with real musicians (see, e.g., Walker 1997). In such a case, the behavior of the virtual improviser relates to the present musical content. Although systems like this are certainly no new development, they are usually not considered in the context of AR.

3.5. AUGMENTED PERCEPTION

It has been argued that AR is in fact an augmentation of our perception (Normand *et al*. 2012; Ross 2005; Hugues, Fuchs, and Nannipieri 2011). In our understanding of AR, this is not the case. According to us, the virtual usually does not relate to our perception but to something that is perceived.

Nevertheless, there are forms of AR that arguably extend our perception. AR potentially allows us to perceive things we normally can't perceive. A well-known example, which is usually not seen as AR, is a hand-held Geiger counter, which produces audible clicks that correspond to the amount of radiation (Schraffenberger and van der Heide 2013). It is debatable whether these forms of AR really extend our perception, or only map the unperceivable to our – unchanged – perceptual space. However that may be, the additional information (e.g., the amount of radiation) still relates to the environment/space.

Other projects have aimed at changing the taste of cookies (Narumi *et al*. 2011) by superimposing visuals and adding olfactory content with an AR system. Again, one could argue, that such additions target our perception. However, it should not be forgotten that artificial flavors have been used in this way for a long time, and hence, similarly could be considered AR. As the superimposed content relates to the real food, we consider this to fit in the category 'augmented objects' rather than 'augmented perception'.

4. DISCUSSION AND CONCLUSION

Little consensus exists on what is augmented in AR. We have proposed an alternative approach to this question that focuses on the relationships between the virtual and the real. Building on this view, we have identified two common forms of augmentation: firstly, cases where the virtual and the real are spatially related and secondly, cases where the relationship is content-based.

We have identified such spatial and content-based relationships between virtual content and the environment, objects, humans and information. We do not claim that we have presented all possibilities. Are there other – non-spatial and non-content-based – forms of augmentation?

By creating spatial relationships between the virtual and the real, we can essentially augment everything that exists in space. So far, AR research and practice has put much emphasize on such spatial relationships. In the future, we can further explore the realm of content-based relationships. Can the virtual relate to thoughts, moods or feelings? What about augmented events, processes and activities?

Much AR is vision-focused and integrates visual virtual content in our view. Strikingly, even in vision-based AR, the virtual can still relate to more than what we see. If, for instance, a virtual visual bird is added to our view of a garden, the bird will relate to the whole environment – a garden we can also touch, smell and hear – not just to the garden we see. Clearly, the real in AR is more than meets the eye.

We have pointed out the possibility of non-visual forms of AR. In this context, we want to pursue research into crossmodal and multimodal AR: When is information of one sensory channel experienced in relation to information of another sensory channel? When do we perceive sounds (e.g., a virtual and invisible bird's twittering) as related to what we see, when do we perceive smells in relation to what we hear? These questions call for an interdisciplinary research approach that incorporates insights from philosophy, perception and AR.

Although we have presented some interesting results, the main contribution of this direction of research is the fact that it brings important questions to the attention of AR research and practice. We are convinced that the AR community will benefit from a theoretical discussion and would like to invite other researches and practitioners to join in on the dialogue about the fundamental characteristics of AR.

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MIGRATIONS: DANCING BODIES ACROSS MEDIA

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Although in public common sense and institutional circuits a notion prevails that dance only fulfils its nature as a live art form, several practitioners have been exploring remarkable and creative endeavours that defy that understanding. Furthermore, stop animation, data processing and motion capture technologies enable choreography to expand beyond the human body, challenging the reasoning that dance must have a corporeal manifestation. While theoretical discussions define dance as a system that combines various elements, they also emphasize the role of the performer to represent the discipline. Looking at early experiences that have transferred theatre performance to the cinema and new media dances that encourage sensual human-computer interactions, this article reviews how choreographers resolve the challenges of migration and keep the body as a central medium to articulate artistic knowledge and identity.

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1. INTRODUCTION

The subject here addressed is part of a larger enquiry regarding how essential characteristics of dance performance transfer or transform when the artworks are instantiated, as medium specific practices, in cyberspace;[1] this article focuses discussion on the body and the dance performer. I depart from the principle that unlike migration in computer science, where data is expected to transfer incorrupt, the migration of art forms to a new medium where the artistic proposal becomes public requires adaptation. Thus in addition to transfer of established conventions, the transformation of components, structure, narrative and craft is inevitable and affects the identity of the work and the discipline.

Literature in media studies provides key sources to analyze processes through which the physical may turn into the digital, and to comprehend how media have evolved, namely with responsive electronic systems. With the term "remediation" Bolter and Grusin (1999) have examined how older media refashion into newer ones[2] and their framework suggests looking at mediation historically. Manovich's scrutiny of "the principles of new media" - numerical representation, modularity, automation, variability and cultural transcoding (2001) - enables bridging computational processes and cultural forms that have aesthetic value and aspire poetic transactions with potential audiences.

For the arts that come from a tradition of live performance, new media are a large challenge since the technological conditions considerably affect how the works are made and displayed. As deLahunta explains, this is a complex equation for dance, which has prevented further explorations:

> *Computer related technologies have not attained the level of integration within the field of dance as with other art forms for the obvious reason that as a material the body in motion does not lend itself to digitisation. (deLahunta 2002, 66)*

Migration to the digital destabilises disciplinary fields and conventions that drive practice development and related theoretical outcomes; in this paper I will look at the assumption that the human body is both source and display for dance in order to verify how this relationship

1 Cyberspace is here used to refer to the navigable space enabled by computer devices, which can render in interactive 2D and 3D environments or web page hyperlinked configurations.

2 The notion of "remediation" has been applied to study digital resolutions of performance such as virtual theatre (Giannachi 2004) and hyperdance (Bench 2006).

remains axiomatic for the identity of dance. In a culture where, as Hayles points out, “information has lost its body” (1999, 4), is the body still an essential medium of dance? Can the expert dance-led practice counterpoint the above statement? I propose examining variations in the way dancing bodies migrate across media and will highlight the importance of anthropomorphic form for representation, identification and interaction. This undertaking engages with innovative practices and reviews how the terms body, dance and medium are engaged in academic discourse.

2. VARIATIONS OF THE MEDIUM

Medium is a word frequently used to refer to a material substance like the paper, the paint, the screen, or the instrument. The term is also meaningful of an agency or a way of doing something; for example learning through movement differs from learning through verbal language, and choreography may be considered a spatial design of motion rather than an arrangement of dance steps. Another conceptualization is that of medium as a territory that carries specific conventions regarding processes, references and modes of exhibition; a novel, for example, can variably be articulated in the form of a book, a film, a TV soap opera, a theatre play or a videogame.

If the body is both the source and display of content in dance, how are the words medium and media integrated in its conceptualization? In Sparshott’s philosophical discussion about dance, considering the body as a medium is reductive and misleading. In dance, he remarks:

> *One does not “use” oneself, and if one truly used one’s body one would do so not as a wholly embodied being but as a spiritual or cerebral entity to whom the body was extraneous (Sparshott 1995, 5).*

This material sense of the term medium as an intermediary substance is manifested in Langer’s assertion that the human body is animated to dance by “virtual powers” as a driving force (Langer 1983). Langer’s understanding resonates with McLuhan’s famous notion of “media as extensions” (1994). Just like the body is for Langer a medium for the content of dance, the content of speech is for McLuhan “an actual process of thought, which is in itself non-verbal” (1994, 8); the body is therefore a vehicle that externalizes information that pre-exists to physical manifestation, which can express in different ways, McLuhan says, such as writing.

Principal procedures in the dance medium are constituent elements such as movement and choreography, which underline the determinant aspect of agency for practitioners to develop a distinctive style and disciplinary approach. Drawing on a definition of digital dance Rubidge claimed that choreographic concepts should be dominant organizing principles in these works, which did not have to feature "images or representations of the human or anthropomorphic body" (Rubidge 1999, 43). While Rubidge intends to emphasize the notion of dance as a medium with specialized agency, she nonetheless accommodates the possibility of disembodiment, which is implicit in Hayles's perception of cyberculture and McLuhan's conceptualization of media.

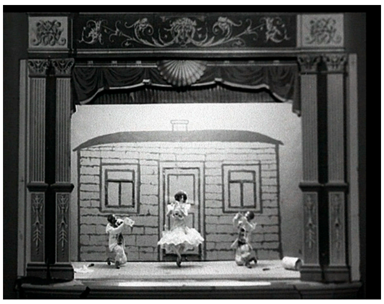
Other definitions of the nature of dance stress the importance of articulating components, regarding it as a "multistranded" medium (Preston-Dunlop and Sanchez-Colberg 2002), or as a system (Thomas 1995; Melrose 2009), which integrates other theatrical elements, visual or aural (Copeland and Cohen 1983). In these discourses a territorial notion of medium is implicit and, according to McFee (1992), what characterizes the dance medium is a suitable group of elements, conventions and procedures in dance that best suit its nature and are integral to its understanding.

3. FROM THEATRE TO THE CINEMA

Dance generates from inanimate materials and screen presentations are not new phenomena, but the techniques used in earlier demands for older screen media gain renewed significance because they indicate what is really new in endeavours that engage computers and dance. Moreover, scholar discussion of the impacts of mediation follows the use of video and computer technology in contemporary dance (Dodds 2001; Dixon 2007); these recent frameworks are better equipped to understand what had been achieved with older media.

The puppet ballets of Alexander Shiryaev (1906-1909),[3] remarkably illustrate how different components can be articulated when dance migrates from the live theatre experience to the cinema. In his films the constituent elements of dance are all engaged in a production that

Fig. 1 Alexander Shiryaev Puppet dance (1906-1909)



3 Shiryaev's films were rediscovered in 1995 and compiled recently; see Bocharov's documentary *A Belated Premiére* (2003).

resembles the proscenium stage performance. Shiryaev literally replicates the theatre frame within the camera frame (figure 1), and reproduces the narratives of classical Russian dance; he distributes cast roles to animated puppets, and respects the design of costumes, stage spacing and choreographic phrases, timed with music, which were used in the stage productions when he was a leading dancer in the Maryinsky Ballet.

By using the screen as a new medium for creation and presentation Shiryaev "remediates" dance performance in relation to the stage. His innovative practice gives form to Bolter and Grusin's conceptual notion introduced a century later to explain the conversion of older media into newer ones. This is accomplished because a medium-specific process is developed; in order to 'stage' a ballet Shiryaev uses stop motion to animate various puppets, which are probably the first cases of virtual dancers on screen. Despite the interruptions in movement fluidity, which is a consequence of the technique involved, these puppets can 'materialize', due to their anthropomorphic form a complex choreographic score, achieving an exemplary migration of the dancing body to the screen.

Shiryaev's puppet dances have an unequivocal disciplinary position, attained by a process that literally transfers to the cinema the theatrical conventions of dance of his time, enabling the art form to appear out of the then ruling institutional frame.[4] A century later, choreographers with other technologies, stylistic languages and thematic concerns had similar challenges ahead.

Fig. 2 Cie. Mulleras, *Mini@tures* (1998)

4 Shiryaev wanted to film the ballets with real dancers in the theatre, but the Maryinsky's directors did not fund nor give him permission to do so.

4. FROM VIDEO TO THE WEBPAGE

Cie Mulleras is a pioneering group that made dance compositions for networked cyberspace. With *mini@tures* (1998/2001) the artists explored the limits of video editing, film compression, computer screen size and Internet signal, to create works for world-wide exposure and access. The available technologies conducted this practice research towards the idea of miniatures in dance; at the time there was no ADSL connection and the films had to be short and light to travel with enough speed and resolution so that the movement fluid quality was not compromised by technical constraints. In addition, the will to transmit the specificity of a corporeal and time based art has influenced the choice of the body as a core thematic concern, represented with different scales that identify the virtual performers (see figure 2). The *mini@tures* project developed across a period of three years and throughout that timeframe the short films gradually moved the virtual dancers' performance from a non-space towards natural and architectural landscapes.

For Didier Mulleras the body image must be present if his work is to maintain roots in his professional field. Because many of the Internet users that become members of his audience never saw contemporary dance before, to include a performer that articulates movement was crucial for his work to be watched and defined as dance in the World Wide Web. Defying the notion that digital dance may not need anthropomorphic representations, Cie. Mulleras migrates dance to cyberspace maintaining the human performer as a featuring agent, which distinguishes the artwork from other dances, other arts and other human activities. This position mirrors theoretical understandings about the nature of dance that were constructed on the basis of a live performance art, in which the body in motion is indispensable for something to be dance, to happen as dance.

Helen Thomas, for example, justifies a sociological approach in dance studies because she sees that it is through the "medium of the body" that dance reflects on its socio-cultural context; in these terms, the dance artwork cannot be seen without the dancer, since "the body is the primary instrument and means of expression and representation in dance" (Thomas 1995, 6). On a comprehensive study about dance and film, Sherril Dodds (2001) compares the features and limits of the "screen body" and the "live body" to explain differences between the territories of stage and broadcast TV; on screen, the body can appear fragmented and multiplied, the scale of figure and speed of movement may be changed, and the variation of point of view provides awareness to the spectator's body. Although I have cited McFee earlier as someone that understood the medium as a territory, his philosophical argumentation acknowledges that "the medium, the body in motion, is involved as soon as anything recognizable as dance exists" (McFee 1992, 222). Extending this position, from the "choreological perspective" of Preston-Dunlop and Sanchez Colberg, an embodied performing art requires having a "performer as a mediator" that interprets and personalizes the choreographic score (2002, 61).

5. FROM DANCE TO ANIMATION

We can find examples that dispense the human body and stress the relevance of agency for the medium. Such works may still be regarded as dance, since camera movement and editing rhythm are ruled by what Rubidge calls a "choreographic sensibility" (1999, p.43). Music plays, in this respect, an important element to convey the sense of movement intentional organization as it can be perceived in the case of *Blinkity Blank* (1955), an animation by Norman McLaren; in this short experimental film the association and sequencing of drawings and sounds appear to be choreographically organized. Choreography clearly disputes leadership with the body as a medium of dance in the short film *Birds* (David Hinton, 2000), where the performers were real birds and no humans featured in the work. International appraisal and prestigious awards have legitimated its status as a dance film (choreographer Yolande Snaith was also a collaborator); such acclaim supports the argument that dance can be expressed without the human body. However, the institutional framework was essential for this film to be treated as a dance artwork, and the same is true for McLaren's animation.

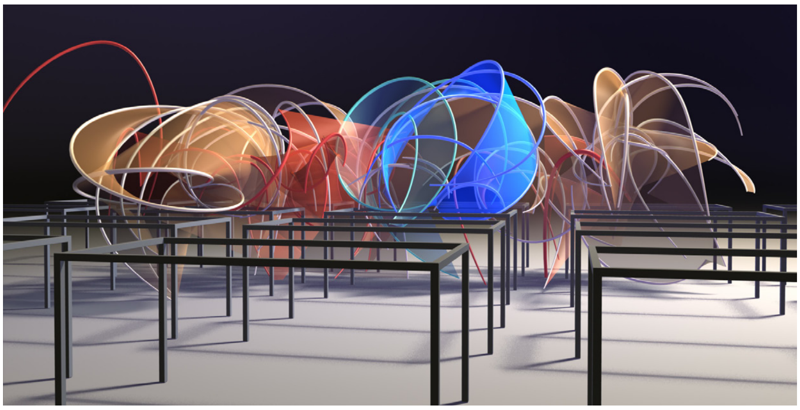


Fig. 3 William Forsythe, *Synchronous Objects for One Flat Thing, reproduced* (2009)[5]

5 Credit: Synchronous Objects Project, The Ohio State University and The Forsythe Company

The above cases prove what Rubidge's theoretical statement sustains: animation and montage techniques allow extending choreographic action to abstract drawings, objects and non-human bodies. This possibility increases when digital technologies are used as it can be observed in the moving electronic drawings (in figure 3) of William Forsythe's *Synchronous Objects for One Flat Thing*, reproduced (2009), that are published online. These films have no intention to stand as artworks; Forsythe wants to use the computer system and worldwide access to disclose the complexity of "choreographic thinking", which is at stake in live theatrical performances (Forsythe 2009).

Like in Birds and *Blinkiti Blank*, the uninformed spectator would hardly identify this electronic reproduction of *Synchronous Objects* as the result of a dance performance, due to its high level of abstraction. However, and despite diverting from the theoretical frameworks introduced above, in this case the body retains an essential generative position. These animated graphics notably indicate another migratory movement of dancing bodies, which differs from the approaches of Shiryaev and Mulleras. Although anthropomorphic form is not on show, the living body is the original source of a specialized and deliberate agency, which produces choreographic visualizations otherwise impossible to attain. This dancing data, it can be argued, ensures for dance a particular place within the emerging aesthetics of new media art.

6. FROM LIVE PERFORMANCE TO MULTIPLE MEDIA

In 2011 whilst investigating the semantic implications of the different uses of the word medium, I saw a performance in Lisbon called *The body is the medium of dance (& other parts)* from Brazilian choreographer Vanilton Lakka (2007). The piece has various independent versions, which can be accessed separately: the live stage performance, a vocal description available by telephone, a flip book and a web-page puzzle game with photographs that can be sequenced to produce a customized dance. On his website Lakka explains that the increasingly present digital reality inspired him to explore choreography in multiple media in order to enable different experiences of a dance work for the audience. Thus this is an appealing case to exemplify how the dancing body can migrate to multiple media.

The performance was striking and powerful for its dynamic and eloquent contemporary composition of urban dance and improvisation, where corporeal energy had a protagonist impact. The experiments with live interactivity were also a knowledgeable way of recreating, in a live version, the functioning of computer networks and hyperlink structures: occasionally some spectators were invited to participate onstage, either by verbally instructing the dancers, manipulating objects, or moving connected to others by a web of strings.

Lakka's proposition of the body as medium was particularly effective, in my view, with the flip-book he handed out at the start of the show (figure 4). With manual animation an actual movement phrase was activated from a group of still images: represented with chalk drawings, a little dancer performed a poetic and stylized dance that united body, movement and choreography, which happened on the palm of the spectator's hand.[6] If the body image was to be replaced by that of a cube, the form, the meaning and the context would change entirely; another kind of experience, eventually not that of a dance transaction, would be created.

Fig. 4 Vanilton Lakka, flip-book distributed at the performance (2007)

While demonstrating the importance of the body's representation for disciplinary identity, Lakka's flip-book also brings forward the issue of audience/user agency. Although an elementary manual animation technique, this latent artistic construction requires, like in much of new media art, an external physical engagement to become actual and originate a "dance performance".[7]

The notion of dance, as a performing art that is majorly instantiated in the theatre, is conventionally based on a contemplative position of the spectator. Interactive practices that appear with new media art expect, on the other hand, the status of an active agent to who ever the artworks establish a relationship with. Manovich argues that interactivity requires specification because "Once an object is represented in a computer, it automatically becomes interactive" (2001, 55); for Dixon such applications in performance must break decisively "from the hegemonic single-track delivery of mass media, particularly television, a generally one-way transmission-reception form" (2007, pp. 561).

6 Visitor or user are terms frequently used when the audience is involved in interactive transactions; I have kept the word spectator because the flip book was distributed in the theatre.

7 I have argued before about the usability of the term performance in relation to dance artworks that are instantiated in media extraneous to the physical body (Varanda 2012).

7. FROM THE DANCER TO THE USER

The French company n+n corsino has been exploring the possibilities of motion capture technology since the late 1990s. For Norbert Corsino body and choreography are essential signs of authorship, which clarify their professional practice as both dance and art;[8] thus in order to make films and interactive installations, the Corsinos specialized in creating virtual performers that are unique 3D dancers, animated with digitized real choreography, which are spatially organized in virtual environments.

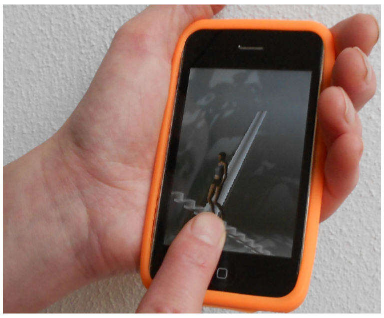
This company conciliates all the aims and processes of "remediation" identified with the previous authors and successfully migrates the dancing body resolving the problems of digitization afore mentioned by deLahunta. Although entirely digital, the Corsino's pieces involve the elements that form the dance medium in its multi-stranded systemic nature, stressed by the theorists; performer, choreography, space, time, costumes, sound and dramaturgy are articulated in a coherent statement that pre-exists public transaction.

Furthermore, the artists have enquired about the possibilities of embodied interactivity and in some works encourage sensual relationships between audiences, machines and the 'worlds' they represent, prompting a sense of navigation inside the digital space. Inspired by touch-screen technologies, they recently made a piece that brings the dancing body to the tools of everyday life.

Soi Moi – Self as Me (2010), is a portable installation for I-phone G3 that explores the modalities allowed by the device, exposing several short dance sequences to tactile manipulation that changes the sounds, visual effects and spaces surrounding the virtual dancer (figure 5); for the choreographers the dancing body expands the tool and brings poetry to the utility, which augments the user's self and body awareness. Despite this being a rather more complex process, kinetic stimulus produced by a dancing body enables a somatic experience in the intimacy of one's hand as it happened with the example of Lakka's flip book.

Approaches to human-computer interaction informed by disciplines stemming from a tradition of embodied practice, such as contemporary dance and somatics, have been a major concern of Schiphorst, who has investigated about computer interactive design focused on human experience (Schiphorst 2008). With artistic practice she

Fig. 5 n+n corsino *Soi Moi, Self as Me*



8 The statements of Mulleras and Corsino were collected in interviews in July 2010 in France.

has explored the importance of body movement and touch as a first person experience integrating computer technologies.[9] On her theoretical developments Schiphort follows Shusterman's proposition that a "somatic turn" is required to find in the body a defence against the rapidly changing society of information and oppressive media advertising; a solution to critique uniform body constructions "would be to privilege the experiential forms of somaesthetics" (Shusterman 2000, 151) because they improve the pleasure in bodily experience in the relation with the surrounding world.

8. CONCLUSION

The practices addressed in this article demonstrate that media technologies - old and new - may unsettle patent relationships between the human body and the dance artwork; it may therefore be incorrect to say that the body is the medium of dance, as Lakka assumed. However evidence was also given that we cannot underestimate the status of the body in motion as a primary element and regard its function for the medium of dance to migrate between different media; thus we can support that the dancing body brings specific disciplinary enquiries and solutions that are relevant to consider in the culture of ubiquitous technology.

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9 As in Schiphort's installations *BodyMaps, artifacts of Touch* (1996) or *Soft(n)* (2007).

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SIMULATION OF PATTERNS ON CIRCULAR KNITTED TUBES

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Keywords: Circular Knitting, Diy, Generative Patterns, Knitting Machine, Mathematics, Modular Arithmetic, Processing, Simulation, Textile Art

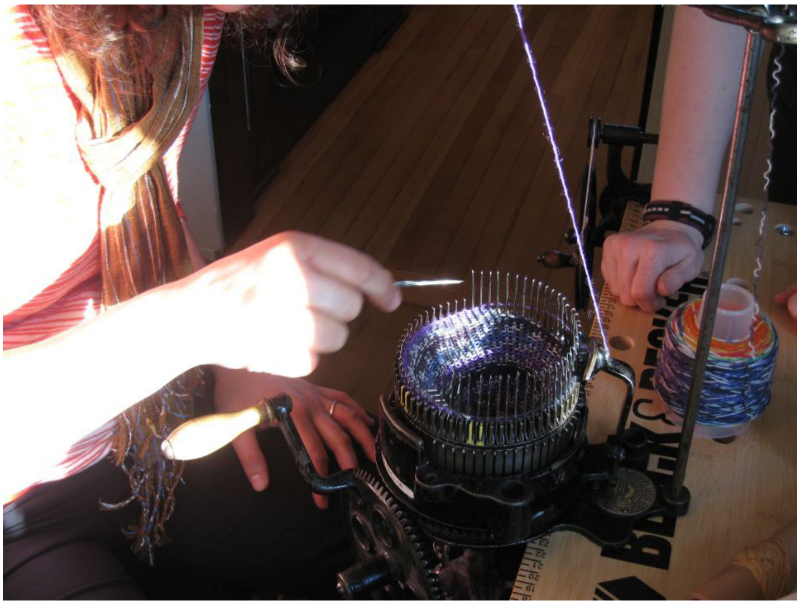
This method paper explores the creation of a pattern with parallel curves on a machine knitted tube in the frame of an artistic research project. Using modular arithmetic and the software *Processing*, the initially empirically generated pattern is analyzed and simulated. The results are then used in order to create intentional iterations of the parallel curve pattern, determining the winding of the yarn for dyeing and the lengths of the yarn strands. The paper draws a connection from a craft based technique (knitting) to mathematics.

1. HISTORY AND CONTEXT

This project took its starting point within the context of Huijnen's research and art practice that investigates the mouth, speech and affect from a physiological, historical and feminist perspective. Her goal to create a knitted tube evoking aspects of the human mouth and esophagus (gullet) would lead to a deeper investigation of circular knitting, yarn dyeing and mathematical principles.

For this project Huijnen had access to an antique Creelman Brothers *Money-Maker* circular sock knitting machine. The Creelman Brothers had founded their knitting machine company in 1876 in Georgetown, Ontario (Canada) and in 1893 the first *Money-Maker*, one of several other circular knitting machines designed for use in the home, came to the market. Those knitting machines are a manifestation of the early years of the industrialization process and of factory mechanization. (Terry 2010)

Fig. 1 Working with the *Money-Maker* sock knitting machine.



Huijnen's motivations for using this knitting machine were twofold. It provided a technical benefit because it worked fast and produced regular stitches (working the machine still required concentration, precise counting and awareness for its failures). The second motivation was the fascination for a machine doing a 'typical' female work and this way embodying two conventionally differently gendered work spheres. While writing this paper the authors had realized that the questionable existence of gendered work spheres had partly reached within their own collaborative process. Excluding the artistic conception of the work, Huijnen realized the knitting related part of the project and Wanner the mathematical part.

2. ARTISTIC GOALS

The goal of Huijnen's art project lied in creating a pattern on a knitted tube that would visualize the peristaltic[1] movement of food through the esophagus. Looking for a way to reference this process of muscular contractions, schematic representations of the peristaltic movement served as visual reference.

They abstracted the fleshy and slippery aspect of the human gullet, transformed it into a drawn tube with waved outlines and a limited colour palette. For the knitted tube a similar level of abstraction should be obtained. Without using a descriptive colour palette, the reminiscence of the gullet should function on a symbolic level through a periodic, cyclic or wave pattern and a reduced use of colour: a dark stain on naturally white sheep yarn.

In addition, Huijnen wanted the pattern to emerge from the ball of yarn itself, instead of using two differently colored yarns to create a predefined pattern. An immediate correspondence between the original ball and the resulting tube could conceptually stand for the transformative process of digestion. Also when looking closely at the knitting movement of the sock machine needles, one can observe how the yarn is continuously grasped by the needles and pulled into a tube. One can then imagine why the opening and closing latches of the needles are called 'tongues'. (Iyer, Mammel and Schäch 1991, 54)

In order to create patterns that would be intrinsic to the ball of yarn, Huijnen decided to dye the yarn in a straightforward way: one half of a yarn ball was dipped in hair dye as schematized in figure 3. Then the yarn was dried and machine knitted into a tube.

The dyed yarn strand can be expected to consist of dashed lines with increasing length, as illustrated in figure 4.

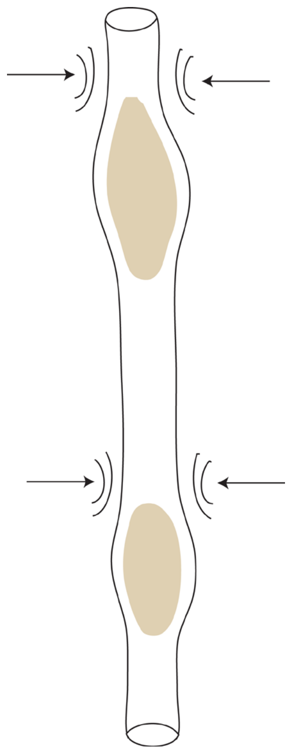


Fig. 2 Peristalsis (schematic).

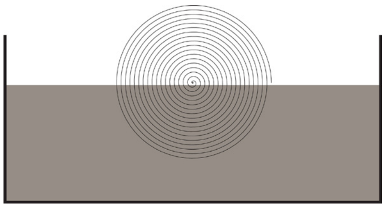


Fig. 3 Dyeing of yarn ball (schematic).

1 The peristaltic movement or peristalsis is a muscular contraction that proceeds in waves and pushes the bolus of food towards the stomach.

Fig. 4 The presumed pattern on the yarn.

The knitted pattern emerging from this process and its reiterations will be presented in the following parts of this paper. The focus will be on the calculation and comprehension of the empirically generated patterns. The artistic aspect of the project will not be discussed in detail.

3. PATTERNS PRODUCED

The first generated pattern exposed a color gradient from white to brown between the two ends of the tube as shown in figure 6. The yarn ball placed in front of the tube in figure 6 visually demonstrates to the art viewer how the yarn ball was stained. Analyzing the pattern, it became clear, that only the outer strands of the yarn ball had been colored, as it is illustrated in figure 5.

In a second iteration, another yarn ball was dipped in hair dye, with an effort to stain the entire half. The dyeing of the yarn is both influenced by the fluidity of the dye and the absorbing quality of the yarn. When dyeing yarn while it's wet, the color diffuses further along the yarn strands which explains the varying color intensities of the patterns that follow.

Fig. 5 Dye not fully penetrating into yarn ball, thus leaving a large inner section of the yarn entirely white (schematic).

Fig. 6 *Tube and Yarn Ball*, 2012. First generated tube with stained ball of yarn **Fig. 7** Second tube

The result of the second tube (figure 7) surprised. Instead of having a more pronounced color gradient from white to brown, another phenomenon had occurred: a delicately drawn pattern of 4 and further up 3 parallel curves (some of which on the invisible part on the back side of the tube) could be distinguished. How had this pattern been created?

4. A MATHEMATICAL MODEL OF KNITTING IN THE ROUND

Discussing this unexpected phenomenon between the authors, it was decided to use the visualization software *Processing* to simulate the generative process leading to these patterns. The authors were curious, whether the patterns could be reproduced in this simulation, and if it would be capable of making predictions and being used as a design tool to anticipate further iterations.

The following sections will introduce the mathematics and simulation assumptions step by step.

4.1 MATHEMATICS AND KNITTING

In her book *Häkeln + Stricken für Geeks (Crocheting and Knitting for Geeks)*, DIY researcher Verena Kuni describes parallels and connections between mathematics, computation and knitting. Kuni states that counting and numbers decide on the execution of the knitwear.

> *Increasing, decreasing, colored and other patterns – all this is applied mathematics with a computational reference; a crocheting or knitting instruction can rightly be considered an algorithm. (Zunehmen, abnehmen, Farb- und andere Muster – alles das ist angewandte Mathematik mit informatischem Bezug; eine Häkel- oder Strickanweisung kann mit Fug und Recht als Algorithmus bezeichnet warden.) (Kuni 2013, 9-10)*

In her research, mathematician and textile artist Ellen Harlizius-Klück reveals a similar and more ancient relationship between mathematics and craft. She describes weaving since Greek Antiquity in relation to dyadic arithmetic, the arithmetic of odd and even numbers. (Harlizius-Klück 2008, 2) Stating that all weaving is done in dyadic terms, the only choice being between “zero (warp-thread down) and one (warp-thread up)” (Harlizius-Klück 2008, 5-6) she accordingly relates the history of weaving to the origins of computing and the fitting of a pattern into a woven fabric to mathematic calculations of numeric divisibility. In analogy to weaving, knitting could also be described as binary, with a choice between a purl and a knit stitch.

As far as knitting in the round is concerned, Verena Kuni introduces modular arithmetic (Kuni 2013, 9-10), a field of mathematics suited to describe repetitive patterns on objects knitted in the round – usually socks – and refers to the knitting projects of mathematician Sarah-Marie Belcastro. Belcastro's pattern of striped *Sublimation Socks* for example is based on a sequence of integer numbers. (Belcastro 2012) In a process between arithmetic and trial-and-error, the pattern is adapted to the shape and design of the socks. An equation for the calculation of the sock rows is also provided.[2]

Huijnen's pattern, empirically discovered, directly relates to these mathematical sock knitting patterns and modular arithmetic.

4.2 MODELING A PATTERN WITH VERTICAL STRIPES

The further investigation will rely on the book *Making Mathematics with Needlework* by Belcastro and her colleague Carolyn Yackel. Belcastro and Yackel present modular arithmetic as an opportunity for a designer to "create a pattern that looks complex but is simple to execute." (Belcastro and Yackel 2007, 95)

They introduce two essential modular dimensions: the row length l_r – the length of yarn needed to complete one row – as well as the pattern length l_p – the length of yarn needed until the pattern repeats itself. If the pattern is supposed to repeat itself on every row, the row length l_r needs to be an integer multiple n of the pattern length (93), so that a resonance (or matching) occurs between the two modular dimensions.

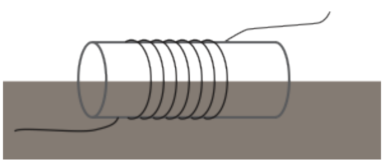
$$l_r = n \cdot l_p \ (n \in Z)$$

In our case, the circumference of the knitted tube was measured to be 70 cm.[3] To verify our hypothesis, that the pattern will repeat itself in every row, we chose a cylindrical winding to result in stained yarn bits of a pattern dividing the row length l_r = 70 cm. To obtain n = 4 vertical stripes, a pattern length l_p = 17.5 cm has to be generated, by winding yarn around a cylinder of d = 5.6 cm diameter, as figure 8 illustrates.

$$l_r = 4 \cdot l_p = 4 \cdot \pi \cdot d$$

Figures 9 (computer simulation) and 10 (photo of knitted tube) show how this pattern was confirmed in

Fig. 6 Cylindrical winding and dyeing

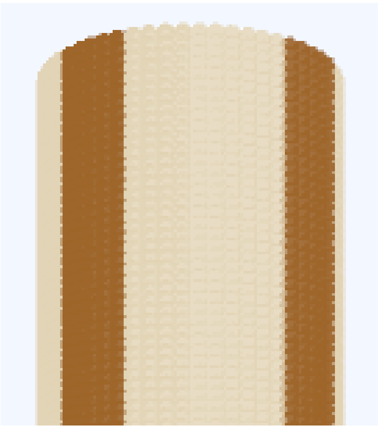


2 On the crafters forum *Ravelry*, her pattern as well as the mathematical equation behind the socks can be downloaded *http://www.ravelry.com/designers/sarah-marie-belcastro*

3 Corresponding to a row length of 60 stitches this results in a conversion factor of about 1.17 cm per stitch. Note that due to the flexibility and softness of the yarn material, these measures are approximate and slight variations are to be expected.

a simulation and verified by actually knitting it. The knitted version shows roughly vertical lines with some variations. The authors attribute the zigzag variations to varying tightness and the overlapping of thread when winding the yarn around the cylinder. This may provide an account of the accuracy limits of the method.

Fig. 9 Pattern with straight lines, the trivial case of the computer simulation **Fig. 10** Pattern with straight lines, some variations occur



4.3. MODELING A PATTERN WITH DIAGONAL STRIPES

Belcastro and Yackel then suggest a way of producing a pattern of diagonal stripes based on a simple counting algorithm:[4]

> *Suppose we wanted to have diagonal stripes advancing across the sock […]. We could achieve this by having a pattern length of 61, with a pattern consisting of a block of navy followed by a block of white. The shift creating the advance arises because 61 ≡ 1 mod 60. […] To have the diagonal going the other direction, use a pattern length of 59. (95)*

Based on the insight that "when l_p does not divide l_r, the pattern does not 'line up' from one row to the next" (95), Huijnen chose a pattern length of 18 cm, resulting from winding yarn around a cylinder of diameter 5.75 cm. With these parameters, a pattern of 4 diagonal stripes was expected, slightly shifted by an offset of 2 cm in each row (or by about 5 stitches every 3 rows).[5]

$$(l_p \cdot n) \equiv offset \bmod l_r$$

or with numbers:

$$(18\ cm \cdot 4) \equiv 2\ cm \bmod 70\,cm$$

4 Belcastro and Yackel's pattern was to be obtained with yarns of two different colors: "In order to make a pattern using colors, at some point more than one color of yarn must be used when making the loops." (92)

5 Modular arithmetic was developed for integer numbers, and works well with stitches – a countable entity that is represented well by integers. Our method however presents patterns of a continuous length range, and is not limited to integers. The authors bend the mathematics a bit here, but their point can be made with both integer and floating-point numeric values.

Figures 11 and 12 show how this pattern was confirmed in a simulation and verified in the knitting machine. The verification with the knitting machine shows variations in the slope of the diagonal stripes, which the authors attribute to the same accuracy limits mentioned earlier.

Fig. 11 Pattern with diagonal lines, obtained by offsetting pattern- and row lengths. (simulation) **Fig. 12** Pattern with diagonal lines, photograph of tube

4.4 MODELING A PATTERN WITH VARYING LINE LENGTHS

With this work done, we can proceed to our main modeling situation: the attempt to generate a periodic or cyclic pattern based on dyeing half a ball of yarn. In the model, the yarn ball is represented with a flat Archimedean spiral.[6] The ball of yarn is immersed halfway as illustrated in figure 3, so that subsequent white and stained bits of yarn have the same length. The color (white or stained) at a specific point on the circular tube will be a function of:

- the specific point x along the yarn
- the pattern with varying pattern lengths $l_p(x)$ along the yarn
- the row length l_r of the tube

Modular arithmetic is not directly applicable in this case, because the pattern length is not constant, but will increase from beginning to the end of the yarn, as figure 4 illustrates it. However, a resonance – an area with locally matching patterns – can be predicted to occur around areas x_0 of the thread, where the row length l_r is an integer multiple of the pattern length l_p.

$$x \sim = x_0 \mid (l_p(x_0) \cdot n) \equiv 0 \bmod l_r$$

With a row length of 70 cm, we expect this resonance to occur for pattern lengths l_p of 10 cm (n = 7), 11.7 cm (n

6 The spatial dimension of the spherical ball of yarn is neglected with this assumption. While this may seem a drastic abstraction, it will qualitatively predict a tube based on a dashed thread, with increasing dash lengths.

= 6), 14 cm (n = 5) etc. Our model does not have enough quantitative prediction power to predict the exact points x along the thread. But pattern lengths along the yarn will be between 0 and d · π (d is the diameter of the yarn ball).

Both the computer model based on the assumption of the Archimedean spiral, as well as the resulting tube confirm these conclusions: figures 13 and 14 show a tube with the parallel curve patterns around specific points, as well as dense almost horizontal lines in between. In both the simulation and the photograph of the actual knitted tube, the density of curve patterns increases from top to bottom. This corresponds to the knitting direction from the outer windings of yarn to the inner ones, in which the pattern length of the stained stretches decreases. In between these decisive resonance patterns, the parallel curves become almost horizontal lines, before they approach a point of resonance again.

Fig. 13 Computer simulation **Fig. 14** Knitted tube with several parallel curve patterns

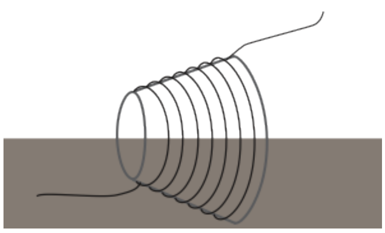
4.5 TOWARDS THE DESIRED PATTERN

The pattern obtained with a ball of yarn shows a progression from the outside to the inside of the yarn ball: there is an increasing fragmentation of shorter and shorter lines (pattern lengths). To obtain a periodic pattern, it is advisable to select a range of pattern lengths yielding interesting patterns:

$$l_p(x_{min}) < l_r / n < l_p(x_{max})$$

Then several pieces of yarn have to be wound in this way, so they all obtain pattern lengths between these boundaries. Adding these yarns in series will then result in the desired pattern. Further research is needed to identify suited yarn winding methods. For now, we suggest to proceed with a winding around a truncated cone with a lower diameter $l_p(x_{min}) \div \pi$ and bigger diameter $l_p(x_{max}) \div \pi$.

Fig. 15 Winding around a truncated cone.



5. FURTHER PATTERNS AND OUTLOOK

In order to create a composed knitted tube where the parallel curve pattern reoccurs in a cyclic and customized manner further experimentation and research will be invested in a more consistent winding of the yarn through a mechanical yarn winder and the specific design of winding objects.

Fig. 16 Periodic tube, composed of 3 subsequent threads of yarn wound up according to the procedurein figure 15 around an area of resonance.

Still another phenomenon caught the authors' attention upon close observation of one of the knitted tubes. One could notice slight distensions within the outlines of the tube, as can be seen in figure 17. These can be due to knitting with yarn that is still slightly wet, taking breaks during the knitting process and thus overstretching the yarn while it is fitted onto the needles of the knitting machine. As other effects that occurred empirically during the process of this project, this effect promises in a further step to be systematically developable into a shape not unlike the desired peristaltic tube.

Fig. 17 Detail of knitted tube showing an overstretching

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CRYSTAL FORMING ROBOTS ON OVERHEAD

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Keywords: Crystal Growth, Diffusion Limited Aggregation, Modular Robotics, Self-Assembling Robots, Generative Art

The following paper presents a robotic system that makes the process of crystal growth tangible. The background of this work are the early experiments from Gordon Pask on building a chemical computer as a learning system and my own interest in brain plasticity. With the help of software simulation the idea of a learning structure that grows and modifies its own perception of the environment is illustrated. The robotic implementation of the growth process is a first step towards making such a process tangible.

1. INTRODUCTION

The topic of this paper are systems of simulated crystal growths and my current research on creating a tangible system of a simulated crystal growth process: *crystal forming robots on overhead*. The background of this quest is my interest in autonomous learning systems and brain plasticity. The process of neural growth and the process of crystal growth are fundamentally different in their details. But as Gordon Pask has shown with his work on chemical computers, on a more abstract level crystal growth may serve as a model for autonomous learning (Pask 1958). The key analogy in his experiments on learning with chemical computers was the circular relationship of perception and learning: how the perception of the environment shaped the outcome of the growth process and how the growth process itself shaped the way the environment was perceived.

The complexity of the nervous system and of our psyche is through a large part due to that circular relationship. Humans are exposed to the world through their senses and it is without doubt in large parts the world that shapes the way our brain is organized. There are numerous examples for this fact, the most prominent are the insights about the cortical organization of the sensory motor system that follows a topographic organization, thus reflecting the structure of how the world is perceived (Sanes and Donoghue 2000). At any time this nervous tissue is plastic, which means that increased activation of a sense will lead to a growing representation in the brain and, vice versa, reduced activation leads to a shrinking representation. Learning to juggle, for example, leads to the growth of those brain areas associated with hand-eye coordination (Driemeyer *et. al.* 2008). But learning to juggle not only affects the skill of juggling, as it modifies significantly the structural organization of the brain it also affects other skills. For example children that learn to juggle show an increased ability for doing mental rotations (Jansen *et. al.* 2011).

A crucial aspect in this example is however that whether we learn to juggle or not depends on our own decision. We thus always actively inscribe ourself in the process of synaptic growth. As Catherine Malabou argues in What to do with our brain (Malabou 2009)

It is precisely because – contrary to what we normally think – the brain is not already made that we must ask ourself what to do with it, what we should do with this plasticity that makes us, precisely in the sense of a work: sculpture, modeling, architecture.

Such questions, about the general structure of learning, about systems that are in a continuous state of becoming, that sort of sculpt themselves into being form the general background of the proposed systems. Even though these systems are far from doing cognition, they provide us with a sense of what it means when a system's growth process is coupled in a circular way to the environment, of what it means when a system has the capacity for autonomous learning.

Gordon Pask was himself active at the interface of art and technology (Pask 1968). As a matter of fact till today he inspires both artists and scientists. The artwork *Roots* by Roman Kirschner is a beautiful example for an artwork based on his ideas on chemical computation (Trogemann 2010). In times when computer simulation of learning processes was almost impossible because of the lack of computing power, Gordon Pask used chemical computation as metaphor for and as simulation of biological systems. He went as far as to use chemical computation "to grow an ear" (Cariani 1993), a device that could differentiate two tones of 50 and 100 Hz. Till today he is the source of inspiration for a number of scientific and artistic projects. However, to my knowledge, few of his experiments could be fully replicated.

I focus on a simpler example Pask gives in his paper *Physical Analogues to the Growth of a Concept* (Pask 1958). Here he proposes a system that he calls a self-building assemblage that has the capacity of learning. This system was based on a ferrous sulphate solution and connected to a current-limited electrical source. When current was applied, ferrous threads would grow between the electrodes. The most interesting aspect of this system was that the growing structure itself was one of the electrodes and would thus modify the force field distribution that contributed to the structure of growth. If one interpreted the grown structure as a sensing element of the electrical field potentials the system was growing its own sensorium.

In a set of software simulations based on the diffusion limited aggregation algorithm I replicate a single experiment and I take these simulations as a proof of concept that crystal growth may help study the interplay of a growing structure and its environment and thus shed light on mechanism of learning.

The aim of this paper is to go beyond software simulation and to develop a tangible system, that allows for experimenting with growth. The idea of using robots is thus that the whole process of crystal formation is taken to a macroscopic level that is much easier to observe in detail. It is like watching the crystallization process through a microscope. The other reason to use robots as an experimental platform is that they offer the potential to link them electronically and to connect them to behavior. Such robots that have the ability to self assemble into larger structures have of course a long history in robotic research, see (Groß and Dorigo 2007) for an overview paper and see the works by Penrose (Penrose 1959) for an early reference. However, using very simple solar powered robots to study and make tangible growth processes themselves is a new approach.

2. SIMULATING GORDON PASKS LIQUID ASSEMBLAGE

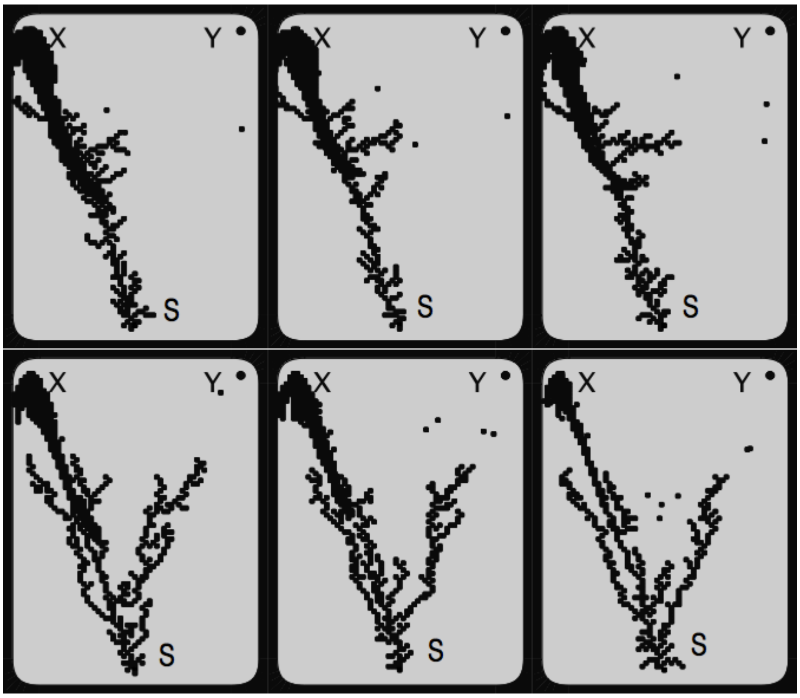
In Gordon Pasks setup what he refers to as the assemblage is an electrolyte solution where two anodes are placed at positions X and Y, that define a force field between them and a single cathode S. He then analyzes two different regimes. He argues that if initially point X has more positive potential than Y, the thread will grow in direction of X and that if at some moment in time the potential at Y is set to equal value the thread might bifurcate and split into two branches. If after this bifurcation, the initial parameters for X and Y are re-established, the behavior of the system will now be very different, because it has already formed a thread towards Y. He argues that the behavior after bifurcation can not be predicted from the observations of the system before the bifurcation. From this observation he concludes

> *Thus an observer would say that the assemblage learned and modified its behavior, or looking inside the system, that it built up a structure adapted to dealing with an otherwise insoluble ambiguity in its surroundings.*

For simulating the force fields created by the different potentials that are defined by the electrodes, the diffusion limited aggregation algorithm (Witten and Sander 1983) is modified. In the standard algorithm the diffusion process of particles is simulated with a random walk and the aggregation is computed just based on neighborhood relations. The aggregate is initialized with a starting seed. Whenever a particle hits the neighborhood of the seed or an already aggregated particle it stops moving and becomes part of the structure. In the original algorithm no force fields are defined.

The first modification to the original algorithm is that the movement of the particles is not defined in cartesian but in polar coordinates. This makes it much easier compute a directional force. The second modification is the introduction of a directional force that acts upon the particles. This force is defined by the growing structure that set an attractive force. In addition to this directional force a random force is defined that follows a Gaussian distribution around the direction of the attractive force. To compute the attractive force of the growing structure on a particle each element of the growing structure sets an attractive force in its own direction. The overall force is then obtained by integrating all forces. The single force of one element on the particle is defined by the distance of the particle with respect to that element of the structure. The further apart the smaller the attractive force. This way of computing the direction for the moving particles is based on the dynamic systems approach to navigation (Schoener and Bicho 1997). The forward speed of a particle may be computed independently, and follows a simple rule: The closer a particle gets to the structure, the slower it speed.

Fig. 1 The top row shows simulation results of three different runs for the regime with constant source distribution 84% of the particles come from location X and only 16% from Y. The bottom row shows three simulations runs with a switch of the distribution to 50% from X and Y after time t1 and again switch back to the original distribution after time t2.



When it hits the structure it stops moving and aggregates to it. As more particles aggregate the force field is modified, because each new element contributes a new force that will be integrated. With this set-up it is now possible simulate Gordon Pask's setup and to compare the two different regimes. The difference in positive potential of a source X versus a source Y is modeled through the distribution of particles they release.

In the first regime 84% of the particles come from source X and 16% come from source Y (see Figure 1 for the spatial setup). In this first regime over the full time of the experiment the distribution is not changed. In the second regime the experiment starts with the same distribution of 84% and 16%, but then switches after some time t1 to an equal distribution of 50% from source X and 50% from source Y and finally after time t2 it switches back to the initial distribution.

What the simulations (Figure 1) clearly show is that in the second regime a bifurcation happens early on, when the switch to the equal distribution happens (lower part of the figure). Two threads one directed toward the source X and the second directed towards the source Y grow. As a result of this bifurcation the thread leading towards Y is so close to the source that after switching back at time t2, particles coming form source Y are rather attracted towards this thread, so that it now continues to grow. In the first regime where most particles come from source X, only small degenerate subthreads towards Y develop and they appear late in the process. What is also remarkable is that while each of the simulations produces locally very different results, the overall shape within a regime looks very similar over different trials. These effects are all very well reproducible.

3. SIMULATING GROWTH WITH HARDWARE

The basic idea of simulating crystal growth with hardware is to render tangible the processes of self-organization and autonomy. The two ingredients of the diffusion limited aggregation algorithm are two processes, the diffusion process of a random walk and the clustering process that leads to the aggregation. The idea of crystal forming robots on overhead is to realize these two processes with small robots. These are based on the overheadbots, which are small solar powered robots that work with the so-called suneater circuit as it has been developed by Mark Tilden.

3.1. OVERHEADBOTS

The overheadbots are little solar powered robots that are placed on the overhead projector. They use the light that comes from the overhead projector as their source of energy and they are fully autonomous. They have been shown in different configurations at diverse media art festivals and premiered at the festival *The Art of the Overhead* in 2005 (Gansing 2013).

With a small solar panel the light energy from the overhead projector is converted to electrical energy and used to charge up a capacitor. A small electronic circuit monitors the amount of energy and whenever a critical level is reached a discharge is triggered that drives a small vibration motor. This cycle of charging the capacitor and discharging it through a motor creates a rhythmic pattern. The overhead projector forms a sort of habitat for the overheadbots, once it is turned on they work fully autonomous. Similar to real particles the overheadbots diffuse and without a physical border on the screen of the overhead projector, it is only a matter of time till they are all off the screen where there is no more energy supply.

3.2. CRYSTAL FORMING OVERHEADBOTS

In order to have the potential for forming patterns on the overhead projector the overhead robots need to be as tiny as possible. To this end instead of using a standard solar panel, a custom made solar module that consists of 9 photodiodes (actually very tiny solar cells) is used. Using this custom made solar panel the robots measure only two by two centimeters. To create the additional attractive force the overheadbots are equipped with a rectangular frame that holds 4 neodymium magnets, one for each side (see Figure 3).

Fig. 2 A series of photographs of a clustering sequence, it took approximately 20 minutes for the final structure to build. fully autonomous. Similar to real particles the overhead bots diffuse and without a physical border on the screen of the overhead projector, it is only a matter of time till they are all off the screen where there is no more energy supply.

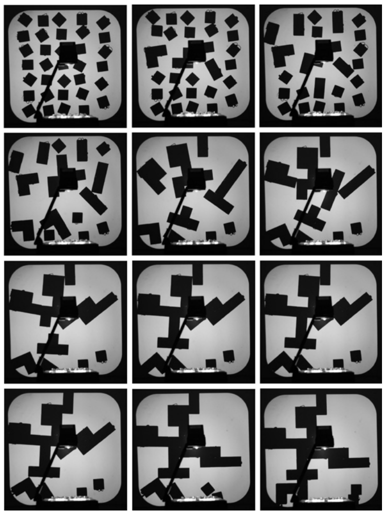
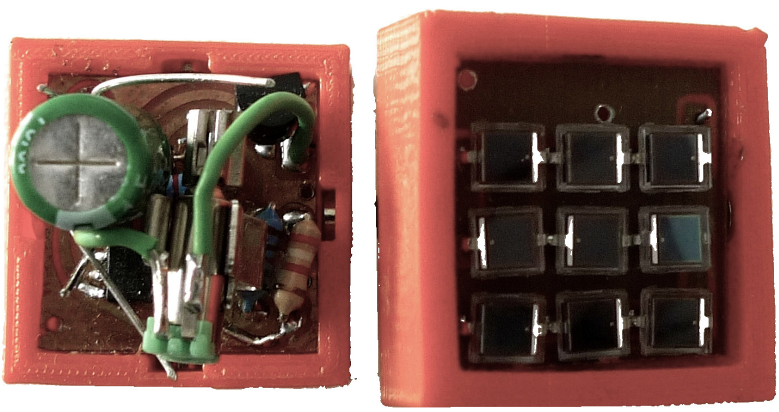


Fig. 3 The left side shows the top view of a crystal forming robot with the electronics and the motor, the right side shows the bottom view with the custom made solar panel.



When two robots with matching polarity come close to each other this attractive magnetic force will form a local cluster. Unlike the standard diffusion limited aggregation algorithm there is not a single seed but each particle is a potential seed for the growth of a structure. Once a cluster is formed the robots start to move together, the trigger of one motor also physically agitates the other robot. However as the cluster grows the overall movement amplitude becomes small smaller and smaller, because the total weight of the structure increases. Figure 2 shows an exemplary run, initially the robots are equally distributed on the screen. After some time the first local clusters of two or three robots appear. Then larger clusters form, only two robots stay separate. In the final frame the three larger clusters all have joined into a single structure.

4. CONCLUSION AND OUTLOOK

The software simulations of Gordon Pask's early experiments show that using the process of crystal growth uncovers interesting couplings between growth processes and the environment they appear in. Such processes act as metaphors in understanding our own processes of learning that have a similar signature in that a learning also may alter the way we perceive the world.

The overheadbots form structures that look very similar to those observed in simulations of crystal growth. Even though there is no global force field but only local attractions between robots of opposed polarity, global patterns may emerge. Sometimes a local sub-cluster remains isolated but always one large structure builds up. Instead of looking through a microscope to watch particles aggregate as during the observation of real crystal growth this process is scaled to the size of little robots and again magnified with the help of the overhead projector.

In order to connect the growth of the structure to functional changes, currently I am working on adding contact points to the side of the robots, so that when they touch an electrical connection between them is created. With these contact points it will become possible to grow electrical connection and to plug those connections to behavior of the robots. As a matter of fact there is clearly the potential to use such robotic systems to simulate interesting aspects of learning where growth affects behavior and behavior affects growth.

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THE ART OF TRICKERY: METHODS TO ESTABLISH FIRST CONTACT IN INTERNET SCAMS

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Keywords: Unsolicited Electronic Mail, Scambaiting, Computer Mediated Communication, Interactive Storytelling

Internet scammers use fictional narratives to gain the trust of potential victims. These narratives are often pre-scripted, get send out by individual scammers or scam-groups and are often copied and reused by other scam-gangs. Vigilante online communities of scam baiters try to jam the practices of these Internet scammers by using similar social engineering techniques to hook the scammers into a story and consequently interrupt their workflow. In this paper, through examples, I want to take a closer look at the scammers working methods and focus on two different strategies on how scambaiters use to approach scammers.

1. INTRODUCTION

'First contact' is a term describing the first meeting of two cultures previously unaware of one another. In this paper, I have outlined the methods by which the online communities of scammers and scambaiters craft their first contact with each other.

Today, most spam messages get send automatically over botnets, yet the so-called 419-scams[1] are still largely performed as manual labour by individuals or groups of scammers (Isacenkova, 2013). The 419-scam is so effective because it appeals to the two basic human traits of greed and superiority (Zuckoff, 2006). Falsification, impersonation, counterfeiting, forgery and fraudulent representation of facts are common tactics that scammers use to gain the trustworthiness of their victims. However, the first contact needs to be well crafted in order to be able to grab the victims' attention. After a first payment is wired, the scammer comes up with further obstacles and story plots asking for more money. This creates a vicious circle where the victim ends up paying constantly more and more money (Isacenkova, 2013).

An online vigilante group called scambaiters use social engineering techniques to get in contact with the Internet scammers. Scambaiting tactics can be seen as subversive while making use of similar strategies as scammers do. When the initial connection is made the scambaiter impersonates the potential victim as long as possible. This both to keep the scammer busy from his other criminal activities as well as to document the scam with the intention of warning others. Some use these tactics to severely criticise the scammers and to put them in the virtual pillory. There are two main techniques that scambaiters use to make this first contact with scammers: 'imposing the simple minded victim' and the 'accidentally send out email messages' (ASEM). This paper will later take a closer look at both these techniques and illustrate their main aspects with examples.

2. A SCAMMERS SCRIPTED STORYLINE

Internet scammers use a number of story lines to grab the attention of other Internet users. These narratives are mostly pre-scripted texts, which get sent out in bulk to millions of people. Freiermuth applied a rhetorical moves analysis on scam emails to assess that scripted messages follow distinctive patterns to develop a trusting relation-

1 The number *419* refers to the article of the Nigerian Criminal Code dealing with fraud.

ship with their marks (Freiermuth, 2011). Hartikainen further examines that the initial email has to provide sufficient degree of credibility and must be both convincing and compelling enough to make the mark respond. This is most often based upon a successful calibration of the narrative with the marks of superior feeling and the stereotypical understanding of Africa or Africans in general and successfully used in e.g. refugee romance scams, charity scams or war booty scams (Hartikainen, 2006). The scripted narratives get often mixed with actual on going events like the struggle of decolonization, corrupt politicians and exploitation of natural resources. This metafiction enhances the credibility of the involved characters and the whole narrative. The scammer is using the credibility of other Internet services like news agencies or other users comments to backup their story.

When a victim replies to a scam-mail, the scammer answers with yet another scripted messages further filtering the naive from the sceptical. In an ideal case the scammer can rely on his scripted narrative until he stipulates a small fee. When following a script the different tasks involved can be executed by a single independently working scammer or by a hierarchical structured gang (Interview with a Scammer, 2010). The following examples demonstrate the share of workload and responsibilities when a gang of scammers use a number of email accounts and involve several interrelated characters in the scam narrative (Hotz-Davies, 2006).

2.1. SHARE OF WORKLOAD

In the hierarchy of scammers on the lower level you find the 'foot soldiers' or the 'yahoo boys', young boys in their late teenage years who harvest email addresses and send out the initial bulk emails (Tade, 2011). Depending on the scripted story, email addresses of a certain gender, occupation or geographical locations are collected. A sign of such shared workload can be a different email address in the 'From:' field than the 'Reply-to:' field or changing locations based on email IP address analysers (Schneier, 2011). Once a victim replies to an email, the message is delivered to a different scammer.

At this level a more experienced scammer – often called 'guyman' – is dealing as efficiently as possible with a lot of victims at the same time. Each task demands special qualifications and has to be delegated efficiently;

an entry-level 'yahoo boy' does not need proper language skills when harvesting email addresses and sending initial emails out in bulks (Ogwezzy, 2012). The final money transactions are then handed over to the higher-level gang-leaders (called 'Ogas') who keep track of the income. This happens through an email message, where the victim is asked to contact yet another person, often claiming to be a barrister or another official representative, who will further deal with the financial transactions. The following e-mail snippet illustrates a typical example how the victim is directed to correspond with another character in this case the family lawyer James Douglas.

> *[…] I will like to inform you that every information concerning the deposited consignment is with our family lawyer Barrister James Douglas, in which case you are to contact our family lawyer who will direct you on how to take custody of the deposit […] So feel free to open up communication with him by calling him and sending your telephone numbers to him for regular communication until the deposits are transferred to you. […] Let me know as you contact the lawyer.*

Once the victim replies, the scammer at the next level of the gang hierarchy is already dealing with the victims who fully trust the story and are willing to 'seal the deal' by wiring the designated advance fee. According to a scammer called 'John', at this level one out of every 20 replies would lead to getting money out of the victim in the end (*Interview with a Scammer*, 2010).

This separation of workload facilitates the use of several interrelated characters within the narrative. The rather practical approach implies similar techniques as used in transmedia storytelling practice, making it the ideal aesthetic form for an era of collective intelligence (Jenkins, 2011). Jenkins defines collective intelligence as 'alternative source of media power' that facilitates new ways for people to participate in knowledge cultures. This can be followed in the genre of fan fiction literature, as Jenkins states:

> *[…] they introduce potential plots which can not be fully told or extra details which hint at more than can be revealed. Readers, thus, have a strong incentive to continue to elaborate on these story elements, working them over through their speculations, until they take on a life of their own (Jenkins, 2011).*

3. ANTI-FRAUD STRATEGIES

There are different anti-fraud strategies that show how you can deal with a scam letter at various levels, starting from reposting the email to warn other Internet users[2] to rather sophisticated social engineering practices to engage with the scammer for a longer term (Zingerle, 2013). Each strategy requires an initial contact with the scammer. Next we will take a closer look at two methods and with the help of examples show how scambaiters intentionally get in correspondence with scammers.

3.1. STRATEGY I – THE BLUE EYED VICTIM

A popular method amongst scambaiters is to directly respond to the scammers email proposal, whether the scam-mail was found in the inbox, a spam folder or an online forum such as *Scamoftheday*.[3] No matter where the email message originates, the receiver replies to the scammers'email acting as believer of the proposed narrative and willing to engage further. A gullible reply gives the scammer the feeling of a 'fast hit', as nearly 70% of all replies wire money at least once to the scammers (Interview with a Scammer, 2010).

During the correspondence with the scammer the scambaiter further defines the created character. A scambaiter never exposes his or her real identity while exchanging messages with scammers. The scambaiter aims to conduct and starts constructing their own narrative, where unforeseen obstacles occur that can bring the scammer 'off the script'. Following actions by the scammer can be 'off-script': your questions are considered and get answered in detail; emails are answered in a rush with certain changes in sentence structure and an increase of typographic or grammatical errors (Bluth, 2010). When the scammer is 'off-script' each scambaiter has their own strategies to develop the storyline with the aim of: documenting the scam-method, collecting evidence of trust in form of photographs, audio- or video recordings jamming the workflow of the scammer and reporting bank accounts or credit cards (Zingerle, 2013).

3.1.1. EXAMPLE: 'RE: DAKAR ARTS FESTIVAL'

The 'Re: Dakar Arts Festival' project documents the practice of scammers, who announce an online open call for a fake art festival in Dakar, Senegal. The festival is just a lead story for advance-fee fraud and victims are lured

2 *http://www.scamwarners.com/*

3 *http://www.scamoftheday.com/*

into wiring money for reservations, transportation costs, commissions or other service charges without knowing that the festival does not exist. The project evolved out of open calls posted on art-forums and personal email messages that invite artists and gallerists to participate in the upcoming Dakar Arts Festival. To investigate a bit further, we started developing online characters that were in contact with the scammers. We created three virtual characters: a gallerist Peter Irrthum, an artist Heidi H. and the gallery secretary Toni Alm. The fake gallerists Peter replied to the email that the festival organizer Mariama Sy sent out:

> *Dear Dakar Arts Festival Team,*
> *my name is Peter Irrthum, I am a gallerist based in St. Gallen, Switzerland. I found your open call on absolutearts.com and find it very interesting. […] It would be really good if it is still possible to sent exhibition proposals. As you know I am a gallerist and I am always looking for international exposure for my artists and good networking possibilities for my gallery. I also think that one of my photographers would be interested to join this unique opportunity to exhibit her artwork. […] Let me know as soon as possible if it is possible to apply to the festival. Best, Peter*

This first email introduces the gallerist and his interest to participate in the festival. He even seems to be eager to get one of his represented artists to participate. After receiving a first answer from Mariama Sy, telling us more about the participation modalities, our artist Heidi H. gets in touch with them:

> *To whom it may concern,*
> *my gallerist Peter Irrthum contacted me about the opportunity to participate at your festival (Dakar Art Festival). I was immediately attracted by this offer of two reasons; I have never had the opportunity to exhibit on your continent and I have never visited Senegal. I have attached to this mail my CV. I just finished working on a photo series that could fit to your exhibition. […] What information do you need about my work? Is there a curational theme for the exhibition? Mr. Irthum informed me as well about the offer that you benefit 50% f the travel costs. […] Please let me know if this can be arranged? Hope to here [sic] from you soon, best regards, Heidi H.*

When the correspondence with the scammers developed further, online representations like Wordpress blogs, Social Media profiles, etc., were created to backup the identities of the characters and to pursue the unfolding of the story. By cross-referencing these online representations in the correspondence we gained the trust of the scammers and this helped us collect more information about them and their practice. The collected data was reported to popular web platforms that publish open calls for artists. Furthermore, artists, state funding offices, embassies in Dakar and other art festivals were informed about the scam.

3.2. STRATEGY II – THE ACCIDENTALLY SENT EMAIL MESSAGES

A second method to contact Internet scammers is to send out 'unsolicited Bulk E-Mails', also referred to as 'accidentally sent email messages' (ASEM). Using this strategy the sender claims to have been in contact with the scammer before, apparently trusts this person, refers to a situation that happened in the past and lays out the steps how to proceed further. By instructing the scammer what to do in order to advance the cooperation the scambaiter is in control of the situation. Any scammer answering such an email steps right into the story world created by the scambaiter and is ready to follow the rules of this world.

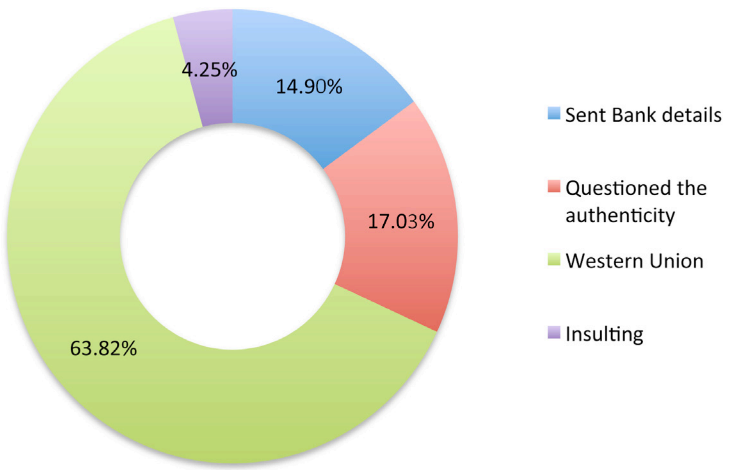
The following example demonstrates how this strategy was tested and examining what kind of response rate engineered stories in ASEMs can have. In this example bulk emailing was used to contact scammers and receive their bank account information. The email addresses were taken from email providers blacklists and got double-checked to avoid contacting innocent people.

This was in order to report those accounts for being monitored or even closed due to criminal activities. In the email, the sender refers to a previous payment via Western Union and put in the urgent request for detailed bank account information to reduce the processing fees for the larger payment they want to make. The email is obviously addressed to the wrong person, but the scammer also sees that there is an opportunity to 'turn a fast buck' (Goffman, 2011) that is supposedly meant for someone else. The e-mail used for the test:

[…] Good that it worked out that you received the €80. I just went back to the Western Union office to send you the missing €920. […] The processing fee for sending the amount is getting quite high, if possible I want to avoid unnecessary service charges. Can you send me your bank account information? […] I await your prompt reply. Best regards a.m.

Figure 1 visualizes the response rate to this unsolicited Bulk E-Mail offer within the first five days. From the total of 500 contacted scammers, 96 emails could not be delivered due to unavailability of the email addresses. This can happen when emails get reported for fraudulent activities and therefore the account gets blocked or closed by the service provider. 404 emails were delivered to the scammers' Inboxes. Over the next five days 47 scammers (11.63%) replied, seven scammers (14.90%) replied immediately with their bank account details, 30 scammers (63.82%) wanted to pay for the processing fees, eight replies (17.03%) questioned why they were being contacted, two (4.25%) were considered insulting.

Fig. 1 Diagram of response rate



3.2.1. EXAMPLE: A RELIGIOUS GROUP EXPANDS TO WEST AFRICA

One example documented on the scambaiter forums[4] that makes use of the ASEM strategy is a transmedia story of a religious group. This online narrative makes use of a number of channels including website, several forms, ceremony manuals and audio recordings.

The bait is based on creating a church so credible and so attractive, that many scammers would want to

4 To protect the method no detailed names, links to the websites or references to the authors are listed here.

join it. Using similar language as that of an advertisement an image is created that there will be a substantial financial gain if one happened to join the church and helped it grow in countries where the group currently does not have a foothold. One of the main hooks is that the religious organization wants to expand into the West African countries and they are currently seeking local representatives to organize the congregational events. Accepted members of the church are able to receive further funds for their missionary. To be able to do this, the applicant has to fulfil several tasks: filling out membership applications, showing his dedication to the church by constructing a 'Monument of Faith' or performing and documenting an ordainment ritual.

The initial email that is sent out to the scammers is supposedly written by the secretary of the church, paving the way for the scammer to accept the story and become a member of the church:

> *Our church states that we can only do business with other members. […] there may be a great many opportunities to do something together, including helping you with your affairs. […] Best regards,*

In the case that a scammer answers to the email, they receive an answer yet from a new character 'Director of Membership' of the church:

> *[…] There are only a few steps need to be taken to become a member. Have you had a chance to visit our website? If not, I suggest you do to become acquainted with our church. I am looking forward to hearing from you soon!*

He refers to the secretary who forwarded him the email and refers to a detailed website of the church as a source for further information about the religious movement. A phone number is provided that is linked to a mailbox where one can listen to recent church activities and follow upcoming event schedules. If a scammer is still interested to continue with the acceptance process, a member request application is sent to him. This pdf includes a personal letter of the reverend, a five pages long survey that the applicant has to fill out. Additionally several photographs of him and other potential church members in various defined poses have to be taken and attached.

Once the scammer sends back all this material it gets revised and a membership status approved. The scammer is further asked to build a physical sculpture to prove his faith in the religious group and all involved participants. A pdf file illustrates the parameters to build a sandbag-pyramid with 4x4 meters width at the base and a height of about three meters. Once the pyramid is successfully built the requested photo documentation is sent to the reverend, an additional 'ordainment ceremony' has to be performed and documented. The ceremony asks one participant to dress up as a reverend in white long dress, light a torch, recite gospel texts and perform a ritual including other participants who carry him around the pyramid.

If the scammer has gone through the ritual, one of the authors states:

> *Your lad is now ready for anything. You own him. At this point, he has totally devoted himself. […] You will be able to ask him to do anything, and he will do it.*

This example uses ASEM in combination with transmedia story telling in a successful way for the scambaiters. It demonstrates how well these strategies can be used. However, the efficiency and ethical aspects of these strategies pose valid questions. From this stage onwards the authors of the scambait suggest to continue with a 'safari', a practice to get the scammer away from his computer and travel to a remote place (Zingerle, 2013). The authors have also felt a rising need to comment on their strategies as well implying that a discussion around the ethics of the scambait is essential as well. The instructions end with an ethical note on the methodology:

> *These ethical dilemmas are easy to deal with. If you don't feel comfortable making a fool out of a lad who thinks that he is truly doing something good, then just stop. […] Quit baiting and go do something else.*

Scammers contact their victims by using the ASEM method, like in this example where the subject line starts with a 'Re:' that indicates a former contact between the parties and the sender refers to an already wired payment:

> *[…] I am contacting you because I've sent you the first payment of $5,000 today from your winning funds total amount of $1.5Million USD. Therefore you need to contact western union agent Mr. Tony Masinas, for him to give you the transfer payment information and MTCN. […] Do get in touch with me once you have received the transfer. Best regards.*

3. CONCLUSIONS

This paper has given an account of the different strategies both scammers and scambaiters use to get in contact with their potential victims. Scammers use pre-scripted narratives to get in contact with people. Scambaiters on the other hand pose as the 'blue eyed victim' when replying to a scammers email to gain the trust of the scammers and try to bring the scammer 'off-script'. Another method to contact scammers is the 'accidentally sent email messages' (ASEM) in bulk method. Both strategies influence the way of storytelling: the 'blue eyed victim' method lets the scammer tell the scripted narrative and the scambaiter slowly infiltrates or tries to infiltrate it whereas within the 'ASEM' strategy the hooked scammer is compelled to play along the scambaiters narrative from the very beginning. In both the examples we have seen that scambaiters use transmedia storytelling practices and spread their story over different social media channels. By doing so scambaiters can reference to this websites in their correspondence with the scammer, unfolding multilayered stories where several twists and turns are possible. Individuals or several scambaiters who work together can operate with both strategies.With both methods it was possible to collect information about the scammer and warn potential victims. Some cases led to the arrest of the scammer (GNA, 2006).

Where law enforcement has failed to internationally develop effective ways to take action against the global phenomena of online scams the vigilante online communities of scambaiters act as a global civil movement against Internet fraudsters. They document the scammers practices, warn potential victims and report to hosting providers, webmail services or law enforcement. However, moral and ethical discussions arise when scambaiters humiliate their counterparts. While scambaiters come from diverse backgrounds and are motivated by various reasons (Zingerle, 2013) ‘ethical’ approaches to scambaiting are continuously under discussion in scambaiting forums. Whereas it is generally agreed, that what differs a scambaiter from a scammer is that a scambaiter does not seek for financial gain, there are a number of documented cases where scambaiters do not agree on the morals of the scambait. These are cases like the ASEM method described in 3.2, or other scambaits where scammers were sent on long lasting and sometimes dangerous travels or were getting tattoos with the logo of the church, which resembles an act of physical punishment. An important and interesting topic for further research would be to examine various guidelines on safe and ethical communication with scammers that emerge from the discussions in the scambaiter forums.

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PARTICIPATORY DATA-DRIVEN ART OBJECTS: VESSELS FOR KINETIC INFORMATION

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Keywords: Interactive Sculpture, Kinetic Sculpture, Data Art, Data Sculpture, Data-Driven Sculpture, Big Data Art, Participatory Installation

The ubiquity of data has spawned the emergence of many forms of data-driven artwork ranging from digital to physical pieces and their perceived intersection. This paper presents novel techniques for interaction design, aesthetics and technical implementation in the creation of participatory data-driven art objects. A subset of data-driven artwork is discussed, which covers data visualization art and data objects, both interactive and fixed, in order to place the authors' work in context.

1. INTRODUCTION

The arrival of the information age caused an evident shift in the industrial sector: the world moved from traditional industry and its textbook manufacturing processes to one characterized by computerization and new media. As computers increase in processing power and storage grows exponentially, this revolution brought forth the rise of data in masses (Compaine and Read 1999). Coupled with the growth of multisensory technology and mobile computing, the presence of mass amounts of information is ubiquitous and can now fit comfortably in our pockets.

"Big Data" has been a buzzword rampant among the tech industry sector since the early 21st century. In 2006, market researcher Clive Humbly declared data as "the new oil".[1] By oil, Clive refers to the notion that untapped data is crude and practically useless – it must be refined and broken down in a way that it provides value. The business world has been quick to capitalize on data in its various sources. Marketers in particular have outlined ways in which to make data more valuable: by understanding that data is not insight and that in order for data to mean something it must be placed in context. By placing data in context, one can begin to make sense of the information, and the conclusions drawn become valuable (Mayer-Schönberger and Cukier 2013).

The implications of the information age have been paramount throughout every sector, and these mass amounts of data permeate our lives on a daily basis: from flight arrivals/departures to stock prices to social network news feeds. As of an IBM study conducted in 2012, we create approximately 2.5 quintillion bytes of data daily[2] – this number only continues to rise. As a collective, humanity produces five zettabytes of data a year (Aiden and Michel 2013). While the ways in which data can be utilized from an economic standpoint have been apparent from this digital revolution, other sectors, including art, are beginning to utilize data streams in unique ways in order to ask questions about the world we live in.

In this paper, the authors discuss multiple techniques for data-driven art objects including installations and sculptures. Section two discusses related work including both digital and physical pieces. Section three discusses two participatory data-driven installations that incorporate novel data creation techniques and their applications

1 *http://ana.blogs.com/maestros/2006/11/data_is_the_new.html*

2 *http://www.ibmbigdatahub.com/*

in data-driven kinetic work. Lastly, section four discusses the interaction model, affordances and drawbacks as well as future applications of data-driven art.

2. RELATED WORK

The presence of large data sets in art is not a novelty ("Data-Driven Aesthetics" 2014). In fact, data has manifested itself in unique ways across various sects in the media arts realm. The most evident outlet for data-driven art can be seen through digital image work and digital art in the form of data visualizations. However, in recent years, artists are beginning to interpret data in more physical ways, as both interactive and fixed data objects, which seek to provide a more tangible representation of information at large.

2.1. DATA VISUALIZATION ART

In late 2012, the Beall Center for Art and Technology at the University of California Irvine exhibited many works utilizing information visualization techniques that caused viewers to reflect on these mass amounts of information.[3] Various artists were featured including artist duo Fernanda Viégas and Martin Wattenberg and their work *Wind Map (Cook 2013)*.

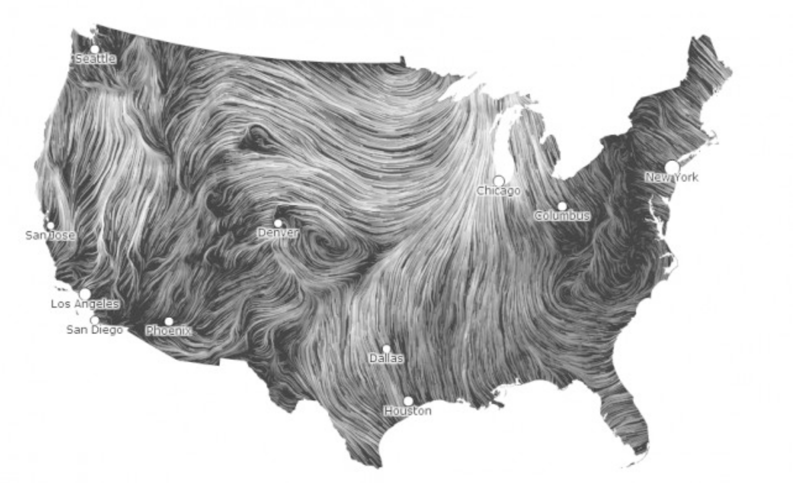


Fig. 1 Wind Map

Wind Map, an online application created by Viégas and Wattenberg in 2012 illustrates the course of the winds moving across the United States (Figure 1. Wind Map). The wind surface data utilized in the work is captured hourly

3 *http://beallcenter.uci.edu/exhibitions/dataviz-information-art* from the National Digital Forecast Database.[4] A programmatic intricate weaving of shaded lines of varying transparencies adds a painterly feel to the work enabling a visual analogy between the physical feeling of wind blowing and its digital representation.

Other artists are using data to extend predefined visualization tactics that have developed as the cross-section between programming and art continues to solidify. For example, artists and researchers Andres Wanner and Ruth Beer have coined a Found Data approach in their installation *Breathe/Live/Speak* (Figure 2. Breathe/Live/Speak) that takes two aspects of computational art: generative art and data visualization, and conceptually intermingles them with found objects stemming from the Post-Modern Readymade. Wanner and Beer borrow the "autonomous generative process from generative art, and the emphasis on representation of abstract data from data visualization." By visualizing the data in conventional graphing ways, the artists began to find patterns that could be considered "natural looking", which they then manipulated to effect (Wanner and Beer 2013).

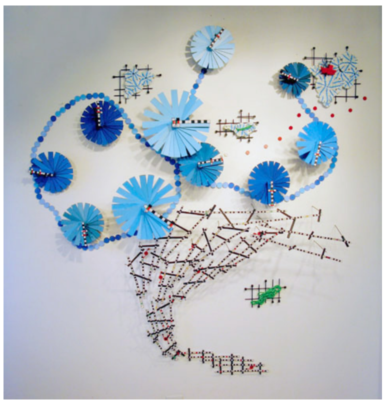
Fig. 2 Breathe/Live/Speak

2.2. DATA OBJECTS

While data visualization artwork may be the most common example of the interplay between data and art, many artists have begun incorporating large data sets in the creation of objects. Sculpture in particular is an area where many artists have begun to incorporate data as the core of the work.

In *She's Coming On, She's Coming On Strong*, artist Nathalie Miebach uses weather data from off-shore buoys all along the Eastern Seaboard to create a musical score in the form of a sculpture, in order to interpret "the Perfect Storm" (Figure 3. She's Coming On, She's Coming

Fig. 3 She's Coming On, She's Coming On Strong



4 *http://ndfd.weather.gov/technical.htm*

On Strong). Miebach uses data as a starting point in order to construct musical scores, which are then translated to sculptures (Hansell 2013).

Other researchers are directly translating data visualizations from digital outlets to their physical manifestations in the form of sculpture. Yvonne Jansen and Pierre Dragicevic outline an interaction model for beyond-desktop visualizations that combine the visualization reference model with the instrumental interaction paradigm (Jansen and Dragicevic 2013). As a result, the researchers are able to collect large data and visualize them by way of physical objects that can be interacted with. For example, the *Emoto Data Sculpture* utilizes data in the form of Twitter sentiments that have collected during the 2012 Olympic Games (Figure 4, *Emoto Data Sculpture*). Two visualizations serve to represent this data: a 3D surface that displays time-series data through one-shot propagation, and another where a subset of the data corresponding to a particular theme is encoded as a heat map and projected on the 3D surface. Visitors can explore this data using a jog wheel instrument located nearby, which moves a time cursor and displays detailed Tweet information below the sculpture (Sánchez 2013).

Fig. 4 Emoto Data Sculpture
Fig. 5 airFIELD

airFIELD, created by Dan Goods, Nik Hafermaas, Jamie Barlow and NASA' Jet Propulsion Lab, is yet another example of a data-driven installation (Figure 5, airFIELD). Similar to the *Emoto Data Sculpture*, the work aggregates and displays individual datum based on flight data. The data is provided by the FlightAware tracking service[5] through a custom C++ application. However, according to Goods, the work is not as much about visualizing a large data set, but using the data in a poetic fashion.[6]

5 *http://flightaware.com/*

6 *http://www.wired.com/design/2012/11/atlanta-airfield-sculpture/#slideid-352091*

As a result, data is used as a starting place to create a physical manifestation of ambient data in a multisensory and experiential manner.

The data-driven artwork presented in this section is by no means an exhaustive list. However, the works presented in this section have served as inspiration for the authors' current work and exploration in participatory data-driven kinetic sculptures and installations. In the following section, the author discuss an approach for participatory data-driven art that builds off the work discussed but incorporates novel aspects pertaining to user experience and interaction design, aesthetics in both the physical and digital realms as well as computation and technical implementation involving the intersection of smartphone applications, web technology and embedded electronics.

3. PARTICIPATORY DATA-DRIVEN ART OBJECTS

The aforementioned works exemplify the aesthetic possibilities of manipulating and incorporating pre-existing data sets in both digital and post-digital ways. These data-driven works have set a precedent for novel ways to not only manipulate data but also create it in real-time. With mobile computing and robotics, it is now possible to incorporate aspects of content creation and data in the mechanics of kinetic sculptures and installations driven by participatory smartphone applications. Two works in particular, *Metal Hearts* and the *(+/-) Pendulum*, utilize data in order to add a collaborative and participatory element to kinetic objects.

3.1. METAL HEARTS

Metal Hearts consists of three nearly identical objects; in each, a bare solenoid strikes an aluminum-coated 3D-printed model of a human heart (Figure 6. Metal Hearts Installation & Smartphone Interface). A fundamental biological human process has now been automated by an electrical circuit serving as a reflection on human autonomy in light of technological progress. Collectively, the hearts beat in harmonic motion to delineate a mechanization of individuality.

The installation's driving mechanism is based on participatory data. Its intent is to serve as a starting point for the creation and collection of participant data.

Participants are able to download and install a smartphone application that captures heart rate and stores it in a database. The master clock of the installation defaults to an average pulse of 72bpm. With each new addition, the average of all heart rates collected over time is distributed to the installation, which adjusts the phasing and computational diastoles of all hearts. Every five minutes, the database is queried and a new average is collected.

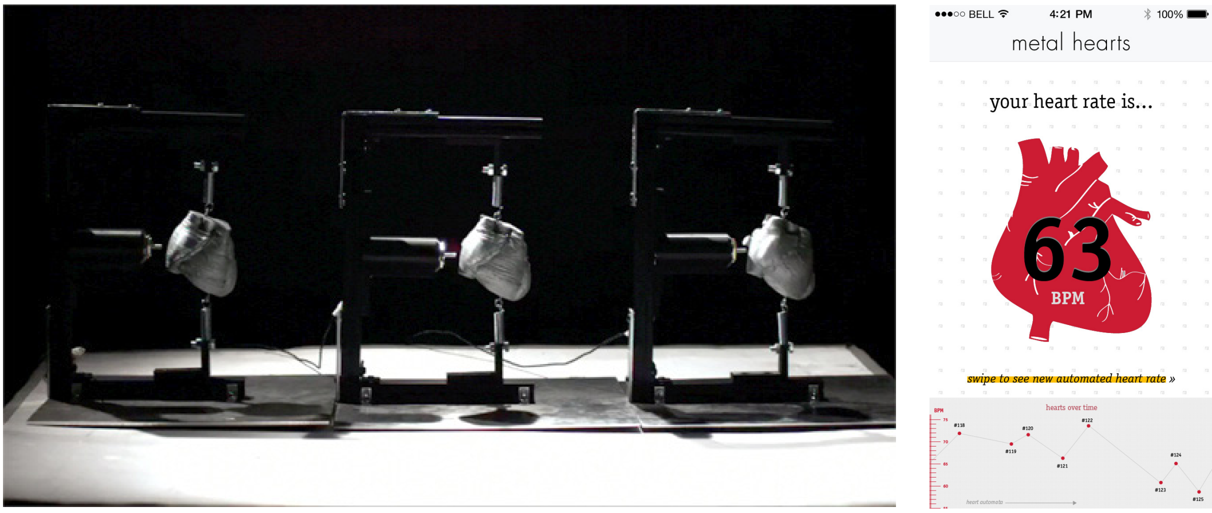


Fig. 6 Metal Hearts Installation & Smartphone Interface

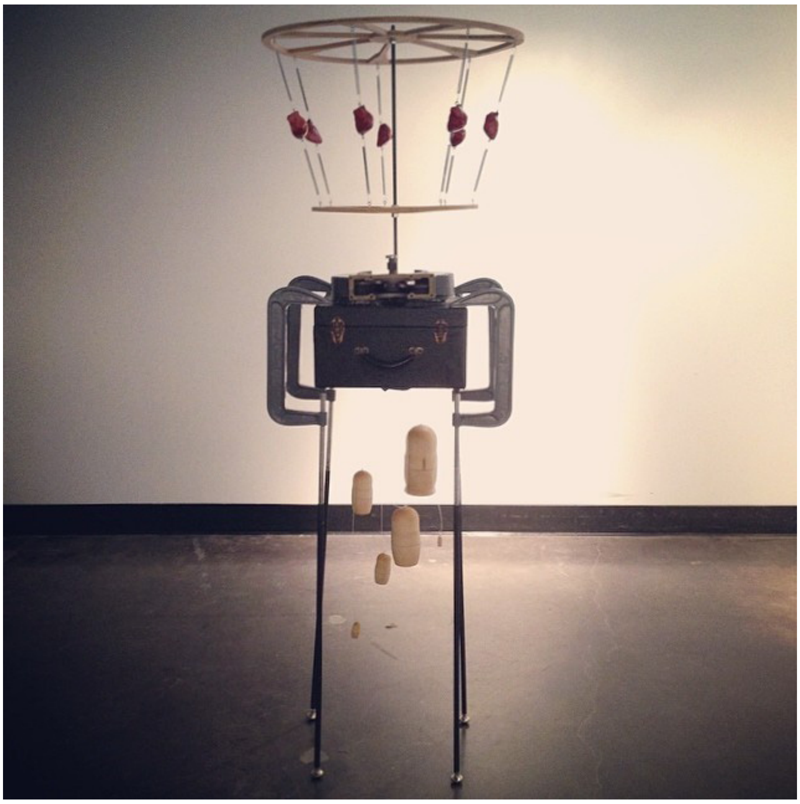
Although the physical manifestation of this aggregate data is not seen at large since only the average is computed and experienced, the smartphone application contains a data visualization of all heart rates collected over time. On the one hand, data is used for purely aesthetic reasons in the sculptural aspect of the work; it is a starting point intended to pique curiosity in the participant. On the other hand, participants have the opportunity to interact with all of the data collected over time in the smartphone application.

3.2. (+/-) PENDULUM

(+/-) Pendulum is another participatory installation (Figure 7. (+/-) Pendulum Materials) created in the same data-driven vain as *Metal Hearts*. The work is meant to serve as a microcosm of the intersection of our digital and physical selves. The basis of the installation is founded on the mechanics of the Foucault Pendulum. Unlike a conventional pendulum, the arm of the installation operates horizontally using the same physical

properties as if gravity is still impacting it. The conceptual basis of the work is to reflect on the intersection of our digital lives with our physical lives. The Foucault Pendulum was created in the mid-19th Century to exemplify the Earth's physical properties (i.e., the fact that it is round and rotates) (Aczel 2003). Many may prescribe to the idea that we now live in an era where the Earth's physical properties are of little importance. As a result, the operation of the *(+/-) Pendulum's* rotation is based on participatory user input from a smartphone application which asks the question "Where do you want to be?". From collective user input, the average of all data points orients the pendulum to a collective desired location, which seeks to show that our world is not flat, round or oblong – it is malleable and democratic in the digital sphere.

Fig. 7 (+/-) Pendulum Materials



The smartphone application component provides a minimal user interface prompting the user for a desired location in the world. After a successful submission, the user is shown the new location of the pendulum, which is collected as running average of all data points in the system. The user then has the option to view all collected data points visualized on a map. Similar to *Metal Hearts*, the *(+/-) Pendulum* has the same two-fold approach: the sculptural aspect serves as springboard for content creation from participants, while the digital interface serves as a media container to view and interact with all data points (Figure 8, (+/-) Pendulum Paper Model and Smartphone Interface).

4. CONCLUSION

Data sets that emerge from questions (whether direct or indirect) generated from artwork have the opportunity to generate unique information by a subset of the population (i.e., art communities) that may not necessarily be grouped together. One potential benefit of this approach is that it allows for participatory artwork as opposed to interactive artwork, which requires participation. As a result, this approach may appeal to a wide variety of users: those who are interested in gleaning more from the participant data and those who may only be interested in experiencing a seemingly fixed kinetic work. Despite these potential benefits, there may be drawbacks inherent with this approach, which were particularly evident in the initial prototypes of *Metal Hearts* and the *(+/-) Pendulum*. While collecting numerical data and calculating the mean may prove interesting for a smaller, more varied data set, as the data set grows and becomes more diverse, the mean remains relatively static. From a mechanical and robotic standpoint, this approach simplifies development; however, the lack of variance in relation to a growing data set highlights issues pertaining to scale. As a result, the aforementioned works will incorporate variants of weighted moving averages, particularly the exponential weighted moving average (Figure 9, Exponential Weighted Moving Average, where the coefficient α represents the degree of weighting decrease (between 0 and 1), Y_t is the value at time period t and S_t is the value of the average at any time period t.), in order to filter out the data, which may be one approach to reestablish variance in the system.

Fig. 9 Exponential Weighted Moving Average, where the coefficient α represents the degree of weighting decrease (between 0 and 1), Y_t is the value at time period t and S_t is the value of the average at any time period t.

$$t > 1, St = \alpha \cdot Y_{t-1} + (1 - \alpha) \cdot S_{t-1}$$

As the amount of data in the world continues to explode, governments, businesses and society at large will continue to try to harness, cultivate and utilize it to devise solutions to increasingly complex problems. Many artists, on the other hand, have been using data in ways to ask questions about the mass amount of information in the world (Hirshberg 2013) in order to try and make sense of the value versus noise. Data-driven art is here to stay. The 21st century has witnessed an emergence of art that exploits the massive data sets we create on a daily basis, and artists can now be making work that not only questions data but also creates it, especially as it relates to the institutions that house works of art (i.e., museums, galleries, etc.), in order to shed light on art communities in addition to the world at large.

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THE REPLACEMENT OF GEOGRAPHY BY STANDARDS: LOCAL BODIES AND GLOBAL RULES

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Anthropometry has historically involved "men of science" carefully measuring and noting down the dimensions of human bodies. Anthropometry is invoked to emphasize the importance of measuring the world at human scale, to achieve better economies of scale in making human-sized objects, and to make arguments and predictions about ideal states of humanity. This paper presents two projects which parse relationships between human bodies and measurement. "Scanning Hands" explores low-end 3D scanning as a probe and catalyst for discussion of the history of anthropometry as it relates to current 3D scanning practices. "Non-Standard Bodies," an interactive wearable sculpture, tackles the imposition of remote standards on individual bodies. The goals of this paper are twofold: to explore systems of body measurement and their often-ignored ramifications; and to introduce an idea, the replacement of geography by standards, as a way of positioning and generalizing such measurement activities.

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1. INTRODUCTION

In Neal Stephenson's 1992 novel *Snow Crash*, franchises like White Columns and Mr. Lee's Greater Hong Kong fill the functions we might expect to see carried out by states. Termed "Franchise-Organized Quasi-National Entities" (FOQNEs), these organizations are half residential subdivision, half nation-state, offering and enforcing services and regulations. Potential customers or nationals choose which FOQNE to opt into and do business with. The FOQNEs are not concentrated in any particular locale, operating around the world. If you belong to Mr. Lee's Greater Hong Kong, its franchises will welcome you, regardless of your geographical location. Stephenson describes the highly-formalized functioning of the FOQNEs, each one governed by its own book of franchise rules, an operating manual which determines how all situations and actions should be handled. The fictional Franchise-Organized Quasi-National Entities are one particular kind of logical extension to a real-life anxiety: the formulaic and formal nature of globalized life. Whether in the form of restaurants, hotels, clothing retailers or myriad other categories, the promise of consistency across distance is one which has provided us with a potent and rich source of stories and anxiety. Less obvious, however, are the underlying standards and infrastructures which make such global sameness possible. This paper tackles one particular kind of global standard: the measurement of human bodies.

In the late-19th century and the beginning of the 20th, detailed scientific measurement of human bodies was in vogue. This science was called anthropometry. For psychological assessment, to determine fitness for work, and to organize humanity into strata, "men of science" carefully measured and noted down the dimensions of so many human bodies. Today, the work of anthropometric measurement is invoked, at turns, to emphasize the importance of measuring the world at human scale (Tavernor 2007), to achieve better economies of scale in making human-sized consumer goods (like clothing, chairs and workspaces as in the ANSUR series of anthropometric data collection initiatives organized by the American military), and to make arguments and predictions about ideal states of humanity (World Health Organization childhood growth charts, for example). When invoked in practice, the collection of anthropometric data is positioned as positive, providing value to both those who are measured and those who are collecting or making use of the measurements. However, as with any exercise in data collection and organization, the collapsing of individuals into standard categories presents problems. To that end, this paper has two specific goals: to explore systems of body measurement and their often-ignored ramifications; and to introduce an idea, the replacement of geography by standards, as a way of positioning and generalizing such measurement activities.

Advancing through a short review of arguments around the historical measurement and codification of human bodies, this paper will briefly examine work on standards, both in general and as they relate to human bodies. In order to bring the issue into a clearer context, the story of two works executed by the author will be recounted and examined. The two works are used as examples of ways in which the measurement of human bodies can be discussed and troubled in public contexts. Finally, the two prevailing themes of the paper – body measurement and the global standardization of previously local objects – will be tied together by a discussion and elaboration of the ways in which formal standards work to replace local context, something that we will term "the replacement of geography by standards."

2. MEASURING BODIES

The relationship between bodies and measurement has changed over the centuries. From defining our units of measurement through their similarity to our body parts, we've moved to an opposite characterization: defining our bodies using standard systems of measurement. Tavernor (2007) argues that the move from imperial measures to metric has heralded a move from measurements with direct relation to the human body to measurements related to the earth. That a meter is defined as a proportion of the circumference of the globe, as measured in revolutionary France, is seen, by Tavernor, as evidence that we have ceased to consider the human as the basis of our measures. Tavernor suggests that, by divorcing our measurements from the human body, we begin to create a built world in which the human form is subordinated to abstract scientific ideals. Thus, we no longer use bodies to measure, but use abstract measures to understand bodies.

The use of abstract measures to understand our bodies is one which might be traced to our modernization. With a greater understanding of and commitment to science, we come to understand the functioning of our bodies in more rational ways, giving vogue to the idea that we can develop a model of what humans are: the standard human. Lengwiler (2009) suggests that we can trace the standard human, as a construct, back to the mid/late-19th century. The assumption is that before statistics (which Lengwiler ties to the development of the standard human), the concept of a standard human did not exist. The introduction of actuarial tables for insurance assessment imposed, Lengwiler argues, a definition of what a human should be. In its evolution, insurance coverage moves from non-standard (coverage determined by the discretion of a doctor) to a binary standard (either one is fit for insurance or one is not) to a gradated standard (different clients treated differently, based on a set of factors). Lowe describes something similar: anthropometrically-derived medical exams of American women at college in the late 19th century, which documented “the dimensions of healthy white American womanhood” (2003, 24). Lowe quotes a period account from a college student, recounting that the medical examiner “made me feel like one of those dictionary pictures of a steer with the parts numbered for each measure she took down in a big ledger” (quoted on pages 24-25). These two examples are positively friendly when compared against body measurement in the service of social stratification: activities like the criminal anthropology of Francis Crick and Cesare Lombroso, using the measures of human faces to determine criminality, or Paul Broca’s attempts to discover character through craniometry (Gould 1996).

Where older modes of body measurement relied on measures of weight and the dimensions of particular parts of the body, we now see a move to a far more detailed set of measures. We begin to see the adoption of body scanning, an activity which makes use of a collection of different imaging technologies, including optical capture based on cameras, backscatter x-rays, and millimetre wave scanners – scanners which bounce invisible waves off of objects in order to image them, to produce high-detail images of human bodies. Body scanning is carried out in a variety of contexts, with perhaps the best known being in security screenings at airports. Such scanning is also being used for purposes of data collection and standardization (as in the example of SizeUSA, a commercial initiative organized to gather up-to-date information about body proportions in the population of the United States or the previously mentioned ANSUR II initiative), national security (like the American Transportation Security Administration's use of 3D body scanners as part of security screenings at airports) and consumer satisfaction (a company like Levi's scanning customers in order to manufacture custom jeans), among others.

Because of the increasing precision and continued ubiquity of mass measurement, much of my work in the last three years has focused on the measurement of human bodies and the implications of those measurements. In this paper, I present two projects which explore different aspects of the relationships between human bodies and measurement. "Non-Standard Bodies" (with Mike Tissenbaum), an electronic wearable sculpture, tackles the imposition of remote standards on individual bodies. My current project, operating under the working title "Scanning Hands," is an exploration of low-end 3D scanning. In scanning body parts, and in organizing workshops in which others scan their own body parts, I aim to embody the history of anthropometry and relate it to current anthropometric practices involving 3D scanning. The two works, taken together, form the beginning of a corpus of projects which seek to make visible the common underlying practices of body measurement and their often-ignored ramifications.

3. A BRIEF WORD ON STANDARDS

This paper frequently invokes the term "standards," a word which has been multiply and variously defined in a variety of different disciplines. For example, in describing a standard for the normal growth of children, Butte et al explain a standard as something which defines "a recommended pattern of growth that has been associated empirically with specified health outcomes and the minimization of long-term risks of disease" (2007, 154). They contrast this against a reference, something which collects and renders statistically useful a set of data from real life. In a different kind of utilitarian turn, the International Organization for Standardization, ISO, describes their standards as documents which "give state of the art specifications for products, services and good practice, helping to make industry more efficient and effective. Developed through global consensus, they help to break down barriers to international trade" (ISO n.d.). The Oxford English Dictionary gives us a baffling collection of definitions for the word "standard," encompassing commerce, horticulture, warfare, and sport, among others (Oxford English Dictionary 2014). Crucially, however, it offers "Exemplar of measure or weight," and "An authoritative or recognized exemplar of correctness, perfection, or some definite degree of any quality" (ibid). Standards are highly contextually dependent.

An increasing body of literature situated within the social sciences attempts to provide a framework within which to view standards. Lampland and Star give five characteristics to standards, namely that they are "nested inside one another[;]… distributed unevenly across the sociocultural landscape[;]… relative to communities of practice[;]… increasingly linked to and integrated with one another across many organizations, nations, and technical systems[;]… [c]odify, embody, or prescribe ethics and values, often with great consequences for individuals" (2009, 5). Lawrence Busch, in a book which explicitly seeks to understand the diversity of standards and their generalizable traits, describes standards as "always [incorporating] a metaphor or simile, either implicitly or explicitly" (2011, 10). In this sense, Busch is describing standards as tools, objects and guides against which other objects can be compared. Busch gives the example of a standard weight, which "can only be used (properly) by comparing other weights that are used in everyday commerce to it" (2011, 11). Finally, O'Connell (1993), though he is not explicitly exploring standards, refers to them as imbued with meaning beyond their physical properties. In particular, he gives the highly evocative example of the physical standard which embodies the legal volt:

> *Without the certificate specifying the true value of the battery and attesting to the time and circumstances of its calibration, the box would hold nothing but four rather ordinary, albeit weak, batteries that are of no use to anyone. With the certificate, the box still holds four batteries, but it also holds something else of far greater importance: it also holds the legal volt. (O'Connell 1993, 148)*

This paper takes a view of standards which draws on many of the above definitions and uses. A standard, for our purposes here, is a set of procedures or rules which renders a practice explicit and transportable. Like O'Connell's volt, it may be embodied in an object. Or, like ISO's standards, it may come in the form of a document. Regardless of its shape, its function is to allow actors in diverse settings to achieve sameness in their activities.

4. "SCANNING HANDS"

"Scanning Hands" is an ongoing series of events exploring both technical and social issues around new developments in 3D body scanning. It uses low-end 3D scanning as a probe and catalyst for discussion of the history of anthropometry as it relates to current 3D scanning practices. Using photogrammetric 3D scanning – a process which takes a collection of images of one object and interprets a 3D object from those images – participants in the workshop scan their own hands. One early implementation of the project uses my own hand as the example, with the hand and its digital representation on display. In order to make the hand less uniform and thus more visible to the software used to render the photos three dimensional, I draw lines of different colours on my hand. The lines follow the external contour of my hand, as well as the creases on my palm and joints. Not only does this process make the hand more visible to the photogrammetry software, it serves as a point of discussion with viewers, and an invocation of body measurement and marking common in medical and cosmetic practices. A visitor coming up to the display sees a 3D hand on the screen, and then its physical analogue, both covered in lines and numbers.

The purpose of "Scanning Hands" is to incite discussion about 3D scanning. As with many technologies currently moving to the mass market, 3D scanning has existed for some time, without consumer applications. As such, many people viewing "Scanning Hands" are encountering low-end 3D scanning for the first time. Their only previous experience with 3D scanning might well be with high end imaging techniques such as those used in medical applications (ultrasound and magnetic resonance imaging, for example) or in security applications (such as backscatter and millimetre wave scanners at airports). "Scanning Hands" uses the low end of

3D scanning technology to give ordinary citizens access to a technology which may be almost entirely alien to them. The message in the project is that if an individual can scan her own hand with only a digital camera and a piece of free software, more expensive and archaic 3D scanning technologies can do far more. The discussion catalyzed by this realization revolves around the ownership and use of such scans. Who is making our bodies digital? Whose cloud do they inhabit? Which server farm does your body live on?

5. "NON-STANDARD BODIES"

“Non-standard bodies” is an interactive, wearable sculpture constructed in winter 2010. It tackles the imposition of remote standards on individual bodies. The sculpture is shaped like a dress, with voluminous fabric concealing a plastic crinoline. Mounted on the crinoline are several small motors, each controlling a different point on the dress. The action of the motors is controlled by the viewer, who manipulates a set of switches mounted onto the spine of the dress. Each switch governs a particular set of motors. One might change the length of the dress’s skirt; another, the length of the sleeves. Anyone viewing the dress has the power to modify it, thus changing the fit and appearance of the dress, without the permission of the wearer. The wearer, by dint of the size of the dress and the positioning of the knobs, does not have the power to manipulate the dress herself.

As such, “Non-Standard Bodies” is a physically instantiated argument about who controls the way we display our bodies. Because our clothing is so fundamental to the way the world sees us, its style and fit is a crucial part of our self-construction. Mass produced clothing, by necessity, comes in a limited number of sizes. Within one clothing line, however, each size will represent same or similar proportions, scaled up or down accordingly. Those sizes fit an abstract person, a person with a particular set of measurements. Unfortunately, human bodies do not come in such standard sizes and same sets of proportions. Thus, a standard clothing shape, scaled to a set of numbered sizes, and then worn on a body which does not conform to the prescribed proportions, cuts an awkward figure. The definition at a distance of a standard body shape acts similarly to the controls in “Non-Standard Bodies.” An actor at a distance controls the fit of a garment on a wearer, with very little recourse on the part of the wearer. The wearer's choice becomes whether or not she will wear the garment, but not what shape the garment has.

6. THE IMPOSITION OF REMOTE STANDARDS ON LOCAL BODIES

Both "Scanning Hands" and "Non-Standard Bodies" make arguments about the standard handling of diverse human bodies. In "Scanning Hands," the issue under scrutiny is the absorption of an individual body into a digital infrastructure through the intermediary of the scanning process. The individual human body is represented by a digital point cloud or set of vertices. It is stored in computational infrastructure, controlled and protected to a greater or lesser degree by a government, a company, or some other agent. The local body, when digitized conforms to a set of abstract, globalized standards.

In "Non-Standard Bodies," the process is somewhat reversed: instead of a digitized body being absorbed into a standardized infrastructure, the local physical body has a globalized standard imposed on it. Through a garment which represents an ideal – or at least "normal" – body, the wearing of the garment by an individual becomes the physical evidence of a difference between the actual wearer and the idealized wearer. A decision based on global systems of fit and manufacturing logistics comes to be imposed on a local wearer, wherever she may be.

7. THE REPLACEMENT OF GEOGRAPHY BY STANDARDS

The imposition of remote standards on bodies is an example of the replacement of geography by standards. Referring to the replacement of geography by standards is giving name to the assumption that physical objects can be the same from place to place, without physical reference or proximity, as long as we can create standards and information systems around those objects. In standardizing goods around the world, physical objects have proved to be comparatively hard to move around. Ideas have proved themselves to be much more portable. Standards and information systems allow us to effectively circumvent proximity. To take a convenient example, if we look at something like lumber, were there not a standard, in every building project, the sourcing of lumber would be completely personal and contingent.

The existence of a standard size of lumber (like a 4x4, for example) means that a set of assumptions can be made about the nature and functionality of a piece of lumber. In that sense, standards form an infrastructure for the construction of physical systems.

Beyond non-human subjects like lumber, standards relate to bodies as well, as evidenced by the example above of “Non-Standard Bodies.” A common, if slightly imprecise, example can be found in shoe sizes. Most people know their own shoe size. We say to ourselves “I’m an 8” (or, for the European context, we might say “I’m a 38.5”). We say to salespeople in shoe stores “I need an 8.” We have a relatively consistent standard for shoe sizes (with relatively stable conversions across national boundaries), with a set of assumptions about the reliability of that standard. A salesperson in a shoe store might say to us “This style runs about half a size big.” The judgment that the style runs big is based on our understanding of graded shoe size as relatively fixed and consistent. Without the shoe size, we would be forced to choose our shoes by other means. We might choose to get shoes custom made. We might choose to wear sandals or clogs designed to fit all sizes of foot. The replacement of geography by standards, in the case of shoes and feet, allows the producer of the shoe to exist and function at a distance from the ultimate wearer of the shoe. Indeed, the construction of a standard set of graded shoe sizes allows shoe manufacturers to avoid dealing personally and individually with their customers. Customers are standard.

If shoe sizes provide one example of the replacement of geography by standards in relation to human bodies, growth milestones and ideal measurements provide another. The World Health Organization publishes a set of tables detailing the healthy range of height for boys and girls of different ages. The tables are used to give doctors and other clinicians a standard by which to measure the health of the children under their care. The standard is, in part, based on reference data. A slew of studies back up the assertion that it is even possible to apply a standard of growth to children the world over (eg: Eveleth & Tanner 1990; Butte, Garza & de Onis 2007; Habicht et al 1974). Thus, in implementing and comparing against such a standard, every individual child comes to be compared against an abstract standard developed on the basis of concrete data. Rather than making a local comparison of children to determine what appears to be normal in a particular setting, such a standard applies a global measure.

The replacement of geography by standards is an attempt to substitute clear, explicit rules and guidelines for local, contingent, cultural norms. O'Connell, describing the need for precise specifications, states that "[w]hen a bomb made in Massachusetts, a bomber made in California, and a bomber pilot trained in Colorado are brought together for the first time in Panama and expected to fight a war, they must fit together as if they had not been formed in separate local contexts" (1993, 163). An attempt is made to achieve a level of precision which allows parts and participants from different geographical areas to function seamlessly together at their destination. In support of this idea, O'Connell discusses the circulation of particulars, which may be practices, definitions, or even physical objects like the legal volt. Similarly, Law describes Latour's immutable mobiles as people, texts, "devices and technologies which also hold their structure as they are shipped from one location to another. The suggestion is that these then get embedded in, and tend to have patterning effects on, other sites of practice" (8, 2009). Both O'Connell's particulars and Law's description of Latour's immutable mobiles are attempts at transporting rules, practices and interoperability from place to place, through the use of standards.

Busch (2011) describes standards as crucial in the project of modernity. Prior to the current system of standards based on documents, technical or procedural know-how existed embodied in people and places. Braverman refers to the pre-1824 prohibition on British mechanics working abroad, describing the craftsman as a "repository of the technical knowledge of the production process" (1974, 133). Sennett calls that particular move, from embodied knowledge of steam engines, to blueprint-based knowledge, "a movement from hands-on knowledge to the dominant authority of explicit knowledge" (2008, 84). The end result of such codification is the ability for knowledge to travel, not with its human knower-workers, but with documents produced by those knower-workers and implemented by potentially less knowledgeable workers.

Making knowledge portable without the transportation of its knowers is one step. Another effect of the clear codification of knowledge is the ability to decentralize production. Scott describes the gun manufacturing quarter which developed in Birmingham in the 19th century. He refers to an extreme state of "vertical disintegration," resulting in master gun makers ordering parts from specialized suppliers, each producing one or few parts of the gun (Scott 1988, 64). This disintegration needed close geography, for the transportation of parts, as well as the transportation of orders for parts. Scott refers to this configuration as being comprised of workshops "huddled close together in order to expedite the whole process of disintegrated but interconnected production" (Scott 1988, 65). Though the downfall of Birmingham's gun quarter was the implementation of American-style centralized mass production, other industries de-cluster for different reasons. In describing the garment industry in New York City, Scott explains the benefits of moving mass production out of the city, namely, cheaper labour on long runs of garments. With cheap transportation and portable, standardized methods, seeking out an advantage through reduced labour cost becomes feasible. Thus, with improved logistics for the transportation of goods and codified knowledge about production processes, the ecologies of production previously created in geographical areas by concentrations of knower-workers, can be reproduced along similar models elsewhere, in cheaper or more efficient circumstances. A standardized good can be produced through standard methods, to a standard specification, by a standardized worker.

Of course, the construction of standardized goods requires the transportation of materials. Such a construction applies in the example provided by "Non-Standard Bodies," which argues something akin to O'Connell's circulation of particulars like the volt, with individual garments representing a larger standard. When we move to processes which are less dependent on physical goods, however, concerns about such material logistics take a back seat. When a standard represents something largely immaterial, such as an action or a process, the circulation of the textual standard is all that is seen as required to achieve consistency across sites. As in the fictional example provided in the introduction to this paper, with nation-states formed on the basis of franchise manuals, entire systems spring up around standard procedure documents. These documents are, in effect, the immutable mobiles of global standardization. They are documents, representing procedures, which allow previously local practices to be transported. In the same way that routinizing the craftsman or knower-worker's knowledge makes it portable without him, routinizing practices which have previously been based in local understandings allows them to be transported beyond their original geographical bounds. This is how standards replace geographies.

8. CONCLUSION

In both "Non-Standard Bodies" and "Scanning Hands," the issue of local bodies caught up in global standards is raised. Our bodies are our most local ecosystems, with individualized practices and understandings. Enmeshing such small systems of knowing and doing in a global network of shared standards is an extreme example of the routinization of local practices in the service of global adoption. Though it is an extreme example, it is also one which is key. The interfaces between our bodies, our most individual locales, and the world of standard understandings and doings are battlegrounds in the adoption and dissemination of standard practices. As we increasingly replace individual geographies with shared standards, negotiating the boundaries between ourselves and our collective (but not always collectively-controlled) rules and routines is of more and more importance. Negotiating the balance between localized practices and globalized rules will require finesse and understanding, taking complex systems and making them approachable. "Non-Standard Bodies" and "Scanning Hands" are first attempts to bring a nuanced understanding of such systems to affected individuals.

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AN ECOSYSTEM OF CORPORATE POLITICIANS

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Nowadays, with the increase of publicly available information on economic and social matters, visualization has targeted such themes in order to promote transparency and raise awareness for the interested audience. This paper describes the design and implementation of an interactive visualization that displays the relations between Portuguese politicians with government positions and companies. The aim of this visualization is to create awareness of these relations, and by using a highly figurative approach, captivate the targeted audience. The visualization was able to gather interest from a broad audience and is available at *pmcruz.com/eco*.

1. INTRODUCTION

The high availability of public information on the relations between highly ranked government members and the corporate world has been raising awareness on this matter all over the world. Several platforms have been developed in order to make this information reach to broader and global audience. Perhaps the most peremptory example is the *They Rule* (*theyrule.net*) website, which provides a glimpse of some of the relationships between the US most powerful companies, which share many of the same directors. On *They Rule*, the user can build and save maps of those connections. With a similar thematic, the wiki *Poderopedia* (*poderopedia.org*) maps the actors in businesses and politics in Chile, as a collaborative platform of data journalism. More on a visualization side, *Retórica* (*retoricaparlamentar.com*) is an interactive visualization that enables browsing Brazilian deputies and discovering the main thematics in their speeches.

This paper focuses on the relations between members of Portuguese governments and their involvement with companies, and nowadays in the Portuguese sphere, such theme does not lack infrastructure: for example, *Tretas* (*tretas.org*) that is a collaborative wiki that aggregates dossiers about important matters in politics and economics in Portugal as well as extensive curricula of public figures, and *Demo.cratica* (*demo.cratica.org)* which is a repository of information about deputies and parliamentary sessions in the Portuguese Assembly since 1976. We wanted to bring a more visualization focused approach to this theme, that could strongly engage a broad audience, create awareness of the theme and clarify the nature of each relation between politicians and companies. For this, we created an interactive visualization called *An ecosystem of corporate politicians* that takes an highly *figurative approach* to the subject: it depicts a set of organisms (politicians) that chase and frenetically jump between companies.

2. DATA

The main data source for this visualization came from the study about politicians and businesses in the book *Donos de Portugal* (Costa *et al.* 2010), which covers members of Portuguese governments between 1974 and 2010 that had prominent positions in important companies. In fact, such study focuses only in ministers and secretaries of state in strategic sectors (i.d. finances, economy and public works) resulting in 115 collected politicians' résumés: describing each position in governments and companies, with the respective time period and political affiliation. The companies can be public or private, and are often corporate groups. Politicians usually participate in such companies as being part of the board of administrators. Our main contribution to this data is its extension to 2013, so for each politician we investigated if its position in 2010 was still effective for 2013 or if had new relevant positions since the last data entry. Unfortunately, this was not always possible to assert since the investigation was based in not always available public information, such as companies' governing bodies available online, companies' public reports, news from online and public *résumés*.

In addition we used another study (Bianchi and Viana 2012) about political connections in stock companies in Portugal to further extend the dataset with politicians that we deemed relevant given the importance of their government's positions and the intensity of connections with businesses – for example we added the current Prime Minister and current President of the Portuguese Republic. This way the dataset was extended to 130 politicians, and in its current state describes 906 corporate positions in public or private companies that date from as early as 1950 to 2013.

The data was transcribed to the JSON format and aggregated on a politician level and on a company level. In order to aggregate per company, company names had to be homogenized and sometimes merged into relevant corporate groups that are in full control of other companies. This resulted in 354 different companies that were frequented by an average of 2,09 unique politicians, with a median of 1 and a standard deviation of 3,26. Table 1 shows the top 10 companies that had more politicians.

Politicians have an average of 6,97 positions in companies each, with a median of 5 and a standard deviation of 6,27. The average of *unique companies* frequented by a politician is of 5,69 companies, with a median of 4 and a standard deviation of 5,58. It is important to notice that this average of companies is not much lower than the average of positions, giving room to imply that usually every position of a politician is scattered through different companies and is not usually concentrated on the same. For example, consider the table 2 that shows the top 10 politicians by number of positions and their corresponding number of unique companies.

Table 1 Top 10 companies with more politicians

Company or group	Politicians
CGD	26
Champalimaud	23
Banco de Portugal	23
PT	23
BCP	20
Mello	18
EDP	18
Galp	16
BES	13
BPI	11

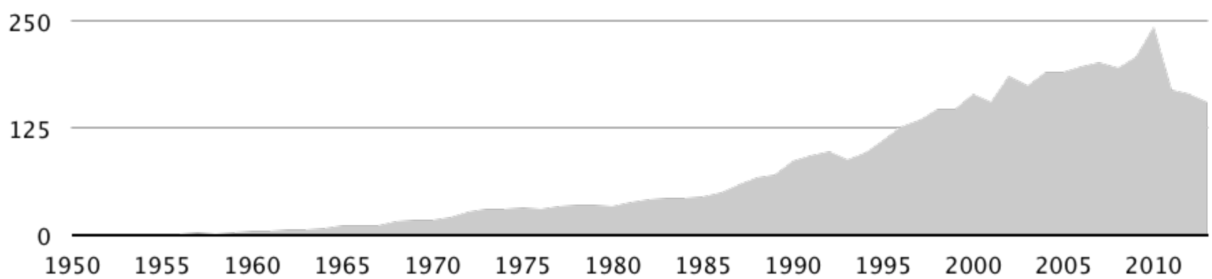
Table 2 Top 10 companies by positions and unique companies

Politician	Positions	Companies
Ângelo Correia	55	51
Luís Todo Bom	25	20
Daniel Proença de Carvalho	21	20
António Couto dos Santos	19	16
Fernando Faria de Oliveira	18	14
Álvaro Barreto	18	15
António Nogueira Leite	16	10
Artur Santos Silva	16	12
Carlos Tavares	15	11
António de Almeida	15	13

By investigating which was the ruling party affected to a politician's governmental position and also by considering party related positions that are also in the dataset, it is possible to determine a party affiliation for a politician. In some punctual cases, a politician had different party affiliations in the past – in these cases the affiliation was determined to be the most recent one. Having this, 58% of politicians are PSD, 34% are PS and 8% are CDS.[1] The remaining 13% could not be determined, either because they are independent or because such information is concealed.

When regarding the distribution in time of the politicians' positions in companies, it can be observed that information is clearly skewed towards more recent years (that is perhaps due to the increase of information availability in recent times), having its peak in 2010 when the study for *Donos de Portugal* was concluded (Figure 1). Nevertheless the amount of contributed information for 2010-2013 in this work is not negligible. Although the gathered data is only a sample of the real dimension of traffic between companies and governments in Portugal, we deem it as highly illustrative of this subject.

Fig. 1 Number of politicians' effective positions in companies per year captures



3. VISUALIZATION

The developed visualization is called *An ecosystem of corporate politicians* (in Portuguese *Um ecossistema político-empresarial*). The visualization is bilingual in Portuguese and English since its main target audience are the Portuguese. Every aspect in the interface is translated except the ones that directly derive from the data (such as positions' descriptions) – translating 906 positions and 354 companies names was not bearable for the return in reaching non-Portuguese. The name *ecosystem* is a metaphor for the visualization model that was built: it represents living organisms (politicians) that dynamically interact with nonliving components (companies) of the

1 PSD – *Social Democratic Party;* PS – *Socialist Party;* CDS – *Democratic and Social Center / People's Party (conservatives)* system. By using such strong metaphors, in order to better communicate a message and captivate the audience, we say that we are using a *figurative approach* to visualization. This section describes approaches in building such visualization, such as choosing narrative aspects, behavior, form, interaction and some technological aspects.

3.1. CHOOSING THE NARRATIVE

Determining the shape of the data (figure 1) is important to justify narrative aspects in the visualization. As was noticed before, politicians usually jump between different companies instead of remaining in the same or in a few. That is a fact that we wanted to emphasize with the visualization. That way, we did not opt for a strictly chronological visualization because we consider that the extreme difference between data concentration around the 70s versus the 90s onwards would not add much more to the story than that the data is biased due to recent increase of information availability. The story to convey is then: politicians jumping frenetically from company to company. Inside this story one can extract sub-narratives such as the jumps of each politician and the jumps in between a company and the companies that share the same politicians.

3.2. BEHAVIOR

Companies are depicted as circles with an area proportional to the number of different politicians that had a position at that company. That way, bigger circles represent companies had more politicians and are more interconnected with other companies. Since we wanted to distribute the companies in space in order to have the politicians interacting with them, we could not find a semantic aspect to dictate such positioning. That way we chose to create a behavior where the companies can organize themselves in space: they are circular rigid bodies that collide with each other and are laid out over a circumference with a fixed radius on the canvas. In order to keep this arrangement, they are constantly being attracted to the circumference's edge. This type of collision based interaction between companies adds more dynamism and graphical richness to the visualization, while serving other purposes related with the user's interaction that are described ahead. In addition, the companies also have a rotational speed around the center of the canvas (see figure 2).

A politician is, before any other metaphorical considerations, a particle. Each politician has a sequence of positions in companies that has to attain. In order to do so, it visits the company corresponding to each corporate position. Therefore the movement's simulation of the politician uses a particle that has to travel in between a set of companies. Although such set is chronologically sorted, the travel times are only dependent on the particle's behavior and are not chronologically synchronized with other politicians' movements. When iterating over the sequence of positions, the politician has the following behavior:

- Travels to the respective company following a trajectory described ahead.
- When a company is reached, the politician starts an encircling movement lasting an amount of time proportional to the chronological duration of the corresponding position.
- When the previous time is over, the politician promptly travels to another company or repeats the encircling behavior if the next position refers to the same company.
- When the sequence is completed, it repeats itself.

A politician's trajectory to the next company is influenced by two forces: one that attracts to the next company's position, and a second one that is perpendicular to the previous and points outwards the center of the canvas. This way, the particle can have trajectories that approximate the circumference of the canvas and avoid passing too close to its center, contributing to declutter the space and enabling a better distinction of a certain trajectory among others. Moreover, the traveling speed is inversely proportional to the distance of the target, diminishing as it approximates the targeted company. For example, if a politician has a set of 3 companies to visit, the followed trajectories would be like depicted in figure 3.

Fig. 2 The canvas' circumference towards which companies are attracted and the direction of the rotational speed. Companies lay out themselves differently each time the simulation is run.

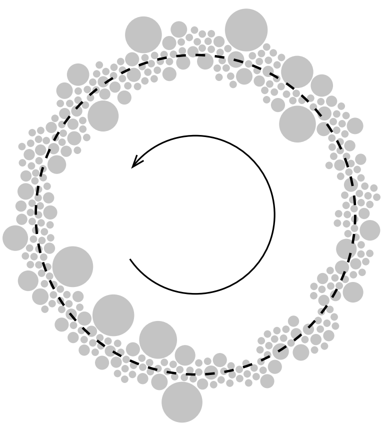
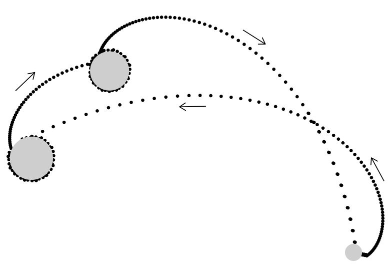


Fig. 3 The trajectory of particle's politician as it travels through a sequence of 3 companies.



3.3. FORM

Beyond the behavioral patterns of the system, which already have metaphorical semantics (e.g. the jumping behavior), elaborating upon the representation of a politician can add much more to this type of metaphorical intent. More than sparingly emulating an organism's behavior, it can just look like one. That way we devised an abstract representation that in our opinion can invoke an organism capable of a frenetic jumping behavior. The *anatomy of a politician* consists of a head, a body or tail, a pair of antennas and 3 pairs of legs or spikes. The silhouette of the head and body is drawn using a sine function that is mirrored on the x axis. The rest of the elements are drawn in relation to this axis (see figure 4). The form of the silhouette is also related with the number of unique companies that the politician has to visit in total. That way, by varying certain parameters of the sine function, we can have a silhouette that makes distinguishable the head from the body if the politician has a small number of companies to visit, or a less curved silhouette if they have a high number of companies to visit (see figure 5).

Fig. 4 The skeleton of a politician (head, body, antennas and legs)

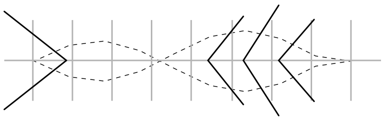
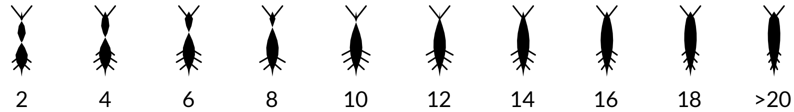


Fig. 5 The shape silhouette of a politician's silhouette accordingly with the number of companies that have to be visited



Each politician's particle leaves a trail that consists of its last 10 points in space. This trail is then used to map the body of a politician using the particle as the head, allowing to curve the politician's body on a certain path. Naturally, when the velocity of the particle is high the spanning of the trail is wider, and vice-versa. This enables to add more variation to the bodies' length, emphasizing the politician when speeding up by drawing a portion of the traveled trajectory and also conveying a more organic expression that relates to our metaphor of jumping organisms (see figure 6). In addition, the politician is also colored based on its latest political party affiliation: pink for socialists (PS), orange for social democrats (PSD), blue for conservatives (CDS) and gray for the remaining. A visual overview can be seen in figure 7 with the colored politicians browsing the space from company to company.

Fig. 6 Example of 3 different politicians curved on different paths and at different speeds; this approach conveys a more organic expression

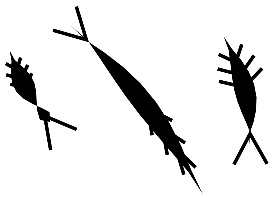


Fig. 7 Visual overview of the system of companies and politicians

3.4. INTERACTION

Interacting with the system is of paramount importance since it contributes to engage the user and adds an exploratory functionality to the visualization. When hovering a company, it increases to certain size and displays the name of the company. This change in dimension forces the surrounding companies to re-organize in order to create spacial room for the hovered company. When a company is clicked it travels to the center of the visualization and all the companies that do not share politicians with the clicked one disappear together with the politicians that frequent none. This creates the sub-narrative of the universe of influence of a certain company and the affected politicians. In addition, it is also displayed a list of the correspondent politicians that is also clickable, and when hovered displays the exact description of the positions of the hovered politician at that company (see figure 8). Once a company is clicked it stays visually marked in order for the user to acknowledge that such company was already explored.

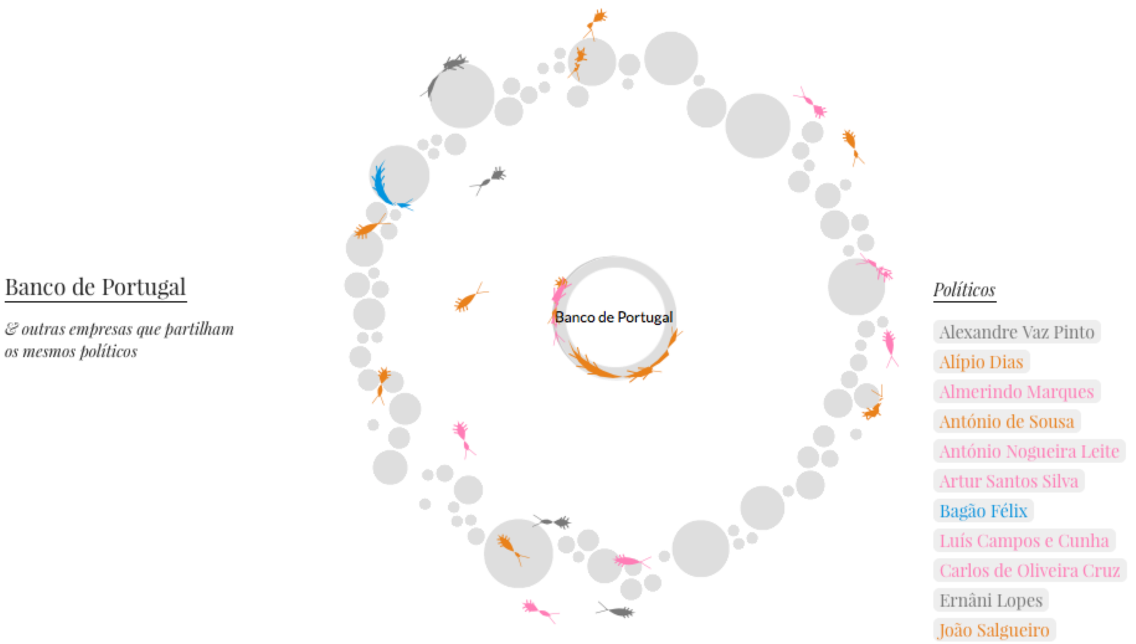


Fig. 8 The universe of influence of Banco de Portugal, displaying the companies that share the same politicians and also those politicians themselves. Explore the visualization at *pmcruz.com/eco*.

Another sub-narrative is the universe of a certain politician, that displays only one single organism traveling through its set of companies (see figure 9). This mode also displays: a list of every corporate position of the politician that can be used to browse the companies instead of clicking them; a non-interactive list of every position in governments and other political activities. One can either enter this universe by clicking on a list of companies, or by clicking directly over the politician's organism. Such task, though, is challenging since as described the politicians exhibit a frenetic jumping behavior. Nevertheless, it is the most ludic type of interaction that we have in this visualization and the following was done to facilitate it: when the mouse is near a certain set of politicians, the closest is selected to be attracted by the mouse and starts encircling the mouse pointer while also displaying that politician name. When the user moves away from that politician, the politician resumes to the next company that has to visit. Furthermore, when the mouse is being moved, every politician in the canvas tend to reduce its speed and in that way the user can better catch and visualize them.

Other more classic forms of interaction were also implemented. The user can browse to the next or the previous sub-narrative that was selected and can also type the name of a company or politician on a search box and jump directly to it.

Fig. 9 The universe of influence of *Pedro Passos Coelho* (current Prime-Minister of Portugal). On the right is displayed a list of his corporate positions that when hovered display a description with a time period. On the left, a list of every government position that he had with the corresponding party. Explore the visualization at *pmcruz.com/eco*.

3.5. TECHNOLOGY

The main purpose of this visualization is to create awareness by reaching to a large audience. Inspired by the ideas of openness and transparency we decided to use standard technologies, such as Javascript, HTML and CSS. Since this particular type of implementation takes a decent amount of computing power and can have a rather large graphical complexity we had to limit the availability of the visualization for clients that are capable of running it. Therefore, we used ECMA5 compliant Javacript, CSS 3 and the Canvas2d element of HTML5.

Other standard recent technologies such as WebGL could also be used to implement this visualization and enhance the performance, but they are not as available as Canvas2d that for example can easily be run on a mobile device. The visualization works in all recent versions of major browsers with the exception of Microsoft's Internet Explorer which is only compatible from version 10. The library *sketch.js*[2] was used for the usual routines of drawing and animating on a Canvas2d element, and the *Coffee Physics*[3] library from the same author was used to implement the collisions.

When using physics simulation in a browser, performance is paramount due to the number of bodies in our system. That way, we used the *Improved Euler* method, that is a second-order *Runge-Kutta* method for integration since it is not as computationally intensive as the *Verlet* method (although with more accurate results) and not as coarse as the *Euler* method (Süli and Mayers 2003).

Although the visualization was not thought for small screens or touch-based interaction, it can be executed on mobile devices – in order to do so smoothly, and strictly for mobile devices, it hides the companies that were only visited by one politician at the initial point in the narrative (figure 7). Such companies are then made visible if they are related with a company or if a politician is currently selected, or they can also be directly accessed trough the search box.

4. FINAL CONSIDERATIONS AND RESULTS

Here we described our *figurative approach* to the visualization of the relations between Portuguese 130 politicians with governments positions and 354 companies. We used the metaphor of an ecosystem with organisms (politicians) that frenetically jump between companies. The visualization went online on 23 December 2013 and can be explored at *pmcruz.com/eco*. Up to the date of this writing it received 117,245 visits in 112 days with an average of 1,047 visits per day, of which 53% are direct hits and 34% originated from social networks, mainly Facebook. It received positive reviews from the blogosphere and it was featured on the front page with two spreads on a major Portuguese newspaper.[4] The visualization's website has a comments section that received 112 voluntary comments, of which 95% are positive and supporting.

2 *http://soulwire.github.io/sketch.js/*

3 *https://github.com/soulwire/Coffee-Physics/*

4 *Os donos de Portugal*. Agora em versão ecossistema interactivo. Jornal i, year 5, nº. 1462, 4 January 2014, pp. 16-19

Given the dimension of involvement with the audience, we constantly receive suggestions to include other politicians and companies in our dataset, which are still being added as we conclude our research. In the future we plan to open the visualization's code to the public in order to see other data ecosystems visualized. On January 2014 we received the news that a new book is going to be released (Costa, Lopes, and Louçã 2014) in 2014 which further extends the initial dataset of 115 politicians to 776 politicians. Although our visualization model was not thought for such amount of information, it presents a new challenge in the visualization of this thematic that can naturally extend this research.

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A SURVEY OF PROCEDURAL CONTENT GENERATION TOOLS IN VIDEO GAME CREATURE DESIGN

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Keywords: Creature Generation in Video Games, Interactive Design Tools, Procedural Content Generation

In this paper we provide an analysis of the participation of Humans and Computers in generating creative content, in the context of video games. More specifically, we analyze the role Procedural Content Generation can play as a means to empower designers to produce artifacts in a more efficient manner. We instantiate this analysis by focusing on the creation of creatures as an area that requires further research. In order to make this analysis, we surveyed the state of the art of Procedural Content Generation and Interactive Design Tools, all with the specific mindset of mapping techniques applied to generating of otherwise helping the production of game creatures and the Human participation involved in the process.

1. INTRODUCTION

Over the years video game development has been made accessible for a broad audience. Nowadays both independent and AAA studios work to produce video games hoping they are played by millions of players. However, this development can be either lengthy or costly (Hendrikx, *et al.* 2013; Togelius, Yannakakis, *et al.* 2011) or, in some cases both, and result in an artifact that may not succeed as developers would expect. Because of this, AAA teams, who work with million dollar budgets and teams with hundreds of people, tend to recycle working formulas with minor improvements so that the risk of failing is minimized. As a consequence, this results in a cultural stagnation of video games. Independent teams, on the other hand, can take more risky approaches as they work with smaller teams and budgets. Nevertheless, these teams are occasionally only composed of enthusiasts with less technical and/or artistic expertize required to develop a video game which may hinder, or stop, the development process.

Hendrikx, *et al.* (2013), Togelius, Yannakakis, *et al.* (2011) and Nareyek (2007) argue that *procedural content generation* (PCG) can solve the first problem, and Merrick, Isaacs and Barlow (2013) state that it may solve the second. PCG is an automated means to create game content. Previously used to overcome hardware restrictions, PCG is now employed as a way to increase game content without increasing development costs and automate some development processes. It is even argued, that it may "ultimately yield designs that compete with human imagination" (Togelius, Yannakakis, *et al.* 2011). Later we will argue that, instead of competing with human imagination, PCG could be used to empower the designer. Moreover, it could be used as a design tool to stimulate the designer's creativity.

Merrick, Isaacs and Barlow (2013) state that there is a potential, yet poorly explored, link between PCG and computational models of creativity that could ultimately contribute to the designer's creative process. In fact, according to McCormack and d'Inverno (2012), computers "can transform and inspire human creativity in significantly different ways than any other artificial or human made device". We suggest this link can be explored further to bring forth ways to help designers in a cooperative environment involving human and PCG techniques.

There are also approaches proposing the creation of *interactive design tools* (IDT). Built upon evolutionary algorithms, *interactive evolutionary computation* (Takagi 2001) differs from regular evolutionary algorithms in the sense that a fitness function is replaced by human evaluation. This kind of approaches can be integrated alongside computational models of creativity and PCG as they share a common ground. Nonetheless, there are other methods for IDT that act as suggestion providers (Chaudhuri and Koltun 2010; Marin, Bignon and Lequay 2008) that simulate user's creativity.

In this paper, we provide an analysis of the state of the art in game content creation approaches. More specifically, we instantiate the abstract notion of content design to that of creature design, an area not sufficiently explored as expressed in (Hendrikx, *et al.* 2013). With this specific intent, we survey PCG techniques to later find a common link between both disciplines in the context of IDT.

2. PROCEDURAL CONTENT GENERATION IN GAMES

PCG is an automated means to create game content. Togelius, Yannakakis, *et al.* (2011) presents a taxonomy and survey for PCG techniques and categorizes them according to the techniques' morphology and application. Hendrikx, *et al.* (2013) provides a different approach to classifying PCG. Instead of grouping PCG techniques, Hendrikx, *et al.* developed a layered taxonomy for game content in which PCG can be used. Nonetheless, both these classifications are not mutually exclusive and they can complement each other.

Khaled, Nelson and Barr (2013) proposed yet another means to analyze PCG techniques. In their work, Khaled, Nelson and Barr developed a set of design metaphors to help understand the relationships between designers and PCG. These metaphors include Tools, mechanisms meant to achieve design goals and empower the designer; Materials, artifacts procedurally generated that can be edited by designers; game-design goal solving PCG algorithms known as Designers; and Experts, monitors and analysts of gameplay data. The authors argue that these metaphors can help better understand and develop PCG.

From the several approaches to PCG including Cellular Automata, Perlin Noise or even Markov Chains, Togelius, Yannakakis, *et al.* (2011) introduce a family of algorithms called search-based PCG. Search-based algorithms generate content candidates (composed of a genotype, a phenotype and its respective genotype/phenotype mapping function) according to an evaluation function and they include, but are not limited to, evolutionary algorithms. Togelius, Yannakakis, *et al.* state that search-based PCG is a valuable tool but it should not be used to solve every existing PCG problem.

Smith and Mateas (2011) introduced a different approach: by defining the design space as a range of answer sets, they can generate content through the means of answer set programming. Both previously mentioned types of algorithms are further explored in (Togelius, Justinussen and Hartzen, 2012b). Here, Togelius, Justinussen and Hartzen create a composition in which a search-based method is used to find the parameters of an answer set program. It is concluded that composition is an ideal framework for PCG as it can be used to circumvent the individual downsides of each type of algorithm and furthermore, it is a framework that supports humans as part of the content creation.

PCG, according to Nareyek (2007) and Yannakakis (2012), is the next logical step for Artificial Intelligence (AI) applied to game development. They claim that Non-Playable Character behavior, a former significant challenge in video game AI, has reached a point where it is practically solved and that AI developers should focus instead on using AI techniques to improve PCG and, consequently, use it to aid game designers. Craveirinha, Roque and Santos (2013) also adapt this notion that AI techniques can help develop PCG to assist human designers and introduce an author-centric architecture for PCG.

2.1. PROCEDURAL CONTENT GENERATION OF CREATURES

Current state of the art dictates that a creature is a composition of several elements which include a mesh, or 3D model, animations and behaviors with some initial work being done in sound. This assumes that creatures, as an artificial being, when used in contexts such as simulations or video games are introduced as this composition as opposed to each individual element. Creatures are inserted in the "game bits" layer of the game elements taxonomy presented in (Hendrikx, *et al.* 2013) which they state that their generation is complex and still requires further research.

The following subsections illustrate state of the art approaches to generate meshes, animations and behaviors. It is clear that most of the literature tackles each of these creature generation sub-problems individually and combining them with a set of dependencies could yield interesting results. However, that is beyond the scope of this paper.

2.1.1. ANIMATION

There are some accounts of procedural animation being used for creatures/animals'. Sims (1994) work encompasses an Artificial Life environment in which populations of geometric creatures compete to survive. These creatures, or individuals, are composed of a Neural Network controller that decides which forces are applied to generate movement. These controllers are evolved in an evolutionary process to fit a given environment.

Sims' work served as inspiration for the motion synthesis tool Euphoria (Champandard 2008). Champandard argues that Euphoria does not achieve realistic results as people expect and it is best used when motion capture is not an option. Another work derived by Sims' artificial life project is that of Wampler and Popovic (2009). Here optimization methods are used to generate gaits and to optimize existing morphologies of legged animals. Wampler and Popovic concluded that while their method does not capture all gaits, such as a horse gallop, it can be used to aid an animation designer by optimizing certain aspects of a gait while the designer authors the remaining aspects.

Hecker, *et al.* (2008) employed a system in the video game *Spore* that applies animations to unknown morphologies. Here, animations are created beforehand by designers using semantic information and are then generalized so that they can be used on an arbitrary morphology. This way, it is not necessary to create an animation for each morphology. This system, however, still has some flaws pointed out by Hecker, *et al.* and most importantly still relies on human testing to ensure that the resulting animations are working on a given morphology.

There are other approaches for procedural animation that focus on specific morphologies. Cenydd and Teahan (2012) developed a system for arthropod animations. Cenydd and Teahan argue that this system achieves realistic locomotion behaviors on spiders and other insects yet they believe that it can be applied on other animals such as mammals. Coros, *et al.* (2011) provided a means to generate locomotion for quadrupeds. By using an abstract skeletal model from which quadrupeds are derived and in conjunction with gait controllers that apply virtual forces to the skeleton, several gaits were achieved. These were then validated through comparison with existing motion data and evaluated for their robustness, i.e., how the model behaves when applied external unexpected forces. From the results, Coros, *et al.* concluded that although their system generated gaits similar to those of a German Shepherd dog there were some motion subtleties that were produced to which Coros, *et al.* argue that can be achieved if complementing their system with a biomechanical model.

2.1.2. MESH

Another part of Sims' work involved the evolution of morphologies of geometric 3D models. In a nutshell, these morphologies were described as a directed graph which went through the evolutionary process alongside a corresponding animation controller. Hudson (2013) also developed an evolutionary process to generate rigged creatures. Using Houdini, a tool built for a PCG game development pipeline, Hudson evolves structures in Houdini's API to create sets of creatures from which the user can choose to evolve further and even crossover with other creatures.

Using conceptual blending, Ribeiro, *et al.* (2003) uses Divago to generate novel creatures from a preexisting database of decomposable models. Divago, much like the tool proposed by Hudson, can be fed by the generated creatures to develop even more creations. Nevertheless, during the time of writing of the article, some modules were not yet tested as it was still a work in progress.

Inspired by computer generated architecture shape grammars, a technique used to generate buildings, Ilcík, *et al.* (2010) developed an extension to these grammars for skeletal generation and consequently, posing models. This extension was used to develop various objects and even organic creatures, including humanoids. Ilcík, *et al.* conclude that there are still some problems, regarding the posing mechanism, that need to be addressed in these extended grammars, including preservation of mass, extreme positions and collisions resolution.

Finally, Simmons, Wilhelms and Van Gelder (2002) present a mechanism to generate animal models that result in the variation of a preexisting model (or canonical as defined by Simmons, Wilhelms and Van Gelder). By using a horse as a canonical model, Simmons, Wilhelms and Van Gelder, built other variations including a pony. A main disadvantage of this model regarding the generation of arbitrary creatures is that it requires the canonical model to be thought of *a priori*, which may not be the case. Another disadvantage, as pointed by the authors, is that some components, such as the muscle model, had to be handmade instead of automatized.

2.1.3. BEHAVIORS

There are two main approaches to develop behaviors for agents in video games: one, named Agent Centric or Bottom Up method, involves the creation of agents as independent entities that have their own goals and objectives that may, or may not, conflict with other agents' goals and objectives. Initial work in this approach was made by Epstein and Axtell (1996). In their work, they provide several, although not procedural, frameworks for emerging social behaviors. The other approach in modelling agent behaviors is known as Master Plan or Top Down method. Essentially, it relies on the creation of controllers that give orders to a collection of agents in order to fulfill some sort of strategic plan or common goal. This latter approach, however, is beyond the scope of this paper as the Agent Centric approach is generally used in the context of creature behavior modelling.

Mateas and Stern (2004) and Young, *et al.* (2004) developed a similar approach in the sense that both set of authors created a means to generate behaviors according to sets of predefined actions. The differences rely on the fact that whilst Young, *et al.* developed an architecture, Mimesis, that can be integrated into game engines so that engines generate plans according to a given goal, Mateas and Stern developed a language, ABL, that supports the definition of behaviors that can even be run in parallel, all of which to achieve a given goal. Both approaches were developed with believable agents in story driven environments in mind.

Kadlec (2008) presented a framework for genetic programming used to evolve behavior trees. By using a tool called Pogamut in the game *Unreal Tournament 2004*, Kadlec evolved agents, known as bots, to participate in the game's Deathmatch and Capture the Flag modes and ultimately compete with humans. Results indicated that the bots learned simple gameplay rules.

Santos and Roque (2010) provided some initial work in procedural behaviors with Petri Nets, where they created an architecture in which Petri Nets, modelling behaviors of agents in a *Pacman*-based game, are reorganized after each game in order to give birth new behaviors. In their work, Santos and Roque compare a strictly random method to reorganize behaviors with a data-fed technique that changes the nets' topology according to gameplay metrics. Results indicated that, in general, Petri Nets have potential for behavior modeling and, in particular, the latter technique ensued a better game experience.

Finally, in Grand, Cliff and Malhotra (1996) illustrated the architecture behind the agents in *Creatures*. These agents, or Norns, are comprised of a multilobe neural network. Each lobe is responsible for a given task such as decision, perception and concepts and they are fed by an artificial hormone system and sensors which allows Norns to develop instinctive behaviors. Additionally, this artificial system also permits Norns to learn experience-driven behaviors. Grand, Cliff and Malhotra argue that emergent social behaviors were apparently observed though they state it could have been an anthropomorphism in the eye of the beholder.

3. INTERACTIVE DESIGN TOOLS

An IDT is software which aims to aid a user's design process through human-computer interaction. Takagi (2001) surveyed a type of approach called *interactive evolutionary computation*, a family of evolutionary algorithms in which the fitness function is replaced by human evaluation. This brings forth a cooperative environment as both user and computer aspire to reach a global, or local, optimum in the intended design space. The potential of this framework is expressed in Nishino, *et al.* (2001) through the case study of a design tool for 3D modeling for both novice and expert users with promising results. However, Takagi stresses that *interactive evolutionary computation* may yield human fatigue as computers cannot get tired. Takagi presents solutions for this problem including faster fitness convergence, fitness prediction and visual feedback of the search process. These solutions are supported by conducted subjective tests with apparent positive results.

Other approaches for IDT include *suggestion providers*. These tools aim to stimulate a user's design process by giving ideas using the user's work as basis. Marin, Bignon and Lequay (2008) use genetic algorithms to evolve 3D models using what the user is creating as initial population. The resulting candidates, i.e. deformations of the original model, are then presented to the user as a means to inspire him. Although not built upon genetic algorithms, the tool presented in (Chaudhuri and Koltun 2010) also intends to aid the design of 3D models. However, the approach relies on suggesting shapes from a given database that are ranked according to the user's current model. The main problem with this approach is that the tool is constrained by the quality of the database.

It is clear that PCG techniques can be used as IDT as stated in (Craveirinha, Roque and Santos 2013; Khaled, Nelson and Barr 2013; Yannakakis 2012; Togelius, Yannakakis, *et al.* 2011) but, it is also evident that *creative computing* can be introduced to enhance content generation. Indeed, there are some accounts of works that combine *creative computing* with PCG. Dormans and Leijnen (2013) provide a PCG technique using a creativity model as they assume that PCG that provides creative artifacts are preferred to those who don't. Dormans and Leijnen do this by splitting the algorithm into two in which one serves to creative novel solutions and the other to evaluate their usefulness.

Merrick, Isaacs and Barlow (2013) argues that creativity models should be used with PCG as "automated game design requires not only the ability to generate content, but also the ability to judge and ensure the novelty, quality and cultural value of generated content". The framework presented in (Merrick, Isaacs and Barlow 2013) also accounts for an IDT as it requires an initial design made by a human. Finally, Ribeiro, *et al.* (2003), as described in section 2.1.2, also uses creativity models for PCG.

4. CONCLUSIONS

To conclude, we surveyed the state of the art approaches for PCG, focusing on creature generation, as it is argued to be not as explored as other areas in PCG. While, each creature's components' generation including meshes, animations and behaviors have been tackled mostly individually, as shown by the literature, we believe that the generation of creatures can benefit from a composite generation of components as they are linked in the final result. Further research on how animations are dependent on behaviors and the mesh's morphology would enable the characterization of the implications of these relations, to improve the generation of high-level content.

Additionally, we surveyed work done for IDT as we conjecture that PCG can be used to enhance designers' work, as demonstrated in some projects. In fact, IDT have been employed for various applications with positive results. Lastly we propose that combining PCG with creativity models and use those as IDT could yield powerful tools that increase designers' productivity. It is not clear, however, how well can IDT reduce the time it takes to design an artifact and, as such, this could be an interesting research area, as some authors have noticed that unexperienced designers have become more efficient when using IDT.

Since creatures are predominant in videogames, their generation could help reduce development costs. More specifically, IDT, with underlying creativity models, for creature creation could increase the richness of artifacts produced as well as potentially speed their conception. Moreover, research made in this area could set the foundation for other less explored PCG areas such as characters which not only include aforementioned elements present in creatures, but also components tied-in with narrative such as background.

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UN-DE-FOCUSED: VARIATIONS OF ATTENTION IN PLAYER ACTION IN VIDEO GAMES

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A video game player manages her attention according to the strategies developed and the challenges unveiled by the game system. The player does this to the best of her capabilities, developing different activities and performing alternative actions and actuations that may or may not be suggested or even imposed by the system.

This paper proposes four dimensions concerning player attention – time span, sensorial scope, frame, and actuation automation –, each being capable of expressing three alternative states – focused, defocused, unfocused –, and through which the game system manipulates the player's affective state.

The variations that can be obtained by calculating all possible combinations, regarding these dimensions and their states, not only influence the affective states of the player, but also specify alternative characteristics regarding the nature of human interaction with the system, transpiring different gameplay dynamics.

1. INTRODUCTION

In this paper we focus on the phenomena related with the attention span of the player. We explore four dimensions whose different states affect her attention. We are not interested in quantitatively measure her attention, but in finding alternative states that the player manages during gameplay.

The player's mood and affective state may influence her attention. Negative affective states make the player anxious, and thus focused on repetitive operations and on developing similar ideas.

> *Indeed, the problem is not to overdo it: too much anxiety produces a phenomenon known as "tunnel vision," where the people become so focused they fail to see otherwise obvious alternatives. (…) "Fire", yells someone in the theater. Immediately everyone stampedes toward the exits. What they do at the exit door? Push. If the door doesn't open, they push harder. But why if the door opens inward and must be pulled, not pushed? Highly anxious, highly focused people are very unlikely to think of pulling. (Norman 2004, 28)*

Positive affective states induce the player in a relaxed disposition, making her receptive to novel ideas, to improvisation, to adaptation, and attentive to the overall scenario.

These affective states can be manipulated by the system, in order to contribute to an increasing expressive and meaningful gameplay experience.

We propose the existence of four dimensions – time span, sensorial scope, frame, and actuation automation – that incorporate three alternative states – focused, defocused, unfocused.

2. DIMENSIONS OF FOCUS

2.1. TIME SPAN

Players' actions and actuations are developed throughout specific temporal durations, the limits of which are often imposed by the game system, either to determine player's successes and failures or simply to enforce a given gameplay speed or rhythm. These limits also stress the player, testing their ability to keep on playing the game. This dimension is related with the *time span* granted to the player to perform a given action or set of actions. We propose the existence of three classes of time spans – *short*, *long*, and *none* – that promote alternative types of gameplay. It is important to notice that these time spans are not to be calculated in absolute measurements, as they are relative to the temporal demands of the activities that the player develops.

2.1.1. SHORT TIME SPAN (FOCUSED)

Short time spans promote fast-paced action and quick decision-making. They enforce the player to act without a careful thought-out plan. We may say that they instigate reaction; to quickly act in response of a stimulus. In these cases, the options presented to the player are usually limited, and sometimes they are even summarily described or explicitly shown to the player.

Quick time events (QTE)[1] are a common trait in contemporary video games. These usually happen during cinematic interludes or cutscenes, in which players perform given activities when prompted, traditionally pressing specific combinations of buttons on the game controller within very limited time spans. From the classic *Shenmue* (1999), to the button-mashing-action of *God of War* (2005) and *Metal Gear Rising* (2013), to the tense scenarios populated by zombies in *Resident Evil 4* (2005), and to more cinematic narratives of *Fahrenheit* (2005), *Heavy Rain* (2010), and *Beyond: Two Souls* (2013), these events call the player to action in moments that could otherwise be of mere cinematic contemplation, promoting a sort of hybridization between cinema and gaming.

In *The Walking Dead* (2012) the player is constantly prompted to choose between multiple possible options, or courses of action, in very limited time spans. If the player delays the choice, the system then chooses on her behalf. The player not only has to read and interpret all of the possible choices, as also to mentally simulate their outcomes in order to establish a fitting decision. *The Walking Dead* constantly challenges the player into making moral choices much quicker than they would otherwise like to, raising a sense of urgency that proliferates throughout the game.

In *Octagon: A Minimal Arcade Game with Maximum Challenge* (2013) the player's avatar advances automatically through the game world, while the player is responsible for avoiding gaps and other hazards that

1 Quick time events derive from the gameplay style introduced by games like *Dragon's Lair* (1983), in which the player had, at specific or key moments, to press the correct button in order to keep on playing.

appear along the way, by moving it to the left or to the right. These options are very limited, but allied to the short time spans that the player has to act they seem very fitting to a focused performance.

The same is true for *Super Hexagon* (2012). The player controls a triangle that is only able to rotate – clockwise or anticlockwise – around a hexagon centered in the screen. A seemingly unending series of hexagons are also displayed centered in the screen, progressively shrinking towards the center entrapping the player's avatar. These are missing at least one side, leaving the shape incomplete and open. As the player's avatar cannot touch them, the player is forced to very quickly escape through those openings. In fact, the game quickly became known for its extreme difficulty, so that each turn can last mere seconds. (Aziz 2012; Rigney 2012; Rose 2012; Smith 2012; Totilo 2012)

We can see the same happening in *Tetris* (1984) where the player has a limited amount of time to stack the bricks that descend automatically. From this perspective, this game further stresses the player when she is short on vertical space, as vertical space equals available play time.

2.1.2. LONG TIME SPAN (DEFOCUSED)

When the player is granted a *long time span* to act, not only she has time to actuate carefully but also to plan her actions. She has time to explore the game world, although a limited time. This careful exploration consists in the realization of a plan the player puts in motion in order to achieve her objectives.

In *Worms* (1995) each player has about one minute to plan and take action against the enemy, choosing from a wide variety of weapons.

In *Pikmin 3* (2013), while in the single player campaign, the player has about fifteen minutes per turn, at the end of which she mandatorily has to retreat to their spaceships with as many 'pikmin'[2] under her command as possible. Due to this, the player is encouraged to plan her turn in order to collect fruit (an item that she needs for daily consumption, in other words, for every turn) and to progress in the game, exploring its world.

Max Payne (2001), a third-person shooter, became famous for the *bullet time* mode, that consisted in slowing down time without affecting the player's aim, increasing the chances of hitting more targets and more accurately.

2 Creatures that follow the player's instructions, having specific and diverse traits, and through which she acts on transforms the game world.

This illustrates pretty well how a short time span may be stretched to a long time span, offering the player enough time to plan her actions.

In *Super Mario Bros.* (1985) there is a time limit that the player has to abide by, otherwise Mario – the playable character – immediately dies, restarting the level or even the game altogether. But the time span feels long enough to provide a careful exploration of the game world. When the counter reaches the last hundred seconds the 'hurry up' theme plays indicating the urgency to reach the end of the level. At this time, what could be once classified as a *long* time span becomes a *short* time span – depending on the location of Mario and if the player is familiar with the level, of course.

2.1.3. NO TIME SPAN (UNFOCUSED)

When the player's actions are not constrained by any time span, she is free to relaxedly explore the game world. Even if in the game's storyline the world is close to an end, the player still has all the time she wants to engage in whatever captures her interest. This is one of the main traits of open-world games, promoting exploration in richly detailed and diverse game worlds.

In *The Elder Scrolls V: Skyrim* (2011) the player is able to explore the game world as she sees fit. The game even permits the player to undertake quests and to face foes of uneven resilience and strength, considering the current status of her playable character. It is up to the player, it is her choice. As a consequence, the experience of *Skyrim* results in a fragmented and non-linear narrative, essentially based on the exploration of its game world. "Actually, the player may spend much more time exploring optional content than on the main storyline or quest – trying to achieve closure." (Cardoso and Carvalhais 2013b) And the player may even never reach the conclusion of that main storyline, abandoning the game after spending hundreds of hours exploring the game world.

Such may also be the case of the *Grand Theft Auto* series that have been progressively offering a wider variety of activities that the player may engage in. And it is also true in more experimental games such as *The Endless Forest* (2005) where "[t]here are no goals to achieve or rules to follow." The player just needs to explore "the forest and see what happens."[3]

3 From the webpage of the game, from the official Tale of Tales website, at *http://tale-of-tales.com/TheEndlessForest/*. Accessed on 2014-01-19.

In *Mass Effect* (2007), *Fallout 3* (2008) and *Deus Ex: Human Revolution* (2011), for example, the player doesn't have a limiting time span in which she has to make choices during conversations with other characters. Not only the player is able to ponder on the direction that the conversation is taking, as she may also explore the ramifications of the script, in opposition to the quick decision making previously described in *The Walking Dead*.

And, in *Super Hot* (2013) time only advances when the player moves, so that every action can be the result of careful ponderation.

2.2. SENSORIAL SCOPE

Visual feedback is an essential component in most video games. It is mostly through image that players inspect the game world, and advancements in technical capabilities of digital systems regarding visual representation are in constant development.

This dimension relates to how much of the game world the player sees in the same image, restricting the amount of visual events she may witness. What is within the field of view is potentially perceivable by the player and all that lays outside is hidden – a sort of backstage area where the game's actors[4] are spawned, respawned, and dismissed as they become irrelevant to the present moment in the game. For example, in *Super Mario Bros.* (1985) the player cannot backtrack.

In some video games this scope changes along the traversal. This ability may be granted to the player or automatically managed by the system, or even both, enforcing, supporting or changing the current play strategy.

In *Ibb & Obb* (2013) and in *Brothers: A Tale of Two Sons* (2013) the player is able to moderately control the field of view of the game world by moving apart both playable characters within a given limit. In *Locoroco* (2006), *Limbo* (2010), and *Badland* (2013) the game system regulates the field of view automatically as the player traverses the game world, allowing her to be more or less aware of her surroundings, promoting an increased focus on the vicinity of her playable characters or on more distant locations.

But, as audiovisual artefacts, video games convey information to players through image and sound. So, in a similar way that the player is be able to observe the game world, she may be also capable of inspecting it through

4 Game elements that may or may not act autonomously and that the player may or may not control and/or manipulate while playing.

sound. And, depending on the hardware, haptic feedback may also play a role here. In future studies this will be further developed.

2.2.1. NARROW (FOCUSED)

A *narrow sensorial scope* focuses the player on fewer game elements. It forces the player to be attentive to the events that occur in the immediate surroundings of her avatar or the actors she controls/manipulates. It forces the player to focus on the immediate present time, promoting quick reaction to external stimuli, as it conditions the amount of time available between the perception of an eventual threat and the time that that threat will actually gets concretized. *Dead Space* (2008) is practically experienced like this due to its poorly lightened environments through which the player fearfully traverses.

2.2.2. WIDE (DEFOCUSED)

A *wide sensorial scope* allows the player to see beyond their immediate surroundings. By being able to witness more events, she may be capable of anticipating behaviours, increasing her capabilities to take action based on those simulations. While on a narrow sensorial scope the player is forced to react almost instinctively, with a wide sensorial scope she is granted some leeway between planning and actuating. Games like *The Sims* (2000) and *Starcraft II: Wings of Liberty* (2010) are good examples.

2.2.3. TOTAL (UNFOCUSED)

A *total sensorial scope* may be described as a fixed self-contained window that displays the whole playable game world or field of play. There are no hidden playable sites or areas. Some game actors may inhabit or be spawned or respawned outside that frame, but that is not a part of the play field, and if the player is able to travel there and stops seeing her avatar or the actor she controls, this dimension stops being applied to sight as the player starts to further focus on other senses, such as hearing or touch. *Pong* (1972), *Asteroids* (1979), *Tetris* (1984) may serve as examples here.

2.3. FRAME

We refer to *frame* to define the windows through which the player witnesses the game world and the events that it encloses. Frames can be *fixed* – increasing a sense of entrapment or confinement – or *scrollable* – allowing the player to travel to a currently hidden part of the world, immediately hiding another, promoting exploration.

Although it is easier to describe this in visual terms – and we use some in the following descriptions –, this dimension may also regard non-visual phenomena – such as haptics and audio – but, so far, in the context of video games, they haven't been so widely explored.

2.3.1. SINGLE (FOCUSED)

When a video game features a *single* frame, the player's visual attention is undivided and focused on it. She may be wondering what is happening in the unobservable parts of game world, but they shouldn't affect gameplay as these 'areas' are not part of the play field.

There are many video games that can serve as an example here, as *Pong* (1972), *Asteroids* (1979), or *Super Mario Bros.* (1985).

2.3.2. NON-SIMULTANEOUS (DEFOCUSED)

In this case, the player is able to inspect the game world through multiple frames, but these can only be displayed alternately, one at a time. Actors in undisplayed frames may get their activities suspended, may be waiting for instructions, or may be engaged in automated actions. The player is thus in a state of permanent concern about what is currently happening in undisplayed parts of the game world. Thus, the player is not entirely focused on the task at hand, as she has to constantly keep in mind all the other ongoing activities that she is not actually witnessing.

In *Beyond: Two Souls* (2013) the player may alternately control two characters. When she is controlling Aiden (a sort of spirit/ghost), Jodie (the other playable character) is sometimes set in a sort of suspension, as if in a state of deep concentration. The same happens in *The Legend of Zelda: The Wind Waker* (2003), when the player uses a *Hyoi Pear* (an item that, when used, attracts seagulls) she gives up the control of Link (the main playable character) to control a seagull – useful to scouting and reach otherwise inaccessible locations. While this happens, Link seems to be set in a state of deep concentration – to control the seagull – vulnerable to enemy attacks.

In *Pikmin 3* (2013) the player controls three teams of variable sizes, being able to interchange between them while they are performing diverse tasks. While one team is engaged in one sort of activity the others are accomplishing other tasks in real time. And in *Thomas Was Alone* (2012) the player may, at any time, interchange control between several 'geometric' characters that possess specific traits that the player must take advantage of in order to successfully traverse the game world.

2.3.3. SIMULTANEOUS (UNFOCUSED)

Here, all frames are simultaneously displayed. The player is thus able to witness several events that may occur in different parts of the game world at the same time, or the same events from alternative perspectives. The player is free from the cognitive strain of simulating undisplayed events, but her attention is seriously divided as all of those activities are simultaneously displayed for her to witness.

Games like *The Legend of Zelda: Phantom Hourglass* (2007) or *The Legend of Zelda: Spirit Tracks* (2009) for the Nintendo DS, and *Assassins Creed III* (2012) and *The Legend of Zelda: The Wind Waker HD* (2013) for the WiiU take advantage of a system that uses two screens.[5] In these games the screens display alternative information: one exhibits the diegetic part of the game world, while the other usually shows non-diegetic components of the game (Galloway 2006), such as maps or menus for configuring the game and/or the characters.

But this is also possible without physical screens, with different frames in the same screen accomplishing the same goal. In *Fahrenheit* (2005), Lucas (one of the playable characters) had just woken up in a café's bathroom covered in blood, on top of a corpse, with a knife on his hand, and without an exact recollection of what happened. After leaving the café, the screen is splitted in two: one side displays the actions of a police officer located inside the café, an event that culminates with him discovering the body in the bathroom; the other shows Lucas controlled by the player, that has to find a way to abandon the area and escape.[6]

In the course of the game, plenty of moments like this happen. For example, shortly after, as a result of recently fleeing a murder scene, Lucas's home gets filled with incriminating evidence. The police appears and knocks on his door. This is a rather tense moment, as within a limited time span the player tries to cover all the evi-

5 The DS is a portable video game console that has two embedded screens. The WiiU is a home video game console – that needs to be connected to a TV screen – that features a remote controller with one embedded screen.

6 This event can be seen at *http://youtu.be/Tzz5VYIp-3o?t=7m37s.*

dence before answering, in order to not raise any suspicions, while constantly monitoring the police officer's behaviour.[7]

But we may go even further. The attention that is given to specific elements in the Heads-Up Display (HUD) may accomplish the same feat. For example, in *Metal Gear Solid* (1998) in the top right corner of the screen there is a map that displays enemies' positions, their field of view and the terrain. As a result the player often has to distribute her attention between the map and the 3D world to be able to traverse the terrain successfully, unnoticed by enemies.

But simpler elements of the HUD may also play an important role here. Lets just consider the attention that the player needs give to the health bar in games like *Street Fighter* (1987) or *Tekken* (1994).

2.4. ACTUATION AUTOMATION

Controls can be *shared* between actors, allowing the player to move two or entire hordes of actors in one move or actuation, managing them as one big collective element, and insuring that the actors are not lost or in jeopardy. Games like *Locoroco* (2006), *Badland* (2013), *Duet Game* (2013), *The Wonderful 101* (2013), and *Super Mario 3D World*[8] (2013) are good examples where the player controls multiple actors in this manner.

Dedicated controls allow the player to manipulate each actor individually. As a consequence, the player may experience some difficulty in controlling several actors simultaneously with dedicated controls, as she tries to divide her attention to the best of her capabilities between all the relevant events in which those actors are involved. In *Brothers: A Tale of Two Sons* (2013) the player controls two characters through the game world, solving puzzles that often require their cooperation. The controls for each character are mapped at opposite sides of the game controller, forcing the player to use one hand to control one character and the other to control the remaining one.

Ibb & Obb (2013) follows the same premise, but unlike *Brothers: A Tale of Two Sons* it is aimed at two players. Although the methods for controlling the characters are very simple – using the analog sticks on the game controller to run and jump –, it is very difficult to synchronize their different actuations when playing alone, although improvement is possible with practice.

7 This event can be seen at *http://youtu.be/BhoA1htU_sA?t=7m13s.*

8 This is witnessable when the player uses the 'double cherry' item, that creates a clone of the player's avatar.

The main difference between these two video games is that *Brothers: A Tale of Two Sons* is tailored for only one player and that means that the limits of the player's attention span were carefully pondered. Sometimes the player just needs to control each character alternately – as when they are climbing a wall with a rope that is attached to both. But, it is when she is forced to control both simultaneously that the different states we propose for this dimension become more evident.

2.4.1. AUTOMATED (FOCUSED)

Here the player is involved in repetitive actions, whose actuations can be trained, incorporated, patternized and thus transformed into automated processes. (Cardoso and Carvalhais 2013a) After that, player is focused on excelling at their execution, grasping their patterns and optimizing their performance. "The ultimate goal is to turn it into a routine. Frankly, my impression is that the brain doesn't particularly want to deal with it again" (Koster 2005, 32) so that she can focus on something else while keeping that operation going.

An example in *Brothers: A Tale of Two Sons* occurs when both characters are pulling levers at the same time, using the same or similar control schemes.

2.4.2. MIXED (DEFOCUSED)

In many of the cooperative gameplay strategies involving simultaneous control of both characters in *Brothers: A Tale of Two Sons*, the player usually executes two very different types of actuation: one is an automated actuation – which is learned, incorporated and its procedures are automatized; and the other is a non-automated actuation – which will be explained next. What is of importance here is that the player's focus is divided between these two types of actuation. Something that is rendered possible because an automated actuation can be kept ongoing without being constantly monitored, which leaves room for the player to focus on the remaining character as well.

Another example can be found in *Brothers: A Tale of Two Sons* when one of the characters is continuously manipulating a sort of lever while the other has to move through the set, being attentive to whatever lurks in its path.

2.4.3. NON-AUTOMATED (UNFOCUSED)

> *In many games, you are asked to find "secrets" or to explore an area completely. This teaches many interesting things, such as considering a problem from all angles, making sure that you should make sure you have all the information before you make a decision, and thoroughness is often better than speed. Not to denigrate training by rote and reflex, but this is a much better and interesting set of skills to teach, and one that is more widely applicable to the modern world. (Koster 2005, 76)*

In opposition to automated actuations, non-automated ones involve the player in constant improvisation and adaptation to the events in progress. Here actions are not repetitive, nor their actuations can be necessarily trained. They consist of a different stage of learning: the moment of surprise, of discovery. They are born of the necessity of exploring the game world. And this unpredictability requires the player to constantly monitor the events they are involved in.

Continuing with *Brothers: A Tale of Two Sons*, when both characters are traveling through the game world, the player is engaged in two simultaneous non-automated actuations, as she needs to be attentive not only to the directions they both take but also to the lurking dangers in their way. This seems a very simple task when controlling one character, but when multiplied by two it can sometimes become pretty daunting.

3. UN-DE-FOCUSED

Considering the mentioned dimensions, we were able formulate three general states regarding player focus: focused, defocused, and unfocused. These states are, as mentioned, generalized concepts, but their serve as a starting point to explore the multiple possibilities that are obtained by combining all of the presented dimensions in all of these three states: 82 in total.

3.1. FOCUSED

A player is *focused* when engaged in activities that require attention to the immediate and present time, to the displayed and perceptible game world, developing single-minded activities and patternized actuations and actions. The focused player is stressed into actuating in short time spans and within a narrow sensorial scope, perceiving the game world through a single frame.

A focused player is driven into monotasking, focusing on one task or activity at a time, and on repetitive and patternized actions. A player that is focused is a player that is fully concentrated on the event at hand, ignoring all that may surround her.

> *In essence, we know how vividly we see some aspects of our world, but we are completely unaware of those aspects of our world that fall outside of that current focus of attention. Our vivid visual experience masks a striking mental blindness – we assume that visually distinctive or unusual objects will draw our attention, but in reality they often go completely unnoticed. (Chabris 2010)*

3.2. DEFOCUSED

A *defocused* player is engaged in activities that require both attention to the immediate time and to the near future, planning and putting those plans into practice. A player that is defocused is granted enough time to plan her actions, possesses a wide sensorial scope, inspects the game world through multiple frames but focusing on one at a time, and is engaged in realizing non-automated actuations while keeping a part of her attention span dedicated to the realization of certain automated actuations.

A defocused player always has her attention span divided between what is happening and what is to happen, between what is seen and unseen, between performing and planning; and is always tracking some side activities. The defocused player suffers the cognitive strain of multitasking, but focusing on one task at a time.

3.3. UNFOCUSED

> *[A] mind adrift lets our creative juices flow. While our minds wander we become better at anything that depends on a flash of insight, from coming up with imaginative wordplay to inventions and original thinking. (Goleman 2013)*

An *unfocused* player is engaged in activities that don't have a temporal limit to be met. Is a player that is relaxed, with a sensorial scope that engulfs the totality of the playable game world, accessing multiple frames simultaneously, witnessing multiple ongoing events at different places. The unfocused player is engaged in realizing non-automated actuations, involved in improvisation and adaptation in order to keep on playing while developing this state.

An unfocused player suffers the cognitive strain of multitasking, constantly distracted by the persistent and simultaneous calls to attention of the multiple tasks and ongoing activities on the game world.

> *[T]he experience of cognitive strain, whatever its source, tends to mobilize System 2, shifting people's approach to problems from a casual intuitive mode to a more engaged and analytic mode. (Kahneman 2011, 65)*

4. CONCLUSIONS AND FUTURE STUDIES

In the future we will focus on exploring all the variations that can be obtained by combining these dimensions regarding their different states, in a total of 82 types. Their exploration will allow us not only to map different gameplay styles, but may also permit the discovery of new and untested ones. With this in consideration, the necessity for the production of prototypes seems now even more evident.

Furthermore, we believe we will be able to obtain even more variations if we take into consideration the specificities between the different human modalities of perception. Sight has been a favored sense in the context of video games – something that has been definitively suggested by the increasing investment in graphics in the development of game engines. Despite this fact, when it comes to the experience of the player, sound and haptics may also play a very relevant role. So, all of the variations previously described can be dramatically increased if we discriminate different senses that contribute to the experience.

Other dimensions may eventually emerge through the course of time, further increasing all variations, but these 82 will already greatly grant us enough material to focus on.

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QUANTITATIVE METHODOLOGY FOR THE ANALYSIS OF COLOUR AND ITS MEANING: AN APPLICATION TO CAREER GIRLS

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Several researchers are dealing with colour, as a basic expressive element of cinema style. Nevertheless, the difficulty in analyzing a large number of images and describing their nature and characteristics in non subjective terms are still among the problems faced in this area.

This research presents a quantitative methodology that enables a systematic, objective and verifiable study of colour, by automatically obtaining accurate colour data from large amounts of images. The proposed scheme also allow us to find possible meanings when relating quantitative information obtained to the narrative content.

In order to test its efficiency, the methodological tool is applied to Career Girls (Mike Leigh, 1997). As a result, hue is found to follow an expressive program evolving within the narrative content, as it is closely linked to the different periods present in the film.

1. INTRODUCTION

Nowadays, image analysis is required in any communication process in the field of journalism, advertising or media, and images are composed of a great number of expressive elements among which, colour stands out due to its high communicative possibilities.

Specifically, studying movie images colour from the perspective of the creators'/authors' decisions and how they are printed on a film, enables access to information which doesn't depend upon viewers, but stays invariable throughout time as the legacy of an author. Those decisions may indicate the presence of some descriptive elements that become patterns, which enable to detect a possible style related to one or several works. Similarly, those decisions may also show possible meanings connected to the use of colour in one or several films.

Numerous scholars have dealt with colour study (Street, 2012; Misek, 2010; Dalle Vache and Price, 2006; Bordwell, 2006, 1998; Bordwell *et al.*, 1997; Haines, 1993) basing their research of movie images on subjective meanings. But Edward Branigan (2006: 170) state that colour has no identity by itself but acquires meaning through its consistency with other elements of the film *mise en scène* such as space, time or characters, and that it is possible to demonstrate those links both numerically and visually.

One of the most innovative and effective methodologies for image analysis was proposed by Barry Salt (1992, 2006) in his stilometry research. Later on, other scholars such as David Bordwell (*http://www.cinemetrics.lv/bordwell.php*), Warren Buckland and Thomas Elsaesser (2002), Charles O'Brian (*http://www.cinemetrics.lv/obrien.php*) and Yuri Tsivan (*http://www.cinemetrics.lv/tsivian.php*) apply and develop this empirical methodology, as can be seen in the collective project entitled Cinemetrics.

Salt uses statistics to obtain an average of several quantifiable cinema variables that depend directly upon the cinema director, such as shot scale, shot duration, camera movements, reverse angle cuts, point of view shots and insert shots. Although in his early research Salt analyzes each film as whole, years later he chooses a sample of the first thirty or forty minutes of each film, which he considers representative of the complete film. Then, more recently, he chooses shots susceptible to analysis in a sequential way throughout the film. (*http://www.cinemetrics.lv/salt.php*).

This statistical-type methodology faces a specific problem when applied to the analysis of colour in films: the need of processing and obtaining accurate colour data from large amounts of images.

Introduction and constant improvement of digital technology enables to obtain, in real time, substantial, objective quantitative data which allow a deeper understanding of visual data (Manovich and Douglas, 2009). In this regard, David M. Berry (2011) notes that digital technology is fundamentally changing research procedures, especially those traditional methods of analysis, and transforming our ability to use and understand information in a different way from traditional knowledge structures.

Therefore, the important work carried out by the California University Department of Visual Arts research group led by Lev Manovich must be considered. They have developed certain methods and techniques – named Cultural Analytics – that use digital tools to create visualizations that allow for the exploration and research of large quantities of visual material (*http://lab.softwarestudies.com/2008/09/cultural-analytics.html*).

This research shows that it is possible to objectively define and measure colour in cinema, and find possible meanings when linking it to the narrative content. To do so, we present a quantitative methodological tool that enables to measure colour variables of a vast array of images, and to automatically obtain objective, verifiable and generalizable results. Moreover, with this tool it is also possible to show visual and numerically what the colour is like, its evolution throughout narrative content development, and how it is related to other variables such as narrative time, specifically the different periods that coexist inside the film.

In some contexts the audience can certainly perceive that there is a certain hue in a scene, but the description of that hue will be subjective and not accurate enough for a scientific approach. Which kind of hue? To which extent can we make a difference between blue and blue-greenish (both of them subjective terms)? And how can you evidence in an objective way that there is a certain hue in a scene? This quantitative approach allows a systematic, verifiable and objective methodology that yields unbiased conclusions, not dependent of the watcher's subjective perception.

In this paper, such methodology is presented through its application to the analysis of *Career Girls* (Mike Leigh, 1997). Hue is analyzed, along with its evolution throughout the film and the significance it acquires when linked to the variable of time, or more precisely, period.

2. MATERIALS AND METHODS

The film *Carrer Girls* is available on DVD. Files in this format are .m2v, which although involves a certain colour compression compared to celluloid, can easily be handled with simple software, and allows for a simple comparison of results with other films in the same format.

Although nowadays the processing power of computers allow to automatically apply this methodology to each of the frames of a film, there is still the necessity of manually choose and cut each of those frames. In the case of *Career Girls*, that means 4860 frames, so it would require 20 times more than the 243 randomly chosen shots.

In statistical analysis, it is quite usual to select a subset of individuals from within a population to estimate characteristics of and describe the whole population (this is referred to as “inference”). This is a time-saving practice that ensures scientific general results and is widely used in all scientific areas.

Simple random sampling is one of the easiest unbiased sampling methods; moreover it offers a sample that is highly representative of the population – with an *a priori* limited sampling error –, and simplifies analysis of statistical results. Using other sampling methods, such as stratified or cluster sampling, can even improve sample representativeness, but they require further information[1] (auxiliary variables or covariates).

2.1. SAMPLE SIZE AND SAMPLING METHODS

As in any inferential statistical analysis, optimum sample size must be determined, taking into account that that the minimum unit in our research is each shot, and the film has a total number of 966 shots. Then, considering a sample error of 5.44%, the optimal sample is composed of 243 shots.[2]

In order the 2403 shots in the sample to have a homogeneous distribution, the film has been divided into four proportional parts or quartiles, according to its duration in minutes: the first division (from 0 to 20 minutes) includes the first 250 shots of the sample, the second division (from minute 21 to 41) includes from shots 251 to 500.

1 Cf.: Smith (2001); Chambers and Skinner (2003).

2 As we have a finite and known universe, we follow this formula (Pérez, 2009):

$$n = \frac{Z^2 \times N \times p(1-p)}{(N-1) \times e^2 + Z^2 \times P(1-p)}$$

Where “n” is the optimum sample size; “N” is the film total number of shots; “Z” is the Normal distribution value that guarantees a 95% confidence level (so Z=1.96), which is the probability that results obtained are true; “p” is the population percentage that has certain characteristics under study (as it is an unknown value, it is assumed that p= 0.5); and “e” is the considered sample error (e=0.0544), i.e. the maximum accepted difference between results obtained by sample analysis and those obtained if the whole film would have been analyzed.

In the third division (from minute 42 to 61) are included shots from 501 to 750, and finally, fourth division includes from 751 to 966 shots (from minute 62 to 81).

Then, a representative frame of each of those 243 shots has been randomly chosen and saved as a .tiff picture.

Afterwards, analysis of formal variables related to colour in each selected frame is carried out employing ImagePlot[3] and its macro ImageMeasure, that transforms images in a RGB colour model into an HSB one, and extract from them statistical data related to hue, among other variables (*http://lab.softwarestudies.com/p/imageplot.html*).

2.2. MEASUREMENT

For performing the quantitative analysis, two variables have been considered, one related to colour and one variable related to time: hue and period.

Image hue measurements are obtained from ImageMeasure on a 0 to 255 scale, but they have been classified along a scale from 0° to 360°, which coincides with the chromatic circle. These results were afterwards also transformed in a qualitative scale including six categories (red, orange-yellow, green, cyan, blue and magenta), according to Table 1.

Results related to hue were also included in a broader scale, which distinguishes between cold and warm hues, according to Table 2.

The temporal variable period is related to narrative time, and has been determined by observation of each one of the chosen shots. In this case, *Career Girls* is composed by flashbacks sequences (representing previous decades in relation to the shooting time, and labeled as "past") and other related to present time (labeled as "present", and in which narrative time coincides with the time of the shooting).

2.3. STATISTICAL METHODOLOGY

Once data related to each variable is obtained, SPSS[4] v.21 software is used to perform a statistical analysis on two levels. The first analysis is based on descriptive statistics and examines the basic behavior of the colour variable, as well as its progress in each quartile and how it develops throughout the film. Quantitative variable information refers to mean, median, standard deviation, minimum and maximum; while qualitative variable information refers to percentages values offered by contingency tables.

Table 1 Hue subdivision codes

Scale (grades)	Hue
330° - 30°	Red
31° - 90°	Orange - Yellow
91° - 150°	Green
151° - 210°	Cyan
211° - 270°	Blue
271° - 330°	Magenta

Table 2 Warm and cold hue codes

Scale (grades)	Hue
315° - 134°	Warm Hues
135° - 314°	Cold Hues

3 ImagePlot is a free software tool, developed by Software Studies Initiative, which enables to create high resolution two dimensional visualizations from a large quantity of images. It is implemented as a macro, which works with ImageJ64 (*http://rsb.info.nih.gov/ij/docs/intro.html*), an open source image-processing program.

4 SPSS is a proprietary software tool, developed by IBM Corporation, for statistical analysis in social science.

When the descriptive stage of analysis is complete, a second multivariate analysis based on inference statistics is performed in order to study possible links between hue and period, and therefore, a feasible meaning of colour.

Since none of the quantitative variables in our study satisfies the assumption of normality,[5,6] Kruskal-Wallis contrast[7] is used to test if there is any relationship between the qualitative (period) and the quantitative variable (hue).

3. RESULTS

In this section, results obtained from the application of the methodological tool are shown.[8] In the first place, the descriptive study of hue is presented, in the second place, inference analysis will show if there is a relationship between hue and period.

3.1. DESCRIPTIVE ANALYSIS

Table 3 shows that *Career Girls* has a mean hue of 134,70°. Furthermore, the highest values for hue are in the second and first quartile.

With regards to hue evolution throughout the narrative development in *Career Girls*, it grows from the first to the second quartile and diminishes in the other two consecutive quartiles in a progressive way.

Table 3 Average hue quartile percentages

	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Mean
Mean	136.65	180.82	123.76	97.57	134.70
Standard Deviation	57.36	52.30	67.84	47.29	56.20
Minimum	58	61	35	40	49
Maximum	229	223	313	202	242

The scatterplot in Fig. 1 represents the evolution of average hue in each of the shots analyzed in *Career Girls*. The “X” axis is divided into four quartiles according to the film duration in minutes, while the “Y” axis represents the average hue of each shot on a 0° to 360° scale. This figure visually shows the film structure according to the hue of the shots.

It also offers a clear pattern of the mean hue distribution, visible in all the quartiles, especially in the first and in the second one. The first quartile is divided into two

5 The assumption of normality implies that data offer a symmetrical distribution with a single mode.

6 To verify this Kolmogorov-Smirnov tests were applied.

7 Kruskal-Wallis is a non-parametric test to contrasts if quantitative variable behavior is the same in each one of the groups defined by qualitative variables, considering independent and more than two. (Siegel and Castellan, 1988: 206-215; Barreiro *et. al.* 2006: 133-136).

8 Due to space limitations, only a part of what this methodological tool is capable of , is shown. In a more extended research – which is part of a PhD (*https://www.educacion.gob.es/teseo/imprimirFicheroTesis.do?fichero=41358*) – evidence is presented to support the relationship between hue and the following variables: brightness, saturation, shot length, shot scale, camera movement, location, exterior, interior, day and night and characters.

parts: the first one is dominated by cold hues and the second one by warm hues; in the case of the second quartile, most of the hues are cold. The third quartile could be also divided into two parts: the first one is dominated by warm hues and the second one by cold ones. Finally, the forth quartile is mostly dominated by warm hues, an opposite tendency to the second quartile.

Fig. 1 Hue evolution throughout *Career Girls*

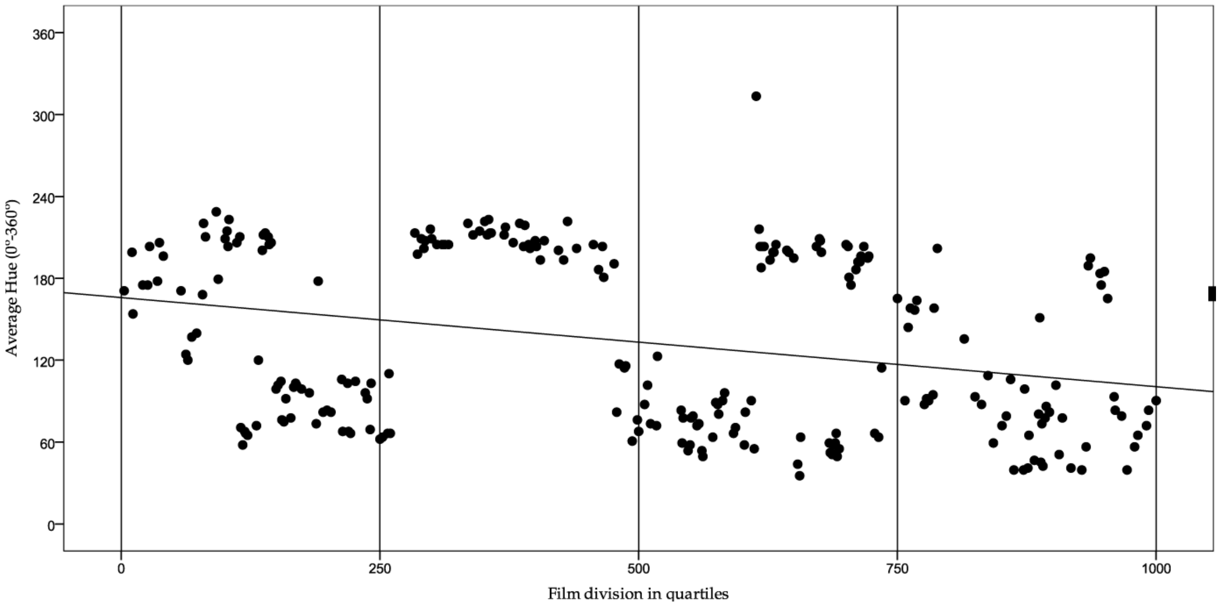

Table 4 shows the quartile-distribution of hue, considering the qualitative six-category scale for this variable.

Table 4 Hue scale quartile percentages

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Shots Total Number
Orange- Yellow	nº.of shots	18	7	38	32	95
	percentage	18.9%	7.4%	40.0%	33.7%	39.1%
Green	nº.of shots	20	4	4	10	38
	percentage	52.6%	10.5%	10.5%	26.3%	15.6%
Cyan	nº.of shots	23	25	27	12	87
	percentage	26.4%	28.7%	31.0%	13.8%	35.8%
Blue	nº.of shots	6	15	1	0	22
	percentage	27.3%	68.2%	4.5%	0,0%	9.1%
Magenta	nº.of shots	0	0	1	0	1
	percentage	0.0%	0.0%	100.0%	0.0%	0.4%

The most outstanding hue in *Career Girls* is orange-yellow with 39.10% of shots in the sample, followed by cyan with 35.80%. Green is next one with 15.60%, blue with 9.10%, magenta with 0.4% and red with 0%.

All the hues are present in all the quartiles with the exception of blue – present in three: first, second and third –, magenta – only present in the third one –, and red –not present in the sample –. Furthermore, the evolution of the different hues throughout the four quartiles is irregular, meaning that a behavioral pattern among them does not exist.

Table 5 shows the quartile-distribution of hue, considering now a binomial scale for this variable (cold-warm).

Except for the second quartile in which warm hues predominate, and in the fourth one in which cold hues prevail, there is a balance between cold and warm hues in the rest of the quartiles.

Table 5 Cold and warm hues quartile percentages scale quartile percentages

		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Shots Total Number
Cold hues	No. of shots	36	11	42	40	129
	Percentage	53.7%	21.6%	59.2%	74.1%	53.1%
Warm hues	No. of shots	31	40	29	14	114
	Percentage	46.3%	78.4%	40.8%	25.9%	46.9%

3.2. RELATIONSHIP BETWEEN HUE AND PERIOD

In this section the relationship between the chromatic variable and the time-related variable is numerically shown. Finding statistically significant differences between the mean hue obtained for each of the categories of period (“past” and “present”) implies a certain association between both variables.

Table 6 shows that in this film, shots related to a past time have an average hue of 202°, while shots related to the present time have an average hue of 85.51°.

The Kruskal-Wallis test performed shows (sig.= 0.000) that hue of each of the analyzed shots is related to the different temporal dimensions of the film. This means that in *Career Girls* there are statistically significant differences between present hue colour and past hue colour.

Table 6 Hue and period descriptive results

	Hue (°)		
	Mean	**Min.**	**Max.**
Past	202.05	154	313
Present	85.51	35	213
Total	133.47	35	313

4. CONCLUSIONS

Conclusions obtained in this research are divided into those related to methodology and those concerning film analysis.

With regards to the proposed methodological tool, it overcomes traditional analysis focused on a limited number of images, since it can cover a higher number of images. Furthermore, it offers an alternative and a complement of subjective analysis to describe colour and also to find its possible meanings.

Such analytical methodology enables the obtaining of data related to colour in a systematic, objective and verifiable way, as well as its visualization from a huge volume of images. As a consequence, it allows us to describe and depict colour, to observe its evolution throughout the film, and to find possible meanings when linking it to the narrative content.

Regarding conclusions about the film analysis, it is shown visually and numerically that, from a descriptive point of view, *Career Girls* has an average hue of 134,70°, which according to table 1 and 2, means that it is a green and warm film. Nevertheless, although *Career Girls* is, on average, a warm film, there is quite a similar proportion between warm and cold hues, with 53% and 47%, respectively.

Concerning hue scale present in the film, the lack of red is noteworthy. Then, from the lowest to the highest percentage, magenta shows only a 0.4%, blue a 9.1%, and green a 1.6% of the sample. Cyan is the next hue (35.8%), followed closely by orange-yellow (39.1%).

Besides, colour evolves with the narrative content of the film: if we take into account the beginning and the end of the film, it becomes warmer. Regarding colour meaning, and as a consequence of statistical inference, it is demonstrated that hue is closely related to the different periods present in the film, as it is possible to associate flashbacks with an average hue of 202° (cyan and cold), while those sequences related to the present have an average hue of 85.51° (orange-yellow and warm).

The described statistical methodology yields unbiased objective results that are basic for the explanation of how period (past and present) is connected to hue, and that´s a meaning for colour: blue means past and orange-yellow, present.

The methodological proposal can be applied to different fields such as art history, design, photography or cinematography, as directions of further research. In the field of cinematography, it allows for the study of the relationship between several chromatic variables (such as hue, brightness and saturation) and other narrative content variables (such as characters, space and time) in any film.

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VISUALIZATION OF SPATIAL RELATIONS IN VIRTUAL ENVIRONMENTS WITH ARTIFICIAL DEPTH CUES

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Keywords: Gesture-based Interaction, Depth Perception, Virtual Environment

Gesture-based interaction in virtual environments often suffers from inaccurate depth estimations by the user. In particular, the usability of selection and manipulation tasks highly depends on correct distance judgments. Since haptic feedback is not available, the visual representation and the unambiguous interpretation of spatial configurations are fundamental aspects that influence the usability of gesture-based interaction in virtual environments. Reasons for incorrect judgment of egocentric depth in three-dimensional spaces are still partially unclear. We propose a different approach to overcome this issue. We introduce additional artificial depth cues, which are designed to improve the user's understanding of spatial relations within virtual environments. Three visualizations of egocentric depth are introduced: a Depth-of-Field effect inspired by focus effects in photography, an effect called Color Perspective based on observations of the use of color in art, and the visualization of volumetric shadows using Crepuscular Rays.

1. INTRODUCTION

The use of gesture-based interaction in three-dimensional virtual environments offers several opportunities. Tracking the user's body is a promising approach to deliver sufficient degrees of freedom for spatial interaction. The use of gestures seems promising as gestural user interfaces offer the potential to reproduce real-world processes and procedures in virtual environments with natural human interaction methods (Seth, Vance and Oliver 2011, 6-7). However, the perception of spatial relations in virtual environments, especially the estimation of egocentric depth, is often inaccurate due to conflicting or missing depth cues. The term egocentric depth describes the perceived distance of an object from the observer's viewpoint. Tasks requiring high spatial precision are therefore particularly prone to errors, especially if only visual feedback is provided to the user. In these scenarios, lateral positions can be determined unambiguously, whereas the correct estimation of spatial distances along the viewing direction is difficult (Fig. 1). Although several studies demonstrated distance judgment issues in virtual environments under various conditions, the specific reasons have not been identified yet (Jones *et al*. 2008, 13), (Piryankova *et al*. 2013, 162-163). Therefore, the question arises, how to enhance the estimation of spatial relationships even if the source of the misperception is unclear and the available visual representation does not provide sufficient natural depth cues. In this paper, three techniques are introduced, which augment a virtual scene with artificial depth cues. The proposed cues were designed to improve the understanding of the spatial layout in a virtual environment. The chosen approach was developed in the context of selection tasks in three-dimensional environments using gestures, since this form of interaction depends heavily on the correct visual estimation of positions due to the lack of haptic feedback. Additionally, gesture-based interaction in 3D is not constrained regarding the available degrees of freedom, hence correct positioning requires a precise judgment of distances in all spatial directions. The overall goal was to convey a more appropriate and intuitive feeling about the current position of the user's hands in relation to the virtual environment.

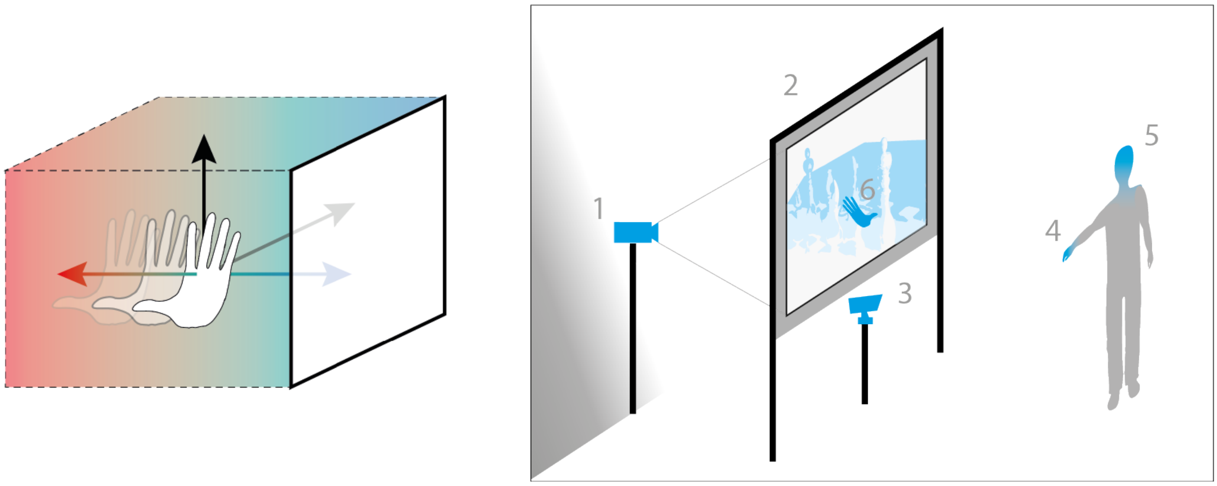


Fig. 1 Left: Spatial gestures performed in front of a 2D-projection. Movements parallel to the projection plane (black arrows) are mapped unambiguously onto the plane, whereas the perception of distances in depth (egocentric depth; colored arrows) is often incorrect in virtual environments. Right: System setup. Projector (1) displays virtual scene on a rear projection wall (2). The user is tracked by a Microsoft® Kinect™ (3). The user's head position relative to the display (5) is used to translate the virtual camera, the position of the hand (4) is projected into the virtual scene (6).

2. RELATED WORK

Interaction and the perception of space in virtual environments have been discussed in research for many years. Several publications in the field of psychology indicate that human depth perception in virtual spaces is less accurate than in reality (e.g. (Jones *et al.* 2008), (Thompson *et al.* 2004)). Although this phenomenon has been observed in numerous studies, the exact reasons are still subject to intense research. To identify the mismatches between virtual representation and the perception of three-dimensional spaces, it is important to understand how humans perceive their surroundings. The most common theory about depth perception assumes that there are several depth cues, which provide necessary information about spatial relations (Palmer 1999, 203-249), e.g. occlusion, perspective, shadow, motion parallax or binocular disparity. Due to the large number of different cues, which have been identified so far, experiments suggest that there is no single dominant cue responsible for depth perception (Wanger, Ferwerda and Greenberg 1992). In fact, humans perceive spatial layout by combining and rating different sources of information depending on the context. Additionally, the influence of specific cues is assumed to be varying depending on the distance of an object relative to the observer (Cutting and Vishton 1995). One possible reason for incorrect depth perception has been mentioned by Wann *et al.*: the conflict between ocular information (accommodation and convergence) and the stereoscopic representation provided by head-mounted displays (HMD) causes irritations, because the contradictory cues cannot be resolved properly (Wann, Rushton and Mon-Williams 1995). Watt *et al*. argued that this issue is not only present when using HMDs but in all stereoscopic representations (Watt *et al*. 2005). On the other hand, Willemsen *et al*. show that incorrect estimation of depth is not restricted to stereoscopic images, but also occurs when using monocular depth cues only (Willemsen *et al*. 2008). Blur is a depth cue, which is rarely represented in virtual environments. Although previous research shows that the distinction of small changes in blur appears to be difficult for the human visual system, blur can be seen as coarse depth cue (Mather and Smith 2002). According to Vishwanath and Blaser, blur has a significant impact on the perceived distance (Vishwanath and Blaser 2010). The authors mention the miniaturization effect used in photography, which changes the perception of the size of objects in images due to the amount of visible blur. Research also shows that, in conjunction with other pictorial depth cues, this miniaturization effect can be utilized for the estimation of absolute distances (Held *et al*. 2010). Another important finding related to virtual environments is, that the realism of the visualization seems to have only minor impact on the accuracy of distance estimations (Thompson *et al*. 2004). As the specific reasons for the inaccurate distance estimations in virtual environments have not yet been identified, the question for an alternative approach arises. Based on findings regarding depth perception, it becomes clear that even elemental cues, such as stereoscopy, are not absolutely essential for correct depth perception whereas subtle effects like blur have relative strong influence. As photorealism seems to have no significant impact on depth judgment, one possible approach could be to augment a virtual scene with subtle, yet unambiguous and easily assessable, artificial depth cues, which provide additional information about the spatial layout of a virtual environment.

3. SCENARIO

In order to identify possible approaches to enhance depth perception in a VR scenario, we used a simplistic setup for gesture-based interaction. The user interacts with a virtual scene presented on a large projection wall by using hand movements. The body tracking is implemented using a Microsoft® Kinect™, which is placed underneath the projection (Fig. 5). Virtual representations of the user's hands are projected in the virtual scene according to their position relative to the head position. The location of the user's head relative to the screen is used as position for the virtual camera. The virtual hand represents a cursor for selecting objects by virtually grasping them. Grasping is achieved by moving the hands to the position of the object. The user can move freely and his body movements trigger appropriate camera translations, in order to create the impression of an immersive interactive environment. The implemented tracking method only takes changes of the position of the user's head into account. The adaptation of the camera direction according to user's view direction was not implemented, due to missing capabilities of the tracking system. Because of the opportunity to move around and the focus on selection tasks within the virtual environment, the absence of this feature is negligible as scene navigation is not explicitly part of the scenario.

4. APPROACH

The design of the proposed artificial cues follows the idea of context-sensitive dynamic cues which should leverage the interactive dynamics of gesture-based interaction. Hence, the provided visualizations need to correlate with the position of the user's hand in the virtual scene and especially have to reflect changes of this position dynamically. Therefore we assumed, that during tasks, which require precise selection or manipulation, the user's attention lies in the area where he or she is currently interacting with his or her virtual hand. Therefore, the design of additional visual representations is focused on the dynamic visualization of the spatial relations between the virtual hand cursor and the objects nearby. The main goal was to support the perception of local depth relations in the area around the virtual hand as this is where the user needs to be supported with additional depth cues in order to achieve an efficient and precise interaction. The main idea behind the proposed effects is to provide additional visual indications, which convey a better impression about spatial relations. The user should be able to interpret these cues intuitively, in contrast to other techniques such as dynamic grids, which force the user to count rows in order estimate a correct depth relation. Therefore, the cues are based on familiar natural phenomena, which are easy to understand and to evaluate. Guiding the user's attention by manipulating the area next to the virtual hand can also reduce the distraction by other objects in the scene. The virtual representation of the user's hand becomes a tool, which is used to explore the scene in detail, without losing the capability to maintain a general overview of the whole environment. Choosing this approach, one design goal for the artificial depth cues was that they have to reflect the interactivity of the gesture-based user interface and therefore have to change their behavior dynamically according to the user's actions. Hence, the additional cues needed to be dynamic cues. Since previous research shows that dynamic depth cues are among the most powerful cues (Domini & Caudek 2003), it can be assumed that the proposed visualizations have noticeable impact on the user's understanding of the spatial layout of a virtual scene.

5. PROPOSED ARTIFICIAL DEPTH CUES

The first proposed visualization of spatial distances utilizes a Depth of Field effect. The area around the cursor is rendered normally, whereas objects farther away or closer to the observer are out of focus and increasingly blurred. As the distance between objects along the viewing direction increases, they appear more and more blurred. Therefore, a narrow area perpendicular to the user's viewing direction, called Depth of Field, is rendered sharply (Fig. 2). The basic idea of using this kind of depth visualization originates from photography, where the Depth of Field effect is used to guide the user's attentional focus to specific areas or objects. Although the different shades of blur over the scene do not serve as reliable depth cue alone, the change of blur during interaction and the corresponding movement of the focal area allow an iterative refinement of the target area. Moreover, the attribute of sharpness indicates clearly that the virtual hand and the object are at the same depth distance - contrary to occlusion alone, where the hand could be behind the object. To achieve this, the blurred region must be easily distinguishable from areas in focus, so that a high amount of blur was applied to the scene, comparable to a wide aperture in photography.

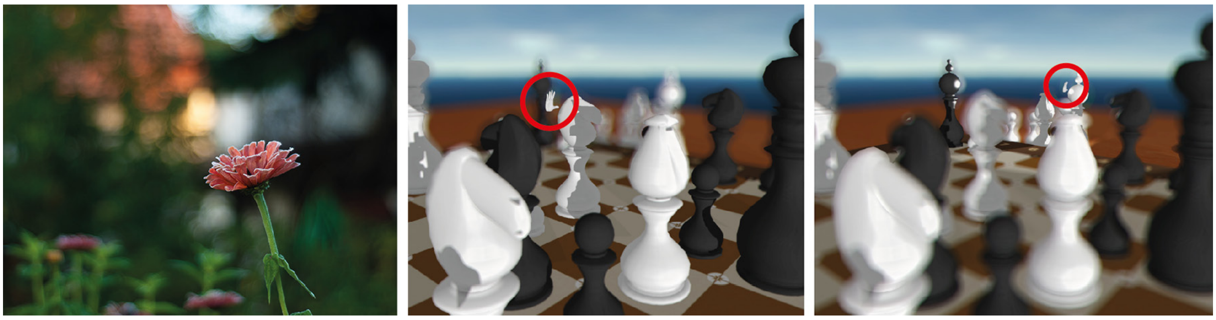


Fig. 2 Left: Depth of Field used in photography to guide the viewer's attention and minimize distracting influences background objects. Right: Implementation of the effect.

The second depth visualization is inspired by painters, who used the effect of color perspective in their pictures to enhance the impression of depth (Gombrich 2002). One part of this technique is called aerial perspective and is one of the pictorial depth cues used for estimation of large distances. Due to dirt particles in the air, the light is scattered differently depending on its wavelength. As long-wave light is scattered to a higher degree, objects far away from the observer have a bluish color (Goldstein 2010, 232). Color perspective uses this observation and its inversion for closer distances by additionally applying warm colors for objects nearby the observer to intensify the spatial impression. This idea is applied to the virtual environment by dividing the scene into depth segments, which are overlaid with different color shades. Before the color overlay is applied, the saturation of the scene is adapted to the current depth position. Therefore, proximal parts are gradually less saturated and get a reddish color overlay. Objects near the current cursor position keep their saturation value and have only a slight color overlay, whereas objects far away from the virtual hand have a reduced saturation and are drawn with a blue shade. Using this effect, we expect the user to be able to intuitively judge depth. Similar to the Depth of Field cue, colors in the area of interest nearby the virtual hand preserve their original color, whereas the effect of the color change increases with the distance to the current hand position.

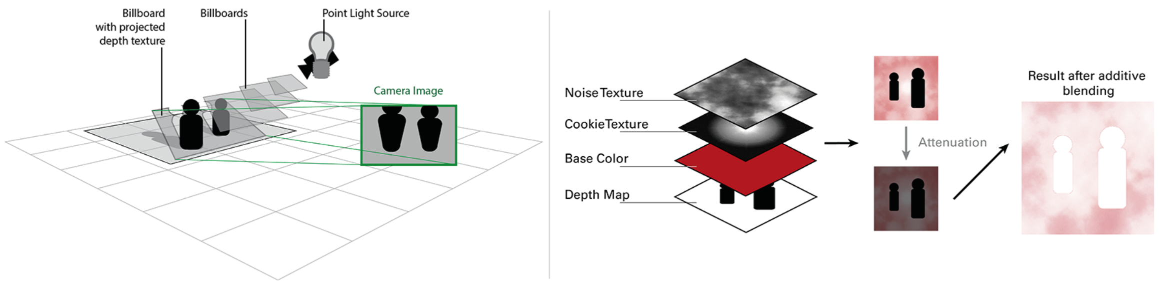
The concept for the third proposed visual effect originates from a natural phenomenon, which can be observed especially in nebular environments. Sunlight, which is scattered by dust particles in the air, produces so called crepuscular rays. This effect is adapted to the visualization of the hand's spatial position: Light shafts are displayed around the position of the hand in all directions. Objects inside these light shafts produce visible shadow volumes (Fig. 3). A torch illustrates this effect, which illuminates its surroundings, whereas the shadows provide the depth cue relative to the torch. The idea behind the effect is to utilize the power of dynamic depth cues. The shadow volumes change their size and shape with the movement of the virtual hand and therefore provide a highly dynamic cue for position relative to nearby objects. Despite being an artificial cue, the resulting shadows are intuitively interpreted and provide a natural hint for the underlying spatial layout, in contrast to "synthetic" cues such as auxiliary grids.

Fig. 3 Left: Implementation of Color Perspective, Middle: Crepuscular rays in natural environments. Right: Crepuscular Rays as artificial depth cue.

6. IMPLEMENTATION

The depth visualizations have been realized as OpenGL shaders. The Depth of Field effect was implemented by computing a depth map and applying a circular blur, with the radius increasing over the distance relative to the focal plane. This approach is similar to the approach described in (Scheuermann 2004), except that no stochastic sampling was chosen, but a uniform circular blur on several rings with increasing radius. This approach has the disadvantage that more samples need to be processed for each segment, but produces less visible blurring artifacts. The number of samples and the count of circle rings along which the blur is applied can be specified to increase the quality of the effect. One issue of this technique is an effect called edge bleeding, where fragments from sharp regions are blurred into regions farther away from the focal plane. In order to prevent this behavior, only fragments with a higher relative depth value than the processed fragment are blurred. Highlights within the scene are additionally intensified by multiplication of a luminance gain value with the resulting color. The Color Perspective effect works in a similar way by manipulating the saturation according to the rendered depth map and adding a color overlay afterwards. The implementation of the Crepuscular Rays followed the proposal of Mitchell (Mitchell 2005). Hence, six cameras in each spatial direction are attached to the virtual hand. Subsequently, a depth map is rendered from each of these perspectives. Additionally several billboard planes are aligned to the camera frustums. In the composition pass these planes are rendered with a semitransparent material, and depth values higher than the distance of the plane from the virtual hand are rejected (Fig. 4).

Fig. 4 Left: Rendering of Crepuscular Rays using projective texture mapping. Right: Composition of noise texture and depth texture to achieve natural look.



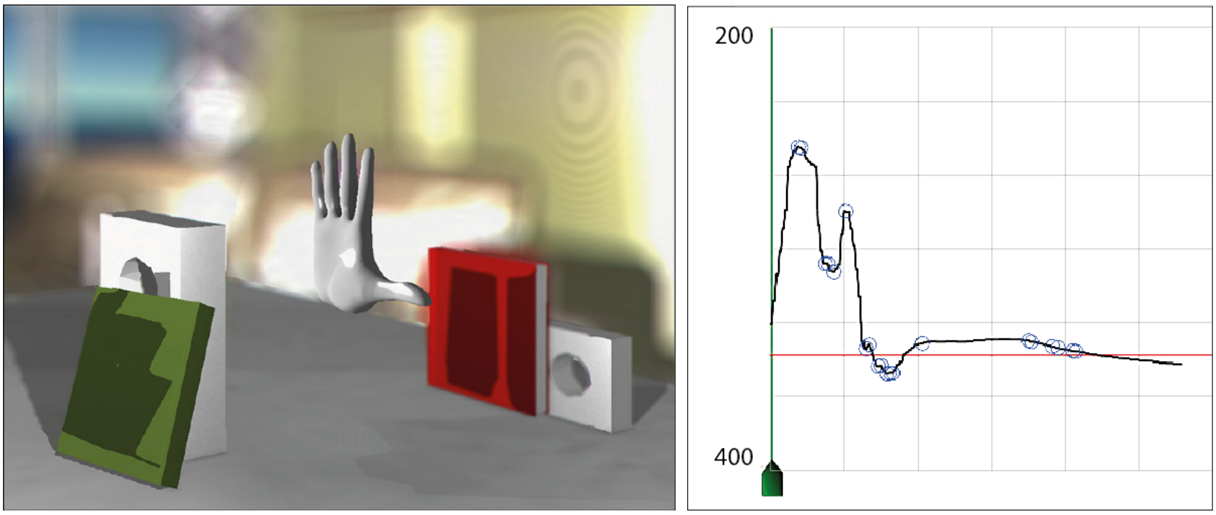
7. EXPERIMENTAL PROCEDURE

In order to acquire feedback regarding the design and spotting weaknesses of the current implementation, a preliminary survey with 24 (15 male) participants between 23 and 36 years (mean: 28,92 years, SD: 3,38) was conducted, using the setup described in Section 3 (Fig. 1). The participants were instructed to grasp different objects in the scene. Before they started, the purpose of the survey and the implemented effects were described shortly. Additionally, participants had 5 test runs for each setting, including test cases with deactivated additional depth cues, in order to become accustomed to the visualizations. Afterwards, they executed 15 trials in which they had to grasp objects with different difficulty, meaning that the objects were partially occluded by other objects or had been placed not directly in front of the user and therefore required more precise actions for selection. After completing the trials, the participants were asked to rate the usefulness of the visualizations and rank them according to their usability and interference factor regarding the visibility of the rest of the virtual scene. Moreover, they could comment on their impressions regarding the additional depth cues, their effectiveness and suggest optimizations, which they could imagine to enhance the usefulness of the system.

8. RESULTS

Due to the preliminary character of the study, the participants were asked to focus on the accurate selection instead of performing the task as fast as possible in order to have the opportunity to understand the visual effects in more detail. As a result, task completion times varied significantly and did not produce a reliable result regarding efficiency of any of the cues. Due to occlusion as very powerful depth cue in this scenario, the evaluation of accuracy alone did not provide better results either. During the trials, tracking data of the participants was recorded, but as assumed before, the tracking-system didn't produce results robust enough for an in-depth comparison (Fig. 5). In addition to the inaccurate tracking method, the simple task and missing constraints for the participants are reasons for very high variance in the results. However, the qualitative analysis of the subjective rating by the test subjects and their comments about the concept revealed valuable insights, hints for possible enhancements, and also several issues and directions for further improvements. The results and comments indicate that the provided cues have some positive impact on depth judgment. 21 Participants (87.5%) rated at least one effect as enhancement compared to the standard 3D representation. The overall design of the effects was appreciated by the users. Although some were irritated due to the overemphasizing of the visualization in the current implementation, only 6 (25%) participants preferred the standard projection without additional depth cues regarding the overall visual impression. Tweaking some parameters therefore is likely to enhance the usability and acceptance of the proposed effects. The ranking regarding the interference factor of the effects shows that users were less distracted by Crepuscular Rays and Color Perspective effects as by the Depth-of-Field effect, which was rated as less distracting than other effects by only 3 participants (12.5%). The Depth-of-Field effect and the Crepuscular Rays were rated to be more useful than the Color Perspective effect and absence of any additional visualization. The participants also mentioned the use of occlusion as the main cue while being in close proximity to the object. As soon as the virtual hand disappeared behind it, they knew that the correct depth had been reached. It was also stated, that the usefulness of the effects might be increased by extending Depth-of-Field and Color Perspective to three dimensions instead of limiting them to the depth dimension only.

Fig. 5 Left: Scene used in the survey. Right: Example trajectory of distance relative to the target.



9. LESSONS LEARNED AND FUTURE RESEARCH

The observations in the preliminary survey reveal that the used tracking technology is one of the main points for optimization. More accurate tracking methods are necessary both for a reliable evaluation of the effects and for the proposed techniques to leverage their entire potential since they are target precise selection and manipulation tasks. Another weak point was represented by the observation that simple grasping of whole objects with the virtual hand does not represent an optimal evaluation strategy as this could be easily achieved by using occlusion as main depth cue without critical impact on the overall performance. Therefore, a more sophisticated task is intended to be used for future evaluation. Possible tasks include the manipulation of small parts or vertices of an object's surface in order to align the surface to given control points or exact positioning tasks in which neither occlusion or collision cues could influence the performance. Additionally, with accurate tracking methods and a more substantial training for the participants, the evaluation task performance regarding time needed for selection could be used to quantify the influence of the proposed visualizations. Currently, the developed prototype is being adapted for usage with the Leap Motion (Leap Motion 2013), which promises to deliver far better tracking accuracy but also requires a very different system setup. Regarding the visualization, mainly two issues are subject to further improvements. One of the most prominent complaints about the visualizations, especially the Depth-of-Field and Color Perspective, was related to the limited possibilities for the user to orient themselves in the scene. Although the proposed techniques were used to support selection tasks, they interfere with orientation and navigation tasks. When entering the virtual environment, users first need to orient themselves. In this phase, the proposed artificial depth cues did receive negative feedback because users were not able to immediately gain an overview of the complete scene. Therefore, the possibility to activate and deactivate the visualizations depending on the current task or interaction context is necessary. The most promising solution is to restrain the Depth-of-Field and Color Perspective effects to the area nearby the virtual hand only, similar to the Crepuscular Rays, which only affects the direct surroundings of the user's hand position. The second issue is related to the adaptation of the design of the proposed artificial depth cues. Subject to further optimizations is the reduction of the intensity of the visualizations in order to produce more subtle effects. Future research directions also include the exploration of additional options for depth visualization and variations of the proposed concepts.

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ON "WORLD CONSTRUCTION", VARIATION "DUODDARIS"

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Keywords: Artistic Intervention, Sound Art, Environmental Art, Field Recording, Audio Analysis, Audio Synthesis, Music Information Retrieval

The title of this contribution refers to a series of four sound-based artistic interventions realized in the crude landscape of the Finnish tundra. By analyzing the natural soundscape, digitally recreating constitutive elements thereof, and projecting those back into the environment using portable loudspeakers, a tilt of the natural setting was created, potentially altering and elevating the attendees' experience of the scenery. The artistic concept and the practical approach as well as the diverse technologies used for the development and realization of the pieces are explained in detail.

1. INTRODUCTION

The Finnish Bioart Society[1] organizes the Ars Bioarctica Residency Program together with the Kilpisjärvi Biological Station of the University of Helsinki,[2] situated in the northwesternmost part of Finland. I was invited to conduct my proposed project of artistic and scientific research for two weeks in July 2013. The residency guesthouse is located by the lake, a few kilometers north of the village, providing convenient access to the region north of the Saana fell up to the border to Norway, spanning an area of about 1.5×2 km (see the map in Fig. 1). Although the predominant tundra landscape looks barren on map scale, there is a fascinating diversity and richness of smaller scale features, moors, cataracts, lakes, etc., inhabited by specific animals and plants, such as birds like Plovers and the Lapland Longspur, different types of mosquitos, and various species of flowers, most noticeable bellflowers and cotton grass. Any such area is also distinguished by a characteristic soundscape – a specific combination of bird vocalizations, insect buzzing, and noises caused by water and wind.

The original residency agenda was formulated as an 'Inquiry into textural structures of nature by means of sound'.[3] During the duration of the stay this intended research stemming from previous publications on textural and environmental sounds (Grill 2010, Grill *et al* 2011, Grill and Flexer 2012) became more and more shifted towards a profound occupation with the analysis of listening situations in the field and adequate interaction with the various habitats' soundscapes.

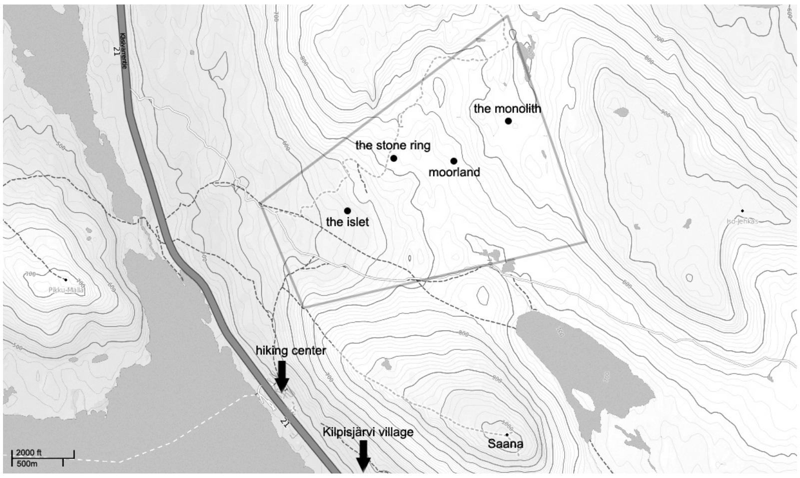

Fig. 1 Map of focus region north of the village of Kilpisjärvi, Finland along with marks for the sites of the artistic interventions. Map data courtesy of OpenStreetMap contributors, licensed CC BY-SA.

1 *http://bioartsociety.fi/1-2*, accessed 2014 04 16

2 *http://www.helsinki.fi/kilpis/english*, accessed 2014 04 16

3 See the project page at *http://grrrr.org/arts/projects/ars_bioarctica-2013*, accessed 2014 04 16

My ongoing series of sound compositions and installations, *world construction*,[4] is an expression of my appreciation of the sounding world. Orbiting around field recordings, their analysis, deconstruction, and later reconstruction and staging, the series provides the conceptual framing to work on-site, to sample, take apart, derive and re-implant sounds of interest. Its variation *duoddaris*,[5] to be described in the following, builds on this fundament to frame four characteristic spots in the tundra, bringing forward specific aspects of their sonic properties, and in each case, creating a well-defined listening space directly on-site. It is an attempt to feature *concrete*[6] and synthetically derived sound where it is alive and in proper context – not in a concert venue, not in a white cube gallery, or any other *general* site, but at a very *concrete* place, and put it right among all the related and corresponding sounds and other sensuous impressions that make up a truly holistic experience – including vision, touch and scent.

The structure of this contribution is as follows: After referring to conceptual underpinnings and artistic precursors of the project at hand in Section 2, I outline the technical and artistic methods employed in Section 3. Section 4 describes in short the four artistic interventions developed and carried out, followed by a conclusion and outlook in Section 5.

2. RELATED WORK

A number of my artistic projects to date, and particularly those of the *world construction* series, have dealt explicitly with the notion and phenomenon of the *soundscape*, a term devised by Raymond Murray Schafer (Schafer 1977), which relates to an environment created by sounds. Schafer also created the term *soundmark*, derived from *landmark*, referring to sounds that are constitutive for an area. Sounds that are in the foreground, therefore listened to consciously, he termed *sound signals*. The identification and analysis of those key sounds can be seen at the core of the project at hand (cf. also the *hearing perspective* of Sam Auinger and Bruce Odland[7]). Clearly, and proven in practice, surveying the diverse soundscapes of a complex environment and discovering constitutive elements requires a considerable amount of exploration, and associates the act of *walking* to an "active engagement with [the] environment" (cf. Harris 2011,

4 *http://grrrr.org/arts/projects/wcon*, accessed 2014 04 1

5 Northern Sami language for 'in the (arctic) mountains', Finnish 'tunturissa'

6 That is, recorded sound (cf. Schaeffer 1952)

7 *http://www.o-a.info/background/hearperspec.htm*, accessed 2014 04 16

Section 3.4). This is true not only for the artist, but equally so for the audience, forced to hike out to remote spots, to take part in the interventions. In Schafer's long-term opera project *Patria*, the epilog *And Wolf Shall Inherit the Moon* "takes the form of an elaborate ritual performance in wilderness forest, lasts for eight days. The same participants return each year to camp in eight clans at four campsites,"[8] thus requiring a real commitment of the audience. This collective experience also "represents a serious attempt at a renewal of the social function of music […]" (Dunn 2008), as also exemplified by Hildegard Westerkamps *soundwalking* practice (Westerkamp 1974), concerted "excursion[s] whose main purpose is listening to the environment," just as it is. The headphone-based *audio walks* of Janet Cardiff on the other hand, examine how the perception of the reality is affected when the character of characteristic sounds is manipulated and changed.[9] The compositions *Five Micro-Worlds* of David Dunn deal with microscopic sounds that are not audible to humans without the aid of special recording devices. Dunn sees his role as a composer as to "bring forth the sonic presence of these worlds for human contemplation […]" because "our modern 20th-century culture […] tends to privilege our understanding of reality through our sense of sight." The addressed sensitivity regarding the constitution of the sonic environment is in the focus of the discipline of *acoustic ecology* promoted by the *World Soundscape Project*.[10]

The project at hand consults concepts and technologies from a few works I have realized in the past: The interactive audiovisual installation *1/space* (Grill *et al* 2011) employs texture analysis techniques in both the visual and sonic domain to create an immersive artificial environment in the presentation space from image and sound snippets picked up at a remote place. *Mimikry*,[11] on the other hand, uses sound and image processing to let technology blend seamlessly (as much as possible) into the surrounding scenery. The electroacoustic composition *Points of View*,[12] produced for a 3D surround sound system creates an immersive sound environment by using a variety of mostly textural concrete sounds, and counterfeits thereof, generated by audio synthesis techniques.

8 *http://www.patria.org/pdp/ORDER/OVERVIEW.HTM*, accessed 2014 04 16

9 See concept for part 1 of the 1997 Münster walk at *http://www.lwl.org/skulptur-projekte-download/muenster/97/cardif/k_01.htm*, 2014 04 16

10 *http://www.sfu.ca/~truax/wsp.html*, accessed 2014 04 16

11 *http://grrrr.org/arts/projects/mimikry*, accessed 2014 04 16

12 *http://grrrr.org/arts/projects/points_of_view*, accessed 2014 04 16

3. METHOD

The discussed artwork intervenes in chosen habitats' soundscapes. The initial hypothesis was that the change of a key sonic constituent – even if subtle – could bring about an amplified experience of a listener with the site, with what is happening in and to its soundscape, probably detecting some subtleties of the soundscape for the first time. This was the primary motivation of this work, and of the overarching series *world construction*.

The chosen process was to first analyze the specific *voice* of a site and identify the most salient contribution(s), be it of animal, herbal or geologic origin. A recreation and interpretation thereof was produced by use of software-based audio synthesis, to be later reintroduced to the same site, using portable loudspeakers. Note, that there was no actual stipulated *workflow* in the first place, since my way of working with media is characterized by a perpetual moving to and fro between concept, sketch board and various stages of realization, until finally arriving at something presentable which will at later stages again be revised or recycled – inherently differing to what is reported here after the fact.

3.1. SAMPLING

The original intent of the residency was to record and analyze environmental sounds, much as a biologist or geologist would sample the nature she or he researches. But more than ever before when prospecting for sounds, it quickly came to my mind that those sonic expressions of nature I discovered are really only kept alive and meaningful in the context of their habitat. The noises of the Tundra are very subtle. Recordings thereof mean almost nothing without an idea of the spatial relationships of the scene, or without some knowledge of how those sounding elements appear altogether. Accordingly, I changed my intentions so that the sampling process turned more into surveying than harvesting the sounds, into apprehending the characteristics of the various soundscapes and capturing sounds only for their later recreation, not for verbatim use. Consequently, I chose to use a portable audio recorder (Sony PCM-D50), relying on its built-in electret microphones in A-B configuration and a standard wind protection. Documentation with a digital camera with automatic geo-tagging and taking additional notes about the configuration of the sites proved indispensable for not losing track of the amassment of material accumulating in the course of three days of intense fieldwork. I recorded several hours of audio material at about 15 different spots.

3.2. SURVEYING AND ANALYZING

Surveying hour-long audio recordings by listening is a tiresome affair. There do, however, exist tools, which can, e.g., automatically reveal the structure of the audio or provide visual representations at various time scales. I regularly use techniques of my own development (originally for the annotation of electroacoustic music, published in Klien *et al* 2012): One is a segmentation technique based on textural properties of sound – timbre and amplitude fluctuations. Based on the self-similarity of short audio segments, the algorithm identifies the extent of homogeneous parts, points of change and parts that are similar to each other – information that can be used to efficiently browse through a long recording. The second technique visualizes the distribution of textural characteristics within a piece of audio by *clustering* short segments in two-dimensional space, using additional color-coding for the time dimension. This representation allows identifying whether sounds occur throughout a recording, or only at specific points in time, and it can be seen how they relate to each other (verbatim copies, variations, or something completely different). For studying various standard low or high-level features of the audio, the *Sonic Visualiser* software comes in handy as a very versatile software tool.

3.3. MODELING

As suggested by the concept, the recreation of *key sounds* – constitutive for soundscapes at the selected sites – is at the core of this project. The elemental forces of Lapland's land- and soundscape are water, wind, birds and mosquitos (apart from reindeer and humans which have not been considered) in various formings. For such general and widespread sound characters a large number of recipes can be found in the web, employing two fundamentally different approaches: A phenomenological one, trying to imitate the quality of the emerging sound using standard sound effects e.g. on typical DAW systems, or, the use of *physical modeling* techniques that implement the underlying mechanics of physical sound production, typically requiring programmable audio synthesis systems like *Pure Data*, *Max*, or *Supercollider*. Both approaches have their merits, much depending on the actual target sound: the former approach is usually easier to implement with just a few influencing parameters, provided that the sound character can be met at all. The latter approach requires in-depth understanding of the physics involved, but can result in much more complex and multifaceted sonic results. For the project at hand both approaches were used, see Section 4 for respective details. In every case, an existing recipe was adopted, but then extended and modified for the use case. Physical modeling as used for water and bird sounds relied on code conceived and exemplarily conveyed by Andy Farnell (Farnell 2010). These synthesis algorithms were implemented as monophonic voices into the Pure Data–based framework of my *Universal Polyphonic Player*[13] software. This system allows the convenient generation and control of simultaneous voice events as well as the spatialization to multichannel (in this case four-channel) speaker setups.

3.4. STAGING

The importance of the presentation setting for loudspeaker-based sound art is considerable. For the project at hand, inevitable technology for the reproduction of digital sounds is in stark contrast to the largely untouched natural environment. I used four portable loudspeakers with built-in MP3 players (see Figure 2) that I built for a previous instance of the *world construction* series, variation *corner passing*.[14]

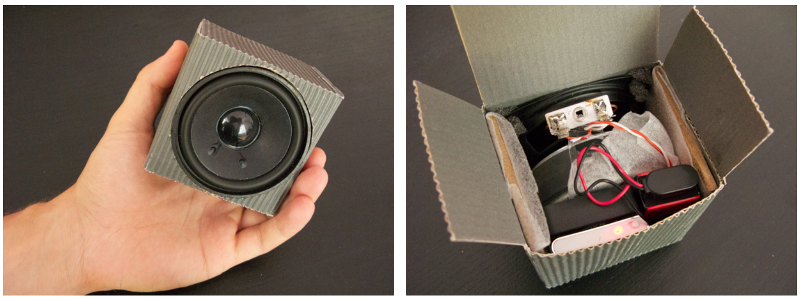

Fig. 2 Portable loudspeaker, closed (l.h.s.), and opened (r.h.s.), showing the transducer, amplifier, MP3 player, 9V battery, and stabilizing and damping materials.

Since these loudspeakers can blend very well into the landscape and don't need any extra audio or power cabling, they allow spanning a listening space of variable size which is hardly recognizable by anything else than the broadcasted sound. Each of the loudspeaker

13 *http://grrrr.org/research/software/upp*, accessed 2014 04 16

14 *http://grrrr.org/arts/projects/wcon/wcon-1*, accessed 2014 04 16 boxes contains a Roadstar MPS 020 MP3 player with a rechargeable lithium polymer battery, connected to a Kemo M031N 3.5 Watt integrated amplifier module, powered by a 9–Volt battery block. The transducers used are Visaton FRS 8 M broadband speakers, capable of delivering considerable loudness for frequencies above about 120 Hertz. Both the MP3 player's battery and a 9–Volt alkaline block last for about 15 hours of playing time at practical volume. The components are encased in 8×8×8 cm cardboard boxes using some foam stuffing to limit unwanted rattling noises at bass frequencies. The audio material was also high-pass filtered at the low corner frequency to avoid unnecessary vibration at inaudible frequencies.

In my personal artistic practice concealing technology responsible for sound presentation is not a general strategy. In fact, the loudspeaker cubes can take on various roles, e.g. also as hand-held personal audio devices, much dependent on the space and performance context. For variation *duoddaris*, the creation of an unobstructed intimate atmosphere was a goal, with a spotlight on the available unprocessed and processed natural sounds. The loudspeakers serve for framing the scenery in space and time within a quasi-boundless nature, spanning an invisible stage for the augmented soundscape.

4. IMPLEMENTATION

The primary dissemination of the artistic residency was in the form of four half-hour long sound interventions on the weekend of July 27th and 28th 2013. The scheduled times were determined so as to match the daytime of the scenery as originally captured, with the first event set for 11:30pm until midnight. Unfortunately, the weather throughout most of the residency was fairly unpredictable. Since fairly dry weather was a requirement for the operation of the loudspeaker boxes, the first event had to be postponed for two days, and one event had to be cancelled.

4.1. "FLOWING" AT THE "MONOLITH", ORIGINALLY SCHEDULED FOR JULY 27 2013, 11:30PM, POSTPONED TO JULY 29, SAME TIME

The *monolith* is a rock cube of about 30 cm side length placed solitarily on a larger slab of rock, located at an exposed plateau at the position 69.0715° N, 20.8568° E. At midnight, this is quite a spectacular site, with low reddish light from the midnight sun and streams of low clouds passing through, often partially covering the site. The chosen title *flowing* refers to that strong experience of being in the midst of a horizontal reddish gray light and airflow. The artistic intervention at this spot should correspond to the wind sounds occurring at this exposed position and also match the strength of the natural signs. I opted for a fixed composition of interwoven streams of noise, over the thirty minutes duration developing from a contained beginning to a more and more extroverted and voluminous irradiation of noise. Just as freestanding boulders have forever been used as orientation signs by the nomadic reindeer herders, the noise beacon was meant to fulfill a similar broadcast function. The composition was prepared using standard editing software, with parameter automation for time-dependent attenuation, filtering, and positioning in the surround field, all applied to synthetic white noise. The color of the noise streams and their musical timing regarding the development and spatial motion was derived from the initial field sampling.

4.2. SOURCING AT THE STONE RING, JULY 28 2013, 9AM

The *stone ring* is a ring-shaped assembly of boulders with a grass patch at its center (see Figure 3, l.h.s.), found at the foot of a terrace, located at 69.0682° N, 20.8283° E. Typically, such boulder fields are interspersed with small – and often invisible – streams of water, causing a resonant gurgling and dripping in the cavities in between the rocks. The stone ring is sourced by a small greenish spring, but the little water it provides immediately drains away in the periphery of the boulder assembly, not to be seen or heard again. My intervention *sourcing* gives a voice to the waters present underneath this particular stone ring, paying tribute to the omnipresent geological and biological activity that is often subtle and comes to appearance only through particular attention. The stage for the sounds is below the surface, spread among the numerous voids, the audience space situated above the ring. The loudspeakers were placed more or less invisibly in the available holes so that the sound would resonate in the cavities, emerging to the surface in a diffuse manner. Since the imagined waters were supposed to be scarce, I opted for a sonification resembling drops rather than flowing water. Starting out with Farnell's tutorial on water bubbles,[15] I found that – guided by the sounds sam-

15 *http://www.obiwannabe.co.uk/tutorials/html/tutorial_bubbles.html*, accessed 2014 04 16 pled at similar sites nearby – a constant pitch (just a sine tone, modulated by a logarithmic attack-decay volume envelope) works equally well, if the individual droplets are assigned slightly varying pitches. Each of the represented water sources (embodied by the four individual loudspeakers) was given an individual character, realized using different parameters for Gaussian distributions of pitch and volume, respectively. For the rate of droplets Farnell's method was kept: a simple algorithm causes the naturalistic formation of droplet groups at different repetition rates.

Fig. 3 The *stone ring* (l.h.s.) and loudspeaker placed between the boulders (r.h.s.).

4.3. "FORMATION FLIGHT" AT THE "ISLET", JULY 28 2013, 3:30PM

A warm and windless humid afternoon near some calm water is usually the best constellation for the experience of mosquitos, an important and importunate ingredient of the tundra fauna and soundscape. The *islet*, discovered at coordinates 69.0633° N, 20.8172° E, an oval-shaped swampy grass patch enclosed by two branches of a small stream, offers near to perfect mosquito dwelling conditions. The intervention *formation flight* seeks to embrace nature and all its expressions in its entirety, also including seemingly troublesome components. It is conceived as a composed chant of many contributing voices, in the course of its half-hour duration transforming mosquitos' characteristic high-pitched buzz sounds – by many perceived as pestering – into an enjoyable, almost jubilant choir, towards the end returning back to their authentic tune. This piece is also a reference to the practice of *joiking*, a traditional Sami form of singing, often dedicated and directed to a landscape or animals living therein. The underlying artificial buzz sounds were produced by adopting a recipe[16] dependent on *Ableton Live* software, involving a filtered and modulated saw tooth-type wave-

16 *http://www.youtube.com/watch?v=6mSFHoHJJ3Q*, accessed 2014 04 16 form generator. Again, different voice characters were defined, representing individual insects. This intervention was implemented using quadrophonic loudspeaker positioning, with insect flight trajectories crossing and orbiting around the islet.

4.4. "LOCALIZING/VOCALIZING" AT "MOORLAND", INITIALLY SCHEDULED FOR JULY 28 2013, 7PM, FINALLY CANCELLED BECAUSE OF HOSTILE WEATHER CONDITIONS

The fourth intervention was dedicated to the *European Golden Plover* (*Pluvialis apricaria*), a middle-sized bird breeding in dry open areas of moorland, such as at 69.0680° N, 20.8434° E. Their call is a very typical, simple and hardly modulated tone produced at regular intervals, audible from large distances.[17] The birds seem very curious, keeping a certain distance by moving on the ground, always observant and signaling their presence. Two or three birds could often be witnessed in the same area, with their calls – at slightly different pitches – superposing to a slow multi-rhythmic pattern. The concept of this intervention dealt with the expanse of the landscape, with life forms claiming their specific share, and negotiating with their cohabitants, focusing on the plover birds. Their call was cloned using a modified general recipe for bird vocalizations.[18] The algorithm is a model of a bird's syrinx, involving three oscillators influencing each other and a couple of other parameters controlling the audio synthesis. Several presets are provided which can serve as a starting point for matching the resulting synthetic calls to the recorded ones. I arrived at calls (again slightly different variations for the four loudspeakers) that feature the characteristic properties of the plovers' calls, while lacking some detail (e.g. the sharp onset transient of some birds' calls) and thus being recognizable as artificial. Human attendees of the intervention would take on the role of a bird by holding one of the loudspeakers, rambling in the wide-stretched moorland area and claiming their lot by emitting characteristic calls. This strategy of distributed roles, with participants spanning a large space by broadcasting audio signals to each other was already applied before in *world construction*, variation *corner passing*. I have created an artistic rendering illustrating this site's soundscape for presentation purposes, blending original recordings and synthetic complements.[19]

17 See *http://www.xeno-canto.org/species/Pluvialis-apricaria*, accessed 2014 04 16

18 *http://grrrr.org/arts/projects/points_of_view*, accessed 2014 04 16

19 *https://soundcloud.com/grrrr_org/in-the-field*, accessed 2014 04 16

5. CONCLUSION AND OUTLOOK

This contribution presented both the artistic motives as well as the technical implementation of the four sound interventions under the title *world construction*, variation *duoddaris*. The concept supporting this series of interventions translates and liberates the experience of sound and its context from an artificial, fixed performance space to primordial sites in a wide open and largely untouched landscape. The presented media is the already present natural soundscape, but slightly tilted and shifted through a conditioning of its constitutive elements, potentially triggering an altered perception of the natural scenery. On a meta-level, the artwork draws on the widespread desire for a "reaffirmation of our connectedness to wilderness" (cf. Dunn 1988), but it does so in a radically different way than, e.g., a *Discovery Channel* TV format, by demanding immediate participation and immersion into the media and its origin, both for the audience and the producer. Other aspects relating to a post-TV notion are, e.g., the integration of different media data (sound, image, geolocation) into the production, the anchoring of synthetic media content in a semantically charged natural environment, and a strong personalization due to audience participation.

The series *world construction* will be continued with more variations on the basis of the described conceptual framework. Variation *Empty Vessel*,[20] concerned with the soundscape of an urban neighborhood resonating in a large industrial hall, was presented as a multi-channel sound installation at *The May Space* in New Orleans, USA, from October 11th to November 23rd, 2013.

ACKNOWLEDGEMENTS

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20 *http://grrrr.org/arts/projects/wcon/wcon-3*, accessed 2014 04 16

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A MOTION-BASED APPROACH TO ANALYSIS, NOTATION AND CREATION OF HINDUSTANI MUSIC

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Performers of Hindustani Classical Music depend heavily on complex models of motion and movement to elaborate melodic ideas through hand gestures and motion metaphors. Despite advances in computational modeling of grammars that govern the elaboration of a raga, these systems run into difficulties because of the nature of pitch systems in computer programs and in performance. We elaborate the problems with trying to obtain the ideas in a flexible-pitch scheme like HCM through the means of a fixed-pitch scheme-like notation and computer music generation. In this paper, we present some experiments to study the effectiveness of a graphical notation scheme in HCM, sound tracing study and an analysis of the terminology used for ornaments – through which to understand motion in HCM. We plan to analyze them computationally to develop a formalism that would be more suitable to the nuances of HCM than the present schemes.

1. INTRODUCTION

Hindustani Classical Music (HCM) typically features a main melodic instrument or voice, and a percussionist. The performances in HCM are centered on the idea of a *raga*, which is a form of melodic abstraction that lies between a scale and a fixed melody (Srinivasamurthy *et al.*, 2011). A *raga* is most easily explained as a collection of melodic motives, and a grammar for expanding smaller pieces into large improvised works. This happens in the framework of a *bandish* or a fixed composition that is based in a hypermetric cycle called as a *taala*. A theme based on a raga is established in a *bandish*, elaborated through the sung octave and improvisation in various forms such as theme and variation, slow and fast elaboration, syncopation and rhythmic play etc is presented in the duration of a performance. The semantic content of a *bandish* can be varied, as well as the thematic properties of different *bandishes* in the same raga, but the fundamental grammar of the raga has to be intact in classical music.

1.1. DEFINITION OF A RAGA

A raga is sometimes compared to a mode in music, although the primary difference is in the elaboration of notes. A raga is always centered on a tonic note or a key center, and one cannot modulate to another key or escape from this central tonic note. A raga typically consists of a selection of between 5 and 8 notes from the scale of 12, making it more like a mode – but the movement between these notes and the allowable phrases are what distinguishes a raga form from a mode.

Although the concept of melodic structures and fixed melodic schemes seems limiting to the concept of improvisation – which is central to HCM, a raga is expounded by performers with various elaborate techniques, thus escaping cliché.

1.2. PERFORMANCE OF A RAGA

HCM is performed with elaborate visualization and gesturing by vocalists. The idea of multimodal associations with musical objects is central to the learning and performance of HCM. Performers and singers often teach with the help of elaborate instructions regarding the mood of the raga, explaining its nature and behavior in terms of the mood, while sometimes attributing personality types or characteristics to the raga.

Some examples of the types of hand gestures used can be seen in Fig. 1. We can see that singers sometimes trace out the phrases that they sing, sometimes display the positioning of these phrases as being located in different places around the body, and sometimes maneuver melodic objects as if they were real objects that they could pick up and use.

Fig. 1 Examples of gesturing during performance of Hindustani Music

1.3. CONCEPT OF NOTE, SEPARATING SPACE BETWEEN RAGAS

Hindustani music is based on 22 microtonal intervals, also called *shruti*. Twelve of these are abstracted to form a scale that is quite close to the just intonation system in Western music. Although ragas are based on these 12 notes and the intervals, practically it is more common for a vocalist to move between pitches freely and render the inter-tonal spaces carefully. Despite the relative flexibility of tones, there is still a definite grammar for pitches and pitch transitions. Thus, what is more important in a performance of HCM is not the intervals themselves, but the spaces between these intervals. Performers often use concepts such as the approach towards the note, the release of it, and so forth, without which a raga does not come to life even though the sung notes may all be correct.

Written notation is still frowned upon by several performers of HCM for the reason that there is no way to represent many of these motion categories in the existing notation system.

For a form that is in its entirety based on the idea of inter-tonal motion, specifying discrete notes becomes a level of abstraction. A form of notation with only discrete pitches is a reduction of HCM. We investigate these intertonal motions with the help of performer gestures and their body movements.

2. INNATENESS OF VISUAL MODELS IN HCM

2.1. PERFORMANCE GESTURES

Gesturing almost always accompanies musical performances. Although the use of gestures is so common, these gestures are neither taught nor formally learnt, and do not get any attention in study. Performers learn these gestures simply from getting familiar with the gestures of their teachers and fellow performers. Students of HCM rely on live interaction and observation of their teacher for learning. In this discussion we are referring to physical gestures, which occur side by side with the music in a performance and are involuntary.

The shapes that are drawn by these hand gestures might have close connections with the musical shapes and patterns that the performers are modeling in their minds. This has been investigated in Rahaim (2010) and Clayton (2008). Performers describe thinking in terms of patterns or shapes rather than notes while improvising or performing. A lot of the gestural vocabulary is directly taken from the guru, and the student imbibes the gestures of the guru's body as their own so as to sing like them. However, there is variability in the amount of gestural use. Some singers represent each melodic figure with their hands, while others use their torso and head, while some others gesticulate minimally.

We investigate these melodic shapes and the characteristics of motion, through which we can arrive at simpler basic units that might explain a raga performance through other schemes than notes and note transitions. This might help us move past the problem of computer-generated HCM phrases that sound mechanical and unnatural.

3. AI MODELS AND THEIR APPLICABILITY TO HCM

3.1. HCM NOTATION

In early 20th century, Dr V. N. Bhatkhande developed his own system of notation and archived hundreds of compositions in hundreds of ragas. His notation system was influenced by western classical notation, incorporating the ideas of barlines, note names, text written underneath, slurs and so forth. Fig. 2 is an example of a composition written in this notation scheme. This is the notation style most commonly used to write compositions from HCM today. As Bhatkhande's work is the first authoritative written source for obtaining data for HCM, it is a natural source to use for creating computer models of ragas.

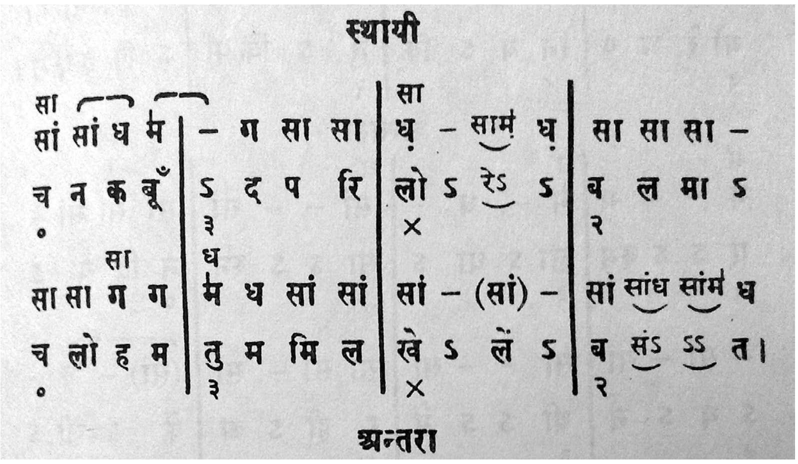
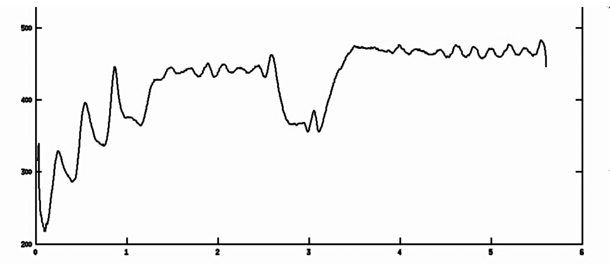


Fig. 2 Example of notation in Bhatkhande's system

3.2. REQUIREMENT OF FLEXIBLE PITCH BASED NOTATION



Ga Ma Dha Ni -
Dha Sa - - -

Fig. 3(a) 3(b) Visualization of pitch data. Fig 3 (a) shows a pitch tracing vs time of the phrase that is written down in notation form in Fig 3 (b).

Although this notation scheme seems fairly straightforward even from the perspective of ragas and their descriptions, when musical phrases for HCM are analyzed for pitch, we get data that looks much less obvious like discrete notes than the notation style suggests. This is because flexible pitch schemes are widely used to sing and perform in HCM. It is implied that discrete notes need to be connected or tied together by using the spaces in between.

3.3. GENERATIVE MODELS OF HCM

There are several models that have tried to simulate generative grammars in HCM by training machines to recognize note patterns, or treating note groups as words and making generative-grammar-like systems for ragas in HCM.

In Srinivasmurthy *et al.* (2012), a scheme to generate valid HCM phrases via Multiple Viewpoint Markov models (MVMs) is elaborated to elicit the grammar that governs a raga. The database is taken from Bhatkhande's notated *bandishes* in various ragas. MVMs allow a computer to construct phrases that are not limited by their length, and due to this limitation, all possible phrases can never be found. Based on the data, instances of phrase that are true to the grammar of the four ragas in the purview of the study were extracted through MVMs.

Despite this, the extrapolated phrases have not been validated against listeners / performers of HCM, or for the ability of the machine to make its phrases sound natural. *Bandishes* that form the database in this study are extracted from Bhatkhande's corpus, which itself only includes the notation system described above, and excludes the inter-tonal spaces and motion content from music. Notes are abstracted into midi-type data points, and then processed. Since much of computer music is written and processed keeping in mind the basic building unit of a fixed frequency to begin with, even if the generated phrases come very close to actual phrases in music, those phrases will only sound somewhat natural.

We propose experiments to extract other forms of melodic ornaments and their associations with shape to elaborate on the idea of a computational model that goes beyond discrete pitches.

4. EXTRACTING SHAPE OF FUNDAMENTAL ORNAMENTS

4.1. TERMS INDICATING MOTION METAPHORS

There are several terms in HCM that are used directly to represent certain kinds of musical movements. Many of these represent ornaments that are sung. It is important to remember that these ornaments do not just serve the purpose of filling out space between notes, but are crucial for note transitions between ragas. In Table 1, we present a list of such words and the motion meanings they incorporate.

NAME	MEANING	STYLE OF PERFORMANCE
Khatka	Sudden force	Force on one note with pressure, and complete the ornamentation
Ghaseet	Drag	Drag the power of one note into others
Sapaat Taan	Flat speedy notes	Notes are strung one after another rather than threading through other notes
Samet	Gather	An improvised phrase is gathered and finished quickly to meet with the tala cycle
Vajan	Weight	A note that is sung with weight
Gumfit	Tied	Notes weave into each other
Andolit	Oscillating	As if the note is swinging, without a fixed intonation
Pakad	To Hold	The phrase which enables you to have a hold on the raga
Chal / Achal Swar	Walking / Steady note	Fixed notes don't have accidentals (tonic and the fifth)
Golai	Roundness	Smoothness in transitioning between notes / legato

Table 1 Words implying motion in music

The songs/*bandishes* sung in HCM often come from a collective database of *bandishes* set traditionally by older musicians, and unless the name of the musician appears in the last line of the piece, the composer is unknown. Even a known composition will have traveled multiple generations thus obscuring or enhancing the composer's intentions.

If ornaments form a part of the music separate from the notes themselves, then they could be freely applied depending on the performer's choices and their artistic voice. This however is not the case: the raga grammar and *gharana*, or the family of music that a performer comes from, determine the ornamentation and the phrases that are legal at different note points in the octave.

The term "Raga Topology" has been used to describe this kind of motional aspects of raga. (Clayton, 2008) This refers to the behavior of raga resembling a physical scheme. If we are able to extrapolate such a topology through gestural studies, then we can model raga in terms of its physical behaviors regarding note values. This means that fixed notes get fixed patterns and qualities of motion such as 'gravity', 'touch', 'strike' etc., which are elaborately described in theoretical works.

4.2. NOTATION USABILITY OF PITCH DATA – BASED GRAPHICAL NOTATION SCHEME

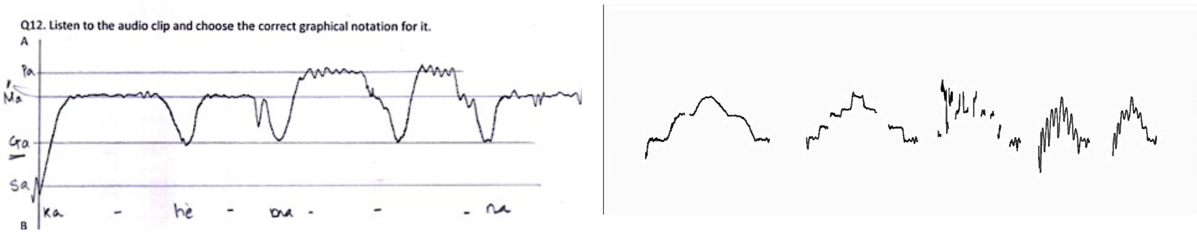
Meer *et al.* (2010) elaborate a scheme of notation system based on pitch movements through time. Their project emphasizes the need for a new kind of notation system that clearly represent pitch transitions. Despite the difficulties in making melograms from recorded music due to the overlapping of different instruments, lack of clarity and differences in intensity, the melogram system surely contains far more information than plain notation. This scheme comes closest to graphical notation.

This notation system is one of many modifications proposed by modern musicologists to better include ornaments specific to Indian music. Some other examples can be illustrated in Magriel (2008) and Bor, J (2002). Many musicologists also prefer to simply use Western notation where a lot more granularity can be represented than just in Bhatkhande type notation as seen in Jairazbhoy (1995).

We conducted an experiment to see the applicability of using actual pitch vs time representation in notation form to find out whether non-expert participants understand these visualizations any better than written notation which doesn't contain graphical information.

We studied this in the form of an identification and recognition task with 24 participants, of mixed genders, all of whom were musically inclined or trained. They were given a day to learn both types of notation systems. An example of the type of questions asked is illustrated in Fig. 4 (a). Fig. 4 (b) illustrates five sung renditions of a musical phrase in melograph notation. All five would be written in the same way in the Bhatkhande style.

Fig. 4(a) Example question from the notation test **Fig. 4(b)** Examples of melographs analyzed for 5 different articulation types. All 5 of these would be written exactly the same way with traditional notation.



4.3. SOUND TRACING STUDIES

Sound Tracing is a method to study motion that has been applied both in Western and Indian musical systems. Tracing sounds and sound objects can also be a direct clue to multimodal mappings as studied in both language and co-verbal gesture (Johnson, 1987; Johnson and Larso, 2003, Lakoff and Johnson, 1980). More recent studies focus on obtaining tracings of musical / sound objects from participants for specific stimuli. These experiments have been done for tracings of sound objects (Godoy *et al*, 2010; Jensenius 2010).

This study aims to further these findings by applying similar principles on sound tracing studies in HCM. Formal theory of melody in Indian music appears across many texts, especially in Abhinavagupta's and Bharatamuni's writings. Features for identifying musical characteristics and analyzing differences between notes have been described in various ways, starting with: a) intonation specifics, b) *jati* of a raga, specifying the characteristics of notes used, their weight and texture, and finally according to the theory of melody, which divides all possible melodic phrases into 4 categories or four *varnas*. Hereafter the rules for combinations of such phrases are described (Rowell, L., 1981)

Table 2 Four Phrase types chosen for experim

Aarohi	These are phrases that ascend from one note to another as prescribed in the raga transition
Avarohi	These are phrases that descend from one note to another as prescribed in the raga transition
Sthyayi	These are phrases that hover around a stationary point in the melodic frame
Sanchari	These are phrases that have a mixture of the three phrase styles

The tracings were recorded on a WACOM Digital Tablet. Each stimulus was played twice with a white noise mask between the two stimuli. We created 32 stimuli mixed across 4 raga groups and 4 phrase types. 2 types of articulations were used: Flat and Gamak. All stimuli were vocal renditions between 4 and 6 seconds. 8 additional stimuli were added at the end of these 32.

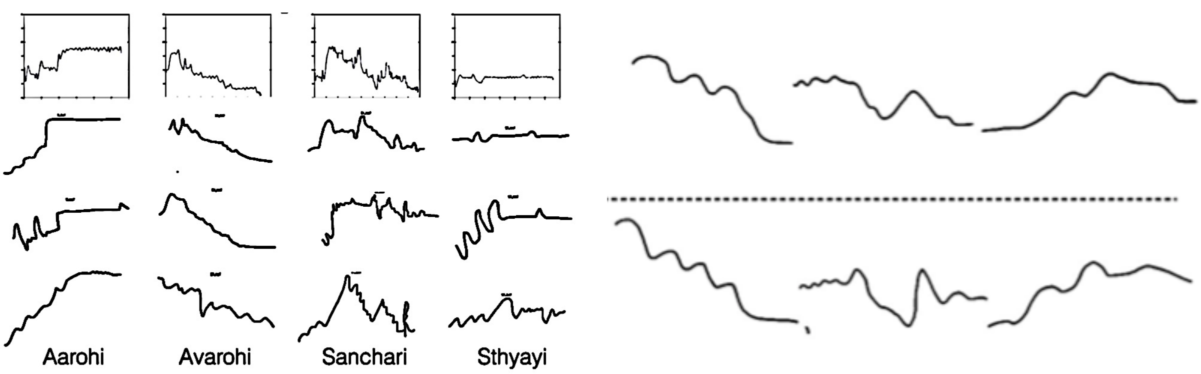


Fig. 5(a) Comparison of pitch with tracings of 3 participants for 4 categories **Fig. 5(b)** Repeated tracings.

5. RESULTS AND CONCLUSIONS

5.1. USABILITY OF NOTATION SYSTEM

The average score for trained and untrained participants for Graphical notation reading was found to be 14.36 (out of 20 points) (std. dev. 5.44), and the average score for Bhatkhande system was found to be 13.305 (std. dev. 4.00). This suggests that it was not significantly easier for the participants to identify pitch-time-based notation as opposed to Bhatkhande system of notation, although pitch-time notation is graphical. An explanation for this could be found in the sound tracing study, where the overall envelope of the melodic phrase depended not just on the pitch at each time interval, but also on the meta-level relationships between pitch, amplitude. Moreover, the local perception of pitch at each different point in the long phrase was found to contribute significantly to the phrase shape.

5.2. LOCAL-GROUP SCHEME, TEXTURAL REPRESENTATION IN TRACINGS

In the experiment for sound tracing, we found that what works most accurately for trained as well as untrained participants is a local idea of shape. Tracings are elaborated phrase by phrase, and the pitch distances drawn are relative to the current phrase rather than having an absolute position. This was consistent among all the participants. This might be the reason that a fixed pitch-time melograph does not correspond well with the mental representations. It was also found that texture or melodic articulation (Flat / Gamak) was drawn often in the tracings.

To classify the tracings into four phrase types, we fit a cubic spline function with 8 knots to the tracings to capture the overall contour. The tracings were normalized with respect to the maximum and the minimum stroke heights, and a randomized 10-fold cross validation was performed on the raw data. Then, a K-NN search using the city block metric as a distance measure was performed, selecting the best mode out of the top 11 results for each query.

We found an overall accuracy of 54%. The accuracies for individual phrases are shown in Table 4. Classification results for the first three categories are above random chance, suggesting that consistent mental models are used for these phrases. The categories Aarohi and Avarohi are found to be the most easily classifiable, as they have fixed spatial properties in the form of an overall ascending / descending envelope, while Sthyayi has fixed temporal properties and Sanchari is a mix of all three.

Table 3 Confusion matrix for classification of phrases

	Aarohi	Avarohi	Sanchari	Sthyayi
Aarohi	**81**	11	24	39
Avarohi	3	**63**	21	13
Sanchari	3	23	**41**	19
Sthyayi	11	1	12	**28**

5.3. CONSISTENCY OF MENTAL MODEL

We compared the repeated phrases for all participants and found several similarities in the corresponding tracings, regardless of whether they reported that this was a repeat or not. Eight out of 32 samples were repeated for each participant, chosen randomly, to analyze whether the tracing is similar – indicating consistency in mental imagery. We report an overall median correlation of 0.68, suggesting high similarity between traces and similarity in trace duration and span. Qualitative results for three phrases and corresponding repetitions for one participant are shown in Fig. 5 (b).

5.4. ORNAMENTS AS BUILDING BLOCKS OF HCM

We have elaborated melographs and sound tracing as methods of extracting information about phrase shapes, melodic forms and ornamentation types in HCM. These ideas of shape were used as basic building blocks to describe HCM in old treatises. We can use a similar method through phrase shape integration for making generative models for ragas in a way that is visually more intuitive, and more accurate in representing HCM than a fixed pitch model. An approach to making a more efficient graphical notation and analysis system can be found through these studies.

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THE AUGMENTED BUSHWALK: ADAPTATION IN CROSSMEDIA ECOLOGIES

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Contemplative interaction appears to be a misnomer; the term 'interaction' implies active engagement rather than quiet reflection. However, we are often engaged on multiple levels simultaneously, particularly inside complex systems. The bushwalk is an active engagement with the environment – a naturally occurring complex system – that occupies the body while the mind is adrift. Similarly, digital systems, such as games – artificially constructed complex systems – can induce a flow state in which actions become autonomic, occupying the mind while the body is at rest. This paper explores possible connections between these experiences, outlining a project that aims to blend the two via a technologically mediated bushwalk experience.

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1. INTRODUCTION

The bushwalk is a widely recognised ritual for contemplation in Australia. In indigenous culture this is highly structured; the 'walkabout' is a rite of passage lasting up to six months during which 'songlines' are traced, literally walking in the steps of their ancestors. Outside of Australia, the 'nature walk' is a common way to engage with the natural environment. While this activity may sometimes take place in a wilderness environment, more often than not, national parks are often managed or cultivated to an extent. Centuries of agriculture and the cultivation of gardens has shaped the natural environment in many ways. Although to players who have grown up in the digital forests and mountains of Azeroth as their wilderness, the local park may still be a wilderness worthy of exploration. More recently, land art and digital interventions into natural spaces have staged new relationships with the environment.

Games, both digital and otherwise, provide frameworks for the traversal of space, in conjunction with codes of behaviour for interaction. Games are defined by verbs and actions that define and stage an experience. They also can facilitate interaction via feedback, providing constraints on the experience through time, space or otherwise. Over the last decade, many games have been situated in mixed realities and we feel that this is a suitable space to explore contemplative interaction. A mixed reality game situates digital systems in an embedded context, shifting away from an isolated, hermetic space with discrete components. A mixed reality is an interconnected system of components in an environment made of many different materials: media, objects, people, actions and so on. It is a complex, experiential system that recognises that environments, such as cities, have their own algorithms and patterns with emergent properties and generative potential. Traversal is a key driver in all these contexts – the experience is generated by traversal through an environment, a game world, or a mixed reality. This paper discusses how this traversal can be augmented to stage contemplative interaction in a bushland environment.

In considering the bush as a site for recreation and with the increasing advancements of pervasive computing technologies to augment our physical environment with digital systems, we see new opportunities to create novel and playful experiences in this setting. Artist Perdita Phillips, known for her photographic, sound and installation work situated in remote parts of Australia has suggested that recent art practice has rarely engaged with these locations due to a lack of "techniques and possibilities that seem relevant to the contemporary" (2007). However in harnessing these technologies we intend to explore alternative ways of being in the bush and demonstrate how this may invite new perceptions and experiences in this setting.

2. THE BUSHWALK AS CONTEMPLATIVE INTERACTION IN AN IMMERSIVE ENVIRONMENT

This paper discusses traversal within a mixed reality, which places the player in an augmented reality (AR) through the exploration of a bushwalk. Walking has a rich cultural and social significance (Solnit 2001) although it has been suggested that its role within aesthetic practice is much less understood (Stalbaum 2011). With the often-cited psychogeography of Guy Debord (Tuters 2004), Dada and Surrealist art (Careri 2002) and the respective walking art of Bruce Nauman (Morrison-Bell 2012) and Stanley Brouwn (O'Rourke 2012) now being acknowledged as pre-cursors to contemporary practice in this area, an historical framework is developing. Urban interventions such as pervasive games, art installations and locative media projects informed by these precedents have received prominent attention (Borries et al 2007), however a relatively small but developing practice has also seen the traversal of non-urban environments ranging from the hiking tracks of British Columbia (Rueb 1999) to the expanses of Anza Borrego desert of Southern California (Stalbaum 2005) that are mediated through digital systems.

If walking is a specific cultural practice (Solnit 2001), how may it considered within an Australian bush setting? Harper (2007) traces bush-walking's iconic cultural and personal importance in Australia, situating it in the context of land ownership, access, conservation, cultural identity and recreation. White and Ford (2010) similarly emphasize the long history of recreation in forming ambulant relationships with the expansive Australian landscape, noting the popularity and significance of nature studies and wildflower hunts as forms of play. Ryan describes these activities as a 'mode of participation' which collapses the "[r]omantic ocular divide between the human appreciator and the picture-esque scene" (2011). Here the environment shifts from 'appearance to experience' (Ryan 2011), no longer perceived in representative, pictorial or scenic terms but instead a dynamic, embodied and multi-sensory experience.

Fig. 1 Australian bushwalk

2.1. RELATED PRACTICE

The augmentation and intervention of wild, remote or natural settings is a long-established phenomenon before the advent of digital systems. The often monumental Land Art and Earthworks of the mid 60s and early 70s, Andy Goldsworthy's ephemeral and intricate site-specific interventions and Richard Long's environmental sculptures made from walks, were all created in and from the landscape itself and re-situated the forms, qualities, lines, and colours of nature in subtle and striking new arrangements. These works have been identified as pre-cursors to contemporary art-based practice that has employed visualisation, sensor, data, GPS technologies in non-urban locations, although Hoy notes this field has been approached far less often than urban projects (2011). LEA's Special Issue: *Wild Nature and the Digital Life* (Grigar 2006) and more recently ISEA's *Machine Wilderness* (Polli 2012) conference in New Mexico has drawn attention to some projects in this area, however models, languages and frameworks are still emerging.

Artist Teri Rueb explores what she describes as "kinesthetic attunement" (2011) with GPS driven audio walks such as *Trace* (1999), *Core Sample* (2007) and *No Places with Names* (2012). Creating spatial narratives of poems, songs and stories constructed by participants as they reflectively move through the landscape with headphones, Rueb has argued that audio is a more appropriate form of engagement for these projects as participants can better engage with the surrounding environment without the distraction of screen-based, visual content (2004). Speculating over a decade ago on how we might adapt to "multi-modal interfaces as they become more pervasive" (Rueb 2004) challenges and possibilities remain in how these may be designed and experienced within non-urban environments.

3. CROSSMEDIA ECOLOGY AS A MODEL FOR CONSTRUCTING THE EXPERIENCE

Given the challenges posed by multi-modal artistic practice in non-urban environments, how can contemplative interaction support multiple modes of engagement in these locations? We propose that digital systems connect with the natural world to form a mixed reality through the concept of a crossmedia ecology. Crossmedia ecologies are complex, emergent systems that blend different media with an awareness of their multiple modalities: phenomenological, semiotic and coded (Fuller 2007). This will be explored as a framework for staging the traversal of an augmented bushwalk. A crossmedia ecology builds on the idea of a media ecology as a materialist exploration of media networks as complex systems. Here, as with other forms of transmedia, the emphasis is on traversal through the system and the ways in which meaning is constructed in that journey. A cohesive event, in this case a bushwalk, bind the various units together in an environment – a crossmedia ecology.

Understanding a media environment as a complex, dynamic system acknowledges the generative aspect of that environment – the ways in which it may be shaped by technology or techniques, how modes of information may impact on its structure, and how codes of communication may shape its experience. From the outset, it is seen as the product arising from the mixing of codes, interaction, perception and play.

Over the past decade, crossmedia ecologies have emerged through gameplay. Play is recognised as a primary force in shaping culture and language, and as a tool for both deconstructing and creating systems (Huizinga 1949). Games have been part of culture for millennia, and recently digital games have dominated mainstream media culture. With a generation growing up with digital game play as one of their primary modes of engagement with the world, they recognise game play rules and systems in their world view. This allows a new generation of players to intrinsically understand and participate in, many kinds of multi-modal and pervasive games.

Pervasive games play outside of digital spaces, with or without supporting digital systems and may provide a suitable habitat for crossmedia ecologies to thrive. Although largely staged in an urban context, many examples of this type of gaming will be explored that demonstrate the idea of the crossmedia ecology and the role that traversal plays in generating these experiences.

3.1. RELATED PRACTICE

Many contemporary works are engaging in ideas of a crossmedia ecology, manifesting in many different configurations of mixed reality. While the overwhelming majority of these are staged in an urban context, they inform this project through their exploration of modes of interaction, rules of engagement, and the construction of meaningful connections in the traversal of transmedia.

One of the earliest combinations of the outdoors and technology is geocaching (Peters 2007), the practice of using GPS devices to locate hidden caches all over the world. Each location has tradable objects and digital traces left as comments on *geocaching.com*; making the solitary bushwalk and interconnected social experience. Caches are rated via difficulty and players often evolve further rules and systems around the sites, playing off mobile technologies and the atmosphere of the sites in varying combinations.

Blast Theory, an artist group using interactive media, have produced a number of pervasive games in cities. *Can You See Me Now?*, one of the first location-based games, is built on a system that blends two different modes of interaction and ways of seeing the city. Street players are literally on the street with access to a GPS view of online players and can contact other street players via walkie talkie. The online players see a diagrammatic, game-like view of the same city and must navigate their avatar to avoid the GPS-synced locations of the street players.

If players are 'tagged', they are out. Thus, street players and online players traverse the same space in different modalities, the experience manifests in the transmedia ecology that emerges through play.

Artist Troy Innocent's *Colony* is described as an 'urban art environment' and stages a more ambient mode of play. A public art commission situated in the Melbourne Docklands, *Colony* is an interactive sculpture garden situated in a residential area. The sculptures 'talk' to one another using a coded language, autonomously generating patterns of light and sound with speakers and lights embedded in their structure. Players, one or more, may also talk to the sculptures via an iPhone app that allows them to be played as synaesthetic musical instruments this also allows for spontaneous play in the space. Paths run through the garden allowing players to traverse the space on foot while using a mobile device – the visual and sonic events made possible by the generative system embedded in the installation of totems allow players to learn its language and the range of expressions afforded by that system. Social rules may also emerge as multiple players – who may be complete strangers – compose together, perhaps developing call and response interactions or simply seeing who can make the most noise.

Both projects illustrate a framework for contemplative interaction utilising traversal through an urban space. The game play in each sets in place rules and systems to connect existing parts of the environment with players, as well as digital systems that construct a crossmedia ecology. It is in the traversal of this newly manifested space that the meaning and experience of the work is constructed. Utilizing this framework, we now turn to contemplative interaction in non-urban spaces.

3.2 X = bushwalk + crossmedia ecology

Central to the different types of experience described in this paper thus far is the traversal of space, whether that be the actual space of a bushwalk or the constructed space of a crossmedia ecology. In each instance the engagement with the experience is dependent on the process of linking and connecting spaces constructed about and around the player or players. Understanding this mode of engagement informs the design, aesthetics and technical resolution of a project that aims to augment the bushwalk via a game-like information layer. How can these disparate elements be combined into a cohesive experience? And does the resulting experience manifest a form of contemplative interaction?

Whilst some may argue that a walk in the Australian bush is an effective way to get away from technology, the augmented bushwalk may also be seen as a 'portal back into nature' for those who primarily see their world through the small screen of a mobile device. On another level, the context of this experience – like many locative media projects – is critical. The simulation of aspects of the natural world within the complexity of actual nature draws attention to limits of that abstraction and the assumptions underpinning its construction.

The central aim of the new project described in this paper is to construct a mixed reality, blending different modes of traversal to engage the player in contemplative interaction. However the project also aims to critique more broadly the understanding of nature as represented in the abstractions many of us are familiar with in a digital environment. For example, simulation games and Real Time Strategy (RTS) games focus on the management and effective use of resources to achieve short and long term goals. This may result in a degree of procedural literacy in understanding how complex environments emerge and evolve over time. Drawing upon this understanding, the game is designed to highlight aspects of the natural environment via their simulation – for example, a 'seed' to plant the next algorithm may be physically carried from one site to the next in the bushwalk to engage the player with the actual processes that occur in a natural environment. Thus, the proposed mixed reality project is a map, a language and journey inviting contemplation on an understanding of the natural environment from the mind of the player.

4. OUTLINE OF THE PROJECT

The project expands upon a previous project that created a series of site-specific mixed reality artworks situated in urban environments. The first iteration of this project, entitled *noemaflux*, was created around nine sites in Ogaki, Japan, which were claimed as 'readymade game spaces'. A series of overt AR marker was placed into each site claiming it as part of the work (see Fig. 2)

This approach marked the territory of the work and signified its presence before the experience of the digital component – each marker functioned as a portal into an artificial world.

Fig. 2 *noemaflux* Ogaki, Japan. Troy Innocent & Indae Hwang 2010

This artificial world comprised of a set of digital entities, one located at each site. Expressed as both a computer graphic and sound, their appearance changed depending on data introduced from the previous site visited by the player. Effectively, the player carried a seed from one site to the next to initiate the process of generating the graphic and sound content. Using the metaphor of pollination, the players were playing the role of honeybees by shifting the data around within a mobile device.

In 2011, a second iteration of *noemaflux* was staged in Istanbul, Turkey as part of ISEA2011. In this iteration, the digital content was represented as a form of digital graffiti inscribed onto the streets of the city, again with the data from each site seeding the next. Players used AR markers and generative writing systems to create an experience of abstract virtual art in urban environments.

The most recent iteration was developed during a residency at the Magic Vision Lab connected to ISMAR 2013 in Adelaide, Australia. Deployed on an iPad and developed using the vuforia library in Unity, this version introduced complex fiducial markers integrated into the urban environment (see Fig. 3) Again a set of nine markers transformed sites into locations for the game, which one or more players could play simultaneously.

Fig. 3 *noemaflux:ia* Adelaide, Australia. Troy Innocent 2013

In *noemaflux:ia* the game is musical. The device displays and plays a sequence that is collected by finding and activating the markers. Players create a piece of music by traversing the space of the work, slowly increasing their presence in the urban environment by making more sound. As each layer of the work is decoded, another code is revealed drawing the player deeper.

The next iteration of the work is situated along a Sherbrooke Forest walking track located within the Dandenong Ranges National Park, Victoria. Having long been a place of interest for artists such as renowned Australian landscape painters Arthur Streeton and Tom Roberts, Sherbrooke Forest has also been a site of study and conservation for its distinctive native flora and fauna. An apt location to explore a crossmedia ecology via a digital system, *Epiphyte* will both draw attention to aspects of its environment as well shifting our experience and perception of it.

The key intention of the work is to encourage contemplative forms of interaction that meaningfully relates players to both the environment and digital system. While mobile devices are not usually associated with these more subtle and slower modes of engagement, the project intends to invoke this reflective process through the traversal of an augmented bushwalk. In a similar manner to Bartle's 'explorer' (1996) play style in interacting with the world and Flynn's description of a virtual flanerie navigating game spaces (2003), the work considers walking, movement and navigation in support of a spatialised, contemplative experience.

This manifests as generative imagery on the screen of the device triggered by the discovery of AR markers on the bushwalk. These on-screen digital entities are based on the adaptive behaviour of actual orchids found throughout the Dandenong Ranges. Similar to how orchids adapt to animals in their environment for pollination, the entities of *Epiphyte* will adapt to one another, the material environment and players interaction with them in the attempt to establish a type of balance within the simulation. This mechanic builds on Melissa Harper's (Harper 2007) description of a bushwalk as a mode of discovery, a recreational activity and a heightened engagement with 'nature' from within the landscape itself as traversal through the environment determines how the adaptations evolve.

The objective of the game is to balance the diversity of this crossmedia ecology while keeping it alive. This begins when a player finds the first site in the bushland and activates it, collecting a seed to activate the next site. The seed has a time limit – it can die – encouraging the player to find fertile ground for it or risk starting over. These simple game objectives and constraints engage the player in meaningful processes and actions that reflect the games objective.

The bushwalk is remapped via thirty-six AR markers temporarily situated near features of the walk – trees, ferns, grasslands, streams and rocks. Held in place using natural cotton rope, knots and pegs (Fig. 4.) these AR markers are both familiar and unfamiliar in the bushland context. They are familiar as environmental signage but have their own unique code that draws on existing practices and signs in non-urban environments such as geoglyphs, orienteering guides and topographic symbols.

The AR Markers serve a number of purposes; redefining the space with signs to establish a crossmedia ecology; distinguishing the species within this ecology, acting as navigation landmarks to guide participants as they traverse the space and finally, as readable signs, they will also trigger changes in the on-screen content of the mobile devices carried by participants.

Fig. 4 Concept art for a bush AR marker in *Epiphyte* attached via rope

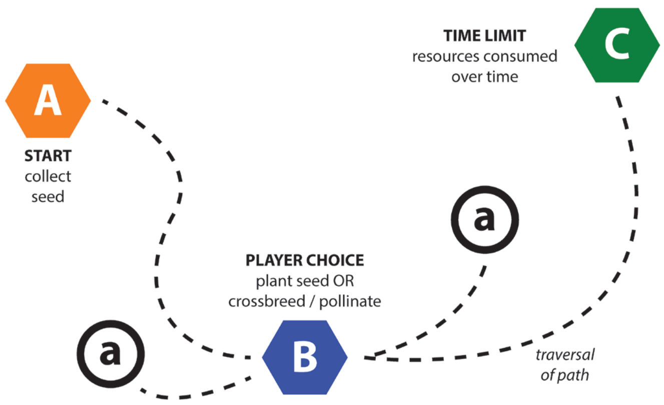

Fig. 5 Player choices when navigating sites in *Epiphyte*

Two types of AR markers appear on the bushwalk. The first set of twenty-seven AR markers represents three distinct species that form the ecology of *Epiphyte* – each species is linked to nine markers. These are clearly distinguished by their colour (orange, green, blue) and their design (physical shape, position in-situ and graphic glyph). A second set of nine markers act as 'resource' points for the player to nurture 'seeds', extend the life cycle of the entities and trigger further behavioral and aesthetic changes. The player must make strategic decisions as to move directly to the next site or take a detour to acquire resources (Fig. 5).

Visually, the AR markers act as a framework to anchor the generative drawing processes. These sprite-like forms reconfigure themselves differently each time a player scans a marker with their device. A simple generative system triggers audio and visual changes that form the digital entities. The relationship between the AR markers and the on-screen content is both aesthetically and conceptually linked, the players connected to both the physical and virtual worlds of the game.

In this game that frames the mixed reality the overall objective is to balance the crossmedia ecology and create a sustainable artificial ecosystem. A player may focus on developing one species, traversing the site specifically in search of the group of markers associated with those entities. In seeking out more striking aesthetic transformations (sound, animation, colour, shape etc) a player may also attempt to crossbreed the three species. However in doing so there is a greater risk of the entities fading and retreating if new conditions created by the breeding are not met. The player decisions are strategic: plant too many singular seeds and the system collapses due to lack of diversity or rely too much on cross-breeding and the system dies due to lack of cohesion as it does not adapt to its environment.

In situating this work in an alternative context we intend to contribute new models and frameworks for designing, experiencing and evaluating these cross media ecologies – specifically in illustrating how contemplative interaction may be supported in harmony with a bushwalk.

6. CONCLUSION

This paper has outlined our project to augment a bushwalk with a game that encourages contemplative interaction via a mixed reality. While urban environments have been well-documented and understood as sites for location-based mobile and pervasive games and artworks, *Epiphyte* will explore the characteristics and features of the Australian bush as a space for interaction. The proposed work considers the rich history of recreation, play, traversal, contemplation and art within non-urban-environments to develop new forms of creative expression that ultimately shift our experience of place. While this paper positions the project, further research will focus on the implementation and study of the behaviour and experience of players within the mixed reality later this year. This will explore and investigate the ideas proposed in this preliminary research.

The themes of adaptation and traversal are explored in a number of new spaces that we hope will inspire contemplation of our complex relationship to these environments via engagement through interaction – in this case a simple game that combines physical and digital interaction in a mixed reality. There is a technological adaptation of AR into a bushland setting, an adaptation of the player into the game of bushwalk, and an abstraction of nature into a digital system that mimics the biological processes of adaptation in Australian orchids. The experience relies on traversal – both of the bushland and the digital system – that combines physical and mental engagement and meaningful switching of modalities in interacting with its content. These are hallmarks of a healthy and diverse mixed reality.

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VIDEO GAMES AS DIGITAL AUDIOVISUAL PERFORMANCE

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Keywords: Audiovisual Performance, Digital Media, Improvisation, Soundpainting, Video Game

Video games are an ideal medium for creating a live-cinema experience because of their potential for cinematic narrative and their open structure. 'Performing digital media' as opposed to 'performing with digital media' or using digital media in performance means to 'play the media' like a musical instrument as much as possible. This is to be able to control and finely nuance the audiovisual and kinetic data stream through live manipulation, and/or to respond instantly to this, on stage. This is, in a sense, to grant the performance an immediacy that belies remediation. This paper looks at recent instances in which as the media itself is being performed, a similar audiovisual contract to that of cinema is being entered into by an audience. Thus, the performance or live event itself, becomes a product of media technologies, yet is indistinctly unified with them.

1. INTRODUCTION

The use of digital technology to enhance music performances or audiovisual shows has become widespread at least since the 1990s. The Internet, for instance, became a prime motivator for networking audiences with artist performers, and extending the idea of what art installations could become. Non-linear video playback systems began to emerge and be accessible, the CD ROM as a medium arguably had its heyday and video games became faster and richer.[1] MUD (Multi-User Dungeons) and MOO interactive scenarios (Online virtual reality systems like MUDs but using object oriented techniques) seeded what would later become MMORPGs. Performance artist Stelarc conducted on himself cyborg-like experiments and other artists experimented with embedding computer chips in their bodies (Dixon, 2007, pp. 1-3). The 1990s could arguably be the decade when digital means began to truly permeate the world of artistic performance. Even when the visuals are not essential to the piece, music may often be played with accompanying video or digital graphics and lighting. Yet, what was once a supplementary element is frequently now central to performance as we find ourselves often intervening or affecting visual media in real time as part of what may formerly have been a music-only performance. Video game worlds or 3D digital scenarios are arguably an ideal partner to sonic media, yet as composers we have done little more than modify either one while triggering the other. What if we could place ourselves in the situation where both the visual discourse and the music embark on an expressive, and possibly narrative, journey with or without a known destination?

The question that this paper intends to examine goes beyond describing the rise of digital media on stage, it aims to question how, and if, digital multimedia can itself be performed. This appears to be a simpler question than it is. The 'triggering' style workflow of digital media, where pre-fabricated elements are played back at different points is fairly common today. This is understandable as sensors, machine listening and computer vision are relatively recent developments. For instance, capturing or scanning movement in 3D is really just beginning, with the *Kinect*[2] motion sensor being less than five years old at the time of writing and similar systems like the *Leap Motion*[3] just starting to scratch the surface of gestur-

1 Meaning that the load times for levels became substantially reduced and the media interaction has become richer as can be seen from the development of dynamic music responses to gameplay.

2 For more information on this controller access this URL: *http://www.xbox.com/en-GB/Kinect*

3 For more information on this controller access this URL: *www.leapmotion.com* al control.[4] The fact is, that computers are still struggling to efficiently follow a human performance (or we could say that programmers are still struggling to account in code for the rich nuance of live performance situations!).

What does it mean, then, 'to perform digital media'? as opposed to 'performing with digital media' or using digital media in performance? In this paper, I would like to propose that it means to play the media like a musical instrument as much as possible. This is to be able to control and finely nuance the audiovisual and kinetic (if implemented) data stream through live manipulation, and/or to respond instantly to this, on stage. This is, also in a sense, to grant the performance an immediacy that belies remediation, and while this can be said of computer system virtual realities (Bolter & Grusin, 1996), expressed through 3D models and animations,it is a relatively new practice in musical performance. My aim in this paper is to look at recent instances in which as the media itself is being performed, a similar audiovisual contract (Chion 1994) to that of cinema and TV is being entered into by an audience of a digital audiovisual performance. Thus, the performance or live event itself, becomes a product of media technologies (Auslander, 2008), yet is indistinctly unified with them.

In particular I would like to examine two works that require a video game to be performed, not merely played, in front of an audience as one may find in video game 'championships' like the ones that take place in Korea (*World Cyber Games*, 2013). The first work we will look at is *Ho – a sonic expedition* (2008/9) by Spanish composer Ricardo Climent. It is intended to be a 'navigation through sound' video game with optional live music improvisers' interaction. The second work is my own *Terra Nova First Person Concerto* (2011) for video game player, laptop artist(s) and rag-tag ensemble in five instrumental ranges. I revised the piece in 2013 with the use of Walter Thompson's *Soundpainting*, a multidisciplinary sign language for live composition created in 1974 in Woodstock, New York (Thompson, 2014).

At this stage it is important to point out that I view both works as experimental artefacts for understanding digital audiovisual performance and that this paper is not an apology of the creative work that they present but rather an enquiry into what may be profitably shared from these experiences for other musical new media

4 Both systems are based on motion sensing technology using a combination of infrared cameras (on the *Leap*) and range camera technology plus infrared on the *Kinect*. I have no deeper understanding of the technology but there are ample sources on the web if you wish to learn more, as well as several Processing language sketches for grabbing the data stream of the Leap Motion, which is as far as I have gotten with it.

practitioners to learn from. For this reason I will attempt an overview of each piece, highlighting potentially interesting contributions and giving analytic insight. Finally I will summarise the emerging themes of this paper.

So, what does it mean to perform a video game? It means that the game-specific iterative sequence[5] of exploration, discovery, challenge and outcome (success/failure) is affected by the presence of an audience to whom it must be made explicit and dramatised. Because of this, actual game success becomes secondary to the simulacra of victory and failure. It also means that other performers, musicians in this case, are able to interact (by immediate reaction or causation) with the video gameplay.

2. HO – A SONIC EXPEDITION

Ricardo Climent is essentially a musical new media[6] artist who works at the University of Manchester, where he lectures in music composition, Climent's work tends to employ custom made systems to create works exploring dynamic music scores, geo-locative sound walks, installations and other collaborative environments. One of these environments is a 3D video game world where sound is featured as a key element called *Ho*. I became interested in *Ho*,[7] a piece originally intended as an interactive sound installation where visitors could embark on an "imaginary sonic expedition to Vietnam" (Climent, 2008). The user navigates various 3D environments by steering a wheel which is an interface to a digital helm that guides an animated ship (fig. 1)

The structure of *Ho* is in a sense aleatoric since one can choose from different 3D environments to traverse using the sound-navigation tool, yet they all share the 'basic promise'[8] of the game, which is that you will find your way around, or simply explore them by following sound cues. The 3D environment quickly becomes visually redundant, everywhere you look is similar, and the user is forced to concentrate on the sound to navigate. Audio cues are triggered by collisions in the 3D space or, as in the case of the radio, by tuning the radio-frequency dial.

Ho, has the following game environments or levels:

- a rickshaw maze (the user is on a rickshaw inside a temple which is in fact a maze)
- a zebra crossing (the user must cross a dangerously busy street in Ho Chi Min city)
- a kitchen party (the user is in a restaurant where

Fig. 1 Climent at Manchester University with the prototype navigation system for *Ho* (2008)

5 This is my own description of gameplay, although I don't imagine it to be very original

6 Partly in the sense described by Cook (2001) when explaining musical multimedia (multimedia where music leads formally) and partly in that his work can be described as 'new media' according to Manovich (2001) or work that is numerically representable, modular, automated or algorithmic, variable and culturally transcodable.

7 A demo can be accessed at *http://vimeo.com/6766860*.

8 As in a 'promise' to the consumer, to use the language of advertising media.

sounds are made by colliding against doors and curtains and other objects)
- Radio Ho (a 3D radio which the user explores by tuning it)
- Water puppetry (a puppet theatre on a lake)
- Labyrinth Island (the user navigates a ship through an archipelago, making sound as it collides with floating balls)

The distinctive feature about *Ho*, is not in fact the use of an alternative controller to explore sound or even 3D environments, it is its public performance. And, arguably, that is not such a novelty either yet what is interesting to me is Climent's recent use of live musicians to function as a sort of 'concertante versus ripieno' ensemble with the videogame navigator. I would say this is an instance of live adaptive video game music.

There is a history of video games where music is the key element and these are explored in a recent article on the rewards of musical video games (d'Escriván and Collins, 2011). The most notable were *Guitar Hero* (2005), *Electroplankton* (2005, for *Nintendo DS*) or , at the time quite novel, *iPhone* mobile applications like *Smule's Leaf Trombone* (2009), and of course, *Rez*[9] (2001). For more on musical interfaces to games see Blaine (2005) Pichlmair and Kayali (2007) and the now obligatory reference which is Karen Collins' book on game sound (2008). Traditionally, albeit their rather recent history, video games have aims and objectives that relate to reward structures in ways that are now fairly established; the music, functions in a diegetic way yet the game does not yield any musical structure per se. In the particular case of musical video games, ranging from the very loose *Elektroplankton* to the very tightly rewarded *BIT.TRIP* (2009) series, 'success' is measured through a wide variety of musical results that aim to conform with some kind of musical structure (d'Escriván and Collins, 2011).

What is of interest to me is not just the use of music as the key incentive for the gameplay as can be appreciated in the work of Rosenstock's *iGotBand*, where avatars are accompanied by representations of 3D note sequences which they must play correctly to win fans (Rosenstock, 2009). Or even, the use of game music in concert[10] (as has been popularised by composers Tommy Tallarico and Jack Wall in their *Video Games Live Series*[11]). What is truly interesting to me is the video gameplayer as performer within a hybrid ensemble of musical instruments and

9 The most comprehensive information about this now discontinued game can be found at wikipedia, video sequences of the game can also be found on youtube but the game is no longer current. <*http://en.wikipedia.org/wiki/Rez*>

10 Which to me is a mistaken approach to lending artistic credibility to the music, as it divorces it from what makes it a distinct and specific art form, the game context.

11 more details here: *http://www.videogameslive.com* digital machines. This renders the video game into a musical instrument of sorts, as it plays a lead musical role.

Using three environments from *Ho*, *the Labyrinth Island*, *Radio Ho and the Rickshaw Maze*, Climent has explored these issues by briefing an ensemble of improvising musicians on how to react to the sounds produced by the gamer. Sounds produced by collisions or manipulations (as in the case of Radio Ho) in Ho are categorised and retrieved following a logic that relies on grouping them according to their acoustic features or typo-morphology (Climent, 2008). The live players are instructed[12] to improvise on the basis of these features as the sounds are triggered by the game player. In this manner, if sounds have short attack amplitude envelopes, for instance, the players will respond with freely pitched sounds or even noises that share this feature. Although this seems like a simple proposition, the variety of instruments present and the interpretations of the musicians, makes for a rich and variedly detailed musical experience as the lead instrumentalist (the game player) navigates through the 3D environments uncovering sound cues.

The scenes in *Ho*, as mentioned earlier, use visuals that quickly become familiar to the player, and there is no real success or failure in the game. So, the musical performance could be described as non-teleological. In a sense it is closer to free improvisation where the lead status of any instrument changes from moment to moment without obvious preparation and with no real overall structural consequence. In this sense *Ho* is closer to, say, *Elektroplankton* although it results in far more unpredictable musical results. For example, the collisions in the latter's *Luminaria*[13] level are very pattern-based while the ones in the *Hanenbow* level where spheres bounce from leaves and fall into the water in a similar fashion to *Ho*, use timbres that are uniformly bell-like and potentially monotonous.

Although *Ho* was not primarily intended as a musical ensemble piece, it lends itself very well to it and it is a credit to Climent's imagination how successful the performance can be. Arguably, it shows that the video game itself can become a musical instrument and the player can become a performer.

12 I know this from private email correspondence with Ricardo Climent, as well as having been at one of the performances

13 A demo video of Elektroplankton can be seen here: *http://www.youtube.com/watch?v=d3v6npP8OZk*

3. TERRA NOVA FIRST PERSON CONCERTO

While the player is a performer within an ensemble when *Ho* is performed live, in *Terra Nova* the role of the player is to be a protagonist investigating the 3D world from a first-person video game perspective. In *Terra Nova*, the player guides the diegetic and non-diegetic functions of the music in a manner more akin to how music is used to accompany silent film.

Improvising to picture is almost a traditional practice. In the early days of cinema, pianists and organists would improvise to film, illustrating the story on screen and at times going so far as to create sound effects through musical stylisation 'on the go'. At other times they made use of extensive music libraries like the *Sam Fox Moving Picture Music* library to select appropriate themes to create moods, or improvise on, or sometimes these selections were prepared for them especially as cue sheets for specific films (Cooke 2008, Cousins 2011, McDonald 2013). Although this practice all but died out with the advent of sound on film, at various times and to this day, composers and improvising performers have been fascinated by this type of audiovisual performance in which musical instruments give voice to the image. *Terra Nova* is an attempt to translate this practice to the video game experience, turning it into a performance and adding the uncertainty of the video game narrative.

Fig. 2 Performance of Terra Nova at West Road Concert Hall, Cambridge, UK

Terra Nova was written to commemorate the 100th Anniversary of the expedition led by Captain Robert Falcon Scott to the South Pole, effectively racing Norwegian Roald Amundsen and his team to get there, which ended in the death of Scott and four of his crew members. The piece calls for up to four laptops in charge of foley, atmospheres and electroacoustic music and an indeterminate ensemble including instruments from five ranges (Bass, Tenor, Alto, Soprano and Very Soprano) and Piano and drums. Matt Hollis created the video game[14] and he played it at the first performance at Cambridge University's West Road Concert Hall in November of 2011.

The video game was structured by broadly following the narrative of Apsley Cherry-Garrard's book on Scott's journey (Cherry-Garrard, 2010). Cherry-Garrard was the youngest member of the expedition and not being one of the final crew to attempt to reach the South Pole, survived. In his book he chronicles the preparation and crossing from England to Antarctica via South Africa and New Zeland, the landfall and preparation of supply depots, a winter expedition to find Emperor Penguin eggs, the spring season and the Polar journey.[15] To illustrate these key periods of the expedition, I created four cutscenes for the video game and Matt Hollis created three levels with simple yet well defined objectives. These are illustrated by Table 1.

14 A student of music for digital media whom I motivated into video game engine programming and who exceeded my wildest expectations in responding very professionally to the brief of creating the polar landscape and a game environment.

15 The chronicle is far more detailed than this but these are the sections used in the Terra Nova piece

Table 1 overall structure of *Terra Nova*

Section	**Theme**	**Game object-tive**	**Musical material**	**Electroacoustic Material**
Cutscene 1	The Crossing	-	Piano vamp plus melodic variations (see fig 3) on all instruments that concludes with a beat coordinated minimalist construction	Laptop(s) provide sounds of the sea, whale singing, various drones and excerpts of partly scrambled radio transmissions and Morse code
Level 1	The Depots prepara-tion	find 3 depots and leave a crate	A basic march pattern is used as a Sound-painting palette (musical material to be cued as appropriate)	Laptop(s) only play sounds of wind, sparsely just to accompany the narrative overall., plus sounds plunging into water and of water laps
Cutscene 2		Winter	-	Double Bass solo improvisation responding to the concrete sounds of the laptops
Level 2	Winter expedition to collect penguin eggs	Collect 3 eggs	Ostinato instrumental patterns with crescen-dos and ascending arpeggios.	Lt1 and Lt2: choose a note every time and play with a very low drone sound, add delay and a nice long reverb. Lt3 and Lt4: create the Foley, including wind and the crashing of rocks falling, etc.
Cutscene 3	Spring	-	Very-Soprano improvisation	Laptop(s) is (are) guided through a process of selection of loops within their samples and they are shortened until granular textures are created. A metaphor of ice breaking and liquefying.
Level 3	Final journey	Find the south pole	Beat-coordinated crescendos as a sonic meta-phor or anaphone to the snow blizzard (for more on anaphones, see Tagg 2012, p487)	Granulations become 'blizzards' through the careful use of amplitude envelopes and live mixing.
Cutscene 4	Monu-ments	-	Chorales created from sets of notes show as chords for each range	Laptop(s) introduce(s) rumbles, low trans-posed sea sounds, and slowed down sounds of water as well as wood creaking sounds from their sample sets.

Fig. 3 Example of melodic material to be improvised on during cutscene 1

Given the unpredictability of the narrative detail, although the overall goals are clear, the music has to adapt to accompany the gameplay. For example, on their way to a depot, the player may stop to survey the landscape, and the music must change as they have come to a stop, or the player may fall into a lake, die and re-spawn. The music must provide an accompaniment for each action. This is not an issue if the musicians knew what was going to happen and the exact time, but as it is, they have to adapt to the incidents as they unfold unpredictably. In Terra Nova this was approached by creating musical elements that could be called-up by the conductor of the ensemble immediately, 'on the fly' (see figure 4)

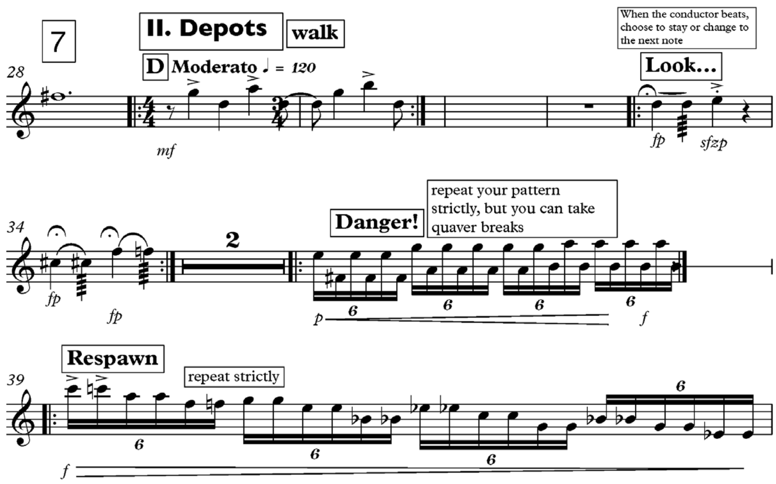

Fig. 4 Cues to be chosen 'on the fly'

The challenge in *Terra Nova* is that unlike computers, which can react to the game-play in the smallest fractions of a second, the ensemble has to wait to be cued-in by the conductor. However, as the conductor is watching the game-play, they can reasonably anticipate the actions and react accordingly. They can also express the mood in a richer way than an algorithm can. In recent performances, cues like those from *fig. 3* were used as a Soundpainting *palette*. This is a set of possible gestures to be cued-in as well (Thompson, 2014) but the palette in one instrumental range can co-exist with live-composed parts in other ranges that the conductor/Soundpainter creates while adapting to the gameplay.

The use of Soundpainting and a basic cue set helps create and fulfil or frustrate the viewer's expectations. If the ensemble was a free-improvisation one, this would be much more difficult as the ever changing musical states of the players would be truly unpredictable for the audience. Free Improviser and author Wade Matthews (2012 : 61) in his recent book *Improvising: free musical creation*[16] argues that although a lone improviser may be guided by their tastes and memories, individual gesture is redefined and contextualised by the collective dynamics of intention in ensemble improvisation. If we agree with Matthews assertion, a free-improvising approach would not be ideal to accompany video gameplay as the traditional film diegetic and non-diegetic roles of the music (Tagg, 2012: 546) would be impossible to fulfil in any obvious way.

4. EMERGING THEMES

4.1. COMPEL FACTOR AND REWARD

In both *Ho* and *Terra Nova*, what I would like to call the 'compel' factor is rather low. In the case of *Ho*, there is no clear expectation of success/failure and thus no point-scoring. This makes the game more '*paidia*' or child-like free play than '*ludus*' or rule-based play. In the former the audience is invited to enjoy exploration in itself, in the latter the audience can anticipate what may be accomplished and participate in the agonistic tension of the game-play. Ideally, for music to have clear diegetic roles there must be a clear narrative sequence and this invites *ludus*. Yet pure *ludus* may lack the flair and unpredictability of serendipitous discovery promoted by *paidia*. The balance between *ludus* and *paidia* is a delicate one and this is something the artists must ask themselves and try to assess within their work in new musical media. In Terra Nova, the gaming compel factor is low as a result of the ease of the game but the musical compel factor is arguably higher than the game itself. This is because it anticipates, rewards or defeats, according to simple narrative conventions, and thus easily identified by the audience. In *Terra Nova*, as a result of the rehearsal process, the musicians learn how to anticipate the game-play and

16 Original title in Spanish: '*Improvisando: La libre creación musical*' eventually are not taken by surprise by the actions they must accompany. This results in the whole ensemble (VG player and musicians) having to 'fake' difficult moments in the game to be able to highlight them to the audience. The game becomes dramatised. In *Ho*, the same thing eventually happens, as the player learns to navigate well, they can use their anticipated sonic results to trigger musical reactions from the ensemble.

4.2. SYNC

In *Ho*, the musicians face the screen and can see the game, thus an element of free improvisation is guided by a response to the visuals. In *Terra Nova*, the musicians do not see the game and thus are following the conductor; their extemporary decisions obey a musical logic of the moment more independent from the visuals. Both methods produce good results, the choice depends on how much formal constraints need to be imposed on the players or not. It is important here not to try and apply political concepts of democracy, independence or authority to the ensemble-versus-visuals disposition as this dynamic is primarily for representation or metaphor. Having stated that, we could characterise *Ho* as a more democratic, yet reactive piece[17] while Terra Nova is more hierarchical.[18]

4.3. LIVE CINEMA

Live video game playing accompanied by music is a form of live cinema. The latter is being practiced since the early 2000s and the VJ like practice of artists like Peter Greenaway, *Eclectic Method*, *Light Surgeons* or *Addictive TV* should be evaluated alongside more 'artistically sanctioned' film work like that of Steve Farrer, Tamara Krikorian and Lis Rhodes. In the case of live video gaming, we potentially have artefacts that are much closer to traditional film itself in the sense of figurative visuals, narratives and plots. An interesting avenue for future work is how to blend the stylistic contributions of both to create interesting and surprising cinematic experiences with a high compel factor that truly unfold before the audience and do not have set endings.

17 The players are cued in by sounds from the game-play.

18 The players follow the Soundpainter or conductor, and have notated music as well.

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COMPOSING WITH SOUNDSCAPES: AN APPROACH BASED ON RAW DATA REINTERPRETATION

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URB is a research project designed to collect and store raw data from soundscapes analysis. This paper presents a study about composing music using URB based on the analysis of work developed by several sound artists, focusing on the evaluation of their creative process and musical outcome. By comparing the processes and statements of each composer, the authors identified diverse systematic approaches to reinterpreting raw data provided by URB, raising questions about the musical outcomes vs original sound sources. Furthermore, some considerations are inferred about the artistic relevance of using URB to compose music.

1. INTRODUCTION

The auditory system tends to have a cultural and social disguised importance when compared to vision. This issue called *The dominance of eye culture* was developed and detailed by Berendt (Berendt 1992). Nevertheless, its importance is undeniable and it represents a vital action, not only in our survival (Middlebrooks and Green 1991) but also in our daily life. Hearing is permanent, unlike vision that can be blocked. To cope with the overwhelming sound information a person is submerged in, humans have different types of listening related with levels of awareness. Most of the time, a person listens without regards to details, what is called casual listening (Chion, Gorbman, and Murch 1994). This leads to an increase detachment from the nuances of soundscapes[1] that surround us, a problem to which Schafer refers in detail (M. Schafer 1977). This detachment represents a problem, for soundscapes have been an important element defining communities, influencing them and imprinting them an identity. The same way a distinctive landmark defines a given place, sound has the same power. These soundmarks can be from natural sources, as the sound of a waterfall, or artificial such as a bell or a factory siren. When recognised as such, one easily understands the influence that they represent towards a community and their social importance (Cordeiro, 2013). Any person transforms and affects his surroundings, in a relationship that is shared among the community. However, how does the ambient sound transform Man? Does the ambient sound influence the artist's work, as a product of their time and space? The usage of the soundscape concept is increasingly relevant not only for acoustic ecology but also in artistic contexts. Using this premise, this investigation focus on increasing the awareness of ambient sound to creators.

> *After all, the soundscape is not an alien force but a reflection of ourselves.(Barry Truax 2001)*

2. FRAMEWORK

2.1. SOUNDSCAPE COMPOSITION

The generalized access to powerful audio technology boosted the use of soundscapes as a resource for composers and sound artists (Westerkamp 1999), increas-

1 The Soundscape concept and movement was presented to the world in the 70's Murray Schafer considerations and researches. (M. Schafer 1977, 1998). Soundscape: Technically, any portion of the sonic environments regarded as a field for a study. (M. Schafer 1977) ing the number of compositions using field-recordings. This possibility potentiated and democratized the trend Pierre Schaeffer had started, when he created *Musique Concrète*. However, according to Westerkamp *the essence of soundscape composition is the artistic, sonic transmission of meanings about place, time, environment and listening perception* (1999). There are two main approaches: 1) only using unprocessed sounds and the composition process focus on selecting, editing, mixing and organizing 2) using audio effects on recorded environmental sounds. Truax remarks that a given work to be considered a sound composition should have direct relations with the sound's original source, place, time, situation or context (Truax 1994). This is because *a piece cannot be called a soundscape composition if it uses environmental sound as material for abstract sound explorations only, without any reference to the sonic environment* (Westerkamp 1999).

2.2. ECO-COMPOSITION AND ECO-STRUCTURALISM

The term Eco-composition term was used for the first time in 2004 by the art critic Robert C. Morgan referring the Keller and Adriana Capasso installation *Vivir sin despué* (Keller and Capasso 2006). It is a more specific posture within soundscape composition. The term is used to describe the composer combining aspects of ecology with compositional processes. He does not work only with field recordings but takes into account the history, ethnography and geography of the sound that he is manipulating (Opie and Brown 2006). The eco-composition definition does not involve only the creation aspect, also requires a new way of listening. The audience is invited to take the context of the sounds into consideration (Field 2000; Keller 1999).

Eco-structuralism is derived from the eco-composition framework. It is a new approach to music composition designed to maintain the characteristics and context of a sound, even if not using the original recording data directly. In eco-structuralism, patterns are derived from analysis of natural environmental sound sources that reveal structures within the material. This structural data is used as the dominant material for creating the musical composition (Opie and Brown 2006).

In this kind of musical practice, structures must be derived from natural sound sources but not all the structures from a sound need to be used. Small sections of the structure may be extracted and used separately. The approach to the data extracted can be very similar to the "classical" composition by using tools such as elongation, compression, inversion, reversing, scaling and offsetting (Opie and Brown 2006).

2.3. URB

URB[2] is a system for automated analysis and storing of an urban soundscape based on available and inexpensive hardware and open source software. It complements the traditional sound maps,[3] allowing the direct access of its features at any arbitrary moment since the system boot, thus facilitating the study of the soundscape evolution and the differences between specific timeframes, and facilitating artistic approaches to such data. It was developed to be used, not only by environmentalists and urban planners, but also by artists with creative intentions.

URB consists in a system for capturing and analysing the soundscape it in real time. The data analysis results in 12 different elements or descriptors of the sound;[4] four listening points in the city of Porto that are capturing and storing permanently; a free access database with all the information resulting from the capture; free software to access the database.

The project also encourages spontaneous initiative for the multiplication of listening points[4] and promotes artistic creation from different areas, with the data in real-time and non real-time. It also makes efforts to present approaches to data processing systems for artistic purposes. (Gomes and Tudela 2013)

3. CASE STUDY

3.1. PROPOSAL

A call was open to the musical and sound art community to work in the challenge of using URB in the creative process. It could be an electronic piece, music for instruments or a sound installation. The only requirement was that somehow the data from the URB had to be used in the composition of the work. Several artist from different backgrounds and with different aesthetic purposes responded to the call.

2 *www.urb.pt.vu*

3 Sound maps are digital geographical maps that associate landmarks and soundscapes.

4 Described in detail in *Urb : Urban Sound Analysis and Storage Project.* (Gomes and Tudela 2013)

The main goal of this investigation, starting from the analysis of the pieces and of the feedbacks and opinions from the authors, is to assesses the relevance of this approach to the ambient sound as gigantic sensor to be used in artwork. If this approach is artistic relevant and if it will contribute to approximate the sound ambient and the creator. This investigation also tries to understand if the aesthetical characteristics of the original sound sources are captured within the structures will remain accessible in the final composition, and, from the comparison of the results, hopefully also to start to point a way to systematize the artistic approach from the comparison of the results between them.

3.2. PIECES DESCRIPTION AND ANALYSIS

… URB to B… [5]
Composer: Nuno Peixoto
For: 2 Percussionists (timpani, vibraphone, and multi-percussion set)

The composed work was commissioned by the Portuguese group *Talea et alaia*[6] to be premiered in a Brazilian tour on January 2014. This provided the perfect setting for the composer to create a piece entirely related and inspired by the characteristic Portuguese sounds. Envisioning this, Peixoto decided to accomplish it through a representation of Porto city. To do so, URB software became the essential tool that granted the necessary data for the elaboration of *… URB to B…*, allowing the transition of urban sound to the musical piece.

The entire musical material used on this piece derives from the extraction of data provided by URB software. This tool is used by the composer not only at a structural level, but also in pitched notes and rhythmic sequences. Through the arrangement of all these elements, Peixoto intends to capture the particularities of each listening point that will characterize and describe the different times of the day in Porto city.

Structure-wise, the composer uses solely data belonging to three listening points (of the four possible ones in URB Software): Casa da Música, Oliveira Monteiro/Rua da Boavista and Sá da Bandeira/Mercado do Bolhão. So we have the following structure:

5 Complete score: *www.jasg.net/URB/URB_to_B.pdf*

6 Formed by the percussionists Rui Sul Gomes and Nuno Aroso

- A – Casa da Música (b.1 – 22)
  Bridge I (b. 23 – 24)
- B – Oliveira Monteiro/Rua da Boavista (b. 25 – 100)
  Bridge II (b. 101 – 106)
  Development (b. 107 – 128)
- C – Oliveira Monteiro/Rua da Boavista (b. 129 – 150/end)

The Sá da Bandeira/Mercado do Bolhão listening point has a very brief part in the … *URB to B…* composition, in comparison with the remaining two. Its sole purpose it is to provide a vibraphone motif which is repeated several times, as can be seen in bar 38, 60, 84 and 127. The second assemblage of the city's characteristics is done through the obtainment of pitch levels (musical notes) and rhythmic sequences. For this purpose, the composer applies a strategic "*reading mode*" (Bernardes *et al*. 2012) over just two table indexes (same number of instrumentalists): *pitch and centroid*. The first one is designated for the timpanist (percussionist 1), due to the low frequency range of the *pitch*. Lastly, the second percussionist that plays several instruments such as the vibraphone, is directly related with the frequencies presented on the *centroid* index table. For the translation from numerical values to musical notation Peixoto developed a process termed *Reading Mode*.

Reading mode: The different values presented on the *pitch* and *centroid* tables were divided into two categories. Firstly, we have what we consider as "correct values", meaning all the frequencies provided by the chromatic scale, such as: 73.4Hz = D1, 440Hz = A3. We also consider as "correct values", frequencies that are 1Hz above and below the ones presented by the chromatic scale. This means that values such as 329.052Hz are equivalent to the E3 (329.6) note. Other examples of this process are: 83.2682 = E1 (82.4); 92.2924 = F#1(92.5); 104.436 = G# (103.8). (The values that result from this two sound features are within the scope F1 to B3. As such the fact of frequency being a logarithmic is not a problem because this process is only applied in a section of low frequencies. The high notes are achieved through octave transposition but always respecting the note.) Secondly, we have what we call "incorrect values", which are the ones that don't fit the "correct values" standards. For example: 90.4796Hz, 94,9886Hz, 95.5805Hz, etc. This category has the task of identifying the duration of a certain "correct value". Therefore, the more "incorrect values" we find associated with a certain "correct value", the longer will be the rhythmic duration of a musical note. For example:

219.621Hz = A2 (220Hz) attack time
214.381Hz = "incorrect value"
234.848Hz = "incorrect value"
235.523Hz = "incorrect value" note end

220.003Hz = A2 (220Hz) attack time
221.799Hz = "incorrect value"
242.159Hz = "incorrect value"
289.992Hz = "incorrect value" note end

292.947Hz = D3 (293.7Hz) attack time
304.007Hz = "incorrect value"
308.547Hz = "incorrect value"
326.367 Hz = "incorrect value" note end

Table 1 The following table depicts the rhythmic and melodic cell values (Fig 1).

Soundscape pitch from URB analysis	Reading Mode process to chromatic scale	Reading Mode process to rhythm
493.128 Hz	= B3 (493.9 Hz)	attack time
440.734 Hz	= A3 (440 Hz)	attack time
369.360 Hz	= F#3 (370 Hz)	attack time
414.962 Hz	= G#3 (415.3 Hz)	attack time
349.419 Hz	= F3 (349.2 Hz)	attack time
310.825 Hz	= D#3 (311.1 Hz)	attack time
417.578 Hz	"incorrect value"	
330.471 Hz	= E3 (329.6 Hz)	attack time
308.012 Hz	"incorrect value"	
298.537 Hz	"incorrect value"	
462.870 Hz	"incorrect value"	
235.322 Hz	"incorrect value"	
330.471 Hz	= E3 (329.6 Hz)	attack time
358.298 Hz	"incorrect value"	

Fig. 1 Excerpt of …*URB to B*… musical composition (bar 84)

If the value determined for each Unix Time unit represents a semiquaver, than the previous values represent the following rhythmic figuration: qqq, with the respective pitch of A2, A2 and D3.The previous example was extracted from Casa da Música's listening point, with the correspondent index time of 1376118294 (2013-08-10 07h04:54).

In the musical composition … *URB to B*…, the value assigned for each input /*Unix Time* is of 250 ms. Therefore, the shortest rhythmic value provided by this *reading mode* will be the semiquaver.
After establishing this algorithm, it was necessary to develop a new URB version in order to interpret the currently *reading mode* and allow it to communicate with a MIDI sequencer, thus making it possible to convert the URB tables for automatic music notation.

Rascunho
Composer: Filipe Lopes
For: Live Electronic

According to Lopes, the mains issues that emerged upon the proposal was "why should one analyze a given soundscape as such?". Intuitively, it seems more expressive and interesting to use concrete sounds of the soundscapes rather than its analysis. Nevertheless, Lopes was curious about what could be revealed by such data and to find if he would be able to use it in a formalized composition.

The first experiments were focused on retrieving the online data, connect it to oscillators and hear the results. Later experiments evolved into controlling more general parameters such as wet/dry reverb, faster or slower pulses (e.g. using the number feed to control a metronome), extended or compressed harmonic fields (e.g. upon a chosen chord, use the number feed to expand, compress or transpose that chord). The initial experiments were done retrieving the values at slower rates, such as a value each second. Overall variations, however, ranged from 500 milliseconds to 5 seconds. In this case, Lopes was evaluating the feeds number by number, assessing the sonic discourse between successive values.

A different approach was to extract the number very fast, in order to get a gestalt idea of the feed, which he used to assess its potential as melodic lines or rhythmic contours. Lopes did such experiments retrieving values at fast speeds such as a value each 100 milliseconds or even faster.

By this time, Lopes was yet not convinced about the sonic results. It all sounded not natural. Melodies didn't have a melodic contour, rhythms didn't relate to each other and using URB to change any given parameter raised the problem of what sound to use. Globally, URB provided values that had no musical feeling between them, at least in Lopes preferred domain: formalized electronic music.

Lopes personal aim to use URB's data values had to match a valid necessity, in order to make sense of them and to make them different from a random generator. This was especially important since the descriptors were sound indicators with possible expressive sonic interest. Unlike sonification environments where often a composition is based on non-musical data (e.g. "*Omega – uma narrativa de sonorização e visualização*" (Lopes and Menezes 2012)), URB is based on extracting musical features from soundscape, which has been the topic of many compositions and, thus, has potential musical interest.

The work *Rascunho* was played live as opposed to a fixed electronic composition. It emerged by the division of URB's feeds between "high-variation" and "low-variation". For the piece, Lopes also decided to use concrete sounds of Porto, playing them with the software *POLISphone*.[7] The form used was the classical: A B A. Part A: Lopes used is older composition *Different Shapes*, *Same Rhythm* multiplied five times and used URB values to change its playing speed. Some of the values controlling playing speed were "high-variation" and others were "low-variation". This produced an organic drone but with a pitched feeling, as the composition itself is played in a piano. In addition, some values of URB were feeding a simple sine wave generator, masked with reverb. Towards the end of this section, it was introduced the concrete sounds of Porto and faded out all the other sounds. Part B: was comprised of very subtle concrete sounds such as night soundscapes or museum gardens and no URB usage. The use of concrete sounds of Porto seemed to fit the piece and the context proposed. The return to part A, was accomplished again with a fade-in, recycling most of the materials and URB's usage. The end was done by stopping sound-sources one by one until, in a slow fashion, reach silence.

Control and Unpredictability
Author: Gustavo Costa and Eduardo Magalhães
Sound Installation

The sound installation used audio recordings and URB data from the Carvalhido listening point. It explored the subjective interpretation of the listeners, especially when confronted with sounds that were embedded in their own particular geographical and social references. Since the parameters extracted from URB were highly objective, this piece relied precisely on the confrontation of objective and subjective data.

7 *https://vimeo.com/85330001*

Control and unpredictability consisted of:

- A loudspeaker inserted into the resonant body of a floor tom;
- A drum membrane with sand over it;
- Two loudspeakers playing processed field recordings from the Carvalhido area. (spectral filters and time stretch previously processed with the Kyma software)

Two URB parameters were used as input values for a Max MSP patch. These inputs acted as triggers for melodic and harmonic content. Input 1: Centroid values Input 2: Amplitude values

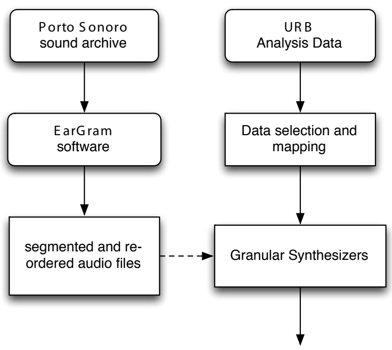
Centroid provided frequency values that were translated into pitch class sets (from 0 to 11), which were then transposed randomly to different octave registers to be played by a virtual instrument (a celesta). The values were then filtered to prevent the occurrence of some undesirable intervals. Only notes from a whole tone scale would be played and unisons, octaves and perfect fifths were blocked. Amplitude values provided a trigger for the processed field recordings after a defined threshold. Since the original values were triggering too many sound events, a re-scaling of that values was made in order to become musically adequate.

The sound of the virtual celesta was played by a loudspeaker inserted inside a floor tom. Over the membrane of the drum was some sand that was being excited when certain frequencies induced the vibration modes of the membrane. Since there was also a light inserted inside the floor tom, the sand created different visual patterns according to different vibration modes of the membrane.

There were many layers of transformation of the natural soundscape of the Carvalhido listening point. The natural sounds analyzed by URB, audio recorded, digitally processed, recombined with a melodic layer provided by URB data and ultimately recombined again with its natural sounds, since the sound installation was on an open air space. Regarding URB, some of the values were translated musically in a way that they became impossible to have a direct identification with the original sources. However, there was an extremely important level of conceptual coherence that was obtained while mixing the objective data of URB and translating it into a subjective, and sometimes distorted, musical reality.

Urban Sonic Impressions
Author: Rui Dias with the collaboration of Gilberto Bernardes.
Sound Installation

"Urban Sonic Impressions" is a sound installation inspired by the URB system, that creates moving sound textures using sounds from the *Porto Sonoro*[8] sound archive. Using the analysis data from the online stream coming from the four URB locations in Porto, the data is used to continuously select and alter the parameters of four granular synthesizers and processors (see Fig.2). Implemented in the Max/MSP/Jitter environment, the data is retrieved and mapped to four audio processor parameters to determine the resulting sound for each one. The audio processors consist basically on granulators and spectral FFT processors. Using the *EarGram* concatenative synthesis software by Gilberto Bernardes,[9] a selection of sound recordings from the *Porto Sonoro* online archive were analyzed and segmented according to the *brilliance* and *amplitude* descriptors. The segments were then reordered into a "scale" of sound grains forming a continuous sound file that starts with the segments with the lowest brilliance values and ends in the segments with the highest values. In order to obtain a greater sonic diversity, for each of the four different locations, a different set of sounds were chosen.



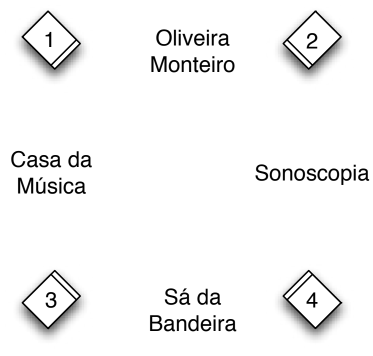


Fig. 2 Workflow diagram **Fig. 3** Source spatial position configuration

Because all of the four listening points are set on city streets, the real sounds that are analyzed are not necessarily very distinct. However, the locations have some relevant landmarks that were used as metaphors for the selection of the sound material. As such, while the selection of sounds for the "Sá da Bandeira" and "Oliveira Monteiro" streets were regular city sounds that include all sorts of vehicles, noises, voices, etc., the sound selection for the lis-

8 *http://www.portosonoro.pt/*

9 *https://sites.google.com/site/eargram/*

tening point in "Casa da Música" includes musical instruments, and the "Sonoscopia" location includes sounds from several percussive and metallic objects, seldomly used in the venue's music concerts and sound installations.

After the segmentation and re-ordering process with EarGram, the resulting sound files are then loaded into the granulators, and the current URB *brilliance* analysis feature is mapped to the buffer read position.

Other audio processors are used to provide more richness and variation, namely FFT filters and resonators. The *amplitude* and *spread* features from URB control respectively the amplitude of the filter and resonator modules, while the pitch defines the base frequency for the resonators module.

The resulting sounds are then arbitrarily positioned in a four speaker square configuration around the space (Fig. 3). Each of the four sound locations is placed in a speaker pair corresponding to one side of the square.

Note: *Rascunho*, *Control and Unpredictability*, *Urban Sonic Impressions* were presented in the event "We, the citizens" at Future Places Festival 2014.[10]

4. CONCLUSION

URB proved to be efficient in the access to audio descriptors data retrieved from sound ambient, particularly to its time alterations. It also provided composers enough raw materials in order to devise their works in addition to an higher awareness about sound environment. The artistic outcomes analyzed point to diverse realization about the aesthetic significance of using URB's raw data. While Peixoto, Costa and Dias guarantied musical elements such as melodies or formal coherences, Lopes claimed that his instinct as a composer induced him to adopt URB's metadata as a 'variation source', independent of the descriptors significance. In the case of Lopes, even if the work is artistically interesting, there is not an evident correlation with the original source, thus, breaking with the Soundscape Composition and Eco-Structuralism principles.

Further research will be focused in determining how these and other artistic outcomes resulting from using the URB system, can converge to an understanding of the different soundscape composition based in raw data, as a coherent musical framework.

10 *Rascunho*, *Control and Unpredictability* and *Urban Sonic Impressions* video: *www.jasg.net/URBconcerts%26pieces.html*

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A STUDY ABOUT CONFOUNDING CAUSATION IN AUDIO-VISUAL MAPPING

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The text reports a study, which draws upon methods from experimental psychology to inform audio-visual instrument design. The study aims at gleaning how an audio-visual mapping can produce a sense of causation, and simultaneously confound the actual cause and effect relationships. We call this a *fungible audio-visual mapping*. The participants in this study are shown a few audio-visual mapping prototypes. We collect quantitative and qualitative data on their sense of causation and their sense of understanding the cause-effect relationships. The study shows that a fungible mapping requires both synchronized and seemingly non-related components - sufficient complexity to be confusing. The sense of causation embraces the whole when the specific cause-effect concepts are inconclusive.

1. INTRODUCTION

Michel Chion coined the term *added value* to describe the expressive and informative value with which a sound affects an image, creating "the definite impression that this information or expression "naturally" comes from what is seen, and is already contained in the image itself." (Chion 1994:5) He noted that audition supports vision:

> *Why don't the myriad rapid visual movements in kung fu or special effect movies create a confusing impression? The answer is that they are "spotted" by rapid auditory punctuation. (Chion 1994:11)*

Musicians and audio-visual performers may find it problematic if perception biases sonic events that facilitate visual apprehension, subordinating timbres, textures, vibrations and nuances of musical expression, which form the wealth of multilayered relations between the sounds themselves. From Pierre Schaeffer (Schaeffer 1966) to recent acousmatic composers, people have argued that sounds must be detached from their originating cause to be fully experienced. Jeff Pressing also investigated the audio-visual relationship in digital 3D environments, noting that perception operates from vision to audition whenever a direction of causation is discernible. (Pressing 1997:8) In fact, 3D animators often place the sound of a footstep slightly before the foot actually hits the ground.

Our investigations are driven by an urge to understand whether, and how, the audio-visual relationship can foster a sense of causation without subordinating the music. As practitioners we desire the image to create a reactive stage scene without distracting the audience from sound organisation. Meghan Stevens proposed that the music remains dominant when the audio-visual relationship is *partially congruent*, but she stressed that her theories were "created from limited evidence." (Stevens 2009:3) Her notion of partial congruency is particularly subjective with abstracting sounds and images, because it relies on the sonic and visual shapes.

In a previous publication, we resorted to cognition/attention research in order to clarify how the audience's experience can be driven through the music – modulated, but not obfuscated, by a moving image. (Sa 2013) In many aspects vision tends to dominate over audition, but attention can be manipulated so that one sense dominates over the other. (Sinnet *et al* 2007) Attention increases the perceptual resolution of the information under focus, whether it is automatically driven to stimuli, or under individual control; furthermore, attention is drawn automatically to stimuli that are infrequent in time or in space. (Knudsen 2007) We concluded that to keep the music in the foreground one must dispense with disruptive visual changes, which automatically attract attention. There can be a wealth of discontinuities at a level of detail, but the image must enable perceptual simplification in order to provide a sense of overall continuity. One should apply gestaltist principles to visual dynamics; these psychological principles describe how we organize the perceptual field in the simplest and clearest way possible, deriving the meaning of the components from the meaning of the whole (Rubin 1921, Koffka 1935, Wertheimer 1938, Bregman 1990, Palmer 1999, Snyder 2001).

Clearly perceivable cause-effect relationships are as problematic for the music as disruptive visual changes. The gestaltist principles are an example of how we form conclusive concepts despite many inconsistencies. Indeed the primary aim of the brain is to be efficient in detecting, perceiving and responding to the world (Calvert *et al*. 2004). Perception is a process of multi-sensorial synthesis, and as we bind aural and visual we also skew stimuli that do not converge (Pick 1969, McGurk 1976, Shams *et al* 2002, Schutz and Kubovy 2009). Kubovy and Schutz explain that the binding of auditory and visual information is not merely associative: the visual discounts the aural and the aural discounts the visual. (Kubovy and Schutz 2010) The process is unconscious and presided by mind-dependent concepts, which they call *audiovisual objects*. Perceptual binding is undoable when the auditory and the visual stimuli appear unequivocally related; that is, when mind-dependent concepts are conclusive.

The question is how an audio-visual mapping can foster a sense of causation, and simultaneously confound the cause and effect relationships so that they remain inconclusive. We call this a *fungible audio-visual mapping*. In a publication titled "how an audio-visual instrument can foster the sonic experience," (Sa 2013) we substantiate the fungible mapping as a principle for instrument design and composition. It goes together with two other principles: to threshold control and unpredictability so as to potentiate sonic expression; and to dispense with disruptive visual changes, which would automatically attract attention, subordinating audition.

The study here reported aims at demonstrating the fungible mapping independently from the other two principles, and regardless of any personal explorations or technical platforms. After watching each of several audio-visual mapping prototypes, the participants are questioned on their sense of causation and their sense of understanding the cause-effect relationships. We will analyze the quantitative and qualitative data by considering gestaltist principles and Kubovy & Schutz' notion of audiovisual object.

2. THE AUDIO-VISUAL RELATIONSHIP

2.1. TYPES OF PERCEPTION

Chion described three types of listening, or modes, which we can extend into the audio-visual domain. The first is *causal listening*, which "consists of listening to a sound in order to gather information about its cause (or source)" (Chion 1994:28). Causal audio-visual perception is equivalent; it consists of listening to the sounds and viewing the images in order to gather information about the audio-visual mapping mechanics.

The second mode is *semantic listening*, which "refers to a code or a language to interpret a message" (Chion 1994:28). Semantic audio-visual perception consists of listening to the sounds and viewing the images while focusing on a goal beyond the perceptual experience, as happens for example in video gaming.

The third mode of listening derives from Schaeffer's *reduced listening*, which "focuses on the traits of sound itself, independent of its cause and its meaning" (Chion 1994:29). Chion provides perspective by stating that hiding the source of sounds "intensifies causal listening in taking away the aid of sight" (Chion 1994:32). In applying to the audio-visual domain, we consider how "reduced" might refer to stripping the perceptual experience of conclusive causes and meanings.

2.2. CONCLUSIVENESS AND INCONCLUSIVENESS IN AUDIO-VISUAL BINDING

Bob Snyder describes how relating new sensory information to previous experience enables perception to operate based on assumptions. (Snyder 2001) Events activate memories that have been previously activated by similar events. Among these memories, very few become highly activated and conscious; Snyder coins the term *semiactivated memories* to describe those memories which remain unconscious, forming expectations.

Expectations condition the process of multisensory synthesis. As we process information, divergences across the sensory modalities can produce phenomena known as multisensory illusions, derived from automatic interactions between the senses in multisensory integration. Well-known examples are the *ventriloquist effect* (Pick *et al*. 1969), in which a sound source is dislocated towards a seemingly related visual stimulus; the *sound-induced double-flash illusion* (Shams *et al*. 2002), in which a visual stimulus is doubled when juxtaposed with a set of tones; and the *McGurk effect* (McGurk 1976), in which non-matching speech sounds and lip movements are perceived as a new phoneme that diverges from both.

Schutz and Kubovy conducted a study about the perception of a (video-recorded) percussive action (Schutz and Kubovy 2009). By manipulating the synchronization between sound and image, they observed that synchrony does not inevitably lead to automatic sensory interactions. Sensory interactions depend on the strength of perceptual binding, which in turn depends on what they call the *ecological fit* between auditory and visual information. For example, the visual impact over a marimba fits naturally with a percussive sound, but not with a piano sound. Thus, when the sound and the image are slightly desynchronised (up to 700ms), the former combination leads to automatic interactions, and the later does not. The ecological fit depends on previous concepts, called audiovisual objects (Kubovy and Schutz 2010). The process of multisensory integration is undoable when audiovisual objects are conclusive: conscious awareness does then not “recover” discounted sensory information.

Chion coined the term synchresis to describe “the forging of an immediate and necessary relationship” between synchronized sounds and images, whether their combination is plausible or implausible. (Chion 1994) We can say that a person binds sound and image while knowing that they have a common origin, meaning a common cause: the film. People can draw upon implausible relationships in film, as it frames attention. We can say that binding sounds and images while finding the combination implausible is forming inconclusive audiovisual objects. And we can say that sensory interactions can be undone when audiovisual objects remain inconclusive.

So how do we form inconclusive audiovisual objects with abstracting sounds and images, which do not refer to anything but themselves? One-to-one synchronization would connote a common cause, but also make cause and effect relationships unequivocal. The challenge is to create an audio-visual mapping that forms causal percepts, but also throttles the fit between the sonic and the visual events so that the audience desists trying to understand the instrument, and focuses on the perceptual experience itself.

3. STUDY

In this section we report a study on how an audio-visual mapping can produce a sense of causation, and simultaneously confound the cause-effect relationships. The study aims at quantitative and qualitative data from the participants' subjective experience.

3.1. HYPOTHESIS

A fungible audio-visual mapping may combine mappings that convey a sense of causation, and mappings that do not. We wanted to see how complexity affects the clarity of perceived cause and effect relationships.

People are generally familiar with audio-visual software and VJ culture, which means that synchrony produces a high sense of causation, and consistent synchrony makes cause-effect relationships clearly perceivable. We wanted to see if these relationships remained clear once synchrony was occasionally interrupted.

Additionally, we decided to see how latency, i.e. the delay between the audio and visual stimulus, affects perceived causation. Using Schutz' and Kubovy's marimba experiment as a guide (Schutz and Kubovy 2009), we compounded the effect of latency by 1.) randomizing latency, 2.) randomly interrupting the cause-effect relationship, and 3.) adding the perturbation of a synchronized, not interpolated visual parameter.

Given that synchrony conveys a sense of causation, does the feeling persist when complexity obfuscates the base cause-effect relationships? That should manifest as a quantifiable gap between the participants' sense of causation and their sense of understanding the cause and effect relationships. To grasp underlying perceptual dynamics, we decided to ask for a description of the perceived cause and effect relationships. We could analyse the qualitative answers by considering gestaltist principles (Wertheimer 1938, Bregman 1990, Snyder 2001) and the notion of audiovisual object as mind-dependent concept (Schutz and Kubovy 2009).

3.2. STIMULI

The study employed four audio-visual mapping prototypes, programmed in Processing Java-based procedural graphics environment,[1] and shown on a computer.

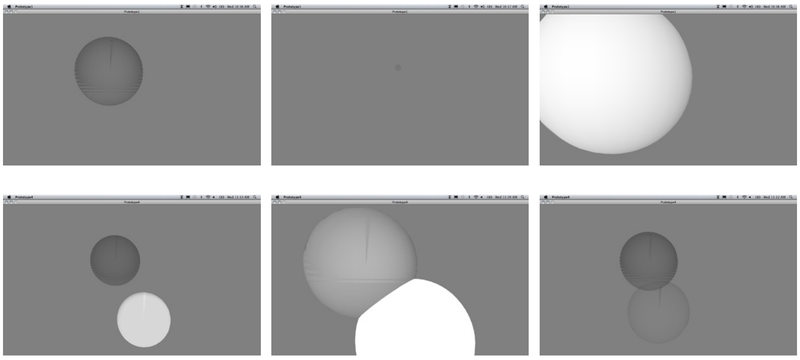

Fig. 1 Prototypes 1, 2 and 3, which exhibit one sphere; and Prototype 4, which exhibits two spheres (*http://doc.gold.ac.uk/~map01apv/StudyMappingPrototypes.mp4*)

The same audio recording was used in all prototypes: a short orchestration of string instruments (37 seconds), with amplitude ranging between 0 and 43 (arbitrary values). We dispensed with computer-generated sounds, which would potentially fit with computer-generated images: we wanted to ensure that perceptual binding was due to the mapping itself, independently from the specific qualities of the sounds and the images.

The prototypes were black and white. They exhibited a sphere (two, in Prototype 4) drawn in a digital 3D space (Figure 1). Audio amplitude was mapped to the spheres' size, colour/ transparency, and position. All parameters except position in Prototype 4 were slightly interpolated, which smoothened otherwise frantic visual changes.

Prototype 1 / Interrupted synchrony

In Prototype 1 the sphere is synchronized with amplitude detection of the audio stimulus. It is invisible between amplitude 7 and 18 (this interval is in the range of average amplitude values).

Prototype 2 / Random latency

In Prototype 2 the sphere is drawn with random delay upon amplitude detection. There are occasional points of synchronization, and maximum delay is 1 sec (automatic

1 *http://processing.org/*

multisensory interactions due to plausible cause-effect relationships may occur even when the effect is delayed up to 700msec (Kubovy and Schutz 2010)).

Prototype 3 / Interrupted random latency

In Prototype 3 the sphere is drawn with random delay upon amplitude detection, as in Prototype 2. In addition it is invisible between amplitude 7 and 18.

Prototype 4 / Complexity

Prototype 4 displays two spheres that merge and split. Sphere A is drawn with random delay upon amplitude detection, as in Prototype 3. Sphere B is synchronized and invisible between amplitude 7 and 18, as in Prototype 1. Because the position parameter is not interpolated in sphere B, the sphere moves frantically through the X and the Z-axis in the digital 3D space.

3.3. PROCEDURE

Participants were recruited from Goldsmiths, University of London. All had knowledge of computing. Thus, if they did not understand a mapping (low Transparency rate) and yet felt causation (high Causation rate), it could not be due to being unfamiliar with software. Importantly, nobody was acquainted with our investigations about cognition/ attention; they were exposed later, in an article which had not been published at the time (Sa 2013).

The experiment included ten individual sessions. Participants were previously asked to read through a questionnaire, which they would fill after viewing each prototype. Firstly they were played the audio recording alone. Subsequently, they were shown the four audio-visual mapping prototypes in random order. After viewing each prototype they were asked to respond to a same set of questions: two quantitative and one qualitative question. They were asked to rate Causation and Transparency on a Likert scale (between 1 and 7). Additionally, they were asked to explain their rates for Transparency.

The questions were formulated as follows:

A. *How would you scale the sense of a cause-effect relation between sound and image?*
(1 = no cause-effect relation between sound and image; 7 = all visual changes relate to changes in sound)
B. *Can you distinguish which input factors affect which output parameters, and how?*
(1 = never; 7 = always)
C. *Please explain the latter rating.*

The average ratings for each mapping prototype were calculated, generated statistics, and compared. Our analysis and discussion make use of the answers to the qualitative question (C).

3.4. RESULTS

Table 1 shows the average over the participants' ratings for Causation (question A) and Transparency (question B).

According to the statistics test (T-test),

- The subjective rating of Causation is significantly higher with Prototypes 1 and 4 ($p < 0.05$) than with Prototypes 2 and 3 ($p < 0.05$).
- The subjective rating of Transparency is significantly higher with Prototype 1 than with Prototypes 2 ($p < 0.05$), 3 ($p < 0.05$) and 4 ($p < 0.05$).
- The subjective rating between Causation and Transparency is not significantly different with Prototypes 1, 2 and 3 ($p > 0.05$), but it differs significantly with Prototype 4 ($p < 0.05$).

Figure 2 represents these results.

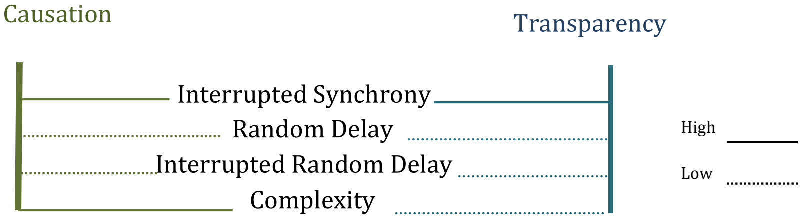

Fig. 2 Relation between Causation and Transparency for each mapping prototype

Both Causation and Transparency were rated high with Prototype 1/ interrupted synchrony (continuous line). Both Causation and Transparency were rated low with Prototype 2/ random latency and Prototype 3/ interrupted random latency (dashed line). With Prototype 4/ complexity, Causation was rated high (continuous line) and Transparency was rated low (dashed line).

The aspect of Prototype 4 can be inferred from the answers to question C, which aimed the participants to explain their Transparency rates.

Several participants specified that they found a relation between sonic and visual events, and that this relation was confusing. For example, a participant who rated Causation with 7 and Transparency with 1 wrote "no idea" when asked to explain the latter rate. [Participant #5]

Table 1 Average ratings for Causation and Transparency

PROTOTYPE	A/ causation	B/ transparency
1	5.6	5.1
2	2.7	2.3
3	1.8	1.9
4	4.7	2.8

A participant rated both Causation and Transparency with 1 for Prototype 3, explaining: "*sound and image do not synch.*" The same person rated Causation 7 and Transparency 5 for Prototype 4, which included both synchronised and non-synchronised components: "*all visual changes are produced by sound*". [Participant #7]

A participant who rated C2 and T1 for P3, "*I can't identify anything*", rated C7 and T4 for P4: "*the instrument type effects position; amplitude effects size; some delay, too?*" [Participant #4] This shows that the delay between cause and effect led to different percepts in P3 and P4: whilst no cause-effect relation was detected in P3, the mechanical delay was detected in P4 (and this person viewed P4 prior to P3).

4. DISCUSSION

Prototype 1 aimed at confirming that audio-visual synchrony conveys causation, and that the cause and effect relationships seem clear even when those relationships are not absolutely consistent. Prototype 2 tested whether random delay disrupts the sense of causation, breaking any audio-visual relationship. Prototype 3 compounded this effect by randomly interrupting the cause-effect relationship. Finally, Prototype 4 tested how complexity effects perceived causation.

Participants found Causation high in Prototypes 1 and 4, which indicates that synchrony was taken to reveal a cause and effect relationship. The low ratings for Causation with Prototypes 2 and 3 indicate that the participants did not sense any cause and effect relationship when points of synchrony were sparse. Combining the mappings of P1 and P3, Prototype 4 produced a global sense of causation, and the cause-effect relationships were unclear. This shows that sensing causation does not depend on perceiving how specific changes in the sound may relate to specific changes in the image.

Synchrony conveys a gestaltist principle called *common fate*, which manifests when we group simultaneously changing elements. We expect that when an object moves, all its parts move together. In the aural domain, we group simultaneously changing sounds (Bregman 1990). In a static visual image, where the movement is suggested by the relative orientation of the elements, we group elements that display a same orientation (Wertheimer 1938). Synchrony also conveys the principle of *good continuation*: it fulfils the expectation of a consistent audio-visual relationship. In the visual domain, the principle manifests when we group elements on basis of their following a consistent, lawful direction (Wertheimer 1938); or when we group visual objects which are arranged in straight lines or smooth curves. In the auditory domain, the principle manifests when we group consecutive sounds that change consistently, for example in pitch or loudness (Bregman 1990, Snyder 2001).

Regarding P1 (interrupted synchrony), the participants' high rates for Transparency indicate that the cause and effect concepts were conclusive. Six participants spoke of a single sphere, in spite of the gaps when the sphere was invisible. This is typical of the *closure* principle, one where we group a series of intervals to interpret the whole as a single form (Wertheimer 1938). In the auditory domain, closure manifests when we complete a linear sound sequence (e.g. a sound repeating at equal intervals, or a note scale) that lacks a sound (Snyder 2001). The six participants who spoke of a single sphere grouped the stimuli within a single cause and effect concept. The other four participants spoke of a "small sphere" and a "big sphere", assigning different cause-effect relationships to each; the stimuli for them comprised two distinct audiovisual objects. This shows that the sense of causation admits inconsistency and multiple audiovisual objects. It also shows that inconsistency does not impede the formation of conclusive cause and effect concepts.

The sense of causation continued in P4, where cause and effect relationships were further perturbated. The mapping used in P4 is one that does not conform to specific concepts. While synchronised audio-visual components convey causation, non-synchronised components counteract conclusiveness.

In P2 (random delay) and P3 (interrupted random delay), sparse synchrony points may have led the participants to momentarily bind sound and image. With P2, four participants did not find any audio-visual relationship, but six affirmed there was some sort of relationship; two of them actually mentioned latency. With P3, six participants did not find any audio-visual relationship, yet four assigned a part of the visual changes to sound. The low rates for both Causation and Transparency show that perceptual binding was too weak to be convincing.

Causation rates were high with P4, meaning that perceptual binding was convincing. Yet, three participants did not distinguish any specific cause-effect relationship. The other seven participants, among whom four stated uncertainty, assigned multiple visual parameters to multiple sonic parameters. This suggests that multiple audiovisual objects were formed at once. Since transparency was rated low, these audiovisual objects remained inconclusive.

Interestingly, several participants assigned a number of sonic parameters to a visual object (sphere A) which, when viewed independently, had been assessed to exhibit no relationship with the audio recording. Rather than segregating the audio-visual components that produced a sense of causation (sphere B) from the components that did not (sphere A), the participants sought for a global ecological fit. Since Transparency was rated low, they were aware of non-fitting information.

There was a sense of causation, given certain amount of audio-visual synchrony. As perception forms concepts of causation, the aural discounts the visual and the visual discounts the aural. But complexity generated confusion, counteracting mechanisms of perceptual simplification. Thus perception kept recovering sensory information that would have been automatically discarded if concepts were conclusive.

5. CONCLUSION

The study showed that the fungible mapping includes components that convey a sense of causation and components that do not; and that the sense of causation persists when complexity confounds the actual cause and effect relationships. The study specified that: a) Synchrony conveys causation even if it exhibits interruptions; one may form a single gestalt or separate gestalts, but the cause and effect relationships are conclusive. b) When sound and image are mapped with random latency or interrupted random latency, occasional points of synchrony do not suffice to produce a convincing sense of causation. And c) interruptions and diverging interpolations create complexity, confounding the actual cause and effect relationships.

The aspect of a fungible mapping was gleaned independently from personal creative explorations, so that it can be explored in many different ways and with any audio-visual platform. Synchrony conveys concepts of causation, and visual elements changing independently from sound do not. The point is, we do not tell them apart conclusively when multiple components changing independently from each other create complexity.

We are driven to form conclusive concepts at the expense of overlooking or skewing any conflicting information. With a fungible audio-visual mapping, perception continues to acknowledge conflicting information, embracing convergences and divergences as inconclusive concepts.

6. COMPLEMENTARY NOTES

Art invites us to shift our usual ways of perceiving the world; there are many related philosophies. For example, Eastern philosophies teach us that one needs to suspend pragmatic thinking in order to permeate a relation between all things. And philosopher Henri Bergson wrote that the intellect shields the human mind from what he called *prime reality*, an evolving dynamic flux that proceeds along a definite but unpredictable course, where “all events, objects, and processes are unified” (Westcott 1968:8). He stated that intuition is a way to attain direct contact with this *prime reality* ordinarily masked from human knowledge, and that the intellect can freely interact with intuition. One may also recall Immanuel Kant’s definition of *sublime* as an extraordinary experience: we fail to understand the greatness of nature by means of determinate concepts, and yet supplant this failure with a delight stemming from our ability to grasp that greatness (Kant 1790).

Any attempt to describe perceptual dynamics in audio-visual performance will remain incomplete, but artistic motivations can be clarified with the aid of science. Our perceptual approach to instrument design and composition frames the development of a personal audio-visual instrument, which explores three principles: audio-visual fungibility, visual continuity and sonic complexity. The instrument outputs acoustic sound, digital sound, and digital image. It includes a zither, that is an acoustic multi-string instrument with a fretboard, and 3D software which operates based on amplitude and pitch detection from the zither input. An early version is described in a special issue of Leonardo (Sa 2013), and a later version in NIME 2014 proceedings (Sa 2014). Further information and videos are at *http://adrianasa.planetaclix.pt/research/AG1.htm* and *http://adrianasa.planetaclix.pt/research/AG2.htm*.

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NODALISM AND CREATIVE PRACTICE

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This paper proposes the notion of Nodalism as a means describing contemporary culture and of understanding my own creative practice in electronic music composition. It draws on theories and ideas from Boden, Lacan, Deleuze, Guatarri, and Gochenour *et al* to demonstrate how networks of ideas or connectionist neural models of cognitive behaviour can be used to contextualize, understand and become a creative tool for the creation of contemporary electronic music.

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1. INTRODUCTION: CREATIVE AND CULTURE

In the hundred years since Russolo's Art of Noises manifesto of 1913 we have witnessed an exponential rise in the number of musical genres as diverse musical practices collide, meld and fracture to create previously unimagined sound worlds. What we hear today is predominantly technologically mediated audio, given a plethora of tags in a vain attempt to define boundaries and normative modes of behaviour. Kim Cascone, uses flocking behaviour as a model to describe the emergence and formation of new genres of electronic music. Cascone writes that,

> *… a group of nodes assembles and follows a set of simple rules, which creates emergent behaviors. These simple rules are the basis of all flocking behavior [sic]: alignment, separation and cohesion… In the context of electronic music a flock consists of a cluster of individual nodes that generate content. Content can consist of a sound file, a software instrument, an algorithm, an idea or information… Because no single node in a flock determines its overall behavior, a flock is not a hierarchical organization but a decentralized one. (Cascone 2005)*

Cascone's quotation is not only interesting in itself but also in its terminology. Although the model Cascone draws on in his paper is based on Craig Reynolds' description of the Boid Algorithm,[1] his use of a decentralized non-hierarchical model is clearly derived from the thinking of Deleuze and Guattari's notion of the rhizome – a distributed network (see Fig. 1). Reynolds' terminology in his paper 'Flocks, Herds, and Schools: A Distributed Behavioral Model' (Reynolds 1987) focuses on emergent and dynamic behavioural models rather than non-hierarchical networks. In *A Thousand Plateaus*, Deleuze and Guattari propose the model of the rhizome as a means of describing contemporary cultural activity, one in which hierarchical structures are supplanted with the concept of a planar (non-hierarchical) network of connections. Such systems are,

> *finite networks of automata in which communication runs from any neighbor to another, the stems or channels do not pre-exist, and all individuals are interchangeable, defined only by their state at a given moment – such that the local operations are coordinated and the final, global result synchronized without central agency (Deleuze and Guatarri 1987).*

1 *http://www.red3d.com/cwr/boids/*

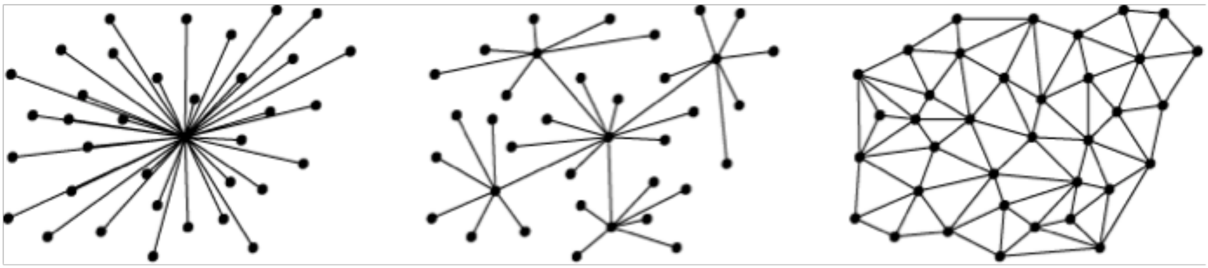


Fig. 1 centralized, decentralized and distributed network models

Cascone is also clearly thinking nodally and his definition of 'content' is what Richard Dawkins would term memes – units of cultural information. Dawkins' notion of the meme is one in which ideas are spread from one brain to the next and that creative activity arises from the intersection of memes in a sound artist or composer's brain. Memes are neuronally encoded cultural information and their phemotypic products (behaviour and artifacts) spread through a process of imitation from one individual's memory to another. Richard Dawkins in *The Selfish Gene* writes that, 'examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or building arches…' (Dawkins 1989).

As composers and sound artists we traditionally pride ourselves on originality or the unique sound world we create in our works. Steven Jan, writing specifically about Dawkins' work in relation to music writes that, 'memetics maintains that conscious intentionality, the fundamental attribute of the human mind, is not some unitary presence, but the resultant construct of a multitude of memes in constant competitive interplay' (Jan 2007). At its most reductive, Jan's work suggests that a composer's musical style or 'musical identity' is actually the result of memes residing within the composer's brain (Adkins 2009). The corollary being the more memes one has absorbed through engaging in all areas of contemporary culture, science and ideas, the more unusual neuronal connections that can be made and hence potentially a more varied and richer compositional style can result as memes are combined and hybridized.

In her paper 'Creativity and unpredictability' (Boden 1995), Margaret Boden uses the term *conceptual space* as an equivalent to Cascone's musical genre. Boden's term is informed by Koestler's view of creativity as the 'bisociation of matrices' (Koestler 1975) and is explored at length in Boden's book *The Creative Mind* (Boden 1990). She writes that, *The 'mapping' of a conceptual space involves the representation, whether at conscious or unconscious levels, of its structural features. The more such features are represented in the mind of the person concerned, the more power (or freedom) they have to navigate and negotiate these spaces. A crucial difference - probably the crucial difference - between Mozart and the rest of us is that his cognitive maps of musical space were very much richer, deeper, and more detailed than ours. In addition, he presumably had available many more domain-specific processes for negotiating them… mental maps enable us to explore and transform our conceptual spaces in imaginative ways. (Boden 1995)*

The inner dynamics of the mind are complex. Each mind is idiosyncratic no matter how culturally conditioned we consider ourselves to be. This idiosyncrasy is, in part, a result of our experiences but is also neural – suggested by Aniruddh Patel's shared syntactic integration resource hypothesis (Patel 1998) which proposes that our neural paths for perceiving sound, touch, sight and smell are shared when first born and develop into independent pathways in unique ways for each of us as we mature from young infants to children. This suggests that creativity and the ability to produce new compositional ideas is the result of both our neurological functioning and an individual's accumulated memetic repository.

Boden states that a quasi-scientific approach to define creativity is through the novel combinations of existing ideas, or in Dawkins' terms, memes. She states that,

At the heart of creativity lie constraints: the very opposite of unpredictability. Constraints and unpredictability, familiarity and surprise, are somehow combined in original thinking… It must show how creativity is grounded in constraints, and why it is that creative ideas are unpredictable - and often inexplicable even after they have occurred… Many creative ideas are surprising not because they involve some unusual mix of familiar ideas, but in a deeper way. They concern novel ideas which not only did not happen before, but which - in a sense that must be made clear (and which combination-theory cannot express) - could not have happened before… A merely novel idea is one, which can be described and/or produced by the same *(specified) set of generative rules, as are other, familiar ideas. A genuinely original, or creative, idea is one which cannot. It follows that constraints, far from being opposed to creativity, make creativity possible. To throw away all constraints would be to destroy the capacity for creative thinking. Random processes alone can produce only first-time curiosities, not radical surprises. (Boden 1995)*

Boden's research is echoed in that of Santanen *et al.* (Santanen, Briggs, Vreede 2000) who present a network model of creativity. Their paper is aimed at problem solving and proposes a new brainstorming technique. However, their premise is applicable to our current discussion of nodalism. In their model they recognize,

…that human memory is organized into bundles of related items that derive from our experiences. These individual experiences are grouped together according to different principles such as the time sequence of events (as in episodic memory), the meaning of the perceived items (as in semantic memory), or the similarity or typicality of the items. (Santanen et al 2000)

They refer to these bundles as *frames*. They posit that over time connections are made between individual frames that manifest as,

vast networks which represent our knowledge and experiences. Due to the sheer size of these networks it is only possible to actively manipulate a very small number of frames at any one given time. This manipulation occurs in our short-term memory, which may be thought of as the workspace for information, which is under active consideration at the moment. We refer to individual frames that currently occupy short-term memory as being salient, and activation as the process that causes some particular frame to become salient. By traversing the links, which connect some activated frame to other frames within our knowledge networks, activation of successive frames spreads through our memory causing the activation of yet other frames. When two or more frames are simultaneously salient that are said to be associated. (Santanen et al 2000)

The authors determine that activation among frames take two forms: *automatic spreading activation* which occurs without conscious awareness - allowing critical reflection, and *conscious*, *limited capacity spreading activation* which requires cognitive intention – allowing analytical insights from determined choices.

Boden proposes a number of creative modes (explorative, associative, transformative and combinatorial). In 'Creativity and unpredictability' she poses the question 'What is it to transform a conceptual space?' One method Boden proposes is the dropping of a constraint characteristic of one genre. Boden writes that, 'Dropping a constraint is a general heuristic for transforming conceptual spaces. Non-Euclidean geometry, for instance, resulted from dropping Euclid's fifth axiom, about parallel lines meeting at infinity' (Boden 1995). I propose that one could equally transform a conceptual compositional space by adopting the constraints from another space, or even another artistic practice altogether and applying them to music.[2] This process may be either a conscious decision in which ideas or nodes are drawn together in a considered manner or an unconscious act as Santanen *et al* propose. Boden writes that 'The more clearly we can map this space, the more confidently we can identify and ask questions about the creativity involved in negotiating it… novel ideas gained by exploring an unknown niche in a pre-existing conceptual space are regarded as less creative than ideas formed by transforming that space in radical ways.' (Boden 1995).

What draws Boden's *conceptual space*, Santanen's *et al frames*, Dawkins' *meme*, Deleuze and Guattari's *rhizome* together is the concept of a network of nodes and the interchange between them. Nodalism describes how we think, create and communicate in interconnected networks or 'chains' of nodes. In a previous article, 'Acoustic Chains in Acousmatic Music' (Adkins 1999) I proposed a similar model for listening using Lacan's signifying chain originally applied to linguistics. Lacan described the model for this chain as "rings of a necklace that is a ring in another necklace made of rings" (Lacan 1977). The dynamic nature of this chain, essential to the development of creative compositional thinking was described by Bowie who writes that,

2 This is something I have consciously done in works such as *Rift Patterns* (2014), which situates the constraints of contemporary prepared piano techniques and the rhythmic and melodic configurations arising from classical contrapuntal writing into ambient/glitch electronica.

> *the chain is also mobile, sinuous, and able to loop back upon itself; any one of its links can provide a point of attachment to other chains… The 'vertical dependencies' of the signifying chain extend as far downwards into the hidden worlds of mental process as it is possible for the speculative imagination to descend (Bowie 1991).*

A nodalist model of creativity and culture celebrates this mobile, sinuous network. Through this model we can posit that listening and composing are culturally conditioned, contextual, relational, reflective and personal acts and that dynamic nodal networks of influences and ideas are constantly formed and reformed by the experiential knowledge of the individual.

Philip Gochenour (Gochenour 2011) 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… 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). For Gochenour this non-hierarchical model is a,

> *significant structural metaphor in contemporary thought. Unlike other structural metaphors, however, the nodalistic trope is not confined to the realm of the linguistic and figurative; as it has migrated from a model of mind in neuroscience into psychology and computer science, it has also migrated from concept to concrete architecture, from a typographic representation in Freud to the technological underpinnings of globalism (Gochenour 2011).*

Gochenour's advocacy of nodalism is compelling. His idea of an open non-hierarchical model is similar to Deleuze and Guattari's planar model proposed as an antidote to the hierarchy of Modernism. However, this it is not a convincing or accurate means for describing, modelling and understanding compositional practice. Composers do not work with a planar or flat model of ideas and influences. This planar model is too neutral – too like Boden's notion of randomness. Creative practitioners have preferences and, more importantly, they have different preferences in different works. Composers do exert a 'central agency' and each work will have its own weighted concerns be they structural, narrative, timbral or technical.

Paul Baran proposes that a decentralized network is a hierarchical network with multiple centres, while a distributed one is a network without hierarchy. We should therefore discuss a composer's work in terms of a decentralized nodal network model. The convergence of memes or nodes within one work of a given composer working (generally) within a specific genre demonstrates that there is a *local hierarchy* of nodal interactions within a given musical work as certain memes are given prominence and hence lend a specific character to a piece. This notion of a *local hierarchy* differentiates nodalism from the postmodern non-hierarchical model of the rhizome as proposed by Deleuze and Guattari.

An individual piece will not always express all of these interests and may deliberately deal with new ones. This model of *local hierarchy* is exemplified by Leonard Meyer's (Meyer 1989) definition of musical style. Meyer identifies six hierarchical levels: (1) intraopus style; (2) style of a period in the life of a composer; (3) idiom – the style of a composer within a particular cultural community; (4) dialect – the style of a cultural community defined either geographically or chronologically – akin to Cascone's definition of genre through flocking behaviour; (5) rules – the system of musical organization; (6) laws – these are the biologically - and physically or acoustically defined attributes of perception and cognition. In my paper 'The application of memetic analysis to electroacoustic music' (Adkins 2009) I demonstrated how Meyer's six levels could be understood from a holistic memetic perspective. The 'intraopus style' of a given composer's work can be discussed in terms of the totality of memes that are replicated within a single work. The 'dialect' of a given musical genre, such as glitch or ambient music, can also been considered as being concerned with a collection of musical memes that characterize this body of work. An interesting analysis can therefore be undertaken to assess how a particular composer uses specific memes in a given work (intraopus) common to and outside of a given 'dialect' in order to asses the creative ambition or novelty of the work and its influences. If, as I propose, when a composer is working on a new composition, a local nodal-hierarchy of memes is established, demonstrating their specific musical and cultural influences within the piece, then a nodal model can be extrapolated following Meyer's six hierarchical levels to aid analysis of the work. We can propose that the nodal model be used as a unifying concept for understanding models of creativity, local hierarchy within a composer's work, the genre in which they work and their cultural community.

Many connectionist models of creativity used in the cognitive sciences (artificial intelligence, neuroscience, cognitive science *et al*) adopt a nodal model, one based on interconnected dynamic networks of simple elements exhibiting emergent forms of behaviour. The origins of these models stem from research done in the 1930s by Warren McCulloch and Walter Pitts, and in the following decades by Donald Hebb and Friedrich Hayek. Hayek's brain research and his proposition of 'connective learning' at the neurological level, was published in his book *The Sensory Order* (1952). Hebb's work resulted in a principle termed Hebbian learning that is still pertinent today. In his book *The Organization of Behavior*, Hebb proposes 'lasting cellular changes' (Hebb 1949), occur in neurons in the learning process through persistent firing in a consistent pattern. What is important in Hebb's model is that the 'metabolic change' that takes place is due to the causal relationship between cell A and cell B through the temporal precedence of the neural firing of cell A. There is a hierarchy of firing to stimulate neural change and connective strength between neurons in Hebbian learning. Hebb writes, 'When one cell repeatedly assists in firing another, the axon of the first cell develops synaptic knobs (or enlarges them if they already exist) in contact with the soma of the second cell.' (Hebb 1949). In his book 'Neural Darwinism' (1987), Gerald Edelman takes this concept of neuronal plasticity and adaptability further exploring a theory of memory based on environmental neural conditioning. This again, can be posited as memetic. Edelman's theory is anti-reductionist (unlike some computational models of creativity) and proposes that consciousness is a unique manifestation of the neurologically complex biology of our brain. Further research by John Horgan demonstrates a Hebbian-like modification of local neighbouring neurons in addition to those directly reinforcing one another in an established network (Horgan 1994). This is termed 'retrograde signalling' and illustrates the ripple effect of such nodal connections. I would contend that this neurological process is also evident in contemporary culture in the way that two differing memes, for example differing musical ideas, when brought together also trigger associations with other diverse and related memes, so enriching and contextualizing the original connection. The connectionist thinking of Hebb and Hayek was much developed in the 1970s and the following decade by James McClelland and David Rumelhart and their work on parallel distributed processing (PDP) models. This model emphasised parallel neural processing and the distributed nature of neural connectivity.

The adaptation of neural pathways proposed by Hebb and Horgan is modelled computationally in neural networks by means of weighting matrices. Such weighting is deemed important in our understanding of how memory and learning occur. 'Memory' and 'learning' are engendered in a neural network by modifying the weighting (or strength) of the connections between nodes. Learning always involves modifying the weighting patterns between neurons and is closely akin to my notion of a *local hierarchy* of nodes when considering the intraopus style of a composer's work.

A further example of embedded local hierarchy is found in the development of Optimality Theory, first proposed by Paul Smolensky and Alan Prince (1993) and concerned primarily with how language arises from the interaction of conflicting constraints. It differs from other linguistic models due to its being concerned not with rule-based systems but rather with constraint-based ones. In Smolensky and Prince's model, the grammar of a language is determined by a ranking of constraints. Joe Pater (2009) has drawn together Smolensky's work with Prince on Optimality Theory and a previous model the former proposed in 1990 along with Géraldine Legendre and Yoshiro Miyata called Harmonic Grammar (Legendre *et al* 1990) with weighted constraints.

Although these connectionist models all contain local hierarchy either in terms of weighted constrains, temporal precedence or adaptive neuronal connectivity and support my concept of nodalism from a creative perspective, Boden states that what is often lacking from such models is not so much an understanding of the mechanisms involved in neural activity in creativity but an explanation of how and why it arises from such mechanisms. Boden writes that,

> *'novel combinations' have to be not only new, but interesting: to call an idea creative is, in part, to say that it is valuable. Combination-theorists, however, usually omit value from their definition of creativity. Also, they fail to explain how the novel combination comes about. They take it for granted (for instance) that we can associate similar ideas or recognize more distant analogies, without asking just how such feats are possible. (Boden 1995).*

Boden draws together connectionist and associative models of creativity as well as PDP-models to consider how ideas from very different sources can be merged to produce new structures, ideas and thoughts. Boden broadly suggests that these associative elements of creativity can for the most part be explained in computational terms and features of connectionist models such as powers of pattern-completion, multiple constraint-satisfaction, and best-fit equilibration.

From a musical perspective these models suggest that composition within a specific genre becomes an established pattern involving the repeated firing of specific neural pathways. This patterning strengthens compositional practice and is further reinforced through listening to similar works within a genre that trigger similar neural firing patterns. It is only when such patterns are consciously questioned that they can be enlarged, or the conceptual spaces occupied, transformed. Nodalism offers a mechanism for this conscious change through the drawing together of differing memes or conceptual spaces and, through the retrograde signalling effect, further associated memes or musical influences.

Although my main preoccupation here is a consideration of nodalism as a model for describing and considering creativity and cultural behaviour more broadly, Gochenour has demonstrated that nodalism is much more than this. Nodalism, with its origin in 19th century graph theory, mathematics, critical theory, neuroscience and Associationist models of mind, does provide a model for understanding contemporary society. Vilem Flusser writes that, *We must imagine a net of relations among human beings, an 'intersubjective field of relations'. The threads of this net should be seen as channels through which information flows. The threads knot themselves together provisionally and develop into what we call human subjects. The totality of the threads constitutes the concrete lifeworld, and the knots therein are abstract extrapolations (Flusser 2005).*

Chris Salter takes Flusser's knot analogy further using the term entangled when writing of technologically mediated activity. Salter writes,

that my appropriation of the term entangled from its anthropological connotations suggests that human and technical beings and processes are so intimately bound up in a conglomeration of relations that it makes it difficult, if not impossible to tease out separate essences for each. (Salter 2010)

The difficulty in unraveling the real, the virtual and our relations within these is that the idea of separation and isolation are conceptually problematic. Our understanding is contextual. Nodes are always relational. Gochenour writes that,

the model of the node and network has taken on epistemic significance to such a degree that it shapes our conceptual frameworks across disciplines, both 'hard' and 'soft'. (Gochenour 2011).

Broader still, multiculturalism and the ways in which we trade and are economically interdependent can also be represented in a nodal model. However, like the local-hierarchical model proposed for composition – our global economy is also not planar – whilst it is decentralized there is definitely a hierarchy of nations and economic prosperity.

I propose that the significance of nodalism is not merely as a model for cross-disciplinary conceptual frameworks. I maintain that nodalism is a 'theory of everything' applicable to societal, scientific and artistic models and as such it is *the contemporary condition.*

2. DEFINITION OF NODALISM

We live in a nodal age in which no one –ism predominates.

We can no longer define what is new, avant-garde, or cutting edge in music or the arts as the unilinear narrative that Modernism purported has been subsumed by a diversity of thought and practice. Culture has splintered into many paths. Parallel streams exist as decentralized nodes of practice rather than one 'true path' - the 'nostalgia of the whole and the one.' (Lyotard 1984). This splintering of culture into different aesthetic concerns is a characteristic of both nodal and postmodern ideas. In his article about the notion of pluralism in the social theories of John Rawls and Jean-François Lyotard, Alemseghed Kebede writes that,

Aesthetically, it [postmodernism] augments our inventiveness, for it is in dissent that the free play of multiple narratives is made possible… Hence, postmodern knowledge allows us not only to recognize multiple discourses, but it also augments our sensitivity concerning the incommensurable nature of narratives… Both contend that contemporary societies are inherently pluralistic because they are characterized by the proliferation of incommensurable narratives/doctrines. Rawls considers pluralism as the positive outcome of the expansion of civil society; Lyotard, on the other hand, aligns pluralism with the demise of grand narratives that he believes hopelessly suffer from the problems of overextension… Indeed, pluralism is a condition that prevails in democratic societies; it is not a mere historical accident that will phase out over time. Democratic societies cannot dissociate themselves from the state of pluralism unless they degenerate into some form of totalitarianism. (Kebede 2002).

Nodalism, with its emphasis on a plurality of decentralized but locally hierarchical loci, thus arises from the postmodern condition but facilitates ideas that have transcended it or been proposed by contemporary theorists as following it. The fact that these conditions exist in parallel rather than in some linear cultural determinism is not new and is already exemplified in the music of Bernd Alois Zimmerman from the 1950s. Simultaneous to the emergence of the modernist composers of the Darmstadt School (Boulez, Stockhausen, Nono *et al*), Zimmerman developed his pluralistic klangkomposition using a combination of serialism, avant-garde techniques, collage, and extensive quotation from medieval music to jazz. Such techniques are evident in the Violin Concerto (1950), Trumpet Concerto (1954) and the Alfred Jarry inspired collage-based work *Musique pour les soupers du Roi Ubu* (1966). Tom Service writes,

> *Unlike his slightly younger colleagues, Karlheinz Stockhausen, Pierre Boulez, or Luigi Nono, Zimmermann never subscribed to the idea that a single musical or political approach was the solution to the world's creative problems. Instead, in his acceptance of the diversity of musical possibility, his postmodern experiments in stylistic and intertextual fusion, Zimmermann looks forward to the generation after him, and to the creative world of today's composers, for whom all of music history is available as material to be worked with. (Service 2012)*

In the past two decades we have witnessed a resurgence of –isms/ities. Re-modernism (Billy Childish, Charles Thomson, Jesse Richard and Harris Smith); Neo-modernism (Guy Denning and fellow artists); Second Modernity (coined by German sociologist Ulrich Beck); Automodernity (Robert Samuels); Hyper- or Supermodernity (Gilles Lipvetsky); Digimodernity (Alan Kirby); Transmodernism (proposed by Argentinian-Mexican philosopher Enrique Dussel) and the Altermodern, proposed by Nicolas Bourriaud at the 2009 Tate Triennial, are but the most prominent. Many of these new theories emphasise connectedness within a global frame. However, Lyotard prefers postmodern 'little narratives' (Lyotard 1984) and for many musicians and artists these local narratives intersect with, or are negotiated within, more global narratives. Kebede writes that these 'little narratives are bound to their own local 'discursive rules' and their 'evaluative logic' is less epistemic and more social… The self, therefore, is not an entity existing unto itself; rather its existence is bound up with the intricate social interaction within which it exists.' (Kebede 2002). Lyotard writes that, 'A self does not amount to much, but no self is an island; each exists in a fabric of relations that is now more complex and mobile than ever before'. (Lyotard

1984). This fabric of relations is inherently nodal. The self exists in relation to others in social groupings. The 'little narratives' of Lyotard contrast with Bourriaud's 'new universalism' of the Altermodern in which Bourriaud proposes that 'Artists are responding to a new globalised perception. They traverse a cultural landscape saturated with signs and create new pathways between multiple formats of expression and communication.' (Bourriaud 2009). Despite the different theoretical standpoints of Lyotard and Bourriaud, the emphasis on connectivity and the relationship between an individual and society can be reconciled in the nodal model. The difference being their respective perspectival starting points from either the individual or the global.

As a composer, I can clearly identify a weighted emphasis on either 'local narratives' or a more global perspective in my work and acknowledge that this weighting will change from work to work depending on the subject matter. In *Rift Patterns*, a work concerned the psychogeography and the 'drift', I particularly identify with the Altermodern as defined by Bourriaud,

> *Altermodernism can be defined as that moment when it became possible for us to produce something that made sense starting from an assumed heterochrony, that is, from a vision of human history as constituted of multiple temporalities, disdaining the nostalgia for the avant-garde and indeed for any era – a positive vision of chaos and complexity. It is neither a petrified kind of time advancing in loops (postmodernism) nor a linear vision of history (modernism) but a positive experience of disorientation through an art-form exploring all dimensions of the present, tracing lines in all directions of time and space. The artist turns cultural nomad: what remains of the Baudelairean model of modernism is no doubt this flânerie, transformed into a technique for generating creativeness and deriving knowledge. (Bourriaud 2009).*

In *Unfurling Streams*, I identify more with Alan Kirby's notion of digimodernism which is related to Chris Salter's idea of the 'entanglement' of the human and the technological. Kirby writes in response to Frederic Jameson's *The End of Temporality* that 'digimodernism does not choose to focus on either time or space in this manner [that proposed by Jameson], but that it combines and enmeshes two relatively new definitions of both. "Real time" and "cyberspace" are the twin axes of digimodernism. The digimodern appears at the intersection of the two.' (Kirby 2010). Finally, in *Spiral Paths*, it is the more localized narrative that comes to the fore. What is important in these three compositions is the weightedness of these influences. In my work I consider all to be important and co-exist reflecting Marc Augé's on supermodernism in which he contends that the contemporary understanding of 'local' can only be defined through reference to the 'global' (Augé 1995).

In contemporary culture we find different nodes of cultural thought or practice each given a specific name as above. Rather than a composer having to sign up to any one of these to legitimate their work, nodalism acts as a unifying network in which these different emergent cultural trends act as local centres of behavioural trends or aesthetic thinking. Furthermore, the composer can freely appropriate and hybridize any of these elements.

Nodalism allows residual and emergent forms of cultural behavior to co-exist. Nodalism draws multiple elements together in a neutral manner.

Nodalism is atemporal. As such it is akin to Integral Theory proposed by Ken Wilber – a contemporary movement that seeks to synthesize the best of pre-modern, modern and postmodern thinking. Modernist and Post-Modernist practices and ideas have not 'died' as have been claimed (Bourriaud 2009, Kirby 2013), but now co-exist in continually reconfigured guises. Notions of the 'canon' have been exploded into a myriad of nodes of cultural activity each with its own sub-culture, modes of thinking, and stylistic referents. Arvo Pärt, Brian Ferneyhough, Georg Frederich Haas, Alva Noto, Andrew Rayel, Björk, Amon Tobin, Eliane Radigue and Taylor Deupree all are key nodal points within specific activities of music – an example of parallel distributed cultural activity.

Within each of these sub-cultures there can exist a radical 'cosmopolitanism'. Just as Ligeti drew together influences from fractal geometry, chaos theory, Colon Nancarrow and African pygmy tribes in his remarkable music of the 1980s onwards, so Alva Noto fuses influences from visual and installation art, techno, minimal music, and glitch experimentalism with its origins in the work of Yasanou Tone and Oval.

In its atemporality, Nodalism does not deny canons but like postmodernism acknowledges a plurality of canons. Although Zygmunt Bauman identifies the nature of contemporary art in the denial of all canons, Bolognini writing that 'according to Bauman, the rejection of all canons has enhanced the critical and liberating function of art, forcing the artist and the public to participate in an ongoing process of interpretation and meaning creation' (Bolognini 2008), there is no need for such denial in the nodalist model. Canons are both localized within global communities of a given cultural practice (art, music *et al*) and potentially reconfigured in each work through Bourriaud's notion of creative practice 'exploring all dimensions of the present, tracing lines in all directions of time and space.' (Bourriaud 2009).

In my own work I make use of tonal musical elements within an abstract electronic music context. In this work there is no specific postmodern irony in musical tonality, no critique of modernity. Such elements co-exist to be utilized within new work. An artist may choose to highlight these influences and feature their 'assemblage' within a work, or simply integrate them into a whole. Bolognini writes that 'This is also the reason why art, its narrative, its branding, are now less tied to the vertical dimension (art history) and more to the horizontal dimension (relations with other disciplines, other existential and cultural contexts)' (Bolognini 2008).

> **Nodalism does not define a style. It is a neutral model of contemporary cultural behaviour. It is apolitical and post-geographical (aterritorial). Nodalism reflects artistic practice in our multicultural post-colonial society.**

Whilst some artists are keen for their work not to be categorized avoiding ideology and the controlling (hegemonic) aspect to –isms, others wish to delineate cultural space for their artistic practice. Recent manifestos marking a cultural territory include: The Istanbul Manifesto (Leonel Moura, Henrique Garcia Pereira and Ken Rinaldo), Avant-Pop Manifesto (Mark Amerika), A Mille Plateaux Manifesto (Szepanski 2001) Altermodern Manifesto (Bourriaud 2009).

Nodalism is apolitical and aterritorial in that it embraces the complexity of the coexistence of multiple politics and territories. Artistic 'globalization' and atemporality are reflected through YouTube and the manner in which music from different periods and styles co-exist in a nodal network of entwined references. Nevertheless, much multicultural influence is still situated within the European-American axis and modes of artistic practice. Although, at its worst this can lead to the multicultural DJ and a form of cultural collectionism, nodalism extends beyond such activities. Nodalism is not merely about sampling. It is, like Bartok's relationship with folk music, about the assimilation and convergence of ideas and integrity of practice that acknowledges the complexity of our artistic practice in today's society. As such nodalism marks a shift from postmodern thinking regarding of the semantic value of the elements drawn.

Nodalism is a means for continual dynamic reconstruction of 'little' and 'grand' narratives over and over.

No experience of music is entirely autonomous. Georgina Born states that the listener is 'entangled in a musical assemblage' (Born 2010). The listener perceives the work as the sum of a network of interactions. Some of these may be due to local circumstance, such as the acoustic of the environment in which the piece is played, extraneous sounds, mood etc. Others however, are to do with the knowledge of the individual, their recognition of this piece as belonging to a genre, how different influences feed in to a given work. Foucault 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). The system of references – the nodes in the network – is of course entirely dependent on the knowledge and cultural acuity of the individual reading the text. Similarly with a piece of electronic music, the nodal network is never fixed, it is renewed in the mind of every listener at each new listening.

This local-hierarchy is essential to understanding and interpreting specific pieces of music and is an example of a decentralized nodal network rather than the distributed (rhizomatic) nodal network favoured by Deleuze and Guattari. Cascone writes 'There are single artists who have initiated the formation of a genre by establishing an initial set of codes and symbols which are reinforced by a hierarchical (one-to-many) network…' (Cascone 2005). Nodalism does not answer the question how or why ideas are connected, or how new genres are created – just that they are. The signification of an artwork is still determined by the semiotic model proposed by Jean Molina (Molina 1990) and developed by Jean-Jacques Nattiez (Nattiez 1990). Meaning is constructed entirely through the intersection of the nodal connections, their perceived weighting within a work, and the individual's own experiential nodal networks. The composition or sonic artwork is a cultural artifact insomuch that within it is a nodal complex of ideas and influences stemming from the creator – a central agent. The work's reception will depend on the listener or viewer and their cultural experience. They will create their own nodal network (consciously or not) due to the neurological patterning of their brain resulting from their experiences, or as Daniel Dennett would contend, the memetic functioning of the brain. Dennett writes that the 'haven all memes depend on reaching is the human mind, but a human mind is itself an artefact created when memes restructure a human brain in order to make it a better habitat for memes.' (Dennett 1993). So the meaning of an electronic music composition as a cultural artifact is constructed through the negotiation of an individual's own nodal network in which meaning is reconfigured at each listening as the selfplex (Blackmore 1999) develops. In nodalism there is not one message but a polyphony of parallel messages.

3. CASE STUDIES

There are a number of projects that could be discussed to illustrate nodal practice. One such is the Présences Électroniques Festival, directed by Christian Zanési, and held annually at the Groupe de recheches musicales (GRM) which has brought together sound artists, acousmatic and electronic music composers since its inception in 2005. The work of Bernard Parmegiani, Luc Ferrari, Ryoji Ikeda, Helena Gough, Matmos, Kaffe Matthews, Antje Greie, Colleen, Fennesz, Amon Tobin and Maja Ratkje amongst others has been presented side-by-side enabling the audience to draw connections between the similarities of approach and sound world of music from superficially different cultural arenas. Similar festivals in Sweden (Norberg), England (Huddersfield Contemporary Music Festival) and Spain (Sónar) also aim to bring diverse forms of music and new media art together. However, the case studies presented here demonstrate nodalism in differing musical and wider contexts: Björk's *Biophilia* (2011) and two projects I have been involved in, the first for hardanger fiddle and electronics initiated by the folk musician Britt Pernille Frøholm, and the second entitled *Rift Patterns*.

Any interpretation of a composer's work is both individual and culturally conditioned. It is acknowledged that Nattiez's poietic and esthesic come into play here. The nodal diagrams presented below although superficially similar, present my esthestic interpretation of Björk's *Biophilia* and a poietic (composer's) view of *Rift Patterns* demonstrating the conscious drawing together of elements. It is not intended or anticipated that the listener would make all of these connections and would in fact make ones of their own.

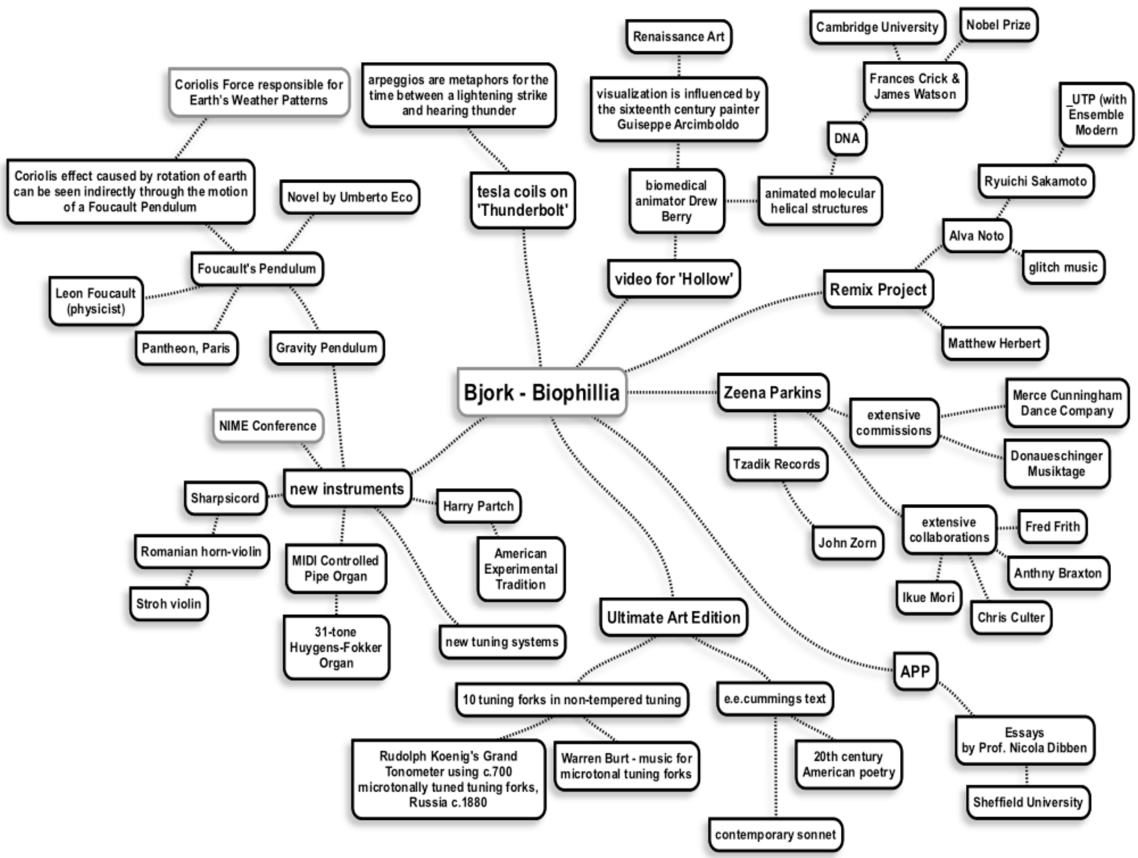
3.1. BJÖRK – BIOPHILIA

Björk's *Biophilia* was released in October 2011. It is interesting in the context of nodal practice due to the wealth of influences and practices that it embraces (see Fig. 2). *Biophilia* comprises a series of live shows, a CD release, an iPad app with games, animations and essays, education projects with schools, as well as the designing and building of bespoke instruments.

The songs were originally debuted during the Manchester International Festival in March 2011. These events were described by Björk as a 'meditation on the relationship between music, nature and technology' (Perpetua 2012). The concerts included the experimental harpist Zeena Parkins, an Icelandic choir (Graduale Nobili), a large brass ensemble as well as a series of new instruments. This instrumental line-up itself demonstrates an original range of nodal influences for what is nominally labeled 'pop music'.

The new instruments used for *Biophilia* are in the tradition of Harry Partch's work in the mid-twentieth century on tuning systems and new percussion instruments. The new instruments for *Biophilia* also reflect the musical intent of the album, as does Björk's use of the titles and lyrics of songs to inform their structure. The manner in which the lyrics and form of the songs are also reflected in the construction of the instruments used in specific tracks clearly demonstrates how nodal thought permeates every facet of the album’s creation.

Fig. 2 Esthesic nodal connections in Björk’s *Biophilia*



The Gravity Pendulum Harp, designed by Andrew Cavatorta comprises four computer-controlled 11-stringed pendulums. This large instrument is particularly evident on the track *Solstice* and is a conscious tribute to Foucault’s Pendulum. Björk maintains that the contrapuntal nature of this song is a reference to the rotation of the earth and the movement of planets in general. This idea is again reflected in *Moon*, which contains musical material that cycles throughout. The Sharpicord, designed by Henry Dagg, is like a large music box in its construction as it contains a rotating studded cylinder amplified through a gramophone horn. Hearing music come from the horns of this instrument invokes similar instruments in folk music such as the Romanian horn-violin and the Stroh violin invented by John Stroh in 1899. The

MIDI controlled pipe organ created by Bjorgvin Tomasson is similar in its control to the 31-tone Huygens-Fokker organ in Amsterdam and older mechanical fairground organs. Tomasson also constructed the Gameleste, a celesta and gamelan hybrid controlled via iPad. Finally, on the track *Thunderbolt*, the bass line is composed from bolts of electricity produced by Tesla coils. The arpeggios are metaphors for the time between a lightening strike and hearing thunder. The nodal connectivity of 'natural forces' - specifically the Corolis effect which impacts on weather patterns as well as being observed indirectly through the movement of Foucault's Pendulum, and the emphasis on orbits and circular motion in the lyrics and structure of the musical materials demonstrate strong nodal connectivity unifying diverse aspects of musical, instrumental and compositional decision making at all levels of the albums production.

The Ultimate Art Edition of the album also reflects these lyric and musical influences. Contained in this limited edition is an additional song featuring lyrics adapted by Björk from e.e.cummings and a wooden box with 10 tuning forks in it, each one tuned to the tone of a particular track from the album and covering an octave in non-tempered tuning. The creation of these microtonal tuning forks suggests nodal links to Australian sound artist Warren Burt's extensive work with these instruments as well as Rudolph Koenig's Grand *Tonometer* (c.1880), based on multiple tuning forks (up to 700), tuned in microtonal scales (see figure 3).

From a wider musical perspective, Björk's interest in contemporary classical music and other forms of experimental music is reflected in her use of unusual time signatures. Instances of 3/4, 6/4, and 7/4 within songs occur throughout the album. *Mutual Core* is in 5/4 whilst *Hollow*, *Crystalline* and *Moon* are all in 17/8. Whilst such time signatures are to be found in electronica artists such as Autechre or Venetian Snares they are unusual in songs.

In the video for *Hollow* directed by biomedical animator Drew Berry a molecular complex based on a head scan of Björk is featured.

The construction of this visualization is influenced by the sixteenth century painter Giuseppe Arcimboldo (1526-1593).

Fig. 3 Rudolph Koenig's Grand Tonometer (c.1880).

Fig. 4 Still from Björk's *Hollow* directed by Drew Barry

The video also includes animated molecular helical structures. Björk's description of this song is included here as it is recalls the quotation above referring to Lacan's signifying chain. Björk says the song is about,

> *the feeling when you start thinking about your ancestors and DNA that the grounds open below you and you can feel your mother and her mother, and her mother, and her mother, and her mother 30,000 years back. So suddenly you're this kinda tunnel, or trunk of DNA… All these ghosts come up so it ended up begin a Halloween song and quite gothic in a way… It's like being part of this everlasting necklace when you're just a bead on a chain and you sort of want to belong and be a part of it and it's just like a miracle (Raby 2012).*

In addition, Björk also curated an extensive eight part remix series of the album featuring remixes by artists as diverse as Alva Noto, Matthew Herbert, Current Value, King Cannibal, Death Grips, Hudson Mohawke *et al*. As with other aspects of *Biophilia*, the scope and ambition of the remix series demonstrates a desire to be stylistically inclusive and it suggests a nodal network adjunct to that illustrated above in the creation of the work itself.

The *Biophilia* project is elaborate even by Björk's standards. The drawing together of scientific, artistic and literary concepts and memes to shape and inform the music, lyrics and even the instruments designed for the performances are the epitome of nodal creative practice. The esthesic nodal diagram above (Fig. 2) illustrates the connections that I begin to make as an informed listener when listening to and experiencing *Biophilia*. I am aware that the connectivity I make, beyond Björk's acknowledged intentions is both personal and culturally conditioned. Nevertheless, it clearly enables the many unique facets of this work and its broader creative context to be explored from a nodal connectivist perspective.

3.2. BRITT PERNILLE FRØHOLM

In 2011–12 Britt Pernille Frøholm commissioned three works for hardanger fiddle and electronics: Rose Dodd's *mobius ii* (2011), Nicolas Bernier's *Phantom*^(1651)^ (2013) and Monty Adkins' *Spiral Paths* (2014). All three works exhibit different nodal qualities.

Dodd's work can be understood nodally as connecting elements of Norwegian folk music, electronic and

Fig. 5 Giuseppe Arcimboldo Vertumnus (1590)

ambient music, and improvisation as well as drawing on ideas of psychosonography. Dodd's use of these elements deliberately brings together differing even conflicting narratives that she wants the audience to absorb and actively explore within the work. For Dodd there is a conscious intention to bring differing performance traditions together – that of an improvising folk musician and acousmatic diffusion as well as the natural environmental sound world. Ambient textures derived from the sympathetic string resonances of the hardanger fiddle create a harmonic field within which the performer has considerable liberty. Dodd's score is a mixture of notation, text and more open instructions to the performer. Dodd also combines original pseudo-Norwegian folk melody with authentic Norwegian tunes the folk fiddler chooses to incorporate in improvisatory passages. In *mobius ii* the nodes are carefully chosen and rather than merely being absorbed into a hybrid work, Dodd intends these differing conceptual spaces to be apprehended and understood by the listener. It is the balance and negotiation of these musically interacting conceptual spaces musically that provide meaning for the listener.

Bernier's work is less consciously considered in its constituent elements but is equally complex from a nodal perspective. The composer writes 'as an artist, I can't say that my work is fitting under one label (I don't think it is my role to think about that)' (Bernier 2014). Although Bernier has a distinctive compositional idiom he does not consciously consider the element that make up his musical language. His background as a musician in punk and rock bands has led to an improvisatory approach to melody, rhythm and harmony, and form. His is a music that is the result of a practitioner absorbed in the moment of the creative act. Bernier writes that in his music,

> *the influences/interests are so multifaceted (theatre, science, sociology, music – every genre, etc.)… I heard composer/performer Dominic Thibault talking about 'post-genre' and I think this is more like it. We are post-post, we are beyond being 'post', as everything is now intrinsically connected, or 'Entangled' as Chris Salter calls it… Ambient, minimal, glitch are also in there but are just some of the ingredients of the overall portrait which also includes influences (even if they can be quite subtle) from romantic, serial, noise, rock, punk, funk, techno, etc. (Bernier 2014).*

In *Phantom*[(1651)] Bernier, like Dodd, draws on Norwegian folk music. However, unlike Dodd's work in which the folk melody is presented partly in fragments of its original form, Bernier subjects the melody to more extreme transformation – augmenting it or stretching it out and pitch shifting it very high (see Fig. 5). He also presents the hardanger fiddle within an environment of sustained electronic tones, glitches and rhythmic passages – a nod to European glitch electronica. Bernier's use of a graphic score, like Dodd's, gives an improvisatory freedom to Frøholm. The final element in Bernier's work is video, which draws upon yet another nodal network of techniques, influences and practice.

My own work consciously draws together a number of differing stylistic influences reflecting both my classical and electronic music training, and my choral background.

In *Spiral Paths* (2014) and in an earlier work *Rift Patterns* (2014) I want to make connections with older musical forms, recasting their strong harmonic foundation in my own musical language. One section from *Spiral Paths* entitled *Lament* (see Fig. 6 for a simplified nodal diagram of the elements drawn on), uses the technique of mensuration canon – a process of melodic imitation in which differing rhythmic proportions are employed to create differing speeds of musical movement. This influence has its origins in my time as a choirboy when I regularly sang renaissance masses – particularly by Johannes Ockegham and also the later influence of Arvo Pärt whose *Cantus in Memoriam Benjamin Britten* is also written in this manner. Although no folk music itself is used, the rhythmic figurations characteristic of Norwegian fiddle music, particularly from the West coast where Frøholm comes from are integrated into original melodic lines.

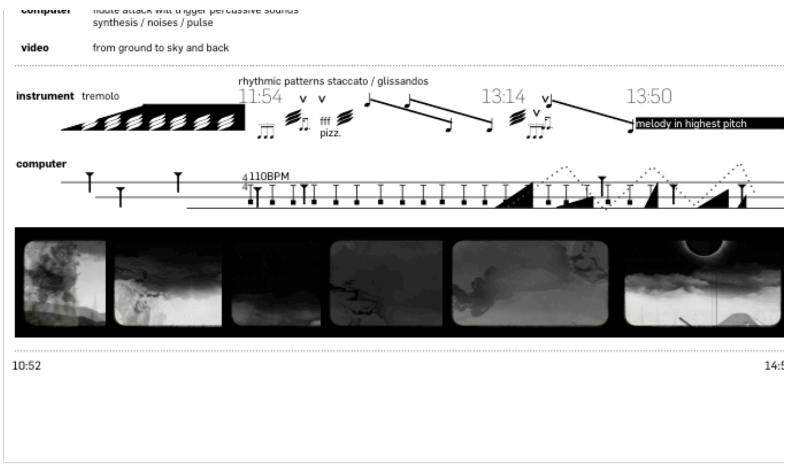


Fig. 6 Nicolas Bernier *Phantom*[(1651)], section 5 score.

In *Lament* there is also the influence of Norwegian hardanger fiddle playing on the musical material itself. The lack of vibrato in hardanger playing suggested to me a playing technique akin to the viol, another important instrument and sound world for me as I have extensively studied late renaissance and early Baroque music – particularly that of Byrd and Purcell. In *Lament* Frøholm plays the principal part, with a viol consort presenting the canonic lines beneath. Ambient and electronic music techniques are also evident in this work. As a result of these influences, the work is more classically oriented than Bernier's glitch folk-electronica, but occupies a different more experimental territory than a work such as Christoph Berg's ambient-classical *Paraphrases*. At the same time the work is less folk inspired that Dodd's work.

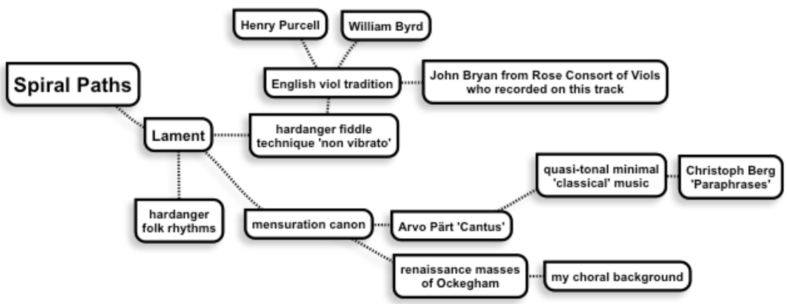


Fig. 7 Poietic nodal diagram of *Lament* from Spiral Paths.

For me, these influences are consciously considered and brought together. It is not that I am trying deliberately to draw together unusual elements – this would lead merely to Boden's notion of novelty. What I am interested in is how the fiddle, its repertoire and style of playing suggest areas for compositional exploration. I want to investigate these as thoroughly and as extensively as possible. Some nodes may become too far removed to be compositionally useful and therefore make direct connections, but may still inform other ideas that are relevant in a manner akin to 'retrograde signalling'. The purpose of this nodal research is simply to make the work as rich and interesting as possible both for a listener and me as composer.

In *Rift Patterns* (2014) I again draw on older classical forms to underpin the harmonic foundation of tracks, specifically *Ecstatic Drift* and *Soliloquy* and, like its partner EP *Residual Forms* (2014), is based on readings from psychogeography. Fig. 6 provides an overview of the principal nodal connections intended from a poietic perspective. *Rift Patterns* is driven musically by the psychogeographical exploration of places and how they impact on our identity and feelings. Psychogeography has historically been associated with the exploration of our cities and the 'drift', and has been described by Joseph Hart as 'a whole toy box full of playful, inventive strategies for exploring cities… just about anything that takes pedestrians off their predictable paths and jolts them into a new awareness of the urban landscape'. In *Rift Patterns* I wanted to continue our drift from the city, into the country and into our inner world of thoughts and relationships. As such it draws on research by the social geographer, Gillian Rose, the neogeographical and virtual geographic theory of Mark Graham as well as psychogeographical writers and theorists in both the French and English traditions. In considering the impact of place on music I was keen to listen as widely as possible from Machaut to the Romantic tone poets, from Elgar to Simon Bainton, John Surman and Richard Skelton. It was through listening to the latter composers, whose work extends beyond the mere musical representation of physical landscape or onomatopoeic imitation of nature or the city in their work that I explore the notion of psychosonography first proposed by Dani Iosofat (Iosofat 2009).

In my choice of the prepared piano as the main instrument for *Rift Patterns* I was choosing something not only that I could play but also an instrument whose sonority I could radically change. In using household objects to manipulate the sonority of the piano I was conscious of the heritage of both John Cage and the more contemporary tonal work of Hauschka. However, in choosing also to prepare the piano with more natural objects found in many of the geographical locations important in the making of this work, my process here is perhaps closer to that of Richard Skelton. At no point is my work merely an emulation or appropriation of these influences. I stand by an adage that one should either know everything or nothing, and that the artistically dangerous place is in the middle. Therefore I try to be aware of as much different musical, literary and cultural thinking as possible and to use it to situate my own work.

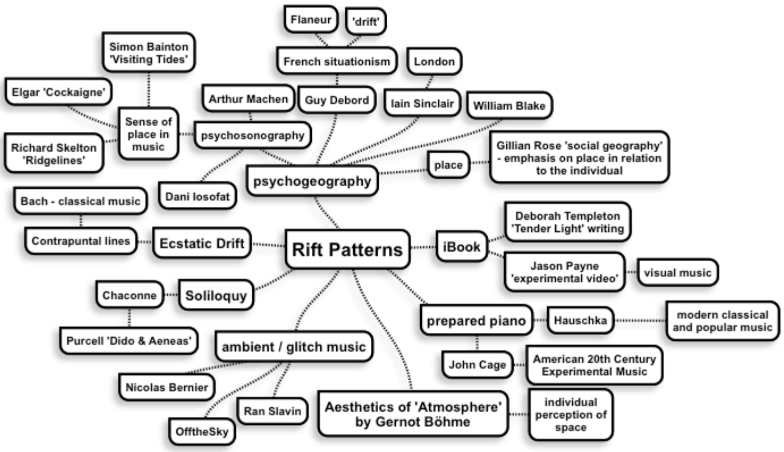


Fig. 8 Poietic nodal diagram of *Rift Patterns*

In all of these case studies I have attempted to demonstrate how each of the artists is trying to draw together a number of Boden's conceptual spaces and in doing so transform them through drawing on a wide and diverse range of memes from science, literature, music, art and culture more generally. The links made between these memes can be illustrated as a decentralized nodal network. A local hierarchy of nodes facilitates the understanding and interpretation of a given work. The concept of retrograde signalling can be used to demonstrate the wealth of possible wider meanings and nodal connectivity that may arise from any given interpretation of a work. In all of these examples, nodalism does not contribute to a given musical or artistic 'style'. Rather, it is either seen as a model for understanding creative thought processes and a mapping of this onto a broader societal framework, or an attitude to creative exploration.

4. CONCLUSION

In this paper I have presented nodalism as a means of describing contemporary culture and thought. As more and more theorists proclaim the death of postmodernism there has been a succession of alternatives proposed of which some of the most prominent and discussed are Lipvetsky's Supermodernity, Kirby's Digimodernity and Bourriaud's Altermodern. As a composer I am open to all creative stimuli and identify with many aspects of each of these proposed successors to postmodernism. There are also many elements of postmodernism that are also still pertinent to my and other composer's thinking. As such I propose nodalism as an over-arching framework for all of these contemporary trends. I contend that our society exhibits elements of all of these proposed ways of thinking and that, like the models of creativity discussed above, that their importance in any given community is weighted. Nodalism allows us to reconcile Bourriaud's questioning of how artists are responding to the reconfiguration of modernity in light of ever-increasing globalization in which 'Multiculturalism and identity is being overtaken by creolisation' (Bourriaud 2009) producing a new altermodern culture, and Marc Augé's idea of non-place as outlined in his book *Non-Places: Introduction to an Anthropology of Supermodernity* (Augé 1995) with painters, sculptures, architects and musicians creating work under the banner of neo-minimalism or reductionism as well as those who draw together aspects of all of these with postmodernism such as sound artists like Janek Schaefer, Taylor Deupree, Kaffe Matthews, Stephan Mathieu and Steve Roden.

My proposition of nodalism as a model to describe the multitude of ways philosophers and theorists attempt to describe contemporary society is derived from associative and connectionist models of creativity derived from our understanding of neurology. I contend that supermodernity, neo-minimalism, postmodernism are simultaneous pockets of activity and thought within society, equivalent to parallel distributed processing within the individual brain. As such I propose that the nodal model extends beyond the planar non-hierarchical network of Deleuze and Guatarri. There is a local hierarchy at play. The extent to which this hierarchy is weighted is both societally, culturally, and individually conditioned. Furthermore, like the neural connections in the brain, we should think of the nodal model as a three dimensional network in which sinuous threads cluster and aggregate around local nodal hierarchies. These agglomerations are dynamic and fluid. It is this ability to reconfigure networks, to consider their nodal properties anew that makes nodalism such an all-encompassing means for understanding the contemporary condition.

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VIDEO, MUSIC, AND SOUND METACREATION

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Metacreation is a contemporary approach to generative art, using tools and techniques from artificial intelligence, artificial life, and machine learning (themselves inspired by cognitive and life sciences) to develop software that is creative on its own. We present examples of metacreative art within the fields of music, sound art, the history of generative narrative, and discuss the open potential of the "open-documentary" as an immediate goal of metacreative video.

1. INTRODUCTION

Generative Art has a long tradition, one that dates back to antiquity, according to Galanter (2003). While the potential of codifying artistic decisions may be alluring to many artists, the challenges are many: for example, can the notion of creativity be extended to machines, or can they (should they?) only remain as tools for the creative artist? The nascent field of computational creativity, also known as metacreation, explores these questions, and is populated by psychologists, art theorists, cognitive scientists, artificial intelligence researchers, machine learning specialists, and, perhaps most importantly, artists. As such, it is not merely an academic pursuit: it is, and has been, a fertile creative domain for artists exploring new avenues of production. This paper will explore three such directions – music, sound, video – and provide some examples, many of which are drawn from the authors' work, as proof of its existence. Lastly, we will describe a current project which aims to blend the three formerly disparate media into a single, cohesive artistic medium.

2. METACREATION

Metacreation is the idea of endowing machines with creative behavior (Whitelaw 2004). Metacreation is a contemporary approach to generative art, using tools and techniques from artificial intelligence, artificial life, and machine learning (themselves inspired by cognitive and life sciences) to develop software that is creative on its own. In other words, software is a metacreation if it exhibits behaviors that would be considered creative if performed by humans.

Artists use tools to produce their artwork. Traditionally, the creator of the tool and the artist using the tool has remained distinct; with digital tools, a growing number of tech-savvy artists design and develop the software tools with which they produce their works. By developing tools with *ad hoc* functionalities, these artist/engineers aim to gain more control over their creative processes. What if these artist/scientists could develop tools that do not need a user to create the finished artworks? The notion that the creation of the computer-tool can take precedence over its utilization is at the root of generative arts.

From a research standpoint, the question regarding metacreation is no longer "can a computer exhibit creative behavior?": that question has been answered, in the positive, many times over. AARON's (Cohen 1995) paintings have exhibited at the Tate Gallery in London, and EMI's compositions (Cope 1991) have created music that could not be discerned from human-composed music by the most educated experts (see Section 3 for more examples of metacreations). The question can now be reframed as "how can artists and scientists collaborate to define, structure, and explore the boundaries of this relatively recent multidisciplinary field?".

Two types of approaches are possible for modelling creative behaviour in metacreation research. One can model systems that produce creative behavior in which the system is a "black box", and only its behavior (i.e. its output) matters. This results in processes that explore creativity as it *could be*, rather than model creativity *as it is*. Moreover, although relatively successful, these systems do not mimic humans in the way they operate. It is clear, for example, that a human improviser does not maintain transition probability tables when playing, as is the case with the *Continuator* and its Markov Model (Pachet 2003), and human composers do not evolve populations of musical gestures and simulate their natural evolution, as *GenDash* does (Waschka 2007).

One can also try to model systems that will be creative using the same processes that humans are thought to use. This approach has been relatively unexplored, mostly because these processes are largely unknown. One would have to address more deeply the question of what human creativity is, and produce models that are believable, not only in terms of their output, but in terms of their internal processes. Our group has been pioneering some early attempts in this regard (Maxwell *et al.* 2012), by starting to bridge the gap between the literature in cognitive science, musical perception and cognition, and generative systems.

3. EXAMPLES OF METACREATIVE ART

Metacreative art is the artifact produced by systems, arising from the implementation of specific models of creativity and creative process. These machine-generated artefacts have been used to observe the validity of the model under investigation, and, often, been positioned within cultural contexts such as performance and exhibition venues. The following examples of metacreative art demonstrate the diversity of approaches that researchers have employed in modelling creative behavior in the domains of music, sound art, and moving image.

3.1. METACREATIVE MUSIC

Music has had a long history of applying generative methods to composition, due in large part to the explicit rules involved in its production. A standard early reference is the *Musikalsches Würfelspiel* of 1792, often attributed to Mozart, in which pre-composed musical sections were assembled by the user based upon rolls of the dice (Ihmels and Riedel 2007); however, the "Canonic" compositions of the late 15th century are even earlier examples of procedural composition (Randel 2003).

Exploring generative methods with computers began with some of the first applications of computers in the arts. Hiller's *Illiac Suite* of 1956 utilized Markov chains for the generation of melodic sequences (Hiller and Isaacson 1979). In the next forty years, a wide variety of approaches were investigated – see (Papadopoulos and Wiggins 1999) for a good overview of early uses of computers within algorithmic composition. However, as the authors suggest, "most of these systems deal with algorithmic composition as a problem solving task rather than a creative and meaningful process". Since that time, this separation has continued: with a few exceptions (Cope 1991, Waschka 2007), contemporary algorithmic systems that employ AI methods remain experimental, rather than generating complete and successful musical compositions.

An approach followed by Eigenfeldt in *Kinetic Engine* (Eigenfeldt 2008) was to model the interaction of human improvisors within a drum ensemble through the use of virtual agents. Player agents assume roles and personalities within the ensemble, and communicate with one another to create complex rhythmic interactions. The software was used in performance many times, controlling the robotic percussion instrument *MahaDevibot* (Kapur *et al* 2009), in which the composer acted as a "conductor", directing the virtual agents in response to other live performers (Eigenfeldt and Bahn 2009).

The notion of modelling a software improvising system after human activity was posited by Rowe (1992): "interactive software simulates intelligent behaviour by modeling human hearing, understanding, and response"; however, *Kinetic Engine* is modelled after human *interaction* using the AI paradigm of multi-agents. Intelligent agents are elements of code that operate without direct user interaction (they are autonomous), interact with one another (they are social), interact with their environment (they are reactive), and make decisions as to when they should operate, and what they should do (they are proactive) (Wooldridge 2009). Since these are also attributes required of musicians in improvisational settings, the use of agents to emulate human–performer interaction has proven to be a fertile field of research. Whalley (2009) gives an overview of the recent state of software agents in music and sound art.

Multi-agents were the basis of a series of compositions entitled *Coming Together*. In these systems, agents negotiate musical content within a defined musical environment, with or without direct performer interaction. In each case, agents begin with random musical material, and through the convergence of predefined musical parameters, self-organisation is demonstrated (see Eigenfeldt 2011 for a detailed description of the series). The interaction between virtual agents and humans was explored in *More Than Four* (Eigenfeldt 2012), which also incorporated a curator agent to create complete compositions for performance from a database of pre-generated movements (Eigenfeldt and Pasquier 2012).

3.2. METACREATIVE SOUND ART

Sound art does not have general representation schema, or an established theory like symbolic forms of music. Thus, sound art has been a more difficult field of study due to the shortage of well defined models, and has not been as frequently explored in metacreation research. Sound art is an interdisciplinary practice that is based on acoustics, psychoacoustics, and music principles, but then often contracts knowledge from a diverse range of other fields; acoustic design (Truax 1998), genomics (Fargher and Narushima 2008), or social media (Roma *et al.* 2009), for example. Although sound art may be reified with a physical object (Bandt 2001), or as tape music, it is typical that a work can be positioned along a spectrum of non-symbolic electroacoustic music. This spectrum includes purely electronically generated sound works on one end, whilst on the other we find works of so called found-sound: concrete recordings aimed to evoke in listeners associations of a real time and place.

The aim of sound art is to transform a concept, devised by the artist, into a set of decisions and processes that will ultimately result in an acoustic work. For example, Philipsz's 2010 soundscape piece *Lowlands* (Philipsz 2010) combines abstracted sounds of the human voice, accompanied with the ambient sounds of modern cities to initiate particular experiential events for the listener. Although the acoustic work is an outcome of sound art, there is, however, no well defined model for achieving it or agreed upon objective function for evaluating its performance.

The want of these constraints has prompted multiple designs of metacreative systems to address the questions of what processes should be used in order to arrive at the sound work, and how to evaluate the work that the system produces. Eigenfeldt and Pasquier (2011) populate a database of sound recordings for the retrieval by autonomous software agents. These artificial agents select recordings based upon semantic tags and spectral audio features, and mix them using a restricted set of digital signal processing techniques. In that work, the concept is established by the domain of tags set by the composer, and the selection criteria employed by agents.

Olofsson (2013) also takes an agent-based approach to generate sound content in his low life series of works. The behaviours of the agents in this work are constituted on rules manifesting from the audio synthesis code they reference. He calls the agents in his "self-referential code" system "audiovisual creatures", which engenders a performative quality to the artificial system. A further example of anthropomorphic agents is demonstrated by Thorogood's artificial life installation *Chatter and Listening* (Thorogood 2007). In this work, behaviour of a bird species is modelled, equipping multiple interacting robots with bird-like characteristics, which then produce a synthesized vocalization based on their behaviour state.

Another approach to metacreative sound art is the use of knowledge representation systems, which aim to model a particular knowledge base in a domain. An example of this type of system is the *ec(h)o* interactive audio museum guide by Hatala, Wakkary, and Kalantari (2005). The authors describe a formal representation for sound objects that address sound content properties, concepts, topics, and themes, including connection to aspects of the exhibition. Their system then updates a visitors display from the input of user data, including physical position of the user, the history of interaction with objects and space, and interests that the user exhibits.

Audio Metaphor (Thorogood and Pasquier 2013) is a system for the generation of sound art from a short text input. The system retrieves labelled audio recordings that have semantic relationships to the input text. These audio recordings are autonomously segmented in response to analysis by a supervised machine-learning algorithm, trained with data from human perceptual classification experiments. The semantic and saliency labelled segments are then processed and combined autonomously based on a composition schema, modelled after production notes from Canadian composer Barry Truax (2008).

3.3. METACREATION, NARRATIVE, AND VIDEO

Some of the first examples of metacreation appeared within the domain of visual art: Romero and Machado (2008) present an overview of many of these systems. While some of the described artworks contain dynamic change, and may border on video – for example, Scott Draves' *Electric Sheep* (2008) – generative video is in a more nascent stage.

Bizzocchi (2011) describes a system entitled *Re:Cycle* which he describes as a generative video engine. The system incorporates a variation on the three aesthetic strategies of his earlier linear video works: strong imagery, manipulation of time base, and carefully designed visual transitions. However, the computationally generative *Re:Cycle* system develops a recombinant aesthetic for the sequencing of shots and transitions drawn from incorporated databases. The system uses meta-tags to nuance randomized selection with a sense of visual flow and coherence.

Traditional video has a long connection with storytelling as a dominant mode. This connection is more problematic with interactive computational video. However, the potential for a sense of "narrativity" rather than traditional "storytelling" is possible within a more open computational approach. Bizzocchi claims that the expressive presentation of character, storyworld, emotion, and narrative theme, as well as a degree of localized "micro-narrative" plot coherence can produce a narrativized experience without the traditional reliance on a full-blown narrative arc (Bizzocchi 2007). We believe that it is also possible to use computationally generative techniques to combine shots, tags, sound and sequencing within a narrativized metacreation aesthetic.

There is a substantial history of writers and artists working across the "narrativity to storytelling" spectrum. Non-digital examples of generative narrativity include a variety of dada and surrealist narrative games from the *Exquisite Corpse* (Gooding 1995) to Burroughs "cut-ups" (Burroughs and Gysin 1978). The most extensive exploration of analog generative narrative is probably found in the Oulipo creators (Wardrip-Fruin and Montfort 2003) and in their digitally-oriented successor groups: Alamo, LAIRE, and Transitoire Observable (Bootz 2012).

A number of digital works link knowingly to this literary tradition of generative and recombinant narrativity. Hayles claims that "Generative art… is currently one of the most innovative and robust categories of electronic literature" (Hayles 2007). Andrews and Wardrip-Fruin explicitly recognize their own extensions of Burroughs's cut-up aesthetic in the works *On Lionel Kearns*, *Regime Change*, and *News Reader* (Wardrip-Fruin 2005). Bill Seaman's installation work *The World Generator* (2002) uses "images, sound, and spoken text to create a recombinant poetics that created emergent and synergistic combinations of all these modalities" (Hayles 2007).

Many contemporary works that rely on generative computation include an explicit commitment to more traditional storytelling. Expressive developments in generative digital narrative works can be seen in contemporary projects such as *Curveship* (Montfort 2009), *Mexica-impro* (Perez *et al*. 2011), *Soft Cinema* (Manovich and Kratky 2002), or the series of works by Harrell (2007). Montfort's *Curveship* systematically modifies storytelling modalities (such as voice, style, focalization) in narrative constructions. Perez's *Mexica* uses a computational cycle of "story generation" and "reflection" to systematically move a narrative to its conclusion. Manovich's *Soft Cinema* video artwork uses database and algorithm to build a recombinant cinema aesthetic. Harrell has designed generative systems based on shuffling text and image to build a series of expressive and emotionally evocative narrative systems: GRIOT, GENIE, and Renku (Harrell and Chow 2008). Montfort, Perez, Harrell, and Campana are currently developing *Slant*, an integrated system capable of generative storytelling (Montfort *et al*. 2013).

4. FUTURE DIRECTIONS

From what we have seen in the literature and practices outlined here, research in regard to metacreative art is concentrated within individual domains rather than across media forms. We propose to integrate our work to explore its metacreative multi-mediated potential. We will do this through the development of generative video systems that are fully integrated with sound and music metacreation.

Clearly, there are several difficulties with which we are faced, perhaps the greatest being that many of the tools used in music and sound analysis do not translate easily into video. Techniques such as recombinance work well in these domains when there is some understanding of the material; within audio, this can be derived from tools found within music information retrieval (Tzanetakis and Cook 2000). While methods of meta-tags, already used by Bizzocchi, could be extended with further associative descriptions, the machine learning described in Thorogood's *Audio Metaphor*, has as of yet to be written for video analysis.

We propose to explore the potential of the "open documentary" through extension of *Re:Cycle* through enhanced "narrativity", relying on variables identified in analysis of interactive narrative (Bizzocchi and Tanenbaum 2012). Work has begun in combining Bizzocchi's generative video system with Thorogood's *Audio Metaphor*, in which each video clip is provided with a descriptive, metaphorical, and contrapuntal commentary which can be used by the audio system to provide a complementary soundworld.

Further, we have begun research toward a system of generative sound design. Leveraging the successes from *Audio Metaphor*, this new system analyzes sentences and systematically selects and segments sound files. Using a state of the art planning algorithm, composition plans are generated and evaluated based on existing principles of sound design (Murch 2007). This research has already shown encouraging directions for generative sound design. We see that the ambient video generation and this new development as a promising avenue for further investigation.

Popular forms of narrative – such as mainstream cinema and novels – typically rely on the complete commitment to the narrative arc as the backbone and the engine for the storytelling experience. Other narrative forms, however, such as video games, song lyrics, television commercials, and the long history of generative narrative art show that narrative can follow other paths. The potential for "narrativity" exists in the design and presentation of character, storyworld, emotional tenor, and thematic sequencing. The ongoing development of micro-narratives and associated moments of narrative coherence in a generative system can do the work of the unitary narrative arc of a more traditional form.

Our work may ultimately approach a more complete commitment to unitary storytelling and the metacreation of a tight narrative progression. This is a much higher order problem to solve – one that may or not be attainable in the context of our current project. A generative and recombinant storytelling system implies significant control over the details of plot sequencing, narrative arc, and narrative closure. This, in turn, will require much higher standards for computation, metadata tagging, and shot selection. The commitment to a loose "narrativity" in an "open documentary" context is a far more reachable intermediate goal. Progressive development of the documentary system will inch towards ever-increasing narrativity. It will be interesting to see how closely it approaches - and whether it ultimately realizes - the narrative coherence of a true storytelling system.

5. CONCLUSION

In general, there is a continuum between traditional praxis or performance tools, and metacreations. At one end, the software simply acts as a tool to be manipulated by the creator: the artist or composer has to do most, if not all, of the creative work, by manipulating the various functionalities of the tool. On the other extreme, pure metacreations are autonomous and proactive in their creative choices, and require no human intervention once running (although human intervention is still needed at design time). Interactive systems that allow for a constructive dialogue, or interaction between the system and its user, are situated in the middle.

We have described several successful metacreations within music and sound art, and noted the dearth of metacreative video; however, the history of generative narrative demonstrates a potential for a true metacreation in this medium. The first step will be the exploration of the "open-documentary".

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FROM THE UNSEEN TO THE S[CR]EEN ESHOFUNI, AN APPROACH TOWARDS REAL-TIME REPRESENTATION OF BRAIN DATA

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Keywords: Brain Signal Representation, Data Visualization, MAX MSP/Jitter, Virtual Physics, Art

In this paper we propose an approach towards real-time representation of brain data using a virtual physics engine built in the Max MSP/Jitter graphical programming environment, and with the real-time raw Emotiv EEG BCI signal. Firstly we summarize about the brain as an electric phenomenon and as a perpetually active system dependent of an environment. Secondly we describe methods of representation of these phenomena in historical contexts such as science and art. We then establish a conceptual relationship between brain's phenomena and Newton's laws of motion and equilibrium. Finnaly we discuss potential gaps to be fulfilled and propose and describe *EshoFuni*.

1. INTRODUCTION

The human brain is a complex system that generates electric signals. It is “perpetually active, even in the absence of environmental and body-derived stimuli” (Buzsáki 2006, 10) but needs environmental inputs to create useful activity. The electric phenomena of the brain have been being recorded in the form of waves, i.e., sinusoids with frequency and amplitude, to which Hans Berger, the pioneer of brain potentials recording called “continuous curves with continuous oscillations”[1] (Hirnströme 2005). The first report of scalp recording based on a representational methodology – photographic – of the human brain’s electric potential was made by Berger at the start of the twentieth century (Desney and Anton 2010) a process that he called *Elektrenkephalogramm*.

During that century, other methods of Electroencephalogram (EEG) representation were invented and implemented e.g., the Toposcope, devised by William Grey Walter, that allowed topographic visualization (Walter, 1951). Artistic approaches also have been being devised. In 1965 Alvin Lucier used EEG signals to acoustically or mechanically active musical instruments (Miranda and Brouse 2005), i.e., he proposed a representation of those potentials through sound. The development of computation occurred after the second world war catalyzed a continuous development of systems, both hardware and software, to acquire, treat, translate and represent both nature constituents (physical objects and events) and human abstractions phenomena (conceptual objects and events), to generate data that could allow us to understand these phenomenons or to create new ones, e.g., metaphors, virtualizations, of this same constituents.

Both sciences and arts have been using representational methodologies based upon different strategies, conventions and purposes, e.g, topographic visualization, i.e., the possibility to denote specific occurrences within specific regions of the brain’s geography – event(s) and place(s) of a phenomenon – , uses (pseudo)color coding schemas to denote and characterize both constituents (Shankar and Ramakrishnan 1951; Teplan 2002).

The representation of the brain’s electric phenomena needs a process – acquisition, transduction, processing, post-processing – that translates the analogic signals into digital data, via discretization, and from that into repre-

1 Free translation from the German original: “ (...) eine fortlaufende Kurve mit ständigen Schwankungen (...)” (Hirnströme, 2005).

sentational forms (Teplan 2002). The representations can be substantiated via offline or online processes, i.e., can be devised *a posteriori* or in real-time.

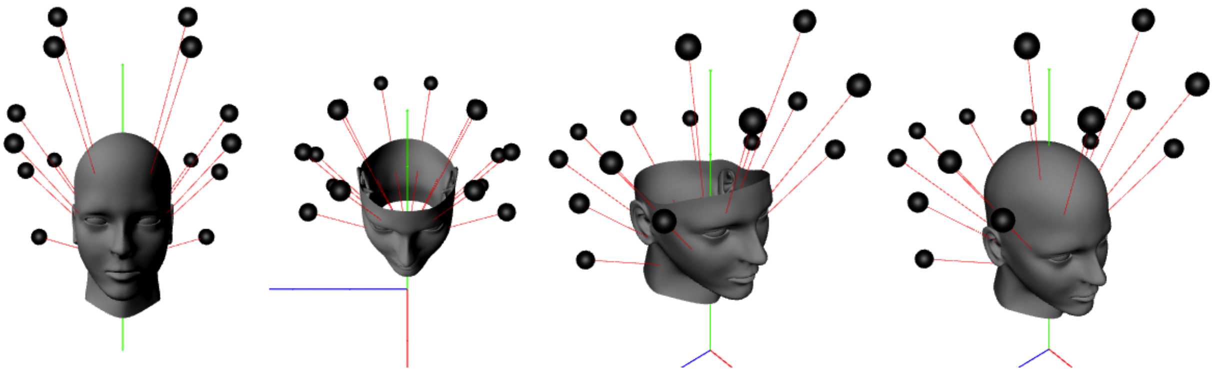
There are now many EEG representational approaches but many are restricted by autoregulation paradigms (e.g., within science) and although they may allow reconceptualization and evolution, they replicate the conventions and theoretical frameworks from which they depend upon, i.e., restrictive and closed positions. Within arts, approaches have been proposed during the last years, mostly related to performative arts such as music (Miranda and Wanderlay 2005). However EEG representation within the arts is still in its infancy. As such it is an emergent opportunity to research, propose and repurpose representational approaches. Our motivation is anchored on a double aspect, since we are dealing with two constituents of a correlated phenomena, i.e., methods of representation of the brain electric phenomena, as well as the phenomena itself. As such, besides the representational aspect, our approach is also framed on a conceptual parallelism inspired on Newton's laws of motion and equilibrium and a theory that proposes that the brain has a default state. Newton postulated that a body continues in its state of rest – or of uniform motion – , unless external forces compel it to change that state (Newton 1728). The same happens with our brain, it has a default mode. In this mode "it develops as a self-organized or spontaneous state without an external input", however, external perturbations are crucial to brain to perform useful computations (Buzsáki 2006).

This project is part of a broader research where we pursue the creation of innovative content. During this process we are often confronted with the lack of ways to "materialize" our ideas. As an answer, and besides creating content, we also have been developing strategies and devices focused on solving these problems where and when they may arise.

In order to fulfill the gaps identified above, we developed *EshoFuni*, a tool that develops a physical simulation to visualize EEG data in real time. With *EshoFuni*, we aim to offer a robust and reliable tool that promotes a non-linear real-time representation of EEG data. *EshoFuni* is intended as a flexible tool that adapts to new needs and paradigms in the representation of EEG data.

Taking this into account, we chose the graphical programming environment Max MSP / Jitter as the development platform. This choice lies in several factors: on one hand, the flexibility offered in the development and maintenance of the system; on the other, the fact of being a cross-platform environment that is well established in the field of digital media and performing arts, enhancing the likelihood of its acceptance and maintenance by the community, that may easily contribute to the improvement of existing functions, and the development of extensions to address emerging paradigms in the field.

Fig. 1 Different views of the representation provided by *EshoFuni*



2. PROJECT

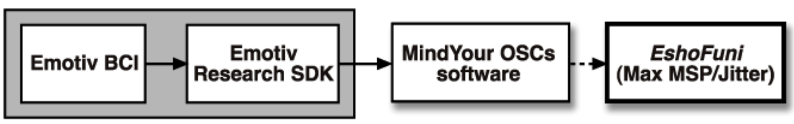
2.1. TECHNICAL SPECIFICATIONS

The system comprises the following hardware and software:

1) Brain Computer Interface by Emotiv (BCIEEEG);
2) Computer(s);
3) Emotiv Research SDK (ERSDK);
4) Mind Your OSC[2] (MYOSCs) ;
5) Max MSP/Jitter (MM/J).

2 Mind Your OSCs uses the Open Sound Control (OSC) protocol to bridge data between ERSDK and MM/J. This software has two versions: one that connects to the Emotiv Control Panel, which allows access to Emotiv proprietary algorithms that fulfill personalized Emotiv paradigms, and another that connects directly to the ERSDK which allows access to the raw data. At the time of the redaction of this document this latter version only exists in Windows platform.

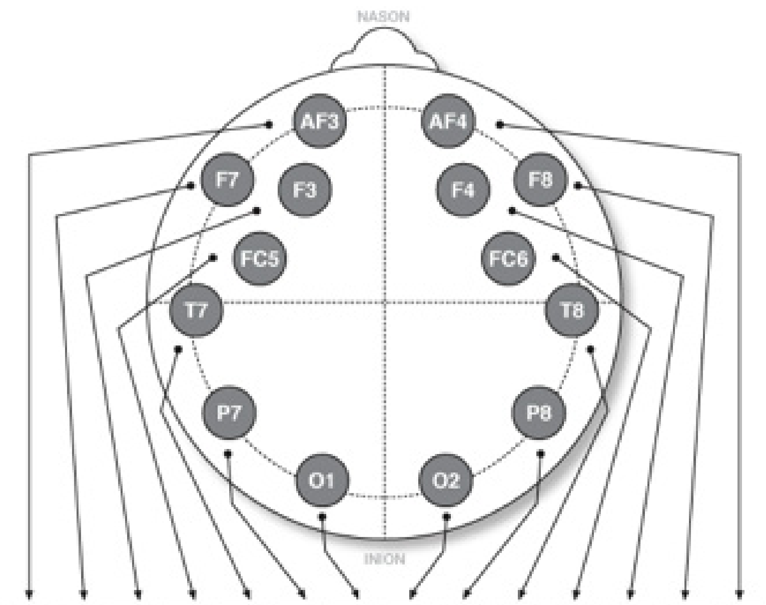
Fig. 2 Scheme of the general architecture of the system implementation



2.2. SYSTEM OVERVIEW

As illustrated in Fig. 2, brain data gathered by the BCIEEEG is wirelessly sent to the ERSDK; MYOSCs is used to establish a wireless bridge between ERSDK and MM/J, using the OSC[3] protocol; the data coming from MYOSC is received in MM/J through a UDP[4] connection, and treated as described in 2.3.1.

BCIEEEG records brain electric signals with 14 channels based on the International 10-20 system[5] on the locations AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4. Emotiv device sends via wireless and USB/Bluetooth interface to the host, i.e., e.g., the computer that hosts the ERSDK, a stream of encrypted data – encrypted by the device's proprietary system. The data is decrypted by the ERSDK. All data exported by the API is raw EEG values in microvolts (μV). EEG data is stored as floating point values directly converted from the unsigned 14-bit ADC output from the headset. DC level of the signal occurs at approximately 4200 μV (Emotiv, 2008).



AF3	F7	F3	FC5	T7	P7	O1	O2	P8	T8	FC6	F4	F8	AF4
4406.4535	4295.4530	4346.1535	4120.4535	4221.4535	4800.4535	4190.2532	4350.4535	4203.4535	4123.4535	4300.4535	4500.4535	4620.4535	4790.9871
4302.4535	4297.3532	4323.3221	4300.4211	4300.4535	8505.4593	4100.4352	4302.4215	4320.4560	4198.4532	4302.4521	4500.4222	4603.0711	4799.0000
...	...	...	...	...	...	...	...	...	...	...	...	...	...

Fig. 3 Relationship between Emotiv channels and incoming data vectors (derived from EDK Channels Enumerator – Emotiv Research SDK)

A physics engine programmed in MM/J applies internal algorithms based on real-world physics, allowing us to simulate a given virtual scenario. It provides internal algorithms that allow us to setup virtual worlds with

3 Open Sound Control (OSC) is an open, transport-independent, message-based protocol developed for communication among computers, sound synthesizers, and other multimedia devices. An OSC packet can be naturally represented by a datagram by a network protocol such as UDP (opensoundcontrol.org).

4 The User Datagram Protocol (UDP) is one of the fundamental members of the Internet protocol suite, designed in 1980 by David P. Reed, formally defined in RFC 768. "This protocol provides a procedure for application programs to send messages to other programs with a minimum of protocol mechanism (http://tools.ietf.org/html/rfc768).

5 A standardized physical placement and designations of electrodes on the scalp, adopted in 1955 by the International Federation in Electroencephalography and Clinical Neurophysiology (Teplan 2002).

complex dynamics. Entities such as rigid bodies – which can have distinct shapes, masses and sizes – are subjected to force vectors (e.g. gravity) and can interact with each other (e.g. collide, constraints). The result of these interactions is based on the dynamics of the system.

2.3. ARCHITECTURE

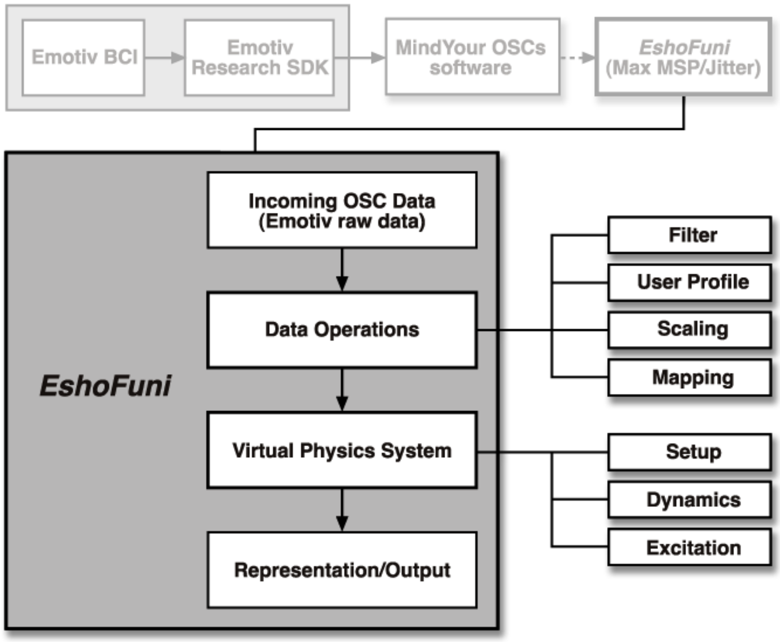


Fig. 4 *EshoFunni*'s architecture. OSC Raw data incomes as a stream of floating point values with an average level of 4200, (which represents the DC offset level of the signal that occurs at approximately 4200 µV). This data is firstly subjected to different data operations (2.3.1), and then sent into the virtual physics system (2.3.2) provided by the MM/J, as a means to create and simulate a conceptual metaphor of the 10-20 system representation.

2.3.1. DATA OPERATIONS

Filter: raw data is subjected to filtering operations, more precisely, a low-pass and a band-pass filter. These can be applied or not, with frequencies adjustable by the user. Additionally, the moving average for each data vector is calculated, for purposes of monitoring as well as to trace a user profile, described below.

Profile: Each individual has a default mode, i.e., a mode that works permanently within a self interdependent dynamics, where the constitutive parts of the individual are permanently exposed and interact within the environment where it inhabits, i.e. itself. Consequently each individual has an offset signal dependent of its default mode.

An excitation, i.e., a(ny) stimuli that does not belong to default mode is what provokes a chain of reactions that modulates the default mode, i.e., generates a signal scale dependent of the interaction of the individual with its environment. Taking this into account, the system collects data and proceeds with a statistical averaging to establish a default mode for each user. This default mode is then the starting point from which the system behaves, more precisely, the default mode values are inserted as the base for the scaling process, described in the next paragraph. Different profiles settings can be stored and accessed at any time. Thus, allowing the system to easily adapt to different subjects.

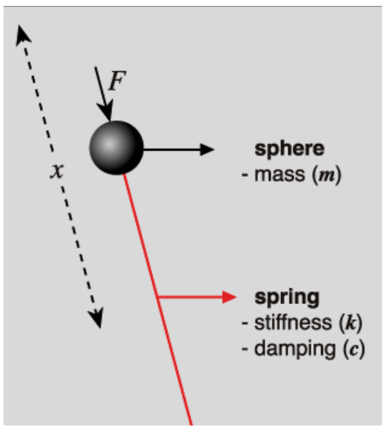
Scaling: Once the data is filtered and a profile of the subject is plotted, we proceed to the scaling process. Originally comprised between 4200 and 5000 (based on the original DC offset of the raw signal), the data is scaled to values between -5 and 5. These will be translated into vectors with a given magnitude and direction, which will act in the form of forces when applied to the physical system (see 2.3.2). The default scaling translates higher EEG values into high magnitude force vectors, and lower EEG values into low magnitude force vectors. By default, the transfer function used in the scaling process is an exponential function of base 2.5. However, cosine, linear, logarithmic, and gaussian functions can be applied, among others. Scaling has a significant impact on the relationship between the input data and the physical forces applied to the system (described in 2.2). For this reason, the possibility of the user to change the scope of scaling as well as its underlying transfer function, translate into important features in the search for a balanced representation of EEG data with different characteristics.

Mapping: At the end of these processes, with properly filtered and scaled data, we proceed to the mapping process. Here, data vectors are translated into forces that will be later introduced in the virtual physics system, described in 2.4. Additionally, there is also a relationship between the activity level of a given EEG channel, and the virtual sphere that represents it.[6]

2.3.2. PHYSICS SYSTEM

The physics system was developed by Hermann (1999) having into account the methodology for the development of an interactive sonification model. Despite its connection to the discipline of Auditory Display and Data Sonification, we did not find any objection for its application in this context. As such, we divided this visual representation system according to its (i) Setup, (ii) Dynamics, and (iii) Excitation.

Fig. 5 Mass-spring system



6 *EshoFuni* allows, at this moment, to map EEG activity to pseudo color code as well as to size.

i) Setup: The proposed visualisation model, is composed by one mass-spring system per data vector (EEG channel), each virtual spring being attached at 3D spheres whose positions are defined by the 10-20 system described in the section 2.2.

ii) Dynamics: As illustrated in Fig. 5 each sphere (with a mass m) is fixed with a virtual spring to its position in the three-dimensional (3D) space, thus, each sphere can perform an harmonic oscillation around its own position, as described by x. This harmonic oscillation is modeled by classical mechanics of mass-spring systems, which is determined by an external force (F), the mass of the sphere (m), the spring stiffness (k), and the damping coefficient – or dissipation rate – (c). At the moment, all spheres share a mass of 2 (m = 2 kg). The same happens with the springs, sharing a stiffness of 15 (k = 15kg s^{-2}), and damping coefficient of 5 (c = 5kg s^{-1}). It is important to note, that these values were set after some tests with different EEG data streamings. However, the user is able to change these values according to his purposes, thus adapting the physical simulation to different EEG data streamings and its features.

iii) Excitation: Initially in its rest state, the model is excited by being introduced a given force (F) in its dynamics. These forces act as vectors with a given magnitude and direction, which will then be applied in the equations of motion of each sphere. Therefore, the change of motion of each sphere, is proportional to the force impressed and is made in the direction of the straight line in which the force is impressed. Vector's magnitude and direction are directly related to the mapping and scaling sections (see 2.3.1), thus, changes in the scaling process (scale values and transfer function) will be reflected on the applied force, and therefore, on the harmonic oscillation performed by each sphere.

3. CONCLUSIONS AND FUTURE WORK

We presented *EshoFuni*, which according to our research is the first system making use of a physics simulation to visually represent real-time EEG data. Being one of the most important purposes of *EshoFuni* to solve personal problems and needs on creating artistic representations of brain electric phenomena (e.g. by means of sound or graphic form) we consider that the way it fulfills that requirement is rather consistent and satisfactory – maybe groundbreaking by itself.

We finally hope that it may contribute to successfully represent this kind of data, particularly in the domain of digital arts. Additionally, the flexibility provided by *EshoFuni* should promote a systematic and versatile approach for data representation within different artistic contexts.

As described in section 2.2, the actual data transmission is based on OSC protocol, provided by MYOSCs. This increases the risk of packet loss along the transmission, thereby representing the major limitation of *EshoFuni*. Having this into account, future work should be centered around the development of a MM/J external, that provides data acquisition to be done directly from the EMRSDK, instead of using third-party software (e.g. MYOSC) to bridge between EMRSDK and MM/J. In this way, we would be able to remove the actual intermediary protocol (i.e, in this case, OSC), thus increasing *EshoFuni*'s robustness and speed, as well as the decreased risk of packet loss. Finally, it is in our interest to implement methods of real-time analysis and artifact removing, thus enhancing rigorous data interpretation and system behaviour.

ACKNOWLEDGEMENTS

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UNCOVERING BIOKINETIC INTERFACING

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Keywords: Biokinesis, Abstracted Musical Form, Neural Networks, PWM Controlled Electromagnets, Deep Cognition, Deep Pattern Recognition, Music-Form-Emotion, Intuitive Interfacing

The following paper details a research tangent explored within the scope of a larger project exploring a new method of interfacing the author has termed biokinetic:

> *A biokinetic interface is a new form of dynamic and ever changing device that enables instrumental mediation between one or more users and an electronic component.*

This research project employs an audio media player as the vehicle for validating the concept. In order for this interface to act in a nominally universal manner, the interface itself is visually abstracted, with the intention that anyone may approach the device and sense how to use it, and intuit what is happening, without recourse to agreed-upon historical symbols such as the play triangle, and the stop square.

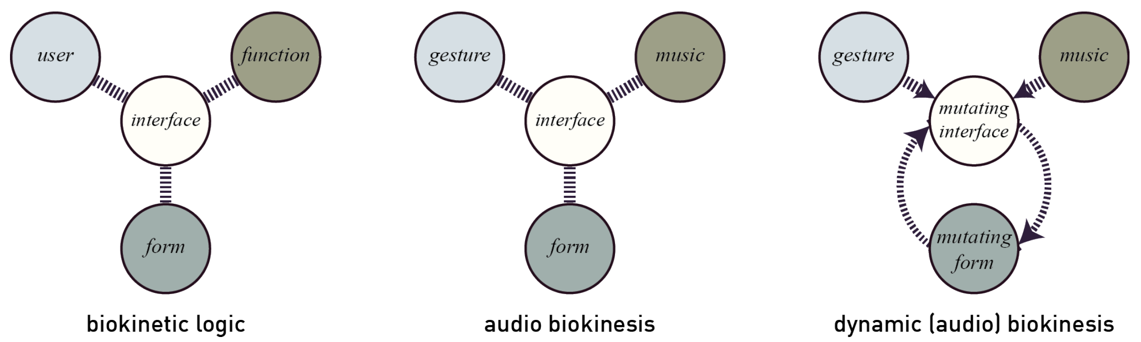
Abstracted form would appear to have no underlying logical inference from which users can navigate the system, however in prior work, the author provisionally demonstrated – that for certain types of music at least – people appear to have a consistent and quantifiable abstracted visual language associated with specific music. It is the author's intent to use this visual language as the basis for interfacing.

1. INTRODUCTION

Current digital interfacing is digital, generally ignoring the particular qualities and sensitivities of each unique situation. This linear progression works precisely because it is indifferent – iTunes plays music we want at the volume we set: it does not matter how sensuously we stroke the play button: it plays. If we angrily stab the stop button: music ceases. The (emotional) state of the user – as evidenced by the quality of gesture and specific music chosen – is neglected in the design of most media players. It is the author's contention that current digital music players disconnect listeners from meaningful interaction from a product that is ostensibly designed to facilitate emotional connection.

Despite design theoreticians positing that intuitive interfaces should be responsive and physically dynamic (Norman, 2007), domestic audio electronics have yet to engage in this emergent field. A simple media player was chosen a suitable vehicle for this design investigation due to both the ease of data capture, and more specifically the quality of the data. There has been much research upon the emotional connection with music; from Kate Hevner's early experiments onwards (Hevner, 1936) and, modern computational methods of analysis such as MIRToolbox[1] have enabled sophisticated insight into audio data.

Fig. 1 Biokinetic interface logic



1.1. BIOKINESIS DEFINITION

A biokinetic interface is a new form of dynamic and ever changing device that enables instrumental mediation between one or more users and an electronic component. Eschewing touchscreens, a biokinetic interface uses physical input from the user to control the component and responds giving the user feedback by moving all or part of itself. The basis of the movement is a combination of user input and the component's function.

1 MIRToolbox for MATLAB by Lartillot, Toivainen & Eerola *https://www.jyu.fi/hum/laitokset/musiikki/en/research/coe/materials/mirtoolbox*

1.2. BIOKINETIC OBJECTS

Biokinetic objects are practically constructed from three interlinking forms: *dynamic*, *base* and *object*. *Object form* simply denotes the form of the physical form of the component itself, *base form* is the underlying structure for a specific class or function (such as a kettle boiling, or a particular song being played), and *dynamic form* is temporal and situation specific (such as gesture input, and instant data feedback).

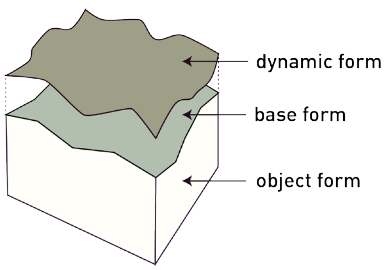
In the following paper a brief overview of visual perception and abstracted form is put forth, followed by deeper examination of the three interlinking forms: *dynamic*, *base* and *object* including different modalities and the use of neural networks. Finally, a tablet-based prototype is discussed, before a conclusion being drawn.

2. VISUAL PERCEPTION AND PATTERNS

The concept of universal human visual languaging is not a new one, although it appears very difficult to achieve in practice – body language being notoriously different across cultural boundaries, for example. The lowered wave of ‘come here’ in Eastern cultures being read as ‘go away’ among Westerners constitutes a common misunderstanding. Hans-Georg Gadamer refers to the crux of this position as *wirkungsgeschichtliches Bewußtsein – historically effected consciousness* (Gadamer, 1960). This referentialist argument of the primacy of the environment in our (visual) cognition, which is also echoed within our knowledge about differing cultural influences in music cognition, makes a strong case for unique individual bias in cognition.

However, if we relax the definition to only ‘reading and understanding’, then in practice, and with practice, we can name dynamic visual patterns that are coherent across all cultures – namely from the natural environment itself. The inherent subconscious understanding of the way clouds ceaselessly swirl, the way fire licks around a branch and the languid splat when fat raindrops hit the ground *are* part of universal human experience. Arguably, a wizened gaucho from the pampas in Argentina, and a young babysitter in Manila have the same physical reality when experiencing these singularities. Of course the reflexive and cognitive dimension of these events within recipient’s consciousness will be likely distinct and different, but the event itself is con-

Fig. 2 Biokinetic object typology



sistent and universal. These natural states surround us – even in the city - and are coherent, meaning that cohesive changes in pattern occur together. For example, the storm surge increases as the rain and wind both intensify.

A quick examination (!) of our current understanding of visual perception, and how it relates to cognition is germane at this point to this discussion. In broad strokes, there are two main schools of thought (Gregory 1997): firstly the *direct perception* model as promulgated by J. J. Gibson. He essentially states that our visual perception requires little or no knowledge – our eyes receive ambient light bouncing off object surface and we then process this information within the brain.

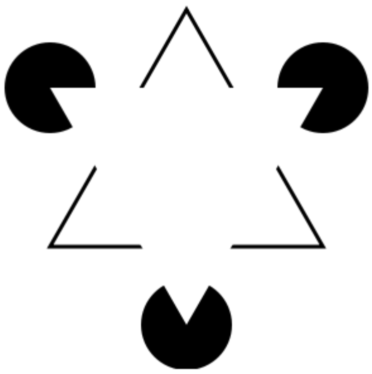
> *Direct perception means that the information in our sensory receptors is enough to perceive anything. We do not need any higher-level cognitive processes to mediate between our sensory experience and our perception (Sternberg 1997).*

Alternatively, the great polymath Hermann von Helmholtz (Helmholtz 1866) posited that visual perception arises out of unconscious inductive inference: we mentally access prior world knowledge and map it into our visual perception in order to process the limited and ambiguous imagery our eyes process. Richard Gregory further states that perceptions are hypotheses permitting us to sense the whole of objects by prediction – this is called amodal perception.

> *The notion is that stored-from-the-past potential intelligence of knowledge, is selected and applied to solve current perceptual problems by active processing of kinetic intelligence. The more available knowledge, the less processing is required; however, kinetic intelligence is needed for building useful knowledge, by learning through discovery and testing. (Gregory, 1997)*

Primate brains such as ours have significant lag between reality and the photoreceptors being active in the brain, which Helmholtz discovered in 1850, and has since been verified scientifically by others (Nijhawan, 2002), which may be indicative of this theory being valid (our minds also predictively account for this lag in moving ob-

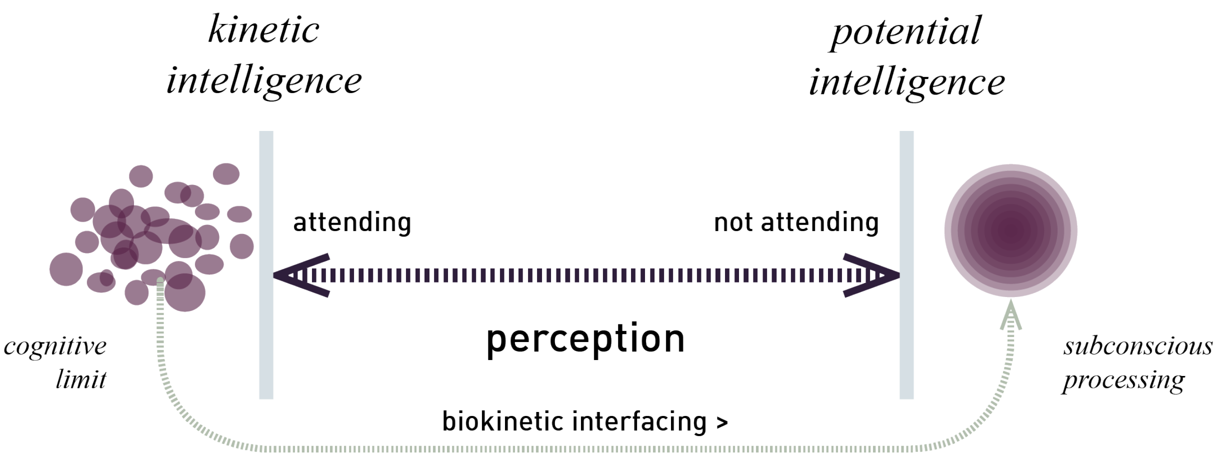
Fig. 3 Kanizsa Triangle: amodal perception



jects). Additionally this theory also explains our visceral response to optical illusions, which the direct perception model cannot.

If we accept the validity of the second school of thought, it becomes possible to intentionally work within the vein of subconscious experience. Acknowledging that visual knowledge is unpacked more easily, and perhaps more quickly, with stored-from-the-past understanding, the author questioned the limits of visual kinetic intelligence, and posited that if we push visual complexity to a point where cognitive load becomes too great we must then intuit an interface, and attempt to process the information at a subconscious level.

Fig. 4 Kinetic vs. Potential intelligence



Conscious (kinetic) processing via either model of representative (symbolic) form inherits distinct cultural bias therefore the concept of an abstracted interface was adopted as a possible route to a *nominally universal* design, which might be applied to music interfacing.

3. BIOKINETIC INTERFACING – DYNAMIC FORM (AUDIO)

Work at the beginning of this project assumed using multiple natural inputs to create computational algorithms that could emulate the dynamic nature of music from sources such as weather patterns, fluid dynamics, thermodynamics from wind and fire, and landscape forms from geography. However, when roughly tested with a series of simple After Effects created ‘hairy interfaces’ animations[2] it was discovered that people found simultaneous and competing inputs hard to ‘read’.

2 Hairy Interfaces *http://www.metier.co/hairy-interfaces/*

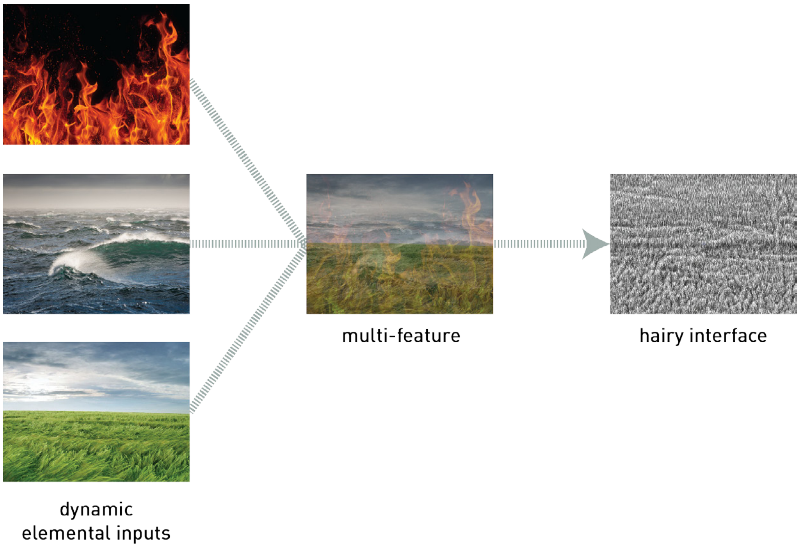


Fig. 5 Multimodal 'Hairy' Interfacing

After consideration, I realized that the best theory to explain why this misperception occurs is because these haphazard combinations constitute a chaotic *visual multi-modal* input. When we remove visual representation of these natural phenomena, and instead use abstracted dynamic form (that is to say using the change in state vs. time as the input), it appears our brains can make a 1:1 intermodal match, but multiple inputs lead to confusion. To put it simply – we shouldn't mix our metaphors.

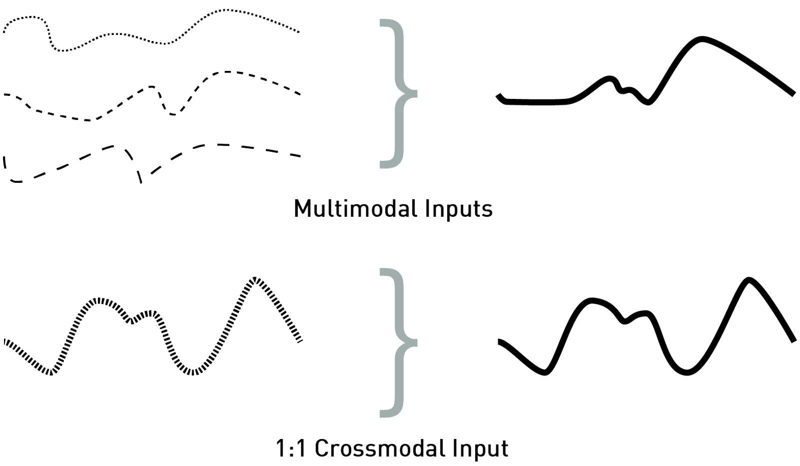


Fig. 6 Multimodal vs. Crossmodal Interfacing

Thusly, we may state for the purposes of this project that for effective biokinetic interfacing within an abstracted vernacular, the following conditions must be observed:

- The *visual modality* translation must be singular
- Users must have deep knowledge of all *visual modalities* presented
- Inputs and outputs must act coherently and consistently

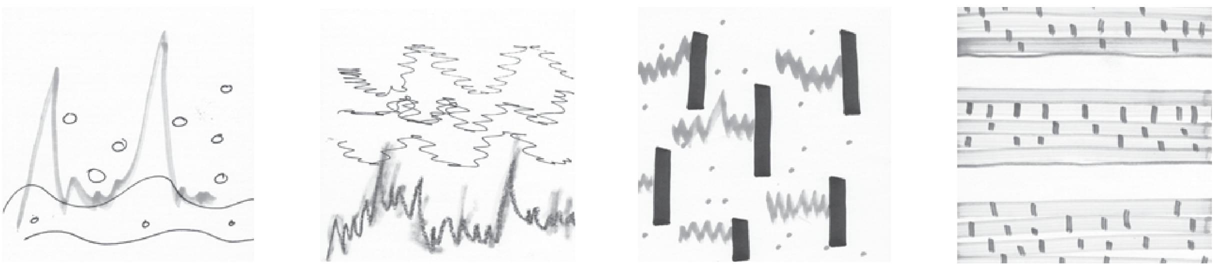
If these conditions are met, then it might be said that these meaningful dynamic patterns project intentional agency. But what of the underlying forms themselves? How might they argue for the sense of thrilling Jazz, or downbeat Electronica?

4. BIOKINETIC INTERFACING – BASE FORM (AUDIO)

What exactly is the shape of sound?

Obviously we can all have different ideas of what colors, memories and emotions music can and does invoke internally. All of these responses are deeply personal, and cannot constitute a unifying constant that we may translate as a coherent, consistent visual language as a basis for interfacing. After looking at several related phenomena such as synesthesia, attempt was made to discover if we do indeed have a deep interrelated visual language associated with specific music. Again, the use of abstracted form was sought; in order to avoid the cultural bias of representative signifiers.

4.1. BACK PROPAGATED NEURAL NETWORKS AND ABSTRACTED MUSIC IMAGING



Opera Blues Electronica Jazz

Fig. 7 User One: Abstracted images drawn to music

A sample set of 40 people were provided with a variety of drawing instruments and asked to draw four - abstracted – black and white images, while listening to four different styles of music. The 160 individual images were then digitized, and loaded them into a Back Propagated Neural Network (BPNN); which designed to find common patterns within each musical image group. New images are then inputted and ideally the BPNN is able to assign the new image to the correct group.

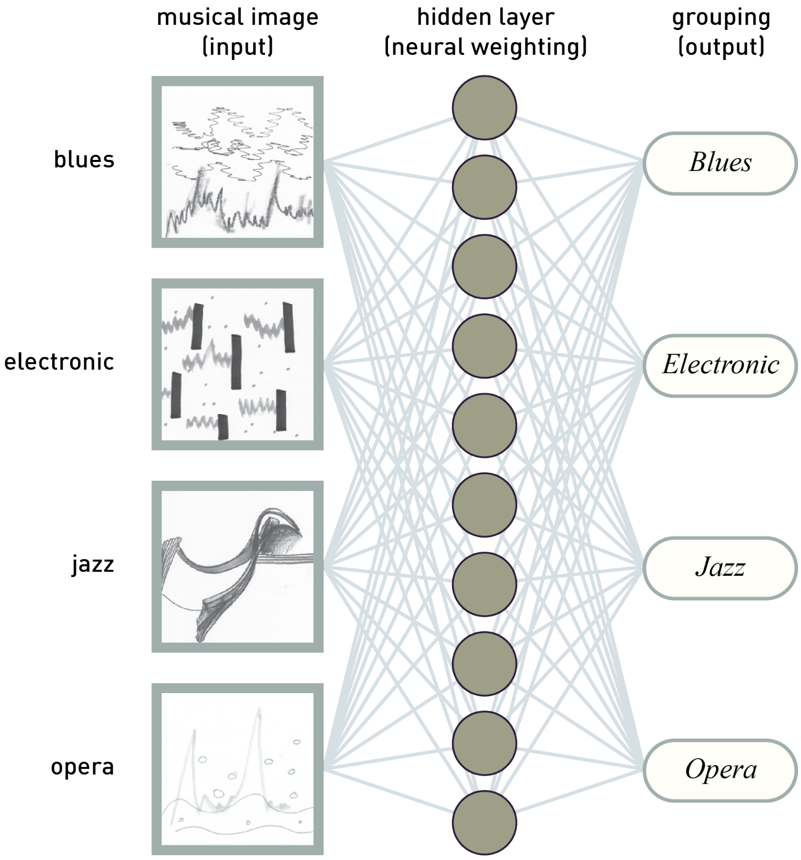


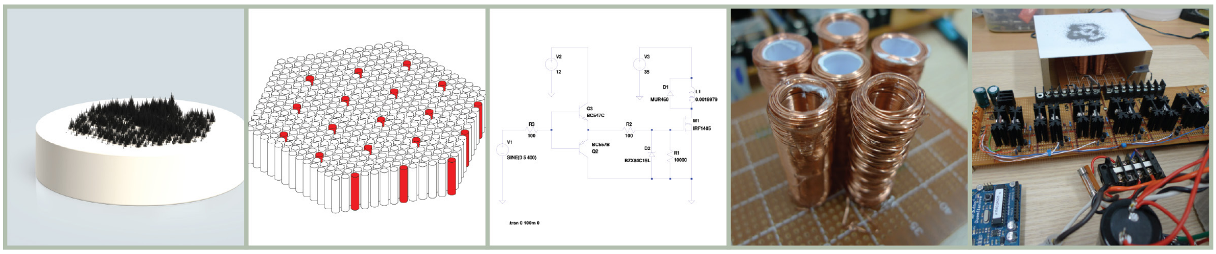
Fig. 8 Back Propagated Neural Networks for abstracted music imaging

Given that it is a small sample with very complex datasets, there does appear a trend towards a common and innate abstracted visual language associated with specific music types, if not all. In the validation set, the following results were recorded, where 25% is random chance:

- Opera 49.2%
- Blues 56.1%
- Electronic 100.0%
- Jazz 47.6%

Other BPNNs were run where drawings that were visually inconsistent or overtly representational were removed first, and the network was able to sort images with a much higher degree of accuracy. More research is presently been done in this area with the aim of validating the position with much larger sample sets collected from a greater diversity of users, which may be automatically analyzed and collated.

5. BIOKINETIC INTERFACING – OBJECT FORM

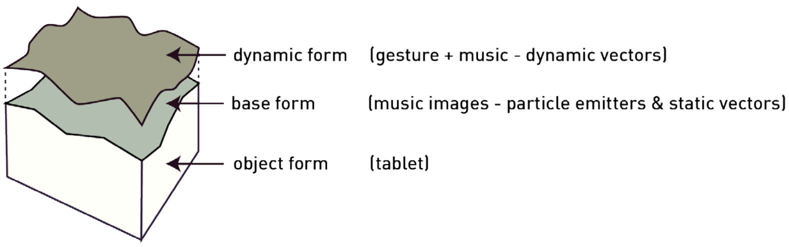


The final intended object form of this investigation is a physical interface that utilizes Pulse Width Modulation to dynamically control a grid of electromagnets. The resultant flux superposition governs the behavior of ferrous powder (magnetite) that is the manifestation of the visual interface. Whilst any given superposition of the magnetic flux is repeatable, the chaotic corporeal qualities of the powder reflect music's emotional complexity. For the purposes of this paper we shall put aside this final output to concentrate on a tablet based simulacra that manifests many biokinetic behaviors.

Fig. 9 Final Object – Biokinesis using magnetite; controlled via a grid of PWM electromagnetic coils

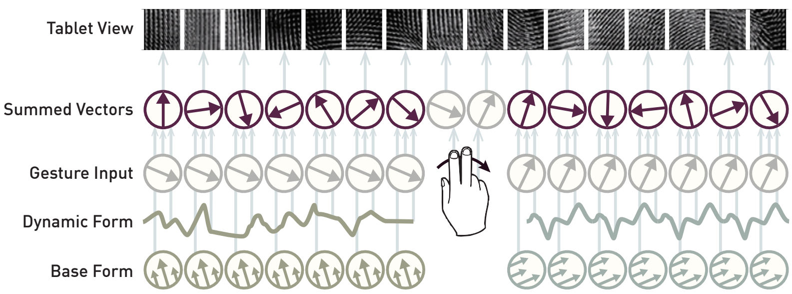
6. BIOKINETIC TABLET PROTOTYPE

Fig. 10 Biokinetic tablet overview



This tablet-based interface currently utilizes Memo Akten's wonderful library: MSA Fluid[3] and coded within C++ / openFrameworks. This particle library responds to vector based inputs.

Fig. 11 Biokinetic tablet inputscoils



3 MSA Fluids Library by Memo Akten *http://www.memo.tv/ofxmsafluid/*

When music is playing dynamic vector forces are taken from two sources: *gesture input*, and *base form (image vectors)*. The *base form* variable is currently derived from the images drawn in the Neural Network experiments. The images are transformed into an of array particle emitters, each with an associated vector, and placed within the application for use as constant *base form*. The *dynamic form (music input)* as the name suggests is derived from the music currently playing. At present this input is simply acquired from discreet audio bands and parsed to the particle emitters; in time it is projected to use a multiplicity of computationally derived musical data such as dissonance, brightness, attack slope, etc. to affect both emission and vector angles. The *dynamic form* dynamically adjusts parameters (number of particles, emission speed, etc.) within the MSAFluid library emulating the desired 1:1 crossmodal input (music : fluid dynamics).

Finally the user's gestures are also used as dynamic inputs. User gestures are used in two ways: firstly there is simple visual feedback that shows the user that the gesture is being read by the machine. Secondly, it is intended that the nature of the gesture is also captured and used to mediate the response of the interface. For example, if the average gesture is fairly gentle in nature, and then the user gestures very aggressively, then the magnitude of the vectors will increase proportionally, mimicking the input. In this way, in concert with the music itself and the volume set we may give the interface a sense of responsive animation.

Fig. 12 Biokinetic tablet screen captures

Furthermore, when the user gestures to change songs, abstracted vector versions of the album cover art appear combined with the abstracted musical images for each track. This highly abstracted representation is the exception that proves the rule. The author found it difficult to create a logical interfacing segue between audio tracks and albums. Early prototyping revealed the users require a consistent and static image that they can repeatedly intuit. Merely abstracting the existing cover art worked is a simple solution that appears to have deeper subconscious connection for users. One possible explanation why the use of highly abstracted cover art appears to work in this context is that it is the artwork is produced artists and designers that are generally trying to convey the essence of the album. This currently feels like a somewhat temporary solution (and is a manual intervention!), and more experimentation and design is been taken within this area in order to get better results as well as automate the process.

7. CONCLUSION

> *Asynchronic events and disproportions caused by the continuously changing matrix-worlds of personalized, globalized, user-generated content are relegating form back into the orders of the unknown, back into exformations, where the encoding patterns of form are only just emerging – in interactive scenes. (Fasser, 2008)*

While conventional interface design seems converge on simple and efficient interaction, utilizing an increasingly standardized set of conventions, the author believes that alternate paths exist. Biokinesis is potentially one such path, seeking to utilize deep pattern cognition and natural mappings, allowing users to intuit an interface subconsciously. Intuitive interfacing is certainly not a new concept, and this form of interfacing is problematic for many, if not most, HCI applications. With the rise of the internet-of-things and the ubiquitous nature of screen-based interactions, one might feel that a new, nuanced physical screen-less interaction for controlling appropriate sense-data is both aesthetically desirable, and cognitively necessary in domestic environments to avoid technological overload.

In a more immediate sense, work is been done to release the tablet prototype as a iOS application that leverages iTunes to act as a media player. Amongst other efforts, further work is also being pursued to understand the relationship between music and form using web-based applications called ‘Interface Design Machines’ that are able to collate far bigger data sets from a much wider target group, and automatically parsed this data into the neural network.

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SOUND CHOREOGRAPHY <> BODY CODE

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Keywords: Choreography, Live Coding, Dance, Hacking, Feedback

A performance work, *Sound Choreography <> Body Code* is introduced, which connects live coding and live choreography in a feedback loop of influence. Both the practice and the discussion of the work raise issues in coding, choreographic scores, and live performance through an exploration of feedback, interpretation and technological mediation of sound and movement in live coding environments. It suggests a model for interpretation of scores that allows for different approaches to scoring and interpretation in live performance settings and proposes how mutable scores differ in the instructional language within Sound Choreography <> Body Code.

1. INTRODUCTION

In the following we consider the movements of choreography and of computer programming together. The discussion centres around *Sound Choreography <> Body Code* (SB<>BC), a collaboration between the present authors, which combines choreography and computer programming in a live performance artwork. To date the piece has been presented three times, at Audio:Visual:Motion in Manchester UK, at Thursday Club at Goldsmiths in London UK, and at Hack Circus at Site gallery, Sheffield UK. The following paper begins by examining the relation between code and choreography as explored in performance. We then describe our own collaboration, centring on the feedback loop created between body and code. We conclude with discussion of the experience of programming, the role of mutable notation in performance, and code as a tool, a language or environment.

2. SOUND > CHOREOGRAPHY > BODY > MOVEMENT > CODE > SOUND

This performance follows individual works, by Sicchio in the relationship between choreography and code (e.g. Sicchio, 2014), and by McLean on designing programming languages for expression in live performance (e.g. McLean, 2013). To achieve confluence from these two practices, we needed to connect aesthetic and technical aspects on both sides, and achieve balance between them. The solution we arrived at maintains a clear distinction between choreography/dance on one side, and code/music on the other, but creates a technological connection between them, via their notations. As a result the music is not coded for the dancer, and the dancer does not move to the music; but still a feedback loop is created that passes through the body and code, via machine listening and computer vision (see Fig. 2).

The piece begins with both performers simultaneously creating live action (dancing, typing), and with projections of both code-scores within the performance space. A diagrammatic score is followed by the dancer (Sicchio), with a small series of instructions that include directions (right, left, up, down, loop, if) and numbers (1-3) that are connected into an acyclic diagram (i.e. one that forks but does not reconnect), according to the minimum spanning tree. The dancer has a set series of gestures that are then organised and performed based upon how the instructions and numbers are connected and continually reconfigured. However, as the performance progresses, the diagram becomes much more complex. The number of instructions fluctuates over time on a scored pattern that peaks at a point of complete overwhelm for the dancer and returns back to a simpler form to end the performance.

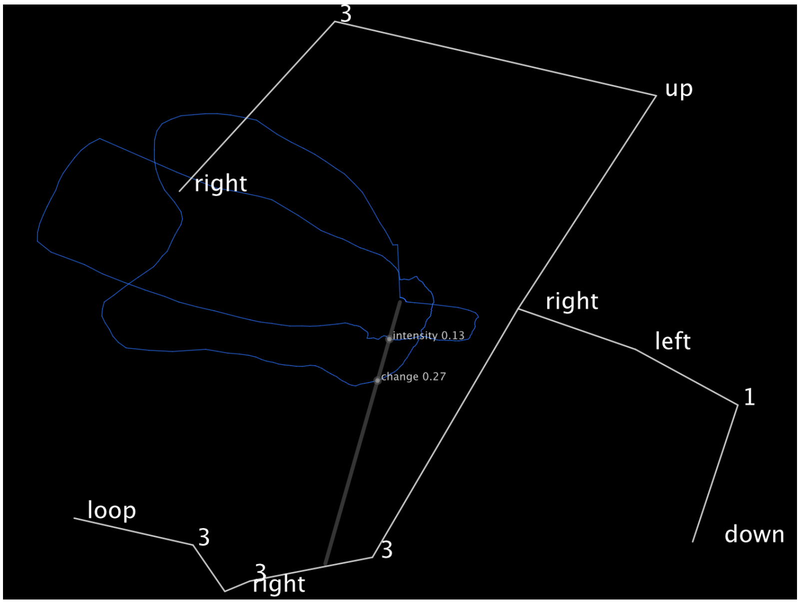

Fig. 1 The Sound Choreographer, showing instructions right, left, up, down and numbers, connected in a minimum spanning tree. The grey line extending from the centre sweeps around, clock-like, through a single cycle during the performance, and the two blue shapes show “intensity” and “change” graphed over time using polar coordinates. Intensity gives the number of instructions, and change the size of each movement that is made in response to sound onsets.

The movement of the dancer is tracked by a Microsoft Kinect via a ‘patch’ made with the Isadora software, detecting the location and shape of the dancer’s body in space. From this two floating point values from 0 to 1 are calculated; one representing the position of the dancer along the horizontal axis, and the other derived from the height/width ratio of the bounding box of their body when viewed from the audience. The latter represents an axis from standing, to crouched (or with arms apart), to lying down (along the X axis). These data are sent via the Open Sound Control network protocol to McLean’s live programming environment, to intervene in the code (as described below). This motion tracking provides one of the two points of contact between the movement and the sound, which forms the feedback loop.

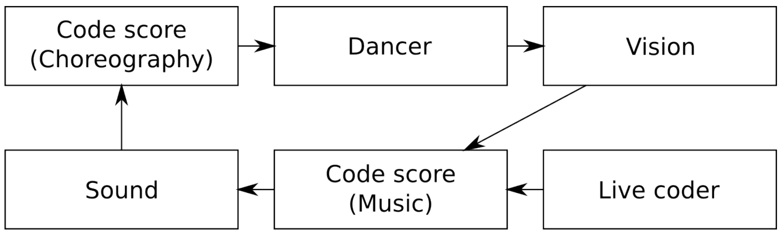

Fig. 2 A diagram illustrating the SC<>BC feedback loop of influence from choreographic score, through the dancer, their movements picked up by computer vision, fed into the live code environment, which produces sound which feeds back into choreography. The live coder is outside this loop.

The danced movements translate into movement within code, in particular that of Texture, a visual live coding environment (McLean 2011; see Fig. 3). Texture is visual in a sense that is stronger than in conventional visual programming languages. That is, the syntax is based on Euclidean distance, whereas in many other visual systems such as Max/MSP or PureData, the programmer makes connections between functions manually (Left-right position is syntactically significant for execution order in Max/MSP, but this is true also of purely text-based languages). Therefore, as the function assigned to Sicchio's position on stage moves around McLean's screen, it interferes and disrupts the running code. Because Texture only connects type-compatible values to functions, the resulting program is always syntactically correct. In practice, this means that program is never disrupted to the point that it falls silent.

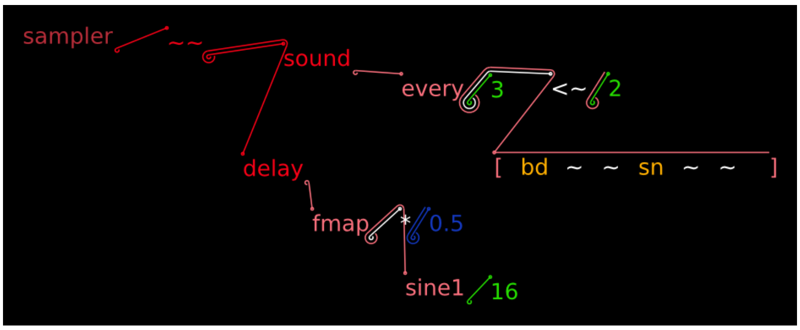

Fig. 3 The visual programming environment Texture. Words are automatically connected (and re-connected) based on proximity and type compatibility (McLean 2011). A version in development, used in Site gallery Sheffield, visualises patterns flowing between functions.

The second point of contact between the choreography and code is via machine listening. The Sound Choreography software performs audio onset detection on the sound produced from Texture, and the words within the choreographic diagram move in response. This can result in connections switching between words, whenever the movement results in a different minimum spanning tree. In this sense, the choreographic structure is dancing more directly to the rhythm of the sound than the human dancer.

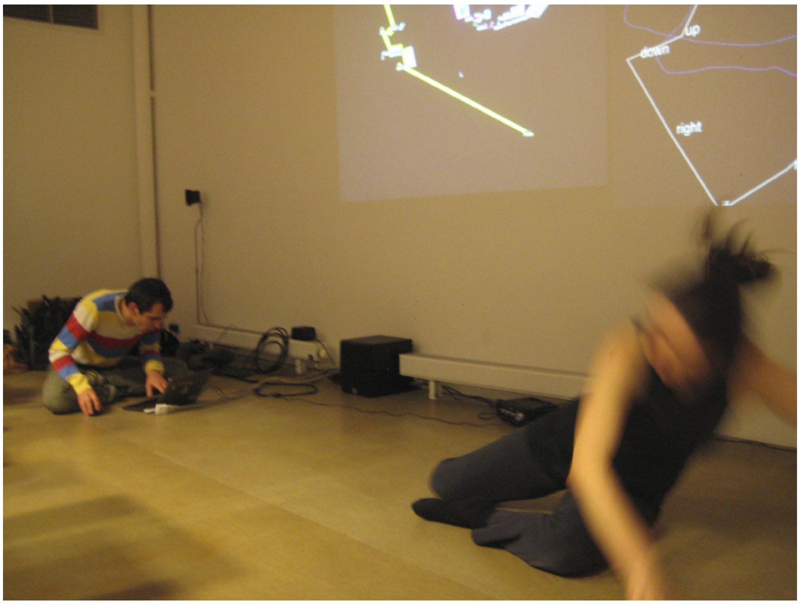

Fig. 3 Still from performance at Site gallery, Sheffield.
Photo credit: Susanne Palzer

These two points of contact create a loop of continuous influence from the body, into the code, into the sound, into the choreography and back into the code (see Fig. 2). This technological feedback loop is instrumental in bringing the piece together; during performances to date, both performers were focused on their individual code-scores, rather than the overall composition of the piece. In particular, Sicchio has not been conscious of developments or changes within the sound as she is dancing and the effect of the sound on her movement is not noticeable by her within the performance. The technology becomes the choreographer in this sense, and is organising the interactions, rather than the performers sensing each other in that moment. Whether there is a subconscious level of interaction between code and movement is an open question.

3. CODE AND CHOREOGRAPHY – MUTABLE PERFORMANCE

Other projects have recently explored the interface between choreography, live art and live coding practices (Cocker, 2014; Collins, 2011). There are also direct connections to the work of Fluxus artists such as Higgins (1961) found in this spectrum of interpreting scores. Higgins discusses this idea of the interpretation of the score, stating “All markings on the face of the notation are to be used or deliberately ignored for the production of movements and sounds according to any consistent system which the individual performer devises for the notation he is using" (Higgins, 1961).

When considering the relation between choreographer and computer programmer, there are three distinct elements at play. Firstly there is the score, which defines some organising principles behind the work. Then there is the notator, who writes the score. Finally there is the score-follower, who carries out the actions defined by, or otherwise organised within the score. In the following we focus on the interrelationships between these elements.

A key point to consider in comparing live choreography with live code is the extent to which the notator dictates the score, and the score constrains the score follower. This reflects two distinct purposes: the use of tools for creating specific outcomes in performance versus creating an environment for exploration in performance. The result is a spectrum of possibilities, where at one end lies mutable scores, or scores open for interpretation by people and machines, through languages. The other end of this contains coded, fixed 'objects' or fixed/coded people reproducing an ideal performance each time the piece is executed.

In terms of "Sound Choreography <> Body Code" two instructional languages are used (one for movement and one for sound) and they address these concerns differently. While the Sound-choreographer for the movement is a mutable-open score, Texture is a mutable-closed score. For example, while certain aspects of the choreography are scored within the performance, there are others that are not explicit within the score. The gestural movements that are repeated throughout are set by the performer, but the amount of repetition, location in space and order of the gestures are determined through following the score. As the score changes, the dancer may change their own system of interpretation. With Texture, the human-technology interface is reversed; the notator is human, and the score-follower is an electronic computer. Accordingly, the score is expressed and followed unambiguously, although the performance is still indeterminate as the score is continuously changed by the notator.

As the choreographic score becomes more complex over time, the dancer eventually has to accept that they cannot perform it accurately, and that they are failing to interpret the score in its entirety. The dancer is therefore compelled to change the way that she interprets the score, for instance focusing on sections, or a looser reading of it. So while there is some set movement vocabulary that is not notated, the interpretation of the system and language is still mutable within a live performance. Instead, the syntax of Sound Choreographer is fixed and based on proximity (as it is tracked by the kinect), and semantics is open to the performer's interpretation.

This model for scoring performance also may be useful in examining coding practices in general. Creating tools versus environments within software may demonstrate various ways in which coding may be approached. Within "Sound Choreography <> Body Code" there is a conversation between disciplines, code and people. It creates a language between these elements and therefore an environment to be explored. When considering code in this way, it becomes less utilitarian and more expressive. The software in this work may in a sense be considered useless; it does not offer utility as a tool, but instead provides a connection between practices. This allows body and code to resonate through notation, but only through difficult struggle.

ACKNOWLEDGEMENTS

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PROCEDURAL SIMULATION AND ITS REVERSAL APPLIED TO GAME DYNAMICS: EXPLORING RULES-BASED SYSTEMS THROUGH PLAY

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Keywords: Procedurality, Performativity, Simulation, Reverse-Simulation, Interaction, Experience, Play

This paper documents a project focused on the use of rules as a structuring element of systems and on promoting a playful interactive experience as a strategy for the creative exploration of those systems. The project contemplates the application of computational principles to physical space through the mediation of human execution. It makes reference to *Game of Life* (Conway 1970) and *Reverse-Simulation Music* (Miwa 2002) as case studies: two opposite poles that illustrate both human and machine execution through procedural simulation and its reversal. Our approach is based on a practical exploration of strategies analogous to both examples. It aims to contribute to an understanding of software code as a creative field inside and outside the computer.

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1. INTRODUCTION

This study was developed under the MA in Communication Design and New Media at the Faculty of Fine Arts, Lisbon and relies on the premise that the same instruction code can be executed by both machines and humans. It is inspired by how contemporary artists seek to reverse computational principles through the mediation of human procedural execution. It reinterprets ideas explored by artistic vanguards of the 1960s, which used the human body as a medium for creation.

From then onward, the spread of electronic media polarized artistic perspectives: either exploring the disappearance of the physical body brought about by media, or emphasizing corporeal presence and materiality (Frieling 2003), as strategies that were transposed to contemporary practices that refer to concepts of process-based art. New forms of computer-based interaction seem to expand the concept of the "open work" (Eco 1989) often resulting in evolutionary systems which are able to learn and act for themselves (Arns 2004), such as the *Game of Life* (*GoL*). This piece exemplifies how, by means of simple rules, it is possible for an artist "to cede some degree of control" to a system, endowing it with the ability to generate complex patterns and behaviors (Galanter 2006). This idea is transposed outside of the computational context, as reflected by methodologies such as the *Reverse-Simulation Music* (*RSM*) that explores the way in which a human system "reproduces in the natural world phenomena based on certain laws that have been investigated within computer space" (Miwa 2007).

This approach proposes a reflection on what software is and how algorithmic instructions can, in theory, be executed by humans as well as by machines; thus resembling the procedural nature found in former practices, such as happenings and performances, namely through the use of instructions and notations for actions. Based on this idea, this project aims to consider the procedural implementation of rule-based processes, revealing how they can be reinterpreted and performed by different types of systems, whether real or virtual.

We focus on the generative and adaptive potential of rule-based systems and the way they "exponentiate" results, leading to self-organization (Galanter 2003). This approach seeks to emphasize the creative potential of rules. We also have a particular interest in promoting a playful interactive experience in order to enhance the engagement between audience, artist and his work. To this idea, we associate the notion of collective experience and free interpretation in order to explore how these can promote specific "pleasures" associated to the system's gameplay (Costello and Edmonds 2007:82). We therefore assume procedurality as a key concept, common to both human and computational execution that extends to software code, variable systems and games as systems. This approach is followed by an analysis of the two case studies mentioned, which seeks to define a set of principles and strategies to be applied to a creative reinterpretation of the *GoL*.

2. OVERVIEW

2.1. PROCEDURALITY

Procedurality is the computer's "defining ability to execute a series of rules" (Murray, 1997). The term arises from the function of the processor, "the 'brain' or 'heart' of a computer" (Bogost 2008:122). According to Bogost, procedurality "creates meaning through the interaction of algorithms". These are the "sets of constraints" that structure the system's behavior and allow the creation of representations and "possibility spaces, which can be explored through play" (2008:122). This term points to the formalization of abstract processes, which we call algorithms (as treatable procedures or methods); abstractions which can be considered independently from both programming languages and the machines that execute them (Goffey 2008:15-16).

2.2. CODE

According to Cramer (2002) we consider that "the concept of software is by no means limited to formal instructions for computers". These instructions "only have to meet the requirement of being executable by a human being as well as by a machine". This idea is tied to what Berry (2008) calls the "dual existence" of code, distinguishing human-readable "delegated code" (source code) from machine-readable "prescriptive code" (executable code). The author distinguishes several "ideal-types" in order to understand "the kinds of ways in which code is manifested", thus demonstrating its "translation quality" from an “atomic” to an “articulatory” form. In other words, from a “non-algorithmic digital code” to an “algorithmic instruction code” (Cramer 2002).

2.3. VARIABLE SYSTEMS

On a computational level this study focuses on “media for which digital computation is required at the time of audience experience (…) in order to be itself” (Wardrip-Fruin 2006:7-18) and whose behavior varies “randomly or otherwise (…) with input from outside” (Wardrip-Fruin 2006:398-399). According to this, we can distinguish autonomous systems from data-driven systems (Carvalhais 2011), which also might be called interactive: these can vary with input from external data or processes, namely, human input (Wardrip-Fruin, 2006:399). In this context, Casey Reas’ notion of “expressions of software” (2003) and Wardrip-Fruin’s concept of “expressive processes” become relevant for understanding these computational forms and their focus on “processes themselves, rather than simply their outputs” (2006:1) – as systems whose software has creative potential on an interactive and generative level. In order to access these processes we consider “close interaction” as a useful strategy for analyzing games, because it allows us to evaluate if the agency (Murray 1997) – a key pleasure in a system’s gameplay – is identified by the players (Wardrip-Fruin 2006:45).

2.4. GAMES AS SYSTEMS

Games can be considered a “subset of the play”, therefore we focus on gameplay as a form of structured play; a “formalized interaction that occurs when players follow the rules of a game and experience its system through play” (Salen and Zimmerman 2004:72-73). In this context it becomes useful to resort to the notions of *ludus* and *paidia* proposed by Roger Caillois, considering two types of games, which may be experienced as *rule bound* or *free form* (Salen and Zimmerman 2006). We focus on the latter notion, as it does not necessarily involve “working with or interpreting a structure that exists outside oneself”, but rather “being creative with or within this structure”. This approach resembles the definition of play as “free movement within a more rigid structure”; an experience that oscillates between a rigid structure (where one questions what can this object do?) and the behavior the player chooses to adopt (what can I do with this object?) (Salen & Zimmerman qtd in. Costello and Edmonds 2009:40), from which different aesthetic pleasures can emerge (Costello and Edmonds 2007:79-82).

3. CASE STUDIES

3.1. GAME OF LIFE AND REVERSE-SIMULATION MUSIC

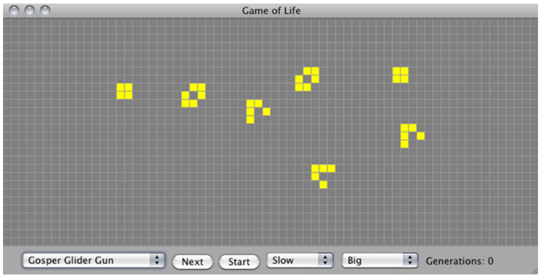


Fig. 1 John Conway's *Game of Life* (Edwin Martin 1996-2004) **Fig. 2** All Koans of *Matarisama* (Method Machine 2005)

These case studies arise as opposite poles that illustrate the idea of simulation and its subsequent reversal. *Game of Life* (1970) is a cellular automaton developed by the mathematician John H. Conway.[1] It simulates life phenomena as a way of describing processes of emergence and self-organization. This represents a starting point for many artists involved in generative practices, such as Masahiro Miwa's *Reverse-Simulation Music*[2] (2002); a methodology that comprises "acoustic events born of intentional human actions (...) carried out according to sequences resulting from iterative calculations" (Miwa 2003a).

3.2. ANALYSIS

We started by considering the context, concepts and methodologies used in each of the examples and then developed an analysis on three levels – internal/ mechanical, interactive/dynamic and external/aesthetic – based on both the MDA framework by Hunicke *et al.* (2004) and the *Rules/Play/Culture* framework by Salen and Zimmerman (2004). In order to establish analogies between both examples, we confronted their different types of code according to Berry's (2008) terminology and his approach to the three compositional aspects of the *RSM* (rule-based generation, interpretation and denomination) as different manifestations of code; an analysis that we extended to the *GoL*.

1 For a complete description see the GoL's first public publication (Gardner 1970).

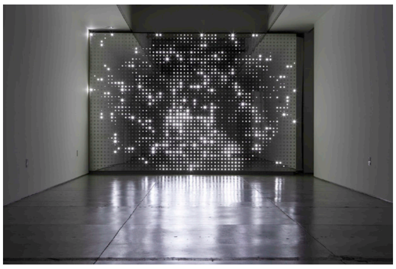
2 For a complete description see Miwa's (2003b) definition of the *RSM*.

Subsequently, we resorted to Dorin *et al*.'s (2012) *Framework for Understanding Generative Art*, which allowed us to describe these works not only in terms of their data representations and algorithms, but also in terms of their observable dynamic processes. According to this framework and its components (entities, processes, environmental interactions and sensory outcomes) we can contemplate the "natural ontology" of the two generative systems and compare them according to the ways in which they operate, taking *GoL* as an example given by the authors and extending this analysis to the *RSM*.

Finally, we conducted a survey of artistic reinterpretations of the *GoL*, in order to describe the "translation quality" (Berry 2008) of its rules and their occurrence and importance in artistic practices. We then compared the *GoL* with the *RSM*, considering the following aspects:

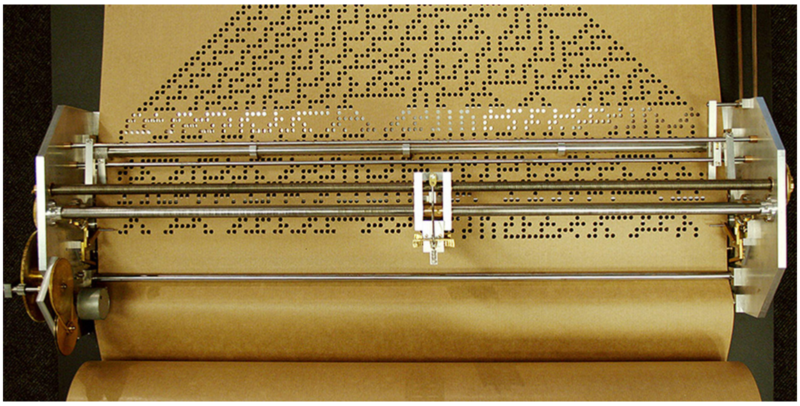
a) The creative potential of rules; contrasting merely illustrative reinterpretations of the game, such as *Life Dress* (Fuller 2009) with creative reinterpretations that adapt the game's original rules, in order to achieve different results, such as *Diamond Sea* (Villareal 2007);

Fig. 3 *Life Dress* (Elizabeth Fuller 2009)
Fig. 4 *Diamond Sea* (Leo Villareal 2007)



b) Materialization and extension into the physical space;

Fig. 5 Rule 30 (Kristoffer Myskja 2008)

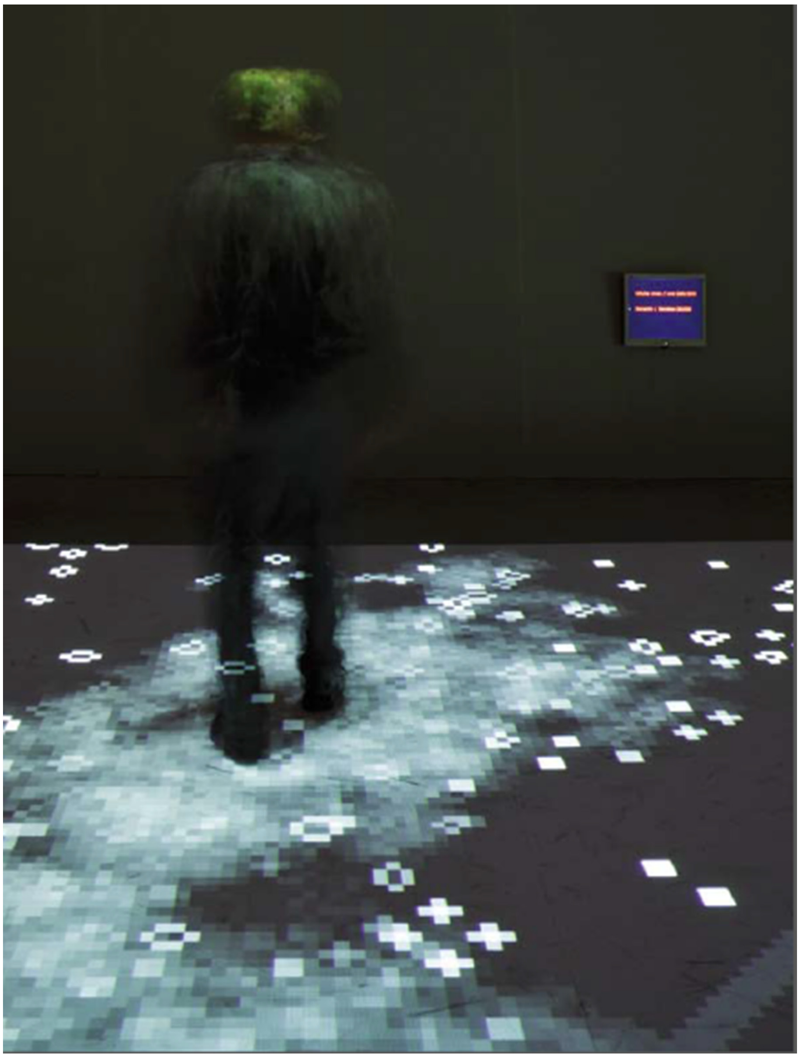


c) Human performativity;

Fig. 6 [Radical] Signs of Life (Marco Donnarumma 2013)[3]

d) Interaction between human and machine;

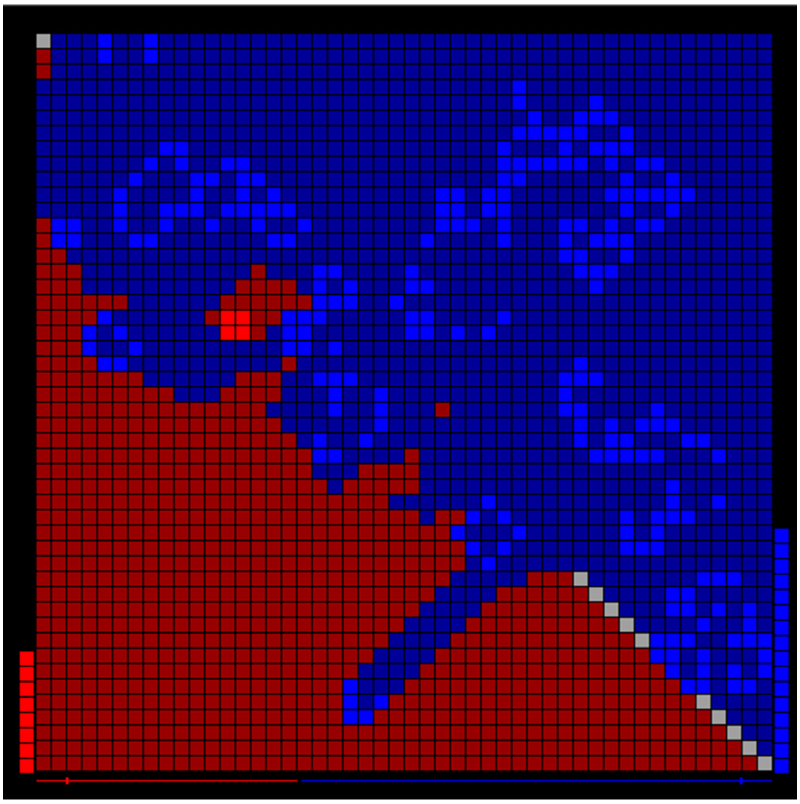
Fig. 7 Floor Life (Román Torre 2008)



3 *http://vimeo.com/65839165*

E) Playfulness.

Fig. 8 Life as War (Erik Hooijmeijer 2008)



3.3. CONCLUSIONS OF THE ANALYSIS

The *GoL* arises at both computer and non-computer levels, and according to Berry (2008), it is this "translational quality of digital representation and storage (…) that highlights the strong remedial qualities of digital representation". As Berry states, when translated from the computational framework to the human, a *RSM* piece becomes "performative rather than compositional", because it presents gaps in terms of: (1) *composition*, in the way Miwa adapts the logic of the XOR operator to the purposes of his composition (2) *reversal of the simulation*, as it requires an external agency for the synchronization of the process, (3) *transparency of the process*, considering how certain operations are hidden (like the system's initial state), (4) and *mediation of code*, made by the participants through a non-exact translation of the delegated code into prescriptive code (Berry 2008). In this sense, and according to Berry, the piece "becomes a representation of some idealized form of computer code", demonstrating how it is "not based on a passive cloning of conventional circuitry, but rather as a creative re-interpretation".

In a simulation process the formalization of real-world phenomena is made according to standardized "digital data structures" (Berry 2008). By attempting to reverse these specific procedures into more abstract processes there are 'open gaps' that can be filled by human interpretation. Conditioned by the system's internal rules, this subjective interpretation leads to the emergence of behaviors that generate novelty and unpredictability at each execution.

3.4. PRINCIPLES GUIDING THE PROJECT

In line with this view, we developed an experiment that seeks to highlight the notion of reinterpretation, which we called *Simulate-Reverse Play*. It considers a type of play that emerges from the simulation and reversal of a specific set of procedures. These procedures define the system's behavior considering both computer and human, while implying an openness (of the work) to chance, that is, its performance is complemented by the audience's active participation.

To this end, we propose an adaptation of the *GoL*'s algorithm through the construction of two co-dependent layers – a virtual computational layer and a real non-computational layer – that communicate with each other on the basis of this algorithm. Given that the project aimed at contemplating the nuances of human performance in the enactment of the work, through the implementation of implicit rules, we sought to recall certain emerging pleasures of play, as defined by Edmonds and Costello (2007:79-80). In particular, we considered the pleasures of *creation*, *exploration*, *discovery*, *simulation* and *camaraderie*, to which we add the pleasure of *immersion*. In order to achieve this, we drew strategies from a set of examples of self-regulating systems, such as *Lumibots* (Kronemann 2009-2011), *Remote X* (Kaegi 2013), *Pong Experiment* (Carpenter 1991) and *UP: The Umbrella Project* (MIT CSAIL and Pilobus 2013).

We established that the virtual entities should be visually simple, revealing how complexity can emerge from simple rules, while evoking organic behaviors in an allusion to the *GoL* and other simulators and how their entities are conditioned by different states of behavior.

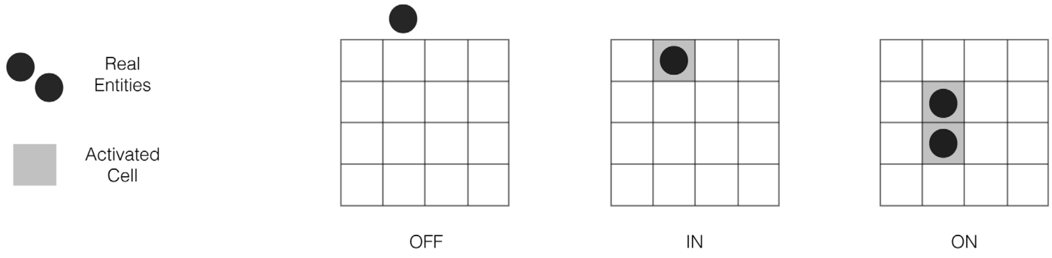


Fig. 9 States of the real entities

The project assumes a grid similar to the *GoL*'s and identifies its real entities as *off* (when outside the interactive area), *in* (when inside), and *on* (when within the group).

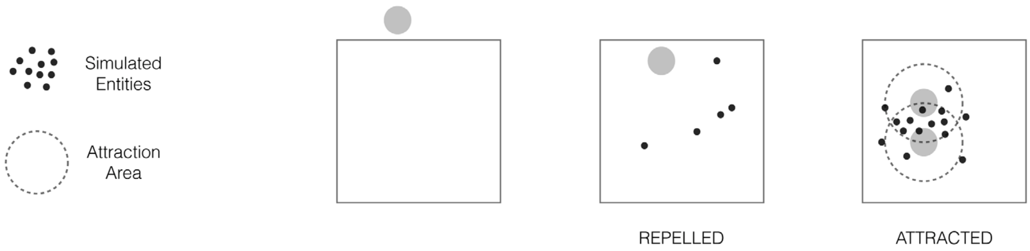


Fig. 10 States of the Simulated entities

In turn, the simulated entities obey to simple rules that correspond to states of remoteness and proximity.

One of the goals was to promote a collective experience, as a form of playful interaction that could contribute to the participants' engagement with the system. Therefore, its operational rules (and formal aspects such as the grid) should be implicit and deduced through interaction, inciting the discovery and creative exploration of the system. In this sense, this procedural reversal differs from Miwa's since we, deliberately, do not provide instructions to the participants but let them figure them out on their own; let them deduce the operational logic of the system.

4. SRP (SIMULATE-REVERSE PLAY)

4.1. META-CODE

The project was developed by adjusting the *GoL*'s original rules into what we've metaphorically called *meta-code*;[4] the algorithm was initially implemented on a *mouse mode* (computational version) and subsequently adapted to a *camera mode* (installation version).

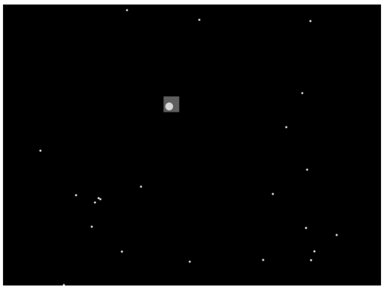
4 The *Meta-code* was adapted using the framework by Dorin et al. (2012) and can be described according to a set of simple rules:
1. If an *off* entity enters the interaction area it turns *in* (is born);
2. If an *in* entity has 0 neighbors it remains *in* (is isolated/ survives);
3. If an *in* entity adds 1 to 3 neighbors *in* or *on* it turns *on* (grows/ reproduces);
4. If an *on* entity has more than 3 neighbors *in* or *on* it turns *in* (explodes);
5. If an *in* or *on* entity leaves the interaction area it turns *off* (dies).

4.2. IMPLEMENTATION AND TESTING

4.2.1. MOUSE AND CAMERA MODE

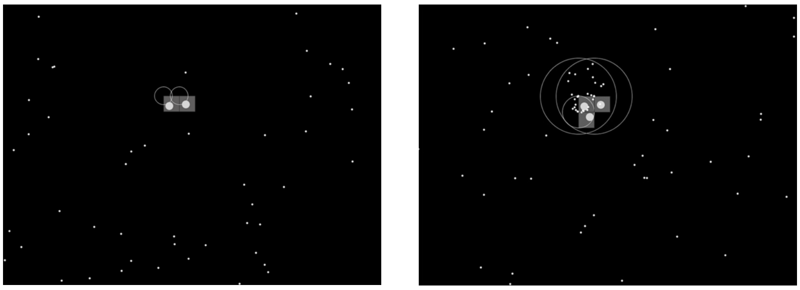
The first version allowed us to define and optimize the intended events, namely:

Fig. 11 *Birth*



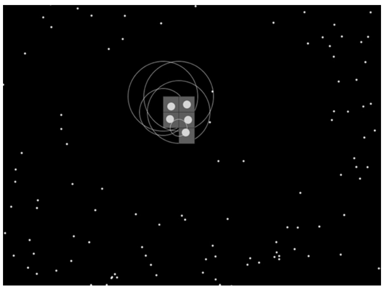
Birth, relative to the generation of particles triggered by the entry of a real entity into the interactive area;

Fig. 12 *Growth/ reproduction*



Growth or *reproduction*, resulting from the agglomeration of those entities; these activate areas of attraction of particles whose strength increases as real entities are being added;

Fig. 13 *Explosion*



Explosion, when the limit of neighbors of each entity is exceeded; *Isolation*, in case an entity gets back to its initial state of *birth* and looses attraction power; and *death*, when the entity leaves the interaction area and its originally generated particles are eliminated, leaving the screen empty.


Fig. 14 Images from the implementation of the *camera mode.*

The implementation of the *camera mode*[5] then entails the human mediation of the adapted algorithm. On this mode the real entities are represented by human participants whose image is captured by a video camera.

4.2.2. INTERACTIVE EXPERIENCE

The prototype was tested with a 'semi-expert' audience, meaning, an audience able to relate to or interpret this kind of work, however having no previous familiarization or contact with this specific system. This strategy, according to Costello and Edmonds, adds value to the development of the artwork during the prototype stage evaluation (2007:82). The experience was analyzed through video recall, along with a written questionnaire delivered to the participants. The method of analysis was based on the aspects identified by Edmonds (2010:257) considering artists concerns in the creation of interactive art, namely: "how the artwork behaves; how the audience interacts with it" and with each other (bearing in mind the pleasures of play proposed); the "participants' experience and their degree of engagement" with the work.

This analysis considers attributes of interactive artworks that incite different modes of engagement, such as *attractors*, *sustainers* and *relators*[6] (Edmonds 2010:262). Similarly, it adresses the different phases and modes of engagement experience by the audience over time, as addressed by Costello *et al.* (2005) and Bilda *et al.* (2008). Accordingly, it adresses transitions in engagement that can range from an "investigative exploration" about what the system does to a "diversive exploration" about what one can do with it (Costello 2009:40). These modes are interchangeable, depending on how the system meets or

5 *https://vimeo.com/91980308*

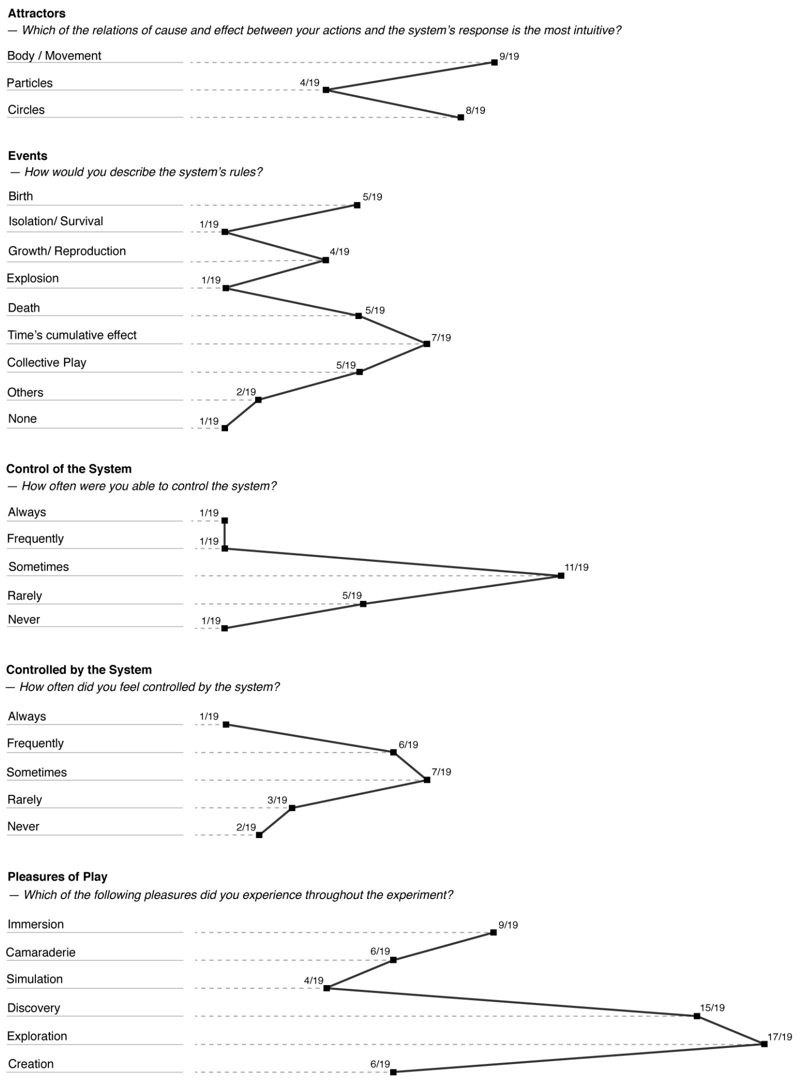
6 The *attractors* are the system's attributes that "encourage the public to pay attention and so become engaged" with it. Then, its up to the *sustainers* to hold that engagement "for a noticeable period of time". Finally, the *relators* are the attributes that extend that engagement "over long periods of time, where one goes back for repeated experiences" (Edmonds 2010).

subverts the expectations created by its users. This idea meets what Kwastek (2009) describes as the "oscillation between playful immersion and moments of distanced reflection" that characterizes the aesthetic experience of interactive artworks.

This analysis allowed us to assess whether the system encourages exploration and promotes engagement; if the users are able to deduce implicit rules and identify cause-effect relations; if the participants could control or were controlled by the system and if they experienced the proposed pleasures of play. We also recognized the different phases and modes of engagement or eventual "disengagement" (Costello, *et al*. 2005:55), as well as the emergence of collective and self-organized behavior.

4.3. RESULTS

Fig. 15 Questionnaire results



Three elements were identified, as attractors to the system, in particular: the circles and the representation of the body's spatial movement. The latter was the most mentioned, possibly for being the element that connects the real entity with its virtual representation. Concerning implicit rules, the audience was able to recognize various cause-effect relations, highlighting the events of *birth*, *reproduction* and *death* as the most obvious. Similarly, they were able to deduce that the system responded to some form of interaction between the participants. The most frequently mentioned aspect was the "time" associated to these events, as the system's rules became more evident when the triggered events multiplied. This leads us to conclude that the responses resulted from an exploration of the possibilities of the system, and not necessarily from being in a controlled state.

The participants demonstrated a willingness to create something, although, when asked how often they felt in control of the system, the most frequent response was *sometimes* followed by *rarely*. However, when asked how often they felt controlled by it, the most common answers were *sometimes* and *often*.

Finally, the most recurrent pleasures experienced were *discovery* and *exploration* resulting from the recognition of implicit rules. In turn, *camaraderie* led to a more rapid and accurate *discovery*, as well as an emergence of playful behavior.

According to these observations, *Simulate-Reverse Play* therefore proposes something other than mere playful interaction with a system. Through the co-dependency of its real and virtual layers, the system both depends on its users to perform (according to a set of rules) but also conditions the users' behavior or performance (with its rules).

5. CONCLUSION

This project reflects on the double execution of instruction code by machine and human, by proposing an interactive system that explores procedural simulation and its reversal and by promoting collective play as a form of free and creative exploration. To meet this purpose we devised two layers that combine both real and virtual dimensions of the same instruction code, based on the *GoL*'s algorithm, as an object of constant reinterpretation.

On one hand, this approach sought to establish analogies between human and artificial systems, and on the other hand, to distinguish the qualities inherent to human and machine performance. In this manner, it highlights the intangible qualities of human performance (i.e. imagination and emotional engagement) by exploring how they can add something to the enactment of the work. This project therefore emphasizes the contemporary interest in process-based practices, addressing how technological virtuality can be articulated with corporeal performativity.

Through its reinterpretation of the *GoL*, and in its attempt to reverse its procedures, this project acknowledges, and takes creative advantage, of the open gaps left in this translation process by emphasizing its openness to interpretation. It explores how human behavior is incorporated in artificial systems, which in turn can condition and influence human behavior, as an essential dimension of the aesthetic experience of the work.

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UBIQUITOUS TYPOGRAPHY

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Keywords: Typography, Graphic Design, Code, Programming

This paper considers the impact that software is having upon typographic principles and practice, and how the conventions of typographic communication are being transformed. Inspired by the possibilities of programming many typographers have begun to work more closely with code to generate designs, facilitate production, or organise layouts. However, the very functionality of code often serves to veil its aesthetic attributes.

An integrating philosophy… does not let itself be seduced by the attraction of the 'great problems', but instead initially finds its themes in the trivial, in everyday life, in the so-called unimportant, in those things that otherwise are not worth speaking about, in petty details. Whoever wants to can, in such a perspective, already recognise the kynical impulse for which the 'low-brow themes' are not too low.
Peter Sloterdijk

1. INTRODUCTION

Gerrit Noordzij, Professor of typeface design at the Royal Academy of Fine Arts in The Hague, Netherlands, defines typography as 'writing with prefabricated letters' (Biľak 2007). This statement neatly encapsulates the attributes that make typography distinct from other visual language systems – such as handwriting, calligraphy or graffiti. The letterforms of non-typographic writing emerge from a process, and as a result makes every letter unique. Typography systematises that process by creating a reserve of glyphs that can then be called upon when required. Each glyph therefore needs to be designed before one can arrange the typography.[1] Such details would likely be of interest to a only a few, until we note how widespread the use of typographic interfaces has become. For the linear flow common to many writing tools has been replaced with the discrete keys of keyboards. Typography transforms the continuum of inscription into an ambidextrous composition of parts.

It is strange then that such a widespread and widely used system escapes the gaze of critics outside of the discipline.[2] To some extent this is understandable. The works that typography supports – and books in particular – are designed to be read. Readable typography *functions* well when its visual qualities recede, enabling one to concentrate on the text. In such a context, poorly designed typography is understood to that which calls attention to itself and so interrupts our attention.[3] Even modernist typographers have prioritised types functionality, arguing that '*how it looks*' should be subordinate to '*what it must do*' (Warde 1930). As such book typography (that which is designed for extended reading) and information design (that which is designed for navigation) tend to define how all typography is understood and categorised. As

1 The term typeface refers to the design while each particular material-technical manifestation is called a font. One could think of the distinction between typeface and font as the difference between a song and an MP3 file, respectively.

2 Marshall McCluhan's *Gutenberg Galaxy* and Régis Debray's *Socialism: A Life-Cycle* are notable exceptions.

3 What Martin Heidegger refers to as *un-readiness-to-hand*.

such, readability and legibility largely define how a typeface and its setting are assessed.

However, while such ideals are not without merit, they fail to consider a number of important factors, such as: the reader and/or writer; the content; the materials, tools, techniques and knowledges available; as well as the historical, social, and economic context in which it will be read. Many of these factors are absent in typographic evaluations. For example, the terms readability and legibility highlight a concern for a (single) reader, but within typography there is no equivalent measure for the writer. Historically, typography was the point in a system of publication that transformed the written or typed manuscript into a printed page. As such, the writer rarely worked with typography and so has elicited little attention from type designers. The rise of programming and read/write interfaces has transformed that mode of production considerably.

Similarly, the reader is assumed to be of a particular kind, to have certain capacities and abilities. For in order to function typography has to work with certain constraints (material, ergonomic, economic etc.). In that sense typography is a compromised system that works for many but not for all. As such typography participates in defining and constructing outsiders. For example, the manner in which type is commonly set will be a challenge for those with impaired vision and so may need to wear glasses. The point being that, any disadvantage is located with the individuals body and not with the manner in which the communication is made available. Indeed, one could suggest that once users are able to change communicative settings to fit their needs and preferences certain social disadvantages are nullified. Space does not permit me to extend this argument further, but hopefully one can see that typefaces and typographic settings are both informed by and have an impact upon the social sphere.

This paper, then, foregrounds the impact that computational technology has had on how typographic texts are received, understood, and communicated. From the fixed-width typefaces favoured by programmers, to the default settings of applications, all suggest that a functionalist aesthetic is becoming increasingly prevalent.

One clear example of such a trend is the electronic displays commonly found at train stations and terminals.

While the typefaces used on these systems vary according to the manufacturer, the differences between them are often minimal and often the result of technological specificities. Typically they are constructed from a modular design with little variation in character shape or letter spacing, as shown in figure 1.1.

Fig. 1.1 A typical dot matrix design

Such an approach often produces strange glyphs. In figure 1.1 for example the descender of the lowercase 'g' has been pushed up to sit on the baseline. The difference between the uppercase A and R is minimal which may lead to confusion. The figures too could be confused with uppercase designs as they share the same width. Most problematic is the spacing which is tight and erratic. For example the lack of internal space with the letters 'ili' means they visually bunch together.

Fig. 1.2 A typographically informed dot matrix design

I have produced an alternative design, (fig 1.2) one that works with the same conditions but is typographically informed. The resultant forms are not only more distinctive but enable the spacing to be more consistent.

In figure 1.3 I degraded these two designs through blurring. While the common design (top) begins to congeal into one mass the typographically informed design remains distinct enough to be legible.

Fig. 1.3 The typographically informed design (bottom) remains legible

Moreover, as the fonts are digital there is the possibility for introducing variability into the system. That is, the typography could adapt to various contexts, conditions, or user requirements.

2. COMPUTATIONAL MATERIAL

Over the past thirty years there has been an increasing development in the field of typography due to the widespread adoption of digital technologies. Such technologies have enabled typographers to question some of the material and temporal conditions that have defined types production, function and appearance. For example, if a different size of a particular typeface was needed it required producing a completely new font. Digital type is not beholden to that same materiality. A digital typeface can easily be scaled to the required size.[4]

The new tools have transformed how type can be produced and so has facilitated the production of new glyph shapes, type styles, formats, as well as production processes. With these new tools designers have begun to explore the possibilities of typography at the macro level of layout as well as the micro level of type design. Indeed, since the introduction of easy to use software the number of typefaces available today has exploded exponentially. The majority of these designs follow the structuring that moveable type required despite the new contexts in which they operate and the affordances such environs enable.

However, replicating historical models presented challenges that required new software to be developed, a deeper understanding of the hardware, as well as a transformation of the models of production and distribution. For example, Beowolf was a groundbreaking typeface created in 1989 by Just van Rossum and Erik van Blokland of LettError. The design used a program that randomly transformed the position of numerous vector points that made up the outline of each glyph. The program ran each time a character was keyed, adjusting the corresponding characters outline. This not only softened the edges of the typeface but also made each glyph unique.

In hot-metal typography it is the font that is fixed while the process of printing produces minute but discernible variability. Digital type appears to shift this relationship, as a computational font is a series of co-ordinates and conditions that define the types appearance in relation to the place it will be seen. That is, printed type is effected by the process of visualisation (pressure, ink and paper etc.) But like platonic forms, digital typography has seemingly escaped the challenges of materiality. In part this is the result of how computing is understood as an

Fig. 2 FF BeoSans & Beowolf designed by Erik van Blokland and Just van Rossum.

4 Scaling type, however, necessitates a reconsideration of the spatial settings and, when available, selecting an optically appropriate size of font.

abstract process. The difference between the same file on a different system or the same file on different screens remains difficult to recognise. We have been told that the digital file can be copied exactly and so fail to discern the impact from a variety of factors, including: the operating system, applications, interfaces, screens, printers, etc. But computational media and the various configurations of software they run are unique material constructs. As such the differences between devices or even a single device remain largely unnoticed.

The typeface Beowolf takes its reference from the irregular patterns of the print process but makes the algorithm that defines the font the site where difference occurs. The font is now the variable while the process and substrate are assumed to be fixed. As such Just van Rossum and Erik van Blokland produced a radical new way of approaching type design. Inspired by such work and the possibilities of code in general many typographers have begun to work more closely with programming languages themselves.

Indeed, typefaces, such as Underware's Liza Pro (2009), have been developed that explore type beyond the level of letter and introduce design at the level of word, employing algorithms to select glyphs according to a carefully worked out character sequence. Such an approach means the design can replicate some of the conditional variants of hand-lettering, something of a challenge for many script typefaces.

Fig. 3 Liza Pro designed by Bas Jacobs, Akiem Helmling and Sami Kortemäki

Paraphrasing the artist Eric Gill,[5] type designer Erik van Blokland has neatly captured this shift in mediums: 'Letters are programs, not results of programs' (Fraterdeus 1997, 130). Indeed, beyond the specialism of type design

5 'Letters are things, not pictures of things' Eric Gill, Autobiography

this is indicative of a wider trend, in which the *sofwarisation* of typography is transforming our visual language more generally.

```
<!DOCTYPE html>
<html id="home-layout">
  <head>
    <meta http-equiv="content-type" conte
    <title>Source Code Pro</title>
      <!-- made with <3 and AFDKO -->
    <meta name="keywords" content="sans,
      monospace, open source, coding, for
    <link rel="stylesheet" type="text/css
  </head>
  <body>
    <div id="main">
```

Fig. 4 Adobes Source Code Pro

3. NEW CONDITIONS, NEW SYSTEMS

All these developments then are linked to the discrete processing capabilities of computational devices, which rely on logical operations, binary processing that are accessed through the symbolic representation known as source code. As philosopher of media and technology, David M. Berry writes, ‘code has a dual existence, as delegated code residing in a human-readable frozen state that computer programmers refer to as ‘source code’ and as prescriptive code that performs operations and processes’ (Berry 2008).

The unusual typographic appearance of code is necessary in order for it to function as prescriptive code. The various alphanumeric symbols are arranged according to the requirements of programming languages such as compilers, interpreters, and scripting languages.

```
▾ <head>
    <meta charset="utf-8">
    <title>xCoAx 2014 - A Conference on Computation, Communication, Aesthetics and X</title
    <!--[if lt IE 9]> <script src="http://html5shim.googlecode.com/svn/trunk/html5.js"></s
    <!--[if gte IE 7]><!-->
    <script type="text/javascript" async src="http://www.google-analytics.com/ga.js"></scr
    <script type="text/javascript" src="//use.typekit.net/jea3aqn.js"></script>
    <style type="text/css">.tk-freight-sans-pro{font-family:"freight-sans-pro",sans-serif;
    <link rel="stylesheet" href="http://use.typekit.net/c/868f51/freight-sans-pro:i4:i6:n4
    3bb2a6e53c9684ffdc9a9bf4195b2a62ac2abccc2253da0ff4783e8b08b75860d42a4b5ea156cecf39b318
    15efde7e82bb4a328aae98daeadfa97986a34b53448308d1370e33425b2becda2ea93ec6361406e476b6f0
    <script type="text/javascript">try{Typekit.load();}catch(e){}</script>
    <link rel="stylesheet" type="text/css" href="styles.css">
    <!--<![endif]-->
    <!--[if lt IE 9]> <link rel="stylesheet" media="all" href="ie.css"/> <![endif]-->
    <!--[if IE 6]> <link rel="stylesheet" media="all" href="ie.css"/> <![endif]-->
```

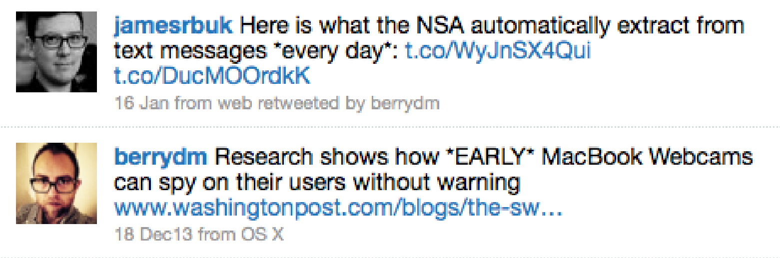
Fig. 5 xCoAx website source code

Working with ‘source code’, used to be the exclusive domain of computer scientists and programmers and was therefore rarely encountered by others outside those interests. The emergence, exploration, and almost total adoption of computational processes has meant that many more people have access to the visual language of computational media. Cultural products have also popularised certain notions of what code is.

Aspects that typographers have long considered important for making a text readable, such as: typeface; styles; glyph range; line length; tracking; kerning; case setting; hyphenation; and leading are now determined by the technical capacities of the platform as well as the discursive practices of programmers.

Such decisions effect how, and subsequently, what people can communicate. For example, an italic style of typeface can be used to add emphasis but is currently unavailable on any of the popular social media platforms. As a result users have developed new methods to convey meaning, such as using an asterisk on either side of a word or section of a sentence (see fig 6). However, while this method makes it clear that there is an emphasis, the particular inflection is hard to determine.

Fig. 6 Twitter users using asterisks and uppercase setting to emphasise text



Where the italic in Fig 7.1 suggests a reminder or request, the bold suggests an order that needs to be heeded. So while the asterisked variant makes it clear that there is an emphasis, the particularities of that inflection are hard to determine. Further complications arise with the use of asterisks due to their resemblance to speech marks, as in figure 7.2.

All communicative systems require certain limitations in order to work. Indeed, certain typographic systems have had to negotiate with considerations similar to the ones outline above. For example, historically Blackletter typefaces did not come with either bold or italic styles, and so emphasis was conveyed through wide letterspacing.

Fig. 7.1 Typographic emphasise using italic and bold

Do not be late
Do not be late

Fig. 7.2 Asterisks are visually similar to speech marks.

Do not be late
“Do not” be late

However, generally speaking, typographers will work to minimise any visual disturbances, particularly when setting a text intended for extended reading. The concern of a typographer in that instance is to convey the meaning of the text in a manner that does not call attention to itself. If the typography is poorly arranged it can call attention to itself and so disrupts the reader and their attention. In that sense it is not dissimilar to the goals of the interface developers – to make it so intuitive, that it erases itself for the user. As Bolter and Grusin write, “In this sense, a transparent interface would be one that erases itself, so that the user is no longer aware of confronting a medium, but instead stands in an immediate relationship to the contents of that medium” (Bolter and Grusin, 2000: 24). Well considered settings enable one to concentrate on what is being communicated and not on how it is being communicated. So, while an unmediated experience is an impossible goal, it guides the work of typographers.

The introduction and widespread adoption of computational devices then has clearly had a great impact on how typography is designed and produced. Historically designers worked directly with materials (metal, wood, paper, inks etc.) to create a font. Today, the material of designers – the digital hardware – is mediated through layers of software. Typefaces are sculpted in programs, and written in scripts. As such they require a textual input to enact certain actions–whether simply naming a file or writing a complex piece of code. As such, typography has itself become a tool in the production of typography. However, the functionality of interface typography and the historical and discursive practices that inform it mean there has been little reflection into its aesthetics.

One notable exception is *Pragmata Pro* by Fabrizio Schiavi (see fig 8). Fabrizio Schiavi understands the concerns of coders but manages to bring a nuanced and detailed understanding of typography to this design. For example, the face has no interline spacing making it more compact; characters shapes are designed to be distinct, making it easy to determine ‘O’ from ‘0’ and the capital ‘I’ the lowercase ‘l’ and the number ‘1’; and has been extensively hinted – a technique that achieves a smooth screen appearance at a variety of sizes across a range of operating systems. As such it represents a good example of how an understanding of technology, contex-

Fig. 8 Pragmata Pro by Fabrizio Schiavi

tual requirements and typographic understanding can be combined to produce a design that does not just function but does so more effectively while enhancing the experience of the user.

4. THE NEW TYPOGRAPHY

Softwarised typography is type that emerges from the discourse of programmers and the cultures that subsequently engage with it. For example, Twitters use of the @ sign to define users and the octothorp (#) to create hashtags that connect common posts can be found in political protests and fashion clothing. The aesthetic of digital communication is commonplace. It is worth noting then that typography in the computational era has become less concerned with certain passive aspects of reading and increasingly organised around certain social or active pursuits. Like the photocopier and other cheap print techniques before it, typography has been passed into the hands of the public. As such the functionalist typography has become an exciting aesthetic in its own right, employed in important and significant manner, whether that be to mark and transmit a political concern or to convey your mood to the world wide web.

Fig. 9 Functionalist typography of Twitter as cultural aesthetic. *Limmy Show* television program written and directed by Brian Limond for BBC Television, UK January 2010.

These graphematic symbols and organisational structuring associated with computational communication do not just perform certain technological functions then. Nor are they simply a visual shorthand for computation. Instead they have been co-opted and disseminated to become social and cultural signifiers in their own right.

5. CONCLUSION

Alphanumeric symbols are arranged according to the requirements of programming languages–such as compilers, interpreters, scripting languages–as well as the conventions of programmers. Thus many aspects that typographers have long considered important are being redefined by programmers and the technical specificity of hardware and software. This will become increasingly significant as more people learn to program and engage with computational media. As type designer Zuzana Ličko stated, 'we read best what we read most' (1990). Functionalist typography will continue to evolve and may become the dominant manner for engaging with text. As such computational media and the visual interfaces required to work with it introduce a whole raft of new typographic approaches and possibilities that have yet to be properly investigated or understood. This paper is a small step in that direction, one that I will be expanding upon and developing. As such, thoughts and insights into how to progress will be gratefully received.

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WINDCHIME: DATABASE DRIVEN MAPPING OF COMPLEX DYNAMICAL SYSTEMS

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Keywords: Audio-Visual Installation, Database Aesthetics, Complex Dynamical Systems

This paper documents *WindChime*, a database oriented, web-driven audio-visual installation. In essence, two complex dynamical systems are interfaced, driven by the principle of 'influence' rather than 'control'. Live weather activity in the world, intensity and direction of wind energy, is interfaced with a distributed particle system. Particles interact and, in turn, condition the behaviour of a self-running non-linear audio synth. We address the challenges of mapping and sonification including the aesthetic issues involved. It is suggested that the intricate interplay of the two systems may provide for a rewarding aesthetic experience.

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1. INTRODUCTION

Project *WindChime* is a large-scale, real-time, web-driven audio-visual installation, it suggests a digital interpretation/implementation of a classic wind chime; the arrangement of objects suspended from a frame creating tinkling sounds in a light breeze.

WindChime challenges the notion of dimensionality; it targets to interface the rhythms of the environment – the world as global found system – with a cultural system of explicit design. Invisible implicit activity in the world is tracked, analysed and converted as to exercise impact on a simple audio patch. The patch is basic, though because of non-linear feedback, it offers a wide palette of responsive options. *WindChime* tracks data from thousand of locations distributed around the globe providing real-time local weather data, information on the intensity and direction of wind is extracted and visualised in an animated world map. Essentially, *WindChime* suggests interfacing two complex dynamical systems; the earth as a found physical system and a sound-producing algorithm as a designed implicit system. Interaction between the many components comprising the global system constitutes a platform for the accommodation of surprising emergent audio-visual complexity. The project explores how the interface of (1) quantitative changes in patterns in wind energy and (2) qualitative changes in musical sound may support a rewarding aesthetic experience.

WindChime was initially documented in an introductory paper for ICAD2012 (Beyls 2012). The present paper specifically addresses the aesthetic orientation taken and provides further implementation details.

2. CONTEXT AND AESTHETIC ORIENTATION

The expression of deep awareness of the ecological impact of sound on a global scale is documented in *The World Soundscape Project*, a pioneering interdisciplinary research project initiated by R Murray Schaeffer in the early 1970's (Schafer 1970). Creating audio mappings of natural spaces as well as viewing them as inspiring spaces for original musical composition developed the notion of acoustic ecology. A unique approach as it merges the analysis of natural phenomena and the synthesis of cultural ones in a single project. A similar mission is at the heart of the Ear To The Earth project in its expression of concern with the environment, more specifically the effect of climate change. Ear to the Earth aims to convey this concern through the production of environmental works of art and by setting up a social network hoping to raise political understanding (Ear the Earth website, 2013).

New media installation art poses new challenges for long-term preservation, the technology changes, operating systems evolve while live data in global networks available today might be gone tomorrow. This raises difficult questions for the survival of real-time data driven audio-visual installations. However, let us approach the problem as a source of creative design; new versions of the same idea usually offer renewed insight in the context of a given aesthetic implementation. Conservation problems are not confined to digital media; consider the preservation problems with Robert Smithson' s landmark project *Spiral Jetty*. The massive land art sculpture deteriorates facing the impact of nature, though ironically, Smithson acknowledged the exposure of natural forces right from the start.

A few relevant instances follow within the realm of media art. One example is the *Eternal Sunset* project (Stellingwerf 2013), it streams live images from over 100 west-facing cameras across 27 countries for tracking sunset – so, the sunset may be experienced irrespective of earthly location. Experience of time and space is perceived as dislocated.

Wind Map (HINT.FM 2013) is a real-time dynamic visualisation project of live wind patterns over the USA; data is gathered in hourly intervals from the national Digital Forecast Database. The beauty of such visualisations follows from the appreciation of complexity in terms of (1) the relative coherence of local wind patterns and (2) the exposure of forceful tension between various islands of distributed wind energy. Complexity is an emergent phenomenon driven by natural forces.

Sunlight Symphony by Alexis Kirke connects architecture with nature and sound. A large building is equipped with four light sensors; light intensity is tracked at sunrise and the data is relayed to sound generating patch. Interestingly, this work explores the slow sub-audio cycles of moving from sunrise to sunset, consequently it can be thought of as a sonification of a rotating earth.

A significant early example of viewing the earth as a source of dynamic information is *The Earth's Magnetic*

Field. Charles Dodge created a computer music composition based on a chart of the *Kp*-indices (a measure of the average strength of the earth's magnetic field) of the year 1961. Mapping consisted of linking musical pitch to the data thus squeezing almost 3000 data samples for the year into eight minutes of musical time (Dodge, 1970).

The Pulse of the Earth is a major piece sound art initiated in 1996 by Lorella Abenavoli, the artist aimed to extract and expose the sculptural qualities of the earth's movements as a form of vibrating matter through the medium of sound. Real-time tracking of seismic activity of the earth is translated into distinct information. Imperceptible vibrations are made audible through a process of sonification; ultra low frequency waves are captured and compressed into the audible spectrum however conserving the overall proportions of the waves (Abenavoli, 2011).

WindChime, the system introduced here, exists as a live database driven work of art – thus, by definition – expressing interest in multiplicity of data, availability of massive amounts of data and a qualitative concern regarding complexity of data in a given specific niche. The publication Making Art of Databases (Brouwer & Mulder, 2003) critically addresses the active use of databases in interactive, dynamic works of art. It is stressed that the production of new knowledge only happens when data stored in memory is approached as something dynamic, when information is logically interrelated and recombined.

Database Aesthetics: Art in the Age of Information Overflow (Vesna, 2007) offers a compelling anthology of scholarly essays documenting both the theoretical foundations of database orientation and the hands-on implementation of artistic database productions. The concept of a database embodies many attractive connotations: memory, organisation, structure, change, information, agency… and in a cultural dimension: metaphor.

Artists do not create in isolation; they connect in a continuously evolving conceptual framework – a local cultural context – culminating into a globally extending networked context. Therefore, we might think of databases as extending in the realm of social (co)existence – even viewing art production as a process of shared initiative. An early example is David Blair's WAXWEB, the first online feature film initiated in 1993 (Blair 2013). In recent years, the Rhizome association organised various panels on Net Aesthetics and, most recently, on Post-Net Aesthetics (Connor, 2013). From here on, we reflect on art as the identification and articulation of data-intensive systems.

Let us consider the aesthetic orientation of viewing art and/or art production as a *found system*. The universe is full of 'systems' large and small, systems that are alive and express rhythms in many dimensions: social systems, biological systems, cellular systems, intergalactic systems and systems of the unconscious… systems exist at social, molecular and evolutionary scales, so it seems natural to think of 'systems' as compound articulate micro-universes (perhaps, parallel universes) to be explored with aesthetic objectives. How might their inherent complexity be articulated as a message of creative imagination?

Human observers engage with systems in either intuitive or explicit ways. While witnessing the logic of a given system, a process of anticipation takes place; the system's actual behaviour is compared to certain private patterns of expectation – generally, signified by a personal belief system – the act of responding to the distance of experience and anticipation is considered a source of aesthetic arousal. In other words, the process of adaptation i.e. bridging the conceptual gap between what we expect to happen and what actually occurs, could be the key to aesthetic appreciation. Perception becomes grounded in a dynamic adaptive process. Beyond any specific medium and more generically, we might claim that 'art is a qualitative oscillator'.

3. STRUCTURAL OUTLINE

Figure 1 shows a general overview of the main components in the implementation. A JAVA program communicates in XML with a remote data server located at the National Center for Atmospheric Research (UCAR, 2013), in addition, it guarantees real-time display of a complex visualisation showing data analysis and a particle system, to be documented in a moment. The program equally sends information to a sound engine running in SuperCollider, the data is sent via OSC (Open Sound Control) (Schmeder, Freed and Wessel, 2010).

The JAVA program contains classes for data collection, data analysis and visualisation. The main classes are: Stations, Field, Particle and World, all are documented next.

Stations. This class holds a uniform data structure containing information on 7961 weather stations distributed around the world. An 80-character entry contains 18 data items including, name of the location, a unique four-letter ID, latitude and longitude, elevation and aviation specific information and country code. For example, the first entry refers to a station in Alaska:

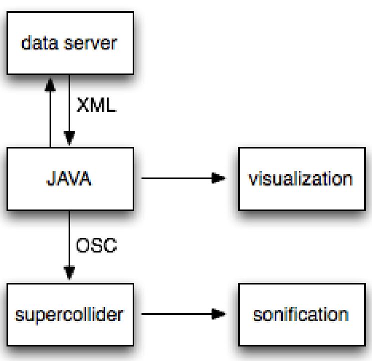
CD STATION ICAO IATA SYNOP LAT LONG ELEV M N V U A C

AK ADAK NAS PADK ADK 70454 51 53N 176 39W 4 X T 7 US

The program instantiates a *Station* object by random selection of a single station from the database. The location data (longitude and latitude) are remapped to Cartesian coordinates to serve visualisation of that location on a large scale projected, animated map of the world. The Station object send a message to the UCAR data server, requesting real-time information for that specific location, when available (not all stations are operational 24/7), the system takes note of the intensity and the direction of the wind at that specific moment in time. The system optimises itself in the sense that, when a data request remains unsuccessful, another station will be selected in the next program cycle. The duration of one cycle is 240 seconds because the system collects, parses and displays data of 24 different stations, the refresh rate being 10 seconds. In the long run, the system will have collected effective 24 stations by random selection using a gradual optimisation policy. Then, the system will further optimise by effectively searching for wind energy thus replacing less effective stations with new more effective ones. Since the weather – looking at it as a complex dynamical system – is in continuous transformation, the optimisation process will never come to an end. Let's consider this a bonus!

In addition, a single effective station will remain active for a certain time interval relative to the amount of change in information it provides (evidence of the dynamics of wind is considered rather than static information) – the data is normalised into time frames lasting between 30 seconds and 5 minutes. The principle of the *appreciation of change* is significant here, our computational structures are driven by fluctuations in data – so is the Field class, discussed next.

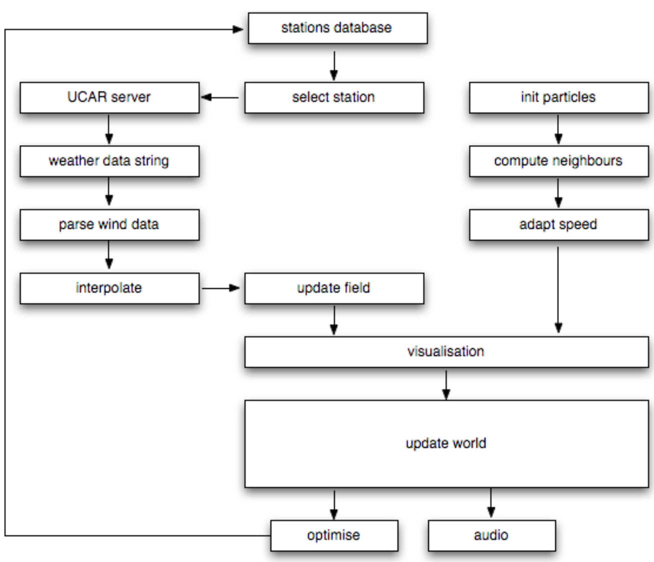
Fig. 1 Structural components of *Wind-Chime*



Field. The Field class is a computational memory construct designed to capture wind energy in an imaginary two-dimensional matrix spanning the whole world. In fact it allows for inference of *changes* in energy because the matrix holds 2 layers: current-data and previous-data, updated in two consecutive time frames. Now, the 2D matrix is projected onto a 2D map is the world. The matrix can be thought of as a low-resolution representation of energy in the world itself, in the current implementation, the matrix is 32 columns by 20 rows. (Considering a distance from Anchorage, Alaska to the South Pole of 16788 km, a single matrix cell corresponds to approximately 839 km.)

After a Station collects data, it will update the matrix at a specific location i.e. where the (normalised) image of the matrix and the station's location coincide. Next, the impact of a single station is computed by interpolating energy for all matrix cells; the effect being inverse proportional to the distance from the original station. Following many process cycles, the matrix will embody a gradually acquired 2D data profile representing contributions of the 24 previously sampled stations. Because of the optimisation process, as explained above, the matrix behaves as a dynamic structure. Initially, large major changes occur since the system starts from scratch. In the long run, more subtle changes appear where newly acquired data assimilates with information yielded in an earlier stage.

Fig. 2 Data flow in *WindChime*



Particle. Multiple particles are a representation of virtual dust, their behaviour being conditioned by actual physical wind – all confined within the inclusive systemic approach of *WindChime*. Particles are imagined to be afloat in 2D space, particle properties (velocity, direction and energy) are influenced by the data accumulated in the Field object; a particle at a particular location in space accelerates/decelerates in proportion to the strength of the wind as reflected in the value at the corresponding matrix cell. In addition, particles interact locally; particles within a critical distance threshold will coalesce into a complex temporary cluster receiving dynamic visualisation. Particles within clusters interact in two ways, (1) a particle will adapt its angle of movement to the angle of one of its (randomly selected) neighbours and (2) a particle's energy level will boost in proportion to its number of neighbours. An isolated particle (no neighbours) will slightly decrement its energy level in every process cycle, energy levels are considered in the audio mapping algorithm documented in section 5. Important, every particle belongs to a specific class, reflected in an instance variable called 'type', valued 0 to 3, type too conditions the mapping scheme (figure 4).

World. A single World object incorporates all components introduced above: a single Field object, a continuously optimised collection of 24 stations and a critical mass of 100 particles. The World object coordinates dynamic visualisation and includes an algorithm conditioning sonification. Visualisation includes (1) the ID (label) of the currently selected stations plus the respective values for intensity and direction of wind, (2) the most recent data string retrieved from the remote data server, (3) the Cartesian position of the currently pinged world location is highlighted by a white circle on the world map, and (4) a dynamic animation of the current particle associations as reflected in a number of cluster, clustering particles are connected by straight lines. All this happens on top of two lower layers, first a map of the world showing up as a fixed background image and, second, a visualisation of the field. Matrix cells in the field are drawn as red circles using a radius proportional to cell's value. We think of the matrix as 'being projected' on top of the world, the interpolated matrix values providing a global impression of the distribution of wind energy. Finally, field values above a certain threshold will be highlighted, a blue curve emerges by connecting local maxima in the field's matrix.

Figure 3a and 3b: Snapshots of *WindChime* showing the world, the interpolated field matrix, temporary clusters of interacting particles and the current data collected from 24 live stations.

Figure 3a documents the activity in *WindChime* a few moments after start-up on December 23, 2013 at 15:08:13 hrs. Notice that 13 (out of 24) randomly selected stations actually acquired information. Station data appears at the bottom of the display, station ID is in blue, wind data (direction and intensity) shows in white. Closer observation reveals maximum wind intensity in station KNGP (350/15), the ID refers to a location in Texas, latitude 27 41N and longitude 097 16W. Station CEWB reports a wind intensity of 2 units blowing in an angle of 310 degrees.

Figure 3b displays system status at 15:14:28 hrs. Twenty-two stations show positive data, the current station's ID is RJOW situated in Iwami, Japan. Notice, the coordinate conversion algorithm is not totally perfect; the displayed XY-position on the world map is approximate.

4. FIRST PRINCIPLES

Let us briefly consider a number of first principles underpinning the work documented here. *WindChime* is based on a first principle implicit in my artistic practice; the principle of influence. Initially, this refers to the principle of *mutual influence*, i.e. a policy of open conversational human-machine interaction where both parties express social pressure on one another given the absence of a supervising agent. Influence is opposite to 'control' i.e. typically, the instrumental manipulation of a control structure (in hard- or software) allowing precise control over a given process. Control implies predictability and absolute certainty of outcome.

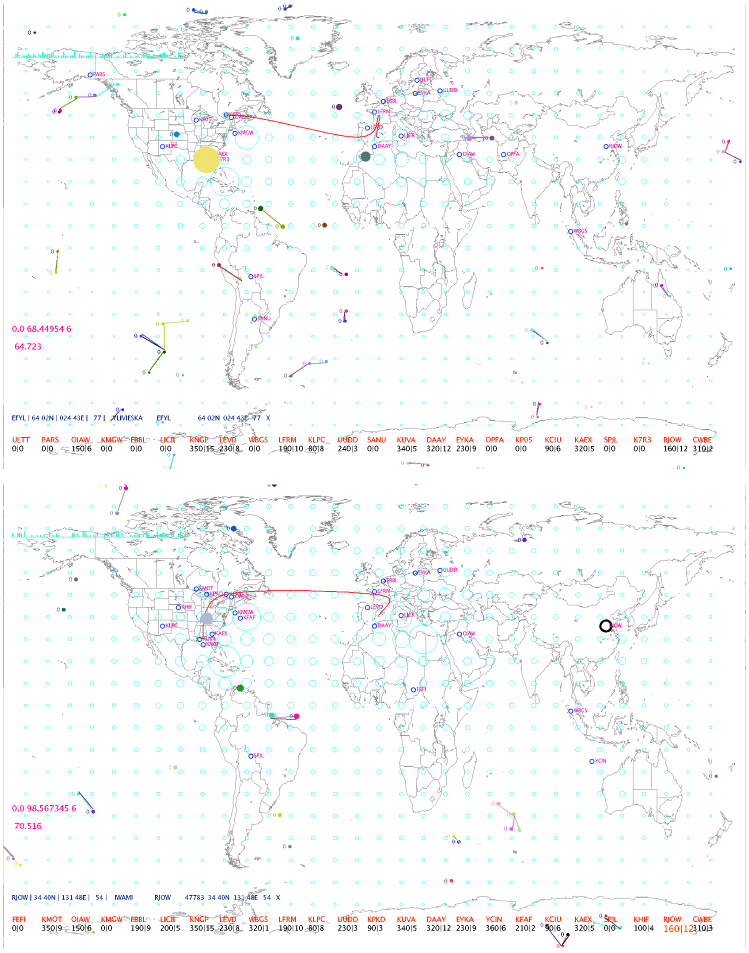


Fig. 3a System status at start-up (image inverted for printing). **Fig. 3b** System status after approximately 6 minutes (image inverted for printing).

The principle of influence acknowledges the relative autonomous existence of an artificial system; it exhibits an internal logic but remains open to outside impact from an unpredictable environment. Organisms in biological workspaces and complex dynamical systems in science are inspiring examples, such entities develop non-linear yet coherent behaviour and cannot be approached as something under control – therefore, they incorporate the potential for offering rewarding aesthetic experiences.

In *WindChime*, the principle of *coexistence* is complementary in the present argument; a number of systems subsist within a given common, shared environment. The installation interfaces weather data, quantitative and qualitative information on wind as a distributed global system, and a digital sound synthesiser in software. In other words, it associates a found implicitly natural system (the earth) with a constructed cultural system (the DSP algorithm). In addition, a human observer witnesses the ever-evolving complex animated audio-visual behaviour.

5. MAPPING, SONIFICATION AND EMERGENT AUDIO

Scientific sonification (Kramer, 1994) usually aims the induction of hidden knowledge from typically massive amounts of data using the medium of sound.

Sonification is distinctive of composition because the objectives and artistic motivation is different. Nonetheless, a thin line might exist between (1) formal data sonification, for example, in the context of meaning extraction in a data mining engineering application and (2) mapping an instrumental gesture to sound i.e. the creation of a musically significant link between grounded action and critical parameters in algorithmic composition. Musical mapping typically aims to convey a meaning implicit in high-level expressive bodily gestures into low-level instrumental control structures, sometimes resulting in exceedingly virtuoso performances (Waisvisz, 1985).

In the present study, mapping is seen as conveying *changes* in the environment to changes in a DSP algorithm conceived and implemented as a complex dynamical system. Notice, very few data items are tracked (only two; strength and direction of wind energy) and only two control parameters impact the sounding patch (conceptualised as a spot on map, identified by a location i.e. the X and Y coordinates).

WindChime implements an experimental mapping scheme, representative of our first principles of *influence* and *change*. The mapping strategy proposes a functional association between complex behaviours in two independent parallel universes that coexist within their private domains.

In addition, *WindChime* acknowledges a massive step in dimensionality – wavelike patterns in wind energy (macro-time) communicate abstract information that is accommodated by the DSP algorithm to result in qualitative gestures in musical micro-time. The purpose of mapping is not to create musical structure as such but to provide a sounding platform to articulate environmental changes. We avoid direct linear mappings between cause and effect in favour of the non-linear influence of environmental forces on a black-box software synthesiser. A synth is considered a network of DSP-modules, complexity issues from the kind of modules and their interconnection. More important, unexpected non-periodic and near chaotic behaviour may result from the application of specific parametric settings to a given synth because the global effect is nonlinear interaction between the synth's individual components.

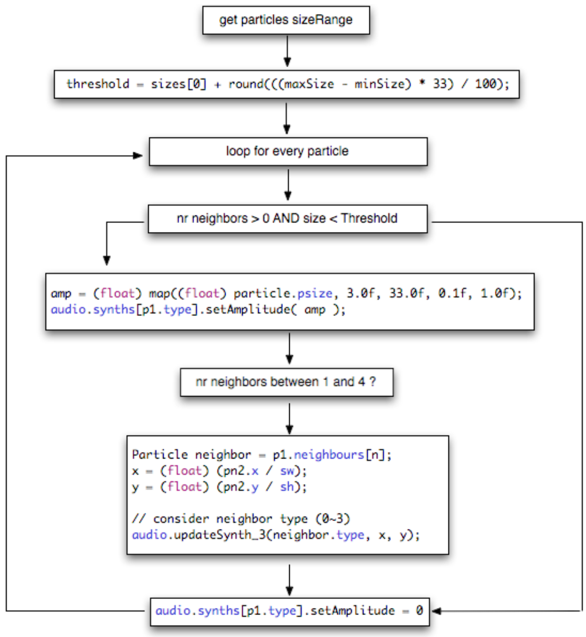


Fig. 4 Information flow in the mapping algorithm.

The notion of mapping is a challenging one, we aim to create a sensible correlation between some abstract behaviour in a specific universe – *WindChime* combines real-world phenomena with dynamic invented artefacts – and an unambiguously designed sounding apparatus. In practice, we avoid simplistic one-to-one relationships, yet we also aim for an *intuitively* perceptible correlation, a relative induction of meaning from the perception of fragmented data. Fragmented because the global audio-visual system is in continuous change and different aspects of its behavioural space are being exposed over time.

Implementation of a non-trivial mapping scheme is typically a process of generate-and-test, not unlike trying patches on a modular voltage controlled synth. Definitely, it also links with the current musical practice of experimental live coding. Our mapping structure is detailed next.

The black-box synth in the most recent implementation consists of a hierarchical network of Frequency Modulation UGens (synthesis modules) written in SuperCollider (Wilson, Cottle and Collins, 2011). Since modules interact in non-linear ways, we consider the modules being pushed (influenced) into chaotic orbits. Remarkably, the overall musical character of the system remains clearly identified, the structure of the algorithm does not change but the implied behavioural space supports a rich palette of expressive sounds.

The output signal of the SuperCollider program results from the multiplication of three simple frequency modulated sine wave generators, triggered by an additional cubic sine shape. The patch features eight 'entry points' i.e. control plugs which accept normalised floating-point values between 0 and 1.

Because the generators interact in non-linear ways, the output signal may engage in chaotic behaviour, in practice, a whole range of sonic phenomena can potentially be synthesised, from simple sine waves to complex audio spectra. We get the impression of relatively independent behaviour in the patch, we loose the notion of 'control' and involve in the appreciation of relative autonomy; the audio patch is definitely influenced but surely beyond explicit external control. As explained above, this approach is implicit in the project's aesthetic orientation.

Figure 4 displays the mapping algorithm. There are four software synthesisers running in SuperCollider, corresponding to four types of particles, visualisation size of a particle is portioned to its energy and equally echoes its type.

Any particle may trigger a sound when its the contents of the Field matrix at the particle's present location exceeds a given adaptive threshold AND it does not live in isolation i.e. it currently sports at least one neighbour within its range of sensitivity. The threshold increases while facing overstimulation. In contrast, the absence of accumulated wind energy will lower the threshold thus increasing the probability of audio responses. Adaption contributes to global emergent behaviour in *WindChime*. Amplitude is further mapped according to the particles size.

Next, particles engage in social collaborative coordination; more neighbours will exercise more control. The highest-ranking neighbour is selected from the current list of neighbours, its XY-location is considered and, according to its type-value (0~3) the x-coordinate and y-coordinate is sent to the corresponding synth in the block of four free- running synths. Finally, any particle momentarily without neighbours and of low energy will switch off a particular synth. Mapping indirectly reflects the interaction between the particles (virtual dust) and captured (physical) wind energy as continuously reflected in the field structure.

6. CONCLUSION

WindChime recommends a perception format of intuitive (partial) understanding of audio-visual behaviour unfolding in a live data driven installation. We appreciate the intricacy in the interface between two complex dynamical systems: firstly, an implicit, found system (the weather) impacting on a dynamic particle system and, secondly, a set of explicitly designed digital sound generators in software. All components are considered complex as they consist of a mass of tiny components interacting in non-linear ways. The notion of 'mapping' is challenged by exploring the first principle of 'influence' rather than 'control'. Globally, *WindChime* suggests a synthetic space effectively influenced by physical real-world features; a complex hybrid universe results affording an unpredictable yet coherent emergent aesthetic experience.

The work reported in this paper took place in the context of the Media Arts and Technology (MAT) project in which CITAR at UCP is a partner organisation. MAT research fuses emergent media, computer science, engineering, and electronic music and digital art research, practice, production, and theory. *WindChime* is an interdisciplinary project proposing novel ways to connect a diversity of aesthetic objectives and technical (implementation related) components, including the notions of database, experimental sonification, dynamic visualisation and perception in an original, innovative presentation format.

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M.M.M.M. — A SOUND AND VISUAL INSTALLATION

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Keywords: Sound Installation, Emergent Composition, Puppet Theater, Audiovisual, Software Performance

M.M.M.M. is a generative sound and visual installation developed as a temporary exhibit for the Puppet Museum of Porto. It leans on the history of the museum and of the company that created it, the Puppet Theater of Porto, and develops a distributed sound composition with generative characteristics, built from sound recordings created through the manipulation of puppets and scenic objects from the archives of the company.

1. CONTEXT

The Puppet Theater of Porto (PTP) was founded in 1988 by João Paulo Seara Cardoso and has since premiered dozens of plays, from performances inspired by the Portuguese puppet tradition, to street theater and stage plays created for both adult and younger audiences.

The Puppet Museum of Porto (PMP) was inaugurated in February 2012, featuring a series of exhibits from the collection of the Puppet Theater of Porto as well as a room for temporary exhibitions.

Miguel Carvalhais and Pedro Tudela first collaborated with the PTP in late 2011 while composing a soundtrack for the play *OVO*. In 2013 they were invited to develop an installation for the temporary exhibitions room of the museum. This piece, titled *M.M.M.M.*, was developed from August 2013 to January 2014 and presented from February to July 2014.

2. "OVO", "AB OVO" AND "M.M.M.M."

For the soundtrack of the play *OVO*, Carvalhais and Tudela composed 19 pieces to be played back on cue and mixed live with the voices of the actors. As a subsequent effort, the materials collected and developed during the composition process were used in the creation of a further set of 6 pieces, released in January 2014 as the CD *Ab OVO*.

Fig. 1 Scene from *OVO*. Photo © Tuna TNSJ.

Working closely with the puppets, designers and puppeteers during the development of these two works, the authors became aware of a rich sound potential to be explored. Furthermore, during the conceptual stage of the installation, they also discovered that whilst the museum was populated by dozens of puppets on display, with the exception of somewhat rare video presentations, all of these were static, being neither manipulated by puppeteers nor visitors. They were presented as motionless objects and not as the dynamic actors that they were created to be and that they only became in the hands of puppeteers. Even when smaller stages or elaborate scenic arrangements are presented at the museum, they are nevertheless displayed without life or action, almost as if they are permanently waiting for puppeteers and audiences to enter at any given time and for a performance to start.

The conceptual starting point for *M.M.M.M.* was therefore found at the intersection of these two realizations and in the wish to bring the sounds and actions of the plays, the dynamism and the life of the puppets, actors and stages back to the space of the museum. As the puppets physical presence is felt everywhere else in the museum, the authors opted to develop the installation focusing on the puppets' sounds, on the audible layer of their manipulation.

3. SOUND SOURCES

The raw material for the installation was assembled through the manipulation of puppets. Besides those on display at the museum, the authors were also granted access to the archives of the PTP, filling three floors of a building in Porto's old town and storing a large number of puppets, sets and stage mechanisms used by the company. The same building also houses the company's workshop, where new puppets are developed and where restoration work for the museum takes place.

During a series of recording sessions organized at the archive, several puppets, sets, mechanisms and accessories were manipulated, exploring their mechanical structures, their articulations, joints and materials, to capture the sounds produced during their operation (including those of the puppeteer's motion, breathing, etc.). These puppets were in varying states of preservation, from well preserved or restored and fully operational, to severely damaged, either due to accidents or decay or simply because they were discarded experiences or prototypes.


Figs. 2 & 3 Recording with puppets.

The recordings were made as 2-channel files. From the several hours of material collected, the authors prepared a selection of over 500 edits, ranging in duration from just under one second to one and a half minutes. Besides minimal equalization or denoising, no further post-production was carried out.

From the same set of recordings, the authors also produced a smaller set of two-dozen sounds with durations varying from just over thirty seconds to almost forty minutes and edited to loop seamlessly. These were more abstract and tended to be continuous or to slowly modulate, they were meant to create an ambient framework for the remaining sound events and to help marking stronger contrasts in the global sonority of the work.

4. PHYSICAL SETUP

The temporary exhibitions room of the Puppet Museum of Porto is a 15.5 x 5 m room without windows, two doors on opposite sides and a small stairwell to access a currently unused underground room.

Six full-range active loudspeakers were mounted on black parallelepipedic stands, not totally dissimilar to those used elsewhere in the museum to display puppets and objects. Although the speakers were kept in plain sight, no effort was made to lighten them or to somehow attract the visitor's visual attention to them. Rather, they were spread over the room, allowing space for circulation and directing the sound projection roughly towards the center of the space. Although it would be possible to hide the speakers, the authors found that a casual setup on stands would be in line with what can often be experienced in puppet theater, where structures for the support and manipulation of puppets, as well as the puppeteers themselves are not necessarily hidden from view, rather assumed to be an integral part of the performance, although not its visual focus.

The computer running the installation and the audio interface were stored away from view, with all the cables casually arranged on the floor of the room, contributing to an overall look of the installation as a *work in progress*. The lights were dimmed to a minimum, with the stronger light source being a visual projection directed to a small wall, illuminating the room with a soft flicker.

Fig. 4 View of the installation

5. THE COMPOSITION

The main software for the sonic component of the installation was developed in Max 6. The patch includes 4 main sound modules – 3 Sample Players and a Loop Player –, a Reverb module and a Master Control module.

The Master Control (MC) module is responsible for marking the structural sections of the composition and for determining volume balancing and the global density of the composition, delegating most of the remaining choices to the other modules.

The 3 Sample Players (SP) share a similar base-structure with a 2-channel sound player that is randomly loaded with one of the edits. All of the edits were named with a serial number and two attributes that determined their probability to be repeated after play and a maximum pause to be respected between plays (in ms).

For convenience, these attributes were included in the file name – e.g. *MMM089-repeat85-pause2000.aif* or *MMM090-repeat20-pause1000.aif* – and are retrieved upon load of each file using a parser of regular expressions. Upon playback of each file, the SP determines whether the file will be replayed or if a new file will be loaded. In either case, before starting a new play, a variable pause is respected (randomized from zero to the value in the pause attribute multiplied by the global density).

At the start of each new play, each SP directs its output to two of the six speakers. This change takes place immediately, in an attempt to maximize the spatial dynamics of the composition. Each of the three SP runs autonomously in regards to timing and sources. All three SP share the same set of files and are not programmed to filter repetitions or to avoid files that may have already been loaded by other modules.

The MC module counts the number of plays from the SP modules and when it reaches a preset threshold, it marks the start of a new section of the composition. At these times, the control of the overall density of the composition is achieved through two systems: by deciding which of the three SP will be active in the new section and by varying the multiplier for the maximum duration of the pauses between plays in the SP. These decisions are probabilistic, the first with a pseudo-random function, the second selecting from a predetermined set of multipliers (0.5, 0.75, 1, 5, 10, 20). Although the number of files to be played in each section is constant, the final duration of each section is determined by the sounds played and by all the pauses, thus varying considerably.

The Loop Player (LP) contains a 2-channel sound player that is randomly loaded with one of the files available in the set of loops. At the start of each section it determines whether to persist playing the same sound or to change and, whenever a new loop is selected, the module cross-fades the currently playing sound with the new one over a period of as much as ten seconds.

The LP also uses two of the six speakers, but the channels are not chosen when a new sound is selected but rather when this happens in the first SP (henceforth SP1). Each new spatial position is cross-faded over the course of five seconds, allowing the looping sound to be continuously moving across spatial positions. The LP is permanently playing; its volume is controlled by the MC and gradually changed to a new value at the start of every section.

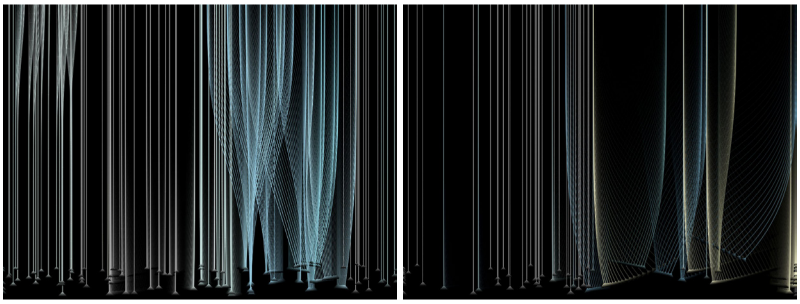
Finally, a Reverb module is connected to the other sound modules, dynamically processing their outputs, with its timing controlled by SP1. Whenever SP1 finishes playing a sound, it instructs the Reverb module to change its parameters, randomly defining new parameters, output volume and destination to its outputs, using a process similar to that of SP. It will also, and perhaps most importantly, select which of the other modules to take as input. Although not producing new sounds per se, because its outputs may be routed to speakers that are otherwise not engaged by any of the remaining modules, the Reverb module is experienced as a de facto fifth sound module.

6. VISUAL PROJECTION

The visual projection was developed with the double intent of providing visual cues of the installation's operations and of conceptually reinforcing it. It is directed at a 1.2 x 0.8 m wall close to the floor.

Over a black background a series of white vertical lines are drawn, hanging from the top of the projection and terminating in a triangular form at a small distance from the bottom of the projection. Although this may at first seem rather abstract, as soon as the projection animates, it becomes clear that through structure and physical dimensions, it intends to develop an analogy with string puppets on what can be read as a stage.

Figs. 5 & 6 Aspect of the visual projection.



The visuals are generated in real time and are synchronized with the audio layer of the installation. Whenever the SP modules play, their outputs are analyzed and, if they exceed a threshold, the value of the maximum amplitude is used to stimulate the strings in the projection. The higher the amplitude, the bigger the number of strings to be stimulated and the stimulus given to each of them. In moments with fewer events and lower overall amplitude the strings remain almost static whereas in moments with a higher activity, the strings tend to jiggle vigorously and sometimes to be violently rearranged. All lines start in white and their colors are gradually changing according to the amount of stimuli received, with the MC module controlling the hue, slowly circling during a period of around 180 minutes.

The system for the visual projection was prototyped in Processing and implemented in openFrameworks, communicating with the Max patch through Open Sound Control.

Fig. 7 View of the installation.

7. CONCLUSION

M.M.M.M. is a generative sound installation with a visual component. It is a site-specific work leaning on the history of its location and on the context it sets for its experience by visitors.

M.M.M.M. develops a distributed sound composition that has characteristics of a generative system. Although the sound sources are prerecorded, their articulations during the presentation are highly variable and there is no score or centralized control of its development over time. After the initial setup, the only control that one can have over its deployment is at the level of the overall volume balance, by adjusting the global output gain. Every other aspect of the runtime articulation of the system, of its performance, was programmed to be autonomous.

M.M.M.M. was created to be shown for six months, therefore needing to balance two characteristics: to be able to showcase its gamut of outputs during relatively short contacts with the visitors, and to develop the composition over a long span of time in a sustainable manner, avoiding excessive repetitions or monotony.

The authors were aware that the average duration of any single visit to the installation would most likely be rather short, perhaps in the vicinity of five minutes. Some visitors would hopefully linger over for a more prolonged time or make repeated visits, and to these, the system should be able to demonstrate a capacity for reinvention or surprise. Although there are no hard-coded time-related variations in the system – e.g. variations mapped to the time of day or day of the week – it was discovered that the autonomous operation of the modules conduced to significant variations of the system's outputs during the performance.

The authors' goal was to build a permanently shifting composition with a sufficiently large variability (so it would seem potentially endless), an open composition that would develop a marked structure, with a clear distinction between sections but that would nevertheless keep its identity in spite of the continuous variations.

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ON THE NOTION OF TRANSMUTABILITY: FROM CONCEPT TO PRACTICE

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The study documented in this paper aims to explore the creative potential that is inherent to the notion of transmutability of digital data. It begins by addressing the topic, discussing its principles and possibilities, while also examining the diverse approaches and practices that it encompasses. Based on these guidelines, we develop a project as a practical illustration of the topic, outlining a methodology that provides a starting point for further creative explorations of the concept. This study suggests the expressive and communicative potential of audiovisual languages that creatively explore the inherent mutability of digital data.

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1. INTRODUCTION

This study was developed under the Communication Design and New Media MA program at the University of Lisbon and assumes as its starting point a focus on sound-image relations in the digital context. With the computer, "all new media objects are composed of digital code; they are numerical representations" (Manovich 2001: 27) which, when regarded as raw material, can be translated into other formats through algorithmic manipulation. New possibilities for linking, generating and manipulating sounds and images arise by corresponding its parameters. This represents a creative potential that is expressed by practices that rely on software to develop aesthetic artifacts that can involve not just articulations between the visual and auditory, but also with any physical or sensory domain.

According to Levin (2010: 271), a principle that motivates the development of this kind of artwork is the transmutability of digital data, which refers to the mapping of some input data stream into sounds and graphics. This paper explores the concept from its theoretical discussion to its practical exploration. We begin by providing an overview of the theme by relating the terms and principles that can be associated with this concept. We then outline the diverse approaches that it can encompass through an analysis of artworks that address or express the concept of transmutability. Based on this framework, we develop a project that aims at highlighting the expressive potential of the theme, while following a methodology that provides a starting point for further creative explorations of the topic. This study considers the notion of transmutability and its significance in exploring, through technological means, dynamic audiovisual languages that can promote new ways of perceiving and experiencing data.

2. TRANSMUTABILITY (IN THEORY)

2.1. CONCEPT AND ASSOCIATED TERMS

The principle of the transmutability of digital data is expressed by the mapping of any input data stream into sounds and images. According to Golan Levin, "the premise that any information can be algorithmically sonified or visualized" motivates the development of aesthetic artifacts, either as "a starting point for a conceptual transformation and/or aesthetic experience", or as "a means to an end, in enabling some data stream of interest to be understood, experienced, or made perceptible in a new way" (Levin: 273-274).

In order to provide a deeper understanding of this concept one can address related notions that similarly express the inherent 'mutability' of digital data, as explored by mapping different physical and sensory domains into new tangible (visual and auditory) forms. This idea relates to the *transcoding* or "conversion of one type of digital information into another" as a direct consequence of describing information numerically (Reas, McWilliams and LUST 2010: 79). As argued by Manovich, this reflects one of the "most substantial consequences" of media computerization, since all "cultural categories and concepts" can be substituted by new ones "which derive from computer's ontology" (Manovich 2001). Similarly, this notion supports *transmediality*, as a "translatability across media" (Hayles 2006: 194). It is also associated to *transmateriality* as a view of "digital media and computation as material flows, … transducing anything to anything else", while "expanding its connections with the environment" by "sourcing new inputs and/or manifesting new outputs" (Whitelaw 2009). These terms invoke software as a means of exploring digital data as a "self-contained abstraction" or its "inherent malleability" (Whitelaw 2008).

2.2. PRINCIPLES AND POSSIBILITIES

Transmutability can be seen as a theme of aesthetic artifacts that use software as their medium and whose focus is on data. This interest is tied to the "nature of our now ubiquitous data systems", as creatively questioned through practices that make data "explicit" and tangible, while probing its "potential, and significance" (Whitelaw 2008).

These practices may entail different approaches and methods for reconfiguring data. Some projects emphasize transmutabilty *per se* as subject matter, or the (transformational) mapping process of data as "an abstract set of potentials, an array of values waiting to be mapped". They explore how any given data can be mapped onto a new representation or tangible form, regardless of its source or origin. In contrast, other projects focus on some data stream of interest, seeking to provide a new perception of it, or to “portray not merely data, but the personal, emotional reality that the dataset refers to” (Whitelaw 2008).

These strategies evoke “the promise of rendering the phenomena that are beyond the scale of human senses into something that is within our reach, something visible and tangible” (Manovich 2002).[1] Following different aesthetic intents, the process of mapping is used as a means to completely reconfigure a dataset into an aesthetic or communication artifact (Whitelaw 2008). In this sense, transmutability puts an emphasis on data as content, on its representation and perception, and on the mediating transformational process.

2.3. VISUALIZATION AND SONIFICATION

By suggesting that any given data can be mapped onto a visual and auditory form, the notion of transmutability is a term that encompasses both the concepts of visualization and/or sonification. In general, visualization refers to the “visual representation of quantified data which by itself is not visual” (Manovich 2002); it involves an interpretative process that implies “the development of a visual image in the human mind” (Tavares and Alexandre 2007). In parallel, sonification is commonly defined as the use of non-speech audio to convey information (Kramer, *et al*. 1997); more precisely, a technique that uses data as input to generate sound signals that reflect objective properties or relations in the input data, and which transformation is systematic (Hermann 2008: 2).[2]

A particular interest of this study is on the associations of these concepts, as circumscribed to sound visualization and image-based sonification processes. Although their logic and representation principles may be similar, the source data diverges, being respectively sound or image.

When assuming visualization and sonification as complementary concepts, it is possible to identify common traits or methodologies. Both involve “two nodes in the process: encoding and decoding”, meaning, a method of mapping data relations to sounds, and the interpretation of relationships contained in the information (Song and Beilharz 2006: 450). While encoding entails “evaluating interesting aspects of data, extracting data relations and choosing appropriate parameters for matching the variation in data”, decoding relates to how users “understand the information embedded in sounds” and images (451).

1 While this may encompass diverse possibilities of representation or tangible forms, including multimodal or tactile experiences, this study focuses on visual and auditory forms.

2 As defined by Hermann, a technique that uses input data to generate “sound signals (eventually in response to optional additional excitation or triggering) may be called sonification, if and only if: (C1) The sound reflects objective properties or relations in the input data. (C2) The transformation is systematic. This means that there is a precise definition provided of how the data (and optional interactions) cause the sound to change. (C3) The sonification is reproducible: given the same data and identical interactions (or triggers) the resulting sound has to be structurally identical. (C4) The system can intentionally be used with different data, and also be used in repetition with the same data” (2008: 2).

Another aspect of this general methodology concerns the nature of the approach; if it is mainly analytical or aesthetic. The objective may be to provide a new reading or understanding of the information, therefore, the mapping "should convey the unique properties of the data set it represents" (Fry 2008: 16). Conversely, the aim can be to create expressive languages or sensory experiences, when the artist defines subjective criteria, and takes advantage of the arbitrary nature of the mapping process, as suggested by Manovich (2002). However, as mapping is always a systematic process, any of these approaches entails "a pragmatic information aesthetic that combines the functionality of information design with the aesthetic sensibilities of the sonic [and visual] arts" (Barrass and Vickers 2011: 152).

3. TRANSMUTABILITY (PRACTICES)

3.1. SELECTION OF WORKS

In order to demonstrate the range and scope of transmutability in creative practices, we selected and analyzed a group of 28 projects that, in a more or less explicit way, relate to, imply or express this concept. We assume a correspondence to the idea of transmutability when the artifact: (1) uses software as its medium; (2) explicitly works on or explores some given input data; (3) entails visualization and/or sonification, and (4) emphasizes as subject matter, or renders significant and meaningful, its data or transformation processes.[3] Having these common traits, we distinguish them in terms of their objectives, format, presentation context, and also data and mapping processes, as well as their variability and audio-visual modes of expression.

1. Nicolas Reeves. *Cloudharp*. 1997.
2. Ken Goldberg, *et al*. *Mori*. 1999.
3. Ken Goldberg, *et al*. *Bloom*. 2013.
4. Lisa Jevbratt. *1:1*. 1999–2002.
5. Lisa Jevbratt. *Mapping the Web Infome*. 2001.
6. Alex Galloway/Radical Software Group. *Carnivore*. 2001.
7. John Klima. *Ecosystm*. 2001.
8. Mark Napier. *Feed*. 2001.
9. Mark Hansen and Ben Rubin. *Listening Post*. 2001.
10. Mary Flanagan. *Collection*. 2002.
11. Cory Arcangel. *Data Diaries*. 2002.

3 Following these criteria, we selected these artifacts primarily from the bibliographical sources consulted during the research process, provided that there was sufficient information about the work, even if we had no direct contact with it.

12. August Black. *Datadada*. 2003.
13. Andrea Polli. *Atmospherics/Weather Works*. 2003.
14. Peter Luining. *ZNC Browser 2.0*. 2003.
15. Jens Brand. *G-Player*. 2004.
16. Stanza. *Sensity*. 2004.
17. Semiconductor. *Brilliant Noise*. 2006.
18. Semiconductor. *20Hz*. 2011.
19. Ryoji Ikeda. *Datamatics*. 2006.
20. Ryoji Ikeda. *Test Pattern*. 2008.
21. Art of Failure. *Laps*. 2007.
22. Lab[Au]. *Binary Waves*. 2008.
23. Ubermorgen. *The Sound of Ebay*. 2008.
24. Chris Sugrue and Damian Stewart. *Waves to Waves to Waves*. 2008–2009.
25. R. Luke DuBois. *Hard Data*. 2010.
26. Nicolas Maigret. *Pure Data Read as Pure Data*. 2010.
27. Marco Donnarumma. *The Invisible Suns Project*. 2010.
28. Carrie Bodle. *Wavelines*. 2012.

3.2. MODEL OF ANALYSIS

The analysis is anchored on the frameworks proposed by Wardrip-Fruin (2006) and Hunicke, LeBlanc and Zubek (2004) for considering and understanding digital computational media.[4] According to which according to the model proposed by Wardrip-Fruin, these entail the following elements: author (who selects and creates the work's data and processes); data (non-process elements of the work); process (operations performed by the work); surface (what the work turns to its outside); interaction, defined as change to the state of the work that comes from outside the work (from outside processes and data sources, requested by the work's processes); and audience (people who experience the work's surface) (2006: 9-11).

These systems can then be distinguished according to the forms and roles of computation they entail, as works that do not just "require computation before the audience experience" (or authoring process), but also require computation during such experience (Wardrip-Fruin 2006: 12-13). They can be "computationally variable" as "works in which the processes are defined in a manner that varies the work's behavior (randomly or otherwise)", i.e., either "without input from outside the work's material", with input from external data or processes, and with human

4 The author establishes a difference between digital computational media and "fixed media" (e.g., fixed music distributed on CDs, video distributed on DVDs) as media that do require digital computation at the time of audience experience, but in a manner that does not define the work. This means "the work does not require digital computation in order to be itself". In contrast, we consider "work which explicitly includes processes of digital computation in its definition, such as a computer game requires digital computation" or interactive work which requires computation to support the interaction – it is "explicitly designed for its surfaces to be experienced in a context employing digital computation", performed by any computational device. (Wardrip-Fruin 2006: 12-19).

input, as audience interactive systems (Wardrip-Fruin 2006: 397-400).

In addition, different perspectives or ways of looking at these systems can be combined, according to the MDA framework (Hunicke, LeBlanc and Zubek 2004), namely: *mechanics* (the particular components of the system, at the level of data representation and algorithms), *dynamics* (the run-time behavior of the mechanics acting on user inputs and each other's outputs over time) and *aesthetics* (the desirable emotional responses evoked in the user, when he interacts with the system).

The conducted analysis was mainly based on the surface of these systems and on the information collected from their associated literature. However, despite the limitations imposed by these means of observation and the absence of direct contact with some of the works, we were able to deduce aspects of their mechanics and dynamics. According to the previous frameworks, our model combines both the focus on processes and on the work's experience, articulating the following dimensions:

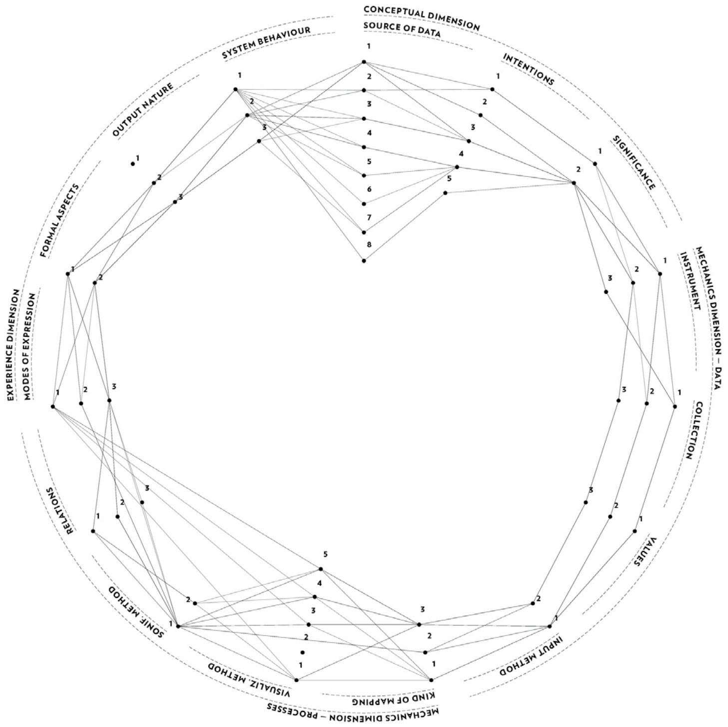
Conceptual dimension (theme and content)
Focusing on the objectives and subject matter of the work, namely, its source of data (as information or content), and the significance and relevance of transmutability (as artistic argument).

Mechanics dimension (data and processes)
Regarding the constituent elements of the system, such as instruments for collecting data, time of data collection, input method, kind of mapping processes (visualization and/or sonification) and their relations (when combined).

Experience dimension (surface and dynamics)
Considering elements that are related to the sensory experience and observable behavior of the work, such as, modes of expression and communication (audio or visual), formal aspects of representation, nature of the outputs (static or not), and the dynamic behavior of the system (regarding its variability).

3.3. OBSERVATIONS

Fig. 1 Projects' analysis diagram



EXPERIENCE DIMENSION				CONCEPTUAL DIMENSION		
MODES OF EXPRESSION	**FORMAL ASPECTS**	**OUTPUT NATURE**	**SYSTEM BEHAVIOUR**	**SOURCE OF DATA**	**INTENTIONS**	**SIGNIFICANCE**
1 ONLY VISUAL	**1** ANALOGY TO THE REFERENT	**1** STATIC	**1** INTERACTIVE	**1** INTERNET	**1** ENPHASIS ON TRANSMUTABILITY	**1** THEME
2 ONLY AUDIO	**2** ABSTRACTED FROM THE REFERENT	**2** TRANSIENT	**2** OPEN	**2** HARD DISK	**2** DATA DENSITY	**2** MEANS TO AN END
3 AUDIOVISUAL		**3** VARIABLE	**3** CLOSED	**3** SOCIAL FLOWS	**3** DYNAMIC FLOWS	
				4 EARTH'S SURFACE	**4** NATURAL PHENOMENA	
				5 METEOROLOGY	**5** NO INFO	
				6 ASTRONOMY		
				7 MAGNETISM		
				8 NO INFO		

MECHANICS DIMENSION – DATA				MECHANICS DIMENSION – PROCESSES			
INSTRUMENT	**COLLECTION**	**VALUES**	**INPUT METHOD**	**KIND OF MAPPING**	**VISUALIZ. METHOD**	**SONIF. METHOD**	**RELATIONS**
1 COMPUTACIONAL PROCESS	**1** REAL TIME	**1** STREAM	**1** AUTOMATIC	**1** VISUALIZATION	**1** GRAPHIC	**1** PARAMETER MAPPING	**1** SEQUENTIALLY
2 DATASET	**2** PROGRESSIVE	**2** CHUNKS	**2** BY THE AUTHOR	**2** SONIFICATION	**2** DIAGRAM	**2** AUDIFICATION	**2** IN PARALLEL
3 SENSORS	**2** A PRIORI	**2** FIXED		**3** BOTH	**3** MATRIX		**3** IN CIRCLE
					4 DYNAMIC MAP		
					5 OTHERS		

The above-mentioned dimensions are inseparable and interdependent, since the work's dynamics arises from the mechanics, which in turn encompasses the formal specification (as data structures and algorithms) of the intentions and aesthetic aims of these projects. Their observation stresses the salient traits of these projects.

We distinguish projects like *Data Diaries* (that fools Quicktime into thinking a computer's memory file is a video file) that explore the concept of transmutability in its essence, while emphasizing the malleability of digital data, from projects that explore representations of human-related dynamic flows of information, or dimensions of natural phenomena that are beyond the scale of the human senses. Such is the case with *Brilliant Noise*, that "reveals the energetic particles and solar wind" in a tangible manifestation.

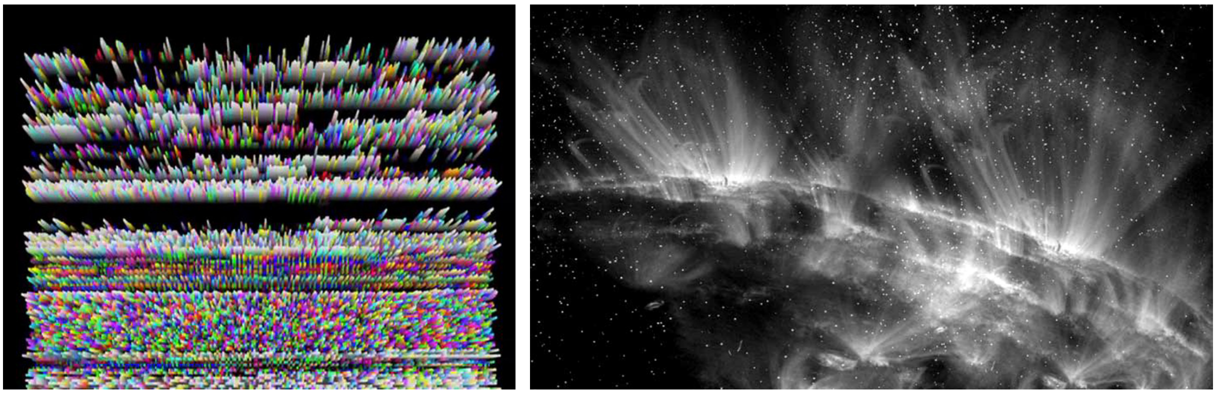
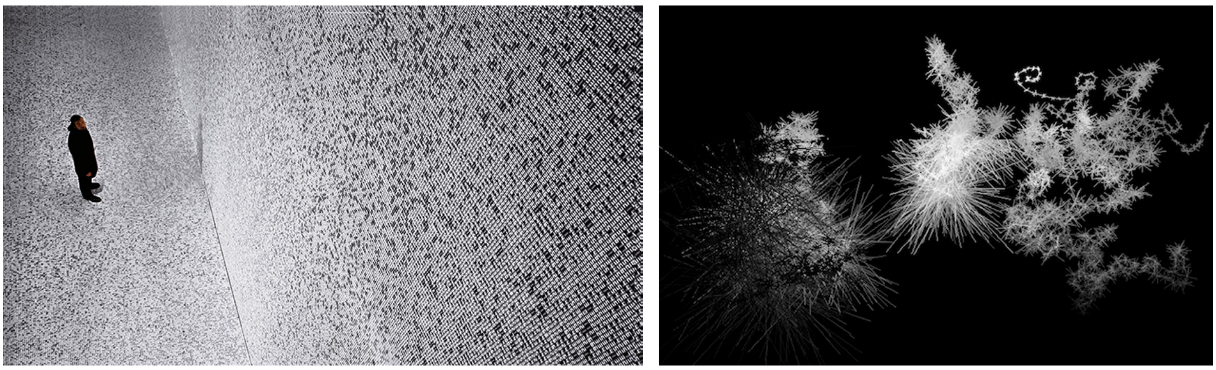


Fig. 2 *Pure Data Read as Pure Data* (Nicolas Maigret 2010) and *Brilliant Noise* (Semiconductor 2006)

These intentions are reflected in formal aspects of expression. Some projects highlight the quantitative nature of data as raw material through abstract visual and auditory forms, as seen in *Pure Data Read as Pure Data* (in which the patterns and sounds are generated by the source code of the program). Other projects deploy more organic languages, such as *Mori*, that uses environmental sound samples (namely rockslides, volcanic eruptions, thunder claps, avalanches, and industrial noise), in order to create an analogy to the represented phenomena.

The source of data and the system's behavior also influence the nature of the output, depending on whether it is open (or not) to interaction with external inputs. For example, the project *Datamatics*, which in its installation version assumes fixed datasets inserted during the authoring process, results in a transient output that favors a contemplative experience of "the invisible multi-substance of data that permeates our world". On the other hand, in *Waves to Waves to Waves*, a continuous data stream determines the real-time variation of the output, promoting interaction and an immediate reading of the mutations generated by the inputs.

Fig. 3 *Datamatics* (Ryoji Ikeda 2006) and *Waves to Waves to Waves* (Chris Sugrue and Damian Stewart 2008–2009)



4. TRANSMUTABILITY (IN PRACTICE)

From the previous observations we extracted principles that guided the practical component of this study, as an exploration and illustration of the topic. This was defined as a meta-project, in the sense that explores different ways of audio-visually translating the textual contents of the dissertation on which this paper is based; it seeks to provide a new perception or experience of this content, through seeing or hearing.

4.1. CONCEPT, MECHANICS, EXPERIENCE

In terms of *concept (theme and content)*, the project departs from an analytical stance towards a more expressive approach. By mapping data relations to graphics and sound, rather than favoring interpretations of relations, these representations become ultimately abstract and emancipated from their referent. The practical experiences were gradually detached from the text's semantic content and oriented towards an aesthetic exploration of the expressive qualities of its visualizations and sonifications.

Regarding *mechanics (data and mapping processes)*, the starting point was a selection of three main sections of the dissertation, as chapters of a different structural and semantic nature; an aspect that gives rise to different visualization and sonification approaches. Following the general steps proposed by Song (2006), and inspired by simple textual analysis and visual mapping techniques, as seen in *Writing Without Words* by Stefanie Posavec (2008), we begin with an analysis of relations between textual elements that are mapped to graphic elements, which in turn are the starting point for algorithmic sonifications that are later combined with these visualizations.

In terms of *experience (surface and dynamics)*, we opted for the use of elementary figures and sounds, seeking to minimize aspects that are accessory to the audio-visual reading of the text. As static representations they reflect the structure, correlation and recurrence of key elements of the dissertation, *in abstacto*. Presented as transient sequences, these images are accompanied by a similarly minimal aesthetic of simple sounds that, when combined, produced more complex textures.

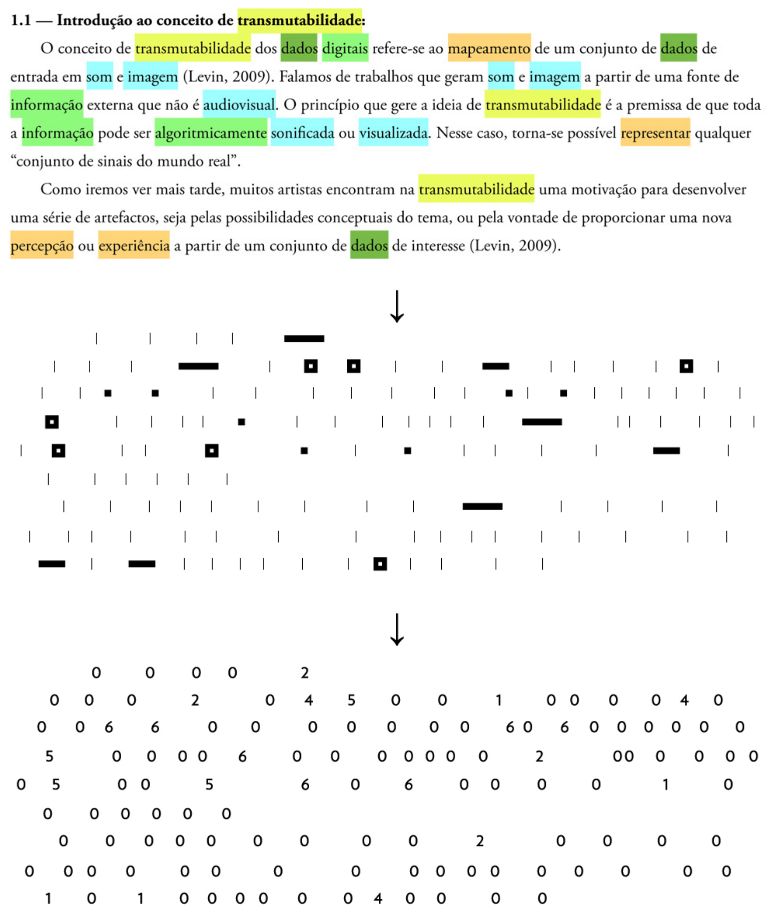
4.2. DEVELOPMENT AND RESULTS

The presented work results from a closed system of correspondences, between text, graphic symbols and sound parameters. Its development involved analyzing and extracting themes and keywords from each section of the text and defining graphic symbols, while similarly considering the tables and diagrams resulting from the analysis of the artifacts studied, as abstract graphic notations for sonification. This set of visual representations pertains to the structure, recurrence and spatial configuration of textual elements in each section of the dissertation.

We then defined their corresponding sound parameters by exploring frequency and amplitude modulation and sound filtering techniques. The visualizations and sonifications were thus combined, resulting in two graphic scores that are presented sequentially and a third sequence combining the diagrams, each with its associated sound, that the user can activate or deactivate.

The visualizations are presented both as static images of a whole section of the dissertation and also combined with the sonifications, where the temporal sequence becomes an abstract narrative of this study. These were integrated in an online platform[5] that contextualizes the project and its methodology, and provides the source files for download.

Fig. 4 Mapping process



5 *http://tinyurl.com/ovj7y7j*

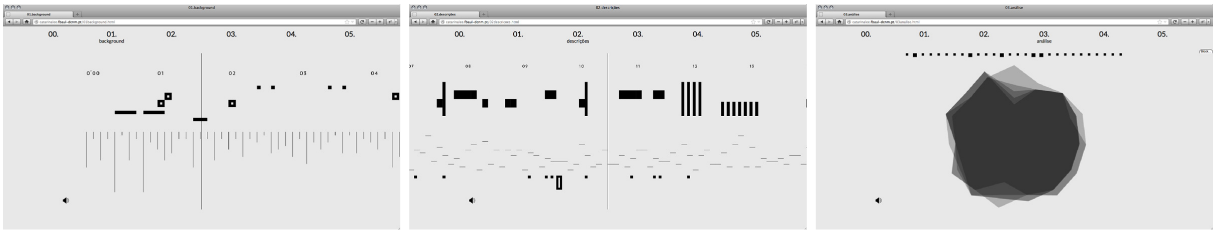


Fig. 5 Resulting audiovisual sequences – screenshot

Consequently, rather than promoting change, the static and transient outputs and the closed non-variable nature of this work highlight a diversity of possible derivations, reinterpretations and subjective approaches to the same referent, therefore promoting a contemplative experience.

This project can then be understood as an open process, where the produced visualizations and sonifications provide a starting point for further explorations of the creative and expressive potential of transmutability, namely through other data and mapping processes. While this study focused on devising an expression adequate to its specific source information or content, further developments contemplate the expansion of this methodology to more complex algorithmic mappings or dynamic results.

5. CONCLUSION AND FUTURE WORK

This study focused on the creative exploration of the concept of transmutability. In order to address this topic we acknowledged its multiplicity by discussing its associated concepts and by examining practices that creatively explore the premise of the mutability of digital data. In line with this idea, this study underlines the theme’s expressive potential by developing a project based on the dissertation’s contents. In this manner, this work sought to contribute to a deeper understanding the notion of transmutability and how it becomes significant and meaningful in the ways it emphasizes data as content, its representation and perception, and the procedures for its reconfiguration.

The notion of transmutability not only implies the development of visual and auditory renderings of data, but is above all, an exploration of expressive audiovisual languages, which, by means of technology, allow a new perception or aesthetic experience of data. These ideas are evidenced by the examples analyzed and guide this practical exploration of the topic.

The interest in data is often connoted with complex and intangible phenomena or with the abstract nature and inherent malleability of digital data, while the processes for its reconfiguration evoke the computational medium's potential for proposing new aesthetic experiences, and allowing the audience to contemplate or interact with the data that permeate our world. This study then sought to reveal how transmutability becomes relevant as an artistic argument, when approaching our contemporary condition of immersion in digital data.

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DRAWING SOUNDS

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Keywords: Sonification, Interactive Installation, Interactive Instrument, Light Drawing, Computational Art, Arduino, Processing, Pure Data

Drawing Sounds is an interactive installation that explores the translation of drawings into sounds. This custom system provides to the audience an immersive and acoustic experience resulting from light drawings. The incident light is momentarily absorbed by phosphorescent ink contained in the canvas surface. These reminiscent traces of light are then translated into sounds, allowing the users to create and experience their own sound compositions.

1. INTRODUCTION

The evolution of technology is promoting the experimentation and the adoption of novel computational approaches in areas such as art or design. Today, technology provides the opportunity to create and mold parameters of image and sound in imagined and unimagined ways. As John Whitney Sr. (1994) stated: "the computer is the only instrumentality for creating music inter-related with active color and graphic design". Exploring this relation between sound and image, Whitney Sr. developed his own equipment to create sounds directly on the soundtrack section of the films. With this equipment, he and his brother, James Whitney, generated and composed sound and image simultaneously. The piece *Five Film Exercises*, created between 1943 and 1944, is an example of their seminal work (McDonnell 2007).

Karen Frimkess Wolff also established a relation between sound and image. In her work *Drawing with Sound* (1991), "sound lines" were defined as "the movement of a virtual point source of a sound in a space so that it is perceived as describing a line in the space". These "sound lines" were generated according to the sound of a voice speaking and electronic tones and the movement of the sound point was equated to the act of drawing.

The process of conversion of data – e.g., images, gestures, weather conditions, and sentiments – into sound has been largely investigated in the past and is commonly called sonification. Previous work on image *sonification* can be divided into two different types: high-level and low-level. The first, is a "symbolic" sonification, e.g., the translation of visual information into natural language. In contrast, the second type of sonification transforms data into abstract audio signals. Works such as *Elementary Gestalts for Gesture Sonification* where the gesture is translated to a sound (Yoshida 2011) and *From Shape to Sound* where the authors generate synthesized friction sounds according with human drawing gestures (Thoret 2012) are examples of low-level sonifications. Likewise the work presented in this paper also explores non-symbolic sonification.

In *HCI Design and Interactive Sonification for Fingers and Ears*, Mikael Fernström, Eoin Brazil, and Liam Bannon (2005) seek to relate sounds and actions in the design of auditory displays. In their work, they explore what people hear and how they associate a particular sound to a particular action. They state, “If the sound will enhance the interaction, we need to explore ways of creating and testing auditory metaphors. We should also investigate to what extent the use of sound contributes to the users’ performance and subjective quality of use.”

Considering this background as basis for this work, and following the footsteps of previous researchers, we explore the relation between gesture, image and sound, with the additional motivation of investigating and exploring new creative possibilities using algorithmic and computational approaches.

2. CONCEPT AND OUTCOME

This work explores the translation between ephemeral visual registries and sound. It comprises an installation, which works as an instrument, allowing the audience to create traces in a canvas, that are then translated into sounds according to their characteristics. The peculiar characteristics of the canvas cause the progressive loss of visual registries over time.

The conversation between the user and the installation is achieved by the simple and natural action of drawing on a surface with a light source. The incident light is momentarily absorbed by phosphorescent ink contained in the canvas surface. The light traces remaining on canvas are then translated into sounds. This translation is achieved by a transformation of the traces’ characteristics into sound parameters: the horizontal axis of the canvas represents time, and can be perceived through two rows of lights placed along canvas; the vertical axis represents the sound pitch; the thickness of the traces represents the intensity of sound.

A video presenting the interactive installation and including explanatory notes is available at the following address: *http://cdv.dei.uc.pt/2014/drawing-sounds.mov*. The sound of the video was recorded with the camera causing some sound distortions. Figures 1–2 present a selection of photographs of the installation.

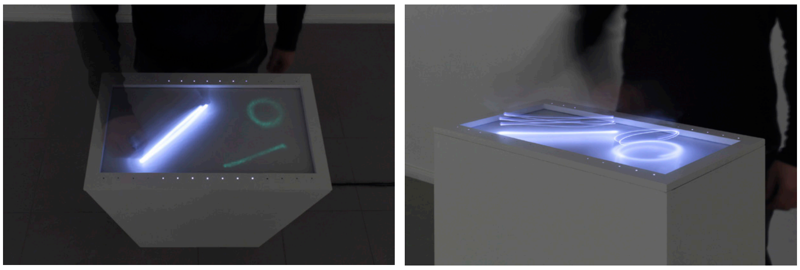

Fig. 1 Overview of the installation space **Fig. 2** The user drawing on the installation canvas with a flashlight

3. THE PROCESS

The initial step for the implementation was to build a box in MDF material. The structure was designed to be positioned vertically in order to allow the audience to interact and draw comfortably on its top. The top of the structure was designed to support a surface painted with phosphorescent ink – a material that absorbs the received energy and slowly releases it in form of light. Therefore by using light sources such as flashlights the audience can create drawings on this surface that will remain visible for a few minutes. The top of the structure also includes two rows of small holes with LEDs inside, which gives to the audience feedback on the translation instant of the drawings into sound. Electronic components such as a power supply unit that powers the electronics, an Arduino[1] microcontroller that controls the brightness of the LEDs, and a camera that sends in real time the light drawings contained on canvas to the computer, are embedded in the structure.

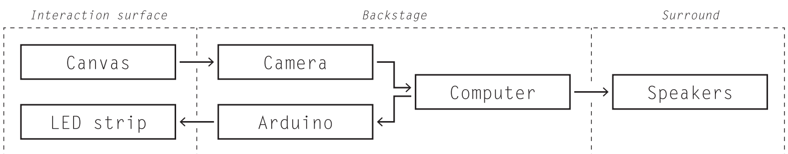

Fig. 3 Scheme of the installation pipeline

Figure 3 outlines the information pipeline, which can be summarized as follows: a camera captures the canvas and sends the images to the "canvas analyzer", a pro-

1 *http://arduino.cc*

gram written in Processing;[2] this program processes and interprets the images of the canvas and sends instructions to the "synthesizer", an application created in Pure Data;[3] this application generates sounds based on the received instructions.

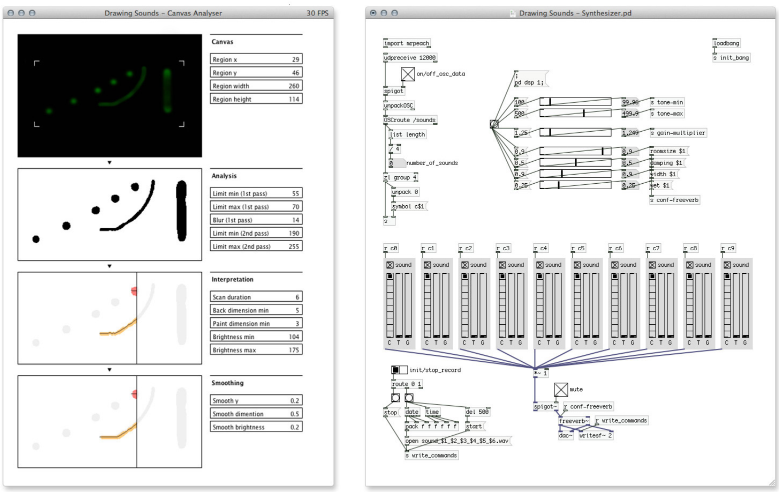

Fig. 4 Screenshot of the canvas analyzer (left) and the synthesizer (right)

The canvas analyzer is responsible for the translation of image into sound. The program includes a chain of processing stages and enables the fine-tuning of the translation parameters. The interface, depicted in figure 4, also provides feedback regarding what is happening at each stage of the process. The different stages are graphically represented through vertically arranged zones, which help perceiving the flow of information and processing.

In the first processing stage, the canvas area is selected from the image coming from the camera. In the following stage the program detects the bright and greenish regions of the canvas. This image processing operation integrates mechanisms such as functions of threshold, erosion and noise reduction. In the third stage the various spots and traces that were drawn on the canvas are identified through the analysis of the image processed in the previous stage. Each detected trace is associated to a sound stream, which allows the simultaneous acoustic representation of multiple traces. In the last phase, the position, brightness and morphology of the drawings are smoothed removing noise caused by the poor contrast of the image captured by the camera. These characteristics of the traces are translated into acoustic parameters (see figure 5), which are then sent via OSC protocol to the synthesizer that generates the sound stream for each individual trace.

2 *http://processing.org*

3 *http://puredata.info*

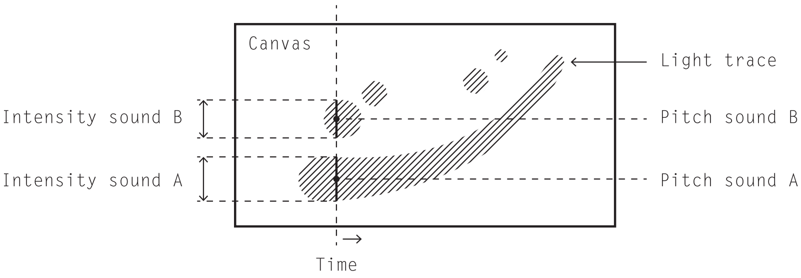

Fig. 5 Translation of drawings' morphology into acoustic parameters

The canvas analyzer is also responsible for instructing, in real time, the Arduino microcontroller, which in turn controls individually the LEDs positioned near the canvas area.

The system was designed to generate simultaneous sounds, enabling the public to acoustically perceive different traces. In terms of sound design, we favored the creation of organic and immersive soundscapes. To attain them the synthesizer produces several smoothing and processing operations.

The fact that the surroundings of the installation require a relatively low luminosity hinders the process of image capture and processing. To overcome this limitation, we used a DSLR camera, whose configuration allows capturing more light in low luminosity conditions. Nevertheless, in the conceptualization stage the brightness of each trace was associated to the intensity of the sound generated by them, and their vertical dimension to sound dissonance, however the low contrast of the captured image didn't allow an accurate reading of brightness. Thus, the dissonance was not applied, and the vertical dimension of the respective trace controlled the intensity.

The sound system consists in two individual channels. Each column is positioned in opposite sides of the installation. The current position of the "canvas reading" sets the panning of the two channels, i.e., the scanning of the canvas is perceived acoustically.

4. CONCLUSION

Today, the adoption by artists and designers of programming as a fundamental component of their creative process allows the development of author tools promoting the creation and exploration of new possibilities. The mastery of technology and programming allows the development of specific tools that enable the creation of new options and paths. In this sense, and taking into account the state of the art in the area of sonification, we perceive that this type of explorations can generate new creative and multi-disciplinary paradigms.

The experiments involving participants show that they quickly understand the behavior and creative possibilities of the installation. In few minutes, the participants start to use the canvas as a musical score. Although the sound generation is properly created according to the public drawing, the analyses of the brightness of the traces is problematic and further steps must be taken to overcome this limitation.

Future work will contemplate new drawing possibilities to increase recognition accuracy; new types of visual feedback through a video projector positioned under the canvas; and the possibility of using a palette of different sounds.

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POSTERS

INTERACTIVE GAME-AUDIO MODELS: THE TIMBILA OF MOZAMBIQUE

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Keywords: Timbila, Game-Audio, Mozambique, Blender, NESS-Project, Interactive, Drumming, OpenAL

This technical demo and the concert presentation feature the creative aspects and technical research behind the Timbila instrument of the Chopi people (Mozambique), which resembles a wooden xylophone. The project merges European and African Cultures throghout the instrument and the use of game audio and composition, by combining real and 3D game-engine-physics models of timbilas. The conference showcase includes a concert perfomance of "Xi" for live timbila and electronics by Ricardo Climent, performed by world-leading percussionist Miquel Bernat (timbila) and a technical demo of 3D virtual timbila models constructed by 'Manusamo & Bzika', an interdisciplinary group created by Manuel Ferrer Hernández (visual artist) y Alena Mesarosova (architect), specialised on Augmented Reality (AR) and 3D modelling. The technical presentation includes two 3D timbila models, the Chikhulu (bass with 3 keys) and the Sanje (18 keys), alongside a real Dbinda (baritone timbila). Its current

sonic typo-morphology includes sample-based recordings and transformations of the instrument which are triggered via the game engine's interactive system. New physical models of the instrument will be implemented shortly using Climent's outcomes from the NESS-project in Edinburgh.

1. DEFINITION

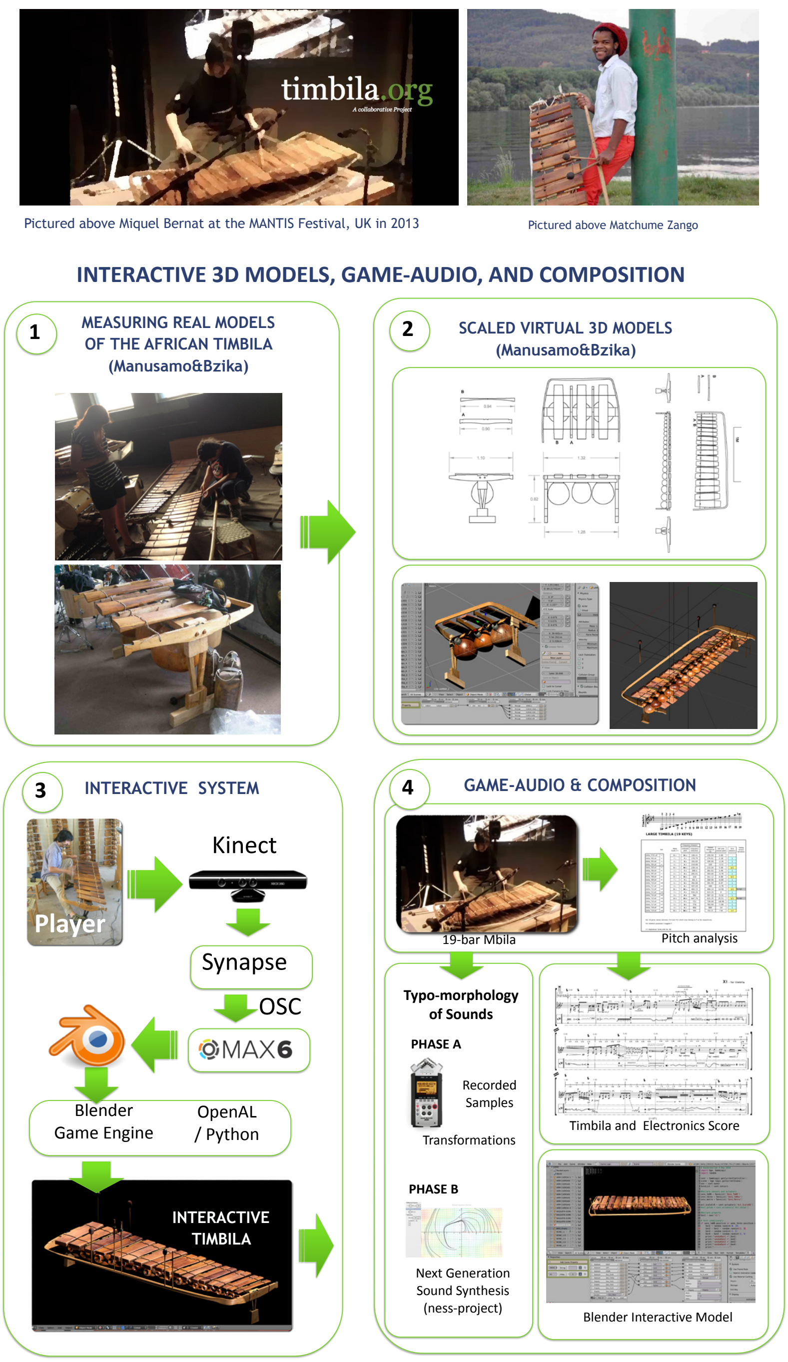
"Timbila" is an ensemble of musical instruments of the xylophone family, built and performed by the Chopi ethnic group from the south of Mozambique. The word Timbila (plural of Mbila) often refers to the 'orchestra of timbilas'. Timbila instruments vary depending on their register and the function held inside the ensemble: e.g. Chilanzane, Sanje, Debiinda, and Chikhulu.

2. HISTORY AND RECOGNITION

The Timbila's first known records date from the 16th century. They were found on letters written by a Portuguese Catholic missionary to his colleagues in India and Portugal. These include references to the particular mastery and sensibility of the Chopi people, and to their exuberant and complex performances of music, dance and poetry. In 2005 UNESCO proclaimed The Timbila as "Oral and Intangible Cultural Heritage of Humanity".

3. THE TIMBILA PROJECT

Started by Miquel Bernat who made with other members of *Drumming grupo de percussão*, a number of fieldwork trips to Mozambique, visiting Timbila master Venancio Mbande, with the assistance of timbila player Matchume Zango. As the result, they brought instruments to Porto and commissioned works to composers, such as Jean-Luc Fafchamps's "Wooden Mind" for 7 timbilas; Ricardo Climent's "Xi" for solo timbila and Electronics (featured at xCoax); George van Dam's violin concerto with orchestra of Timbilas and Polo Vallejo's work for timbila "Palindrumming". Climent built the first interactive gameaudio prototypes of the timbila in Blender3D game engine using the Microsoft's Kinect as the interface, Synapse and OSC (Open Sound Control), OpenAL and. In 2014, new improved 3D models were accomplished by Manusamo & Bzika for xCoax2014. Since there are fewer and fewer makers of this instrument, the interactive 3D models have the double aim to function as a tool for live interactive performance alongside the real timbila, while preserving the instrument in the virtual world. It aims a mix between creative archiving and cultural preservation with full respect over the instrument's inherent tradition.



4.3D-MODELS SONIC TYPO-MORPHOLOGY IN "XI"

It combines original recordings from the instrument, obtained using Rick Nance's technique of Aural Scores applied to the recording process. At a later stage it will incorporate Next Generation Sound Synthesis on which Climent is working at present as part of the NESS-project.

SONIC EVOCATIONS

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Keywords: Accelerometers, Arduino, Chinese Music Instruments, Electroacoustic, Gesture Recognition, Guqin, Machine Learning

Sonic Evocations **is an electroacoustic work for solo Guqin and electronics, inspired by the poetic evocations and illustrations used to describe playing techniques in ancient Guqin tablatures. It aims to explore the performance application of the digitized Guqin hand gestures, traditionally metaphorically portrayed through movements found in nature. This work is the cumulative effort of the initial research in digitizing Guqin performance gestures, and gesture recognition using machine learning.**

1. INTRODUCTION

The Guqin is a Chinese fretless plucked seven-stringed instrument with a history of about 3000 years. The three main categories of sounds produced by ambidextrous playing methods are: *san yin* (open strings), *an yin* (pressed sound), *fan yin* (harmonics).

Before the existence of Guqin handbooks, students traditionally learnt finger techniques by imitating their teacher's playing (Gulik, 2011). The ancient Guqin players eventually created a method to technically record notes, finger technique instructions, hand gestures and positions into a tablature notation system. Typically, these bound tablatures began with pages dedicated to describing the produced tones, as well as both poetic and technical descriptions of the hand positions used in the repertoire. Fig. 1 shows an example of such hand gesture illustration from Volume 3 of *Taiyin Daquanji*, an early Ming tablature that was re-printed in the early 16th century (Zha, 2010).

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The illustration of an (按) technique in Fig. 1 describes its execution as follows: Press down on the string forcibly using the side of the thumb between the nail and the flesh, as if it would penetrate the wood. In addition, the author of the tablature metaphorically described this technique to be "*in the manner of the mythical phoenix grasping a letter in its mouth*".

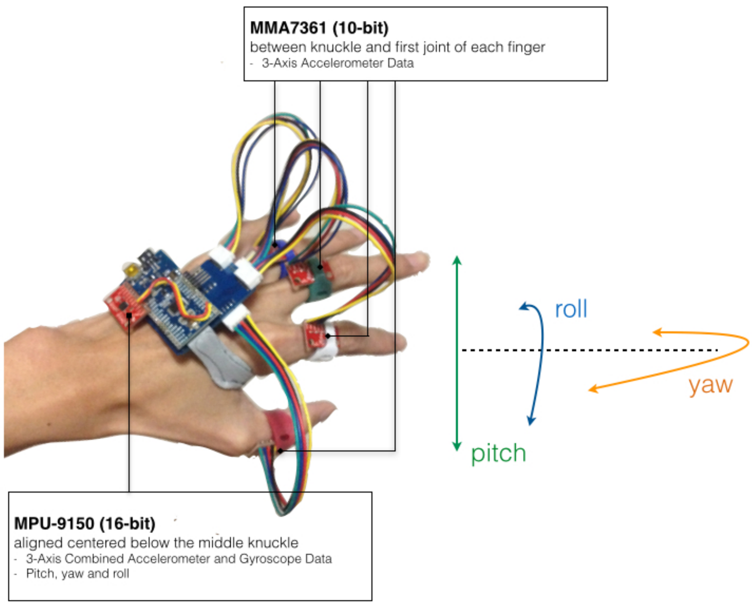
Inspired by the representative methods mentioned, Sonic Evocations marks the preliminary study of digitizing Guqin hand gestures. The piece presents the performance application of using digitized Guqin gestures for real-time interaction with other media.

2. PERFORMANCE SYSTEM

The system utilizes ubiquitous sensor technology to extract Guqin performance techniques. Due to the nature of these performance techniques, the Guqin player needs to directly touch the instrument. As such, glove-based controllers similar to Michael Waisvisz's *The Hand* (Waisyisz, 1985), are unsuitable for this application. The hardware used to capture the hand gestures is a custom version of *Kontrol* (Christopher, He, Kapur, & Kapur, 2013). *Kontrol for Guqin* senses the movement of each finger with independent accelerometers, similar to AcceleGlove that is used to interface sign language with the computer (Hernandez-Rebollar, Kyriakopoulos, & Lindeman, 2002). Fig. 2 shows the position of these sensors on the left hand and the data extracted with their respective resolutions.

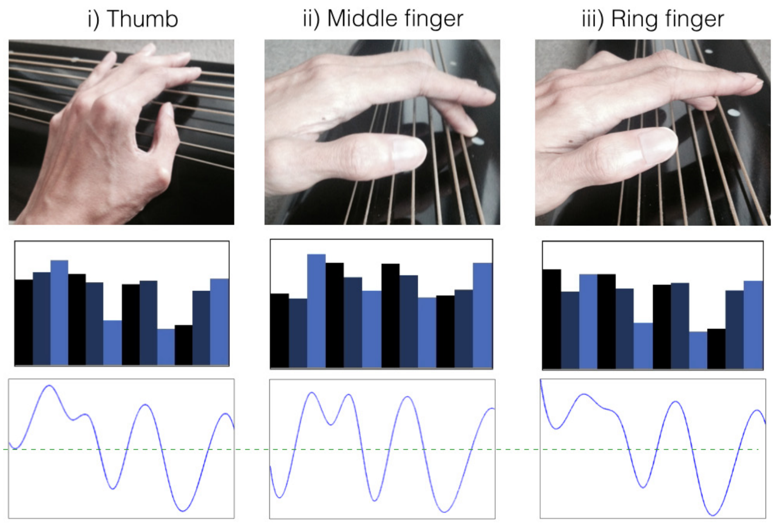
Fig. 1 A hand gesture illustration for *An from Xin Kan Tai Yin Da Quan Ji*. (Zha 2010)

Fig. 2 *Kontrol for Guqin* on left hand



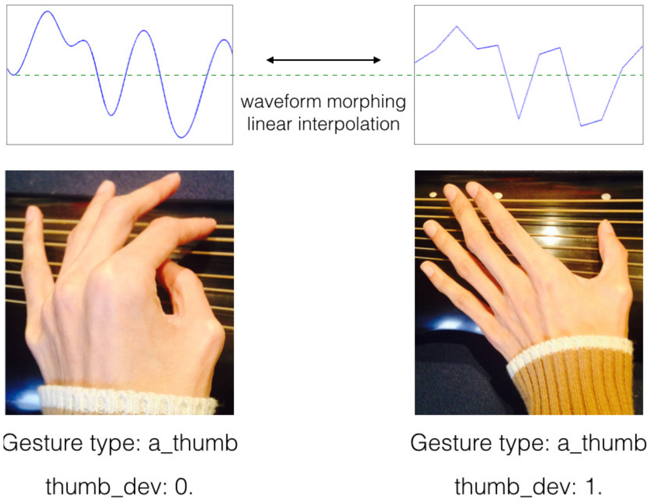
Three most commonly used performance gestures of the left hand are chosen - the different types of *an* (stopped, or pressed) that utilize the left thumb, left middle finger, or left ring finger. The shape of the accelerometer data for different hand gestures is used to generate a wavetable (Fig. 3).

Fig. 3 Three most commonly used



Using *Wekinator* (Fiebrink & Cook, 2010) for machine learning, each gesture is described with two parameters. The first parameter determines the type of gesture the current input is likely to be, denoted by *gesture_finger*. The second parameter, *finger_dev*, describes its deviation from its static state as illustrated in Fig. 4. *Gesture_finger* is used to trigger audio effects, while its corresponding *finger_dev* is used to control modulation parameters such as LFO speed, waveform morphing and delay time.

Fig. 4 An example a gesture describe using parameters.



3. CONCLUSION

The realization process of this work demonstrates how literal the descriptions are shown in the extracted gesture data, whether the ancient masters who authored these tablatures intended so or not. It is also observed that *finger_dev* describes whether the left hand articulation functions as a prefix to the actuation of a string by the right hand or suffix as subsequent ornamentation to the preceding gestures. It also elicits the rhythmic patterns in the *nao* and *yin* techniques, which are usually not explicitly stated in the bounded tablatures.

4. MEDIA ASSETS

Fig. 5 demonstrates the recognition system in a natural performing environment.

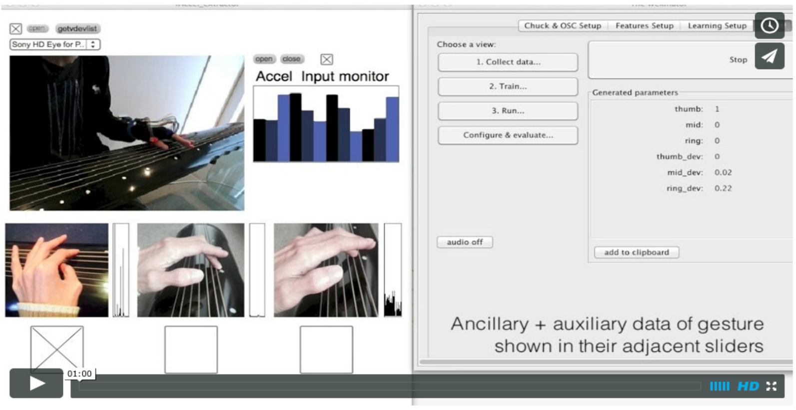


Fig. 5 Guqin Hand Gesture Recognition N° 1 (*http://vimeo.com/90441379*)

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TACTICAL TEMPORALITIES: A LIVE CODING PERFORMANCE

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Keywords: Music, Perfomance, Live Coding

***Tactical Temporalities* is a semi-improvised live coding performance that manipulates algorithmic descriptions of musical processes in the context of an Algorave setting. The work employs algorithms developed through research into musically salient computational processes and insights from studies in music perception. These are combined into a interactive performance that manages the dance of agency between the human musician and semi-autonomous computational systems. Stylistically, Tactical Temporalities is metrically regular, harmonically diatonic and utilises electronic and sampled timbral elements typically of those employed in electronic dance music.**

1. INTRODUCTION

The live coding performance of *Tactical Temporalities* is a study in minimalist rhythmical structures. The work is a semi-improvised musical performance that is a practical outcome of research into musical structures and their succinct description as computational algorithms. The work focuses on subtle shifts in musical texture designed to induce an engaging but largely uninterrupted flow of attention underscored by a consistent trance-like pulse that affords "dancability" in the Algorave context. Elements available for modulation and variation by the performer include sound timbre, rhythmic complexity, melodic contour, harmonic stability, textural density and more. As is typical with a livecoding performance the music is described and managed as a textual representation in a general-purpose computer programming language which is projected for the audience to see, as shown in figure 1.

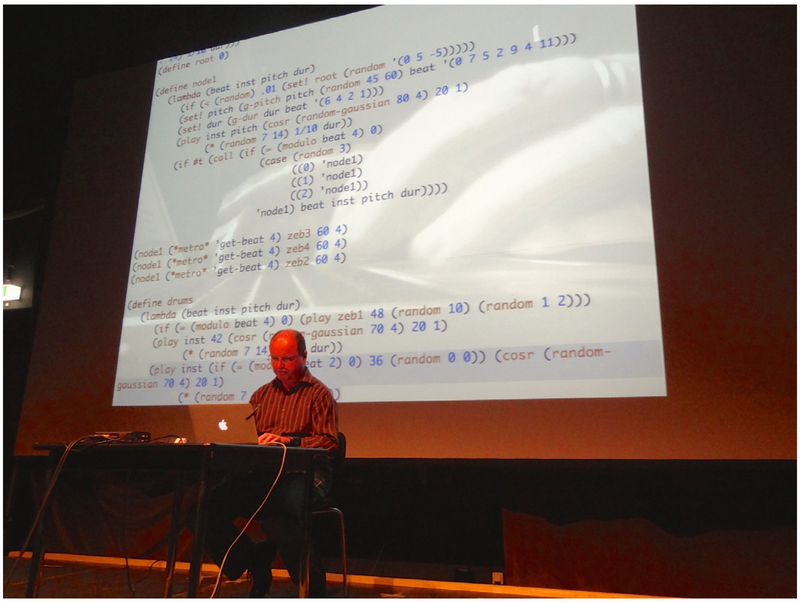

Fig. 1 The author performing at the Live Code Festival in Karlsruhe in

2. PSYCHOLOGICALLY INSPIRED TECHNIQUES

The algorithmic music practices explored in this live coding performance include techniques that can be concisely implementable and are open to improvised modification (Brown and Sorensen 2009). Many of these techniques are psychology-inspired (Brown, Gifford and Davidson, in press) and seek to expose musically salient parameters to facilitate control during live performance. The practical constraints of live performance act as a filter on the types and complexity of the musical and psychological theories that can be applied. Indeed many of the individual techniques are simplistic, however in keeping with the Gestalt psychology perspective, the performance hopes to demonstrate that their use in combination amounts to more than their sum.

3. RHYTHMIC EXPECTATION

Music is often pulse-based and Western music theory highlights that durations are generally simple multiples or divisors of this pulse. In music psychology the phenomenon of pulse, and durations that are simple ratios of pulse, have been demonstrated to exist outside of any cultural music context by various “tapping” tests (e.g., Fraise 1984). This performance leverages these simple mathematical properties of musical rhythm to create and vary onset and durational characteristics of musical parts. In particular much is made of what Justin London (2004:18) describes as the “temporal perspective model", developed by Mari Jones. In the terminology of this model a temporal pulse serves as the referent time period that "anchors" our temporal attention. Subdivision and larger groupings of the referent period are perceived as such. Conforming to, or deviating from, this model allows for the managing of varying degrees of rhythmical coordination. This performance explores algorithms based on this model and focuses on use of regular metrical organisation with variations in syncopation and hypermetrical structures as are typical in electronic dance music styles appropriate for the Algorave context.

4. PITCH AND HARMONIC ORGANISATION

The performance stays largely within the tradition of symbolic music making in a Western tonal and metric setting. As such it is concerned with pitched material in a diatonic context. The performance draws on techniques for generating pitch and harmonic material that have been inspired by theories of pitch class set theory and music perception, in particular on theories of proximity, goal seeking, good continuation, context sensitivity, and closure (Brown, Gifford and Davidson, in press). These principles are applied to the generation of melodic contour, harmonic language and progressions, and phrase endings.

5. PERFORMATIVITY AND AGENCY

Live Coding performances challenge our understanding of creative agency – the opportunities and responsibilities for decisions and actions in creative activities – which is reshaped by the live coding relationship with the computer where creative control is shared with a semi–autonomous computer system. In Live Coding performance the degree of agency handed over to the computer is managed by the performer but is constrained by the need to have the computer continually produce sound that allows the performer to generate new, and manipulate existing, algorithmic structures. This interactive relationship with the computer is differentiated from those typical of acoustic instrumental performance, where the "material agency" of the technology is usually fixed prior to performance. The Live Coding context allows the performer to experiment with what Pickering refers to as the "dance of agency" and is a example of emerging digital arts practices that explore what Picking suggests is a fundamental aspect of the human condition; that we "as human agents, manoeuvre in a field of material agency, constructing machines that… variously capture, seduce, download, recruit, enroll or materialize that agency, taming and domesticating it, putting it at our service, often in the accomplishment of tasks that are simply beyond the naked human minds and bodies, individually or collectively" (Pickering 1995: 11–12).

6. CONCLUSION

The performance of Tactical Temporalities is part of an ongoing research process that explores live coding as artistic expression. In particular the constraints of an improvised and performative context bring into focus questions of representation, expression and interaction. The practicality of solutions to these issues, particularly those derived from theories of music perception, are explored through and demonstrated by this performance.

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CHROMOPHORE

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Keywords: Audio-Visual, Visual Music, Field-Recordings, VVVV, Generative, Multimodal, Performance, Real-Time, Geometric, Chromophore

Chromophore is an audio-visual performance work that applies bi-directional communication between audio and visual systems, in real-time, to create colour-shape-sound modalities. Its visual system is formed using transformations and deformations of three-dimensional geometric primitives, super-ellipses and spherical harmonics. The dynamic surface textures of these transforming primitives are informed by data derived from audio analysis. Additionally performative MIDI control allows precise structural modulations and surface perturbations of the visual system to be further synchronised to sound.

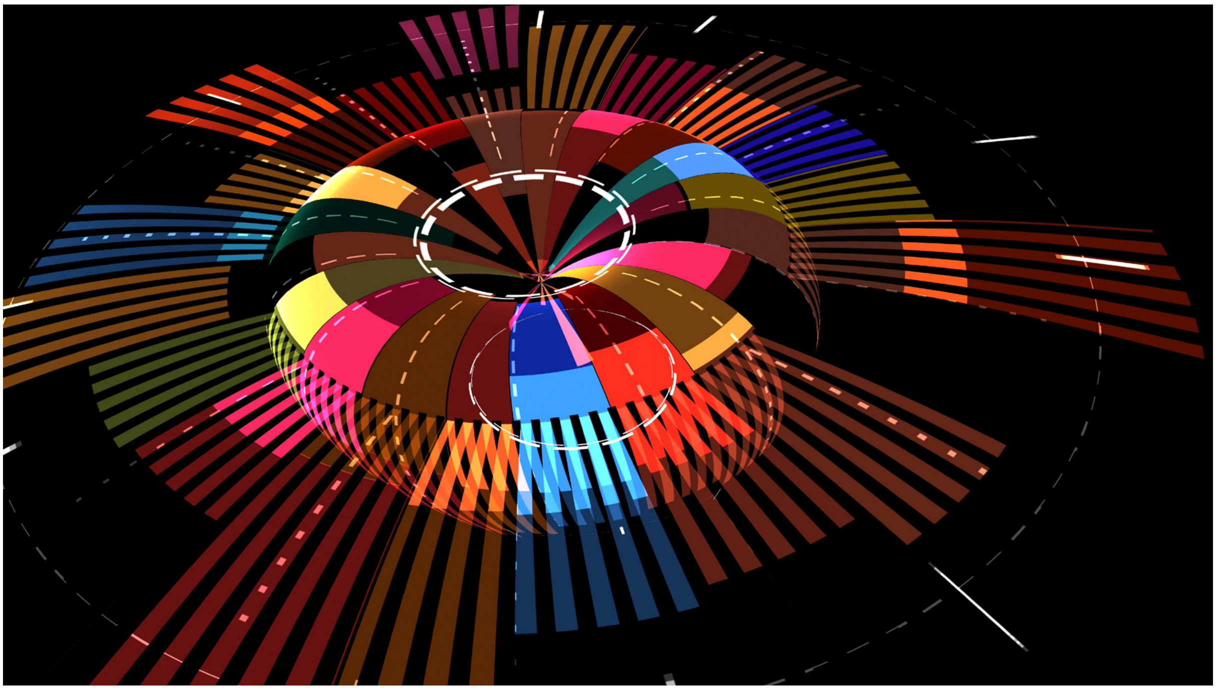
1. CHROMOPHORE – AN AUDIOVISUAL PERFOMANCE OF COLOUR-SHAPE SOUND SYNERGIES

Chromophore uses the patch-programmable video synthesis tool-kit VVVV alongside the digital audio workstation Ableton Live to generate precise synergies between audio and visual material within a live performative context. All sound design, synthesis and sonic composition was realised using a wide range of field recordings and found sound as base material. Various techniques are used to transform sound into visual material and vice-versa. These include audio-visual domain mapping strategies using algorithmic sound analysis techniques as well MIDI/OSC audio time-line data transmission for bi-directional communications between audio and visual domains. Real-time performative control of Chromophore, using external (MIDI) controllers and keyboards, allows the triggering of associative, symbolic and metaphorical bindings as well as lyrical inter-modal analogies.

Important considerations in the creation of Chromophore were as follows:

- Relationships and isomorphisms of three-dimensional architectural forms to sound spatialisation and stereoscopy.
- Textural surface modulations and synergies that correspond to melodic, harmonic or rhythmic designs.
- Contrapuntal audio motifs as a dynamic apparatus for movement and transformation of form.
- Use of polyrythmic sound sequences for localised acoustic architectural developments.
- The role of perceptual aspects of light and sound such as blend modes in conjunction with pulsing artefacts combined with rhythmic motifs leading to quasi-hypnotic influences on the audience.
- Associative and symbolic bindings between visual and audio signifiers and motifs.
- Expressive and dynamic parameter mapping as opposed to closed static mapping systems to avoid mechanical translations between domains and avoid literal, and predictable, translations.

Fig. 1 Chromophore (Still screenshot)



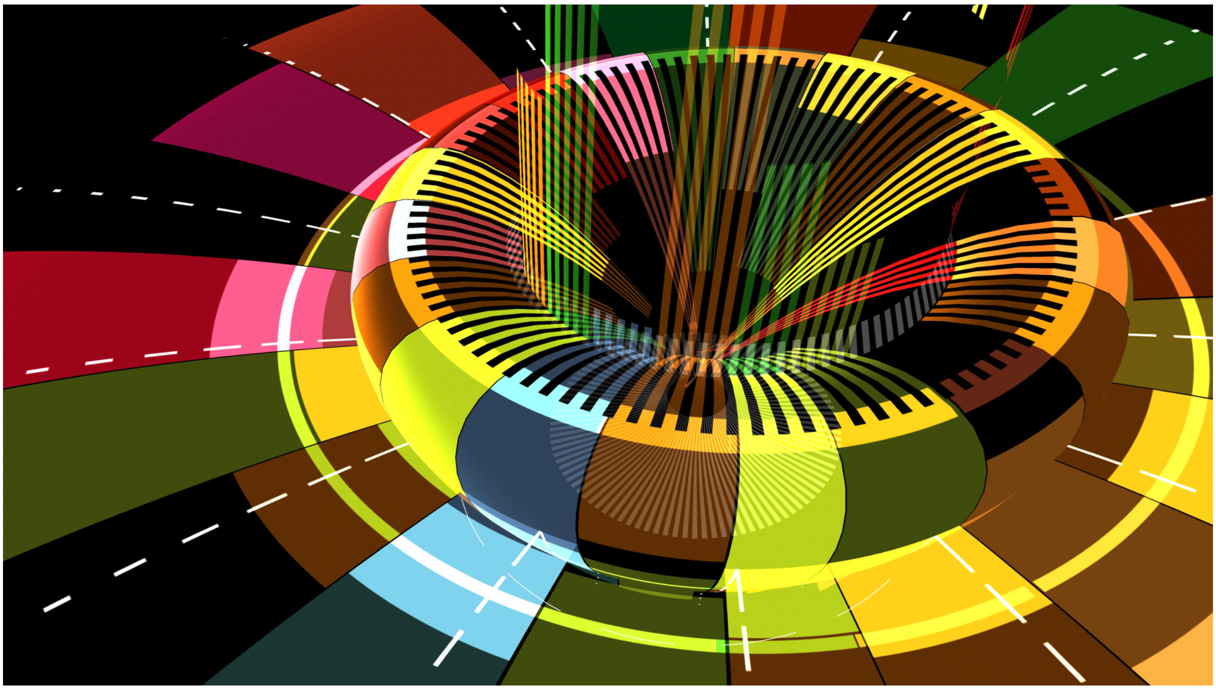


Fig. 2 Chromophore (Still screenshot).

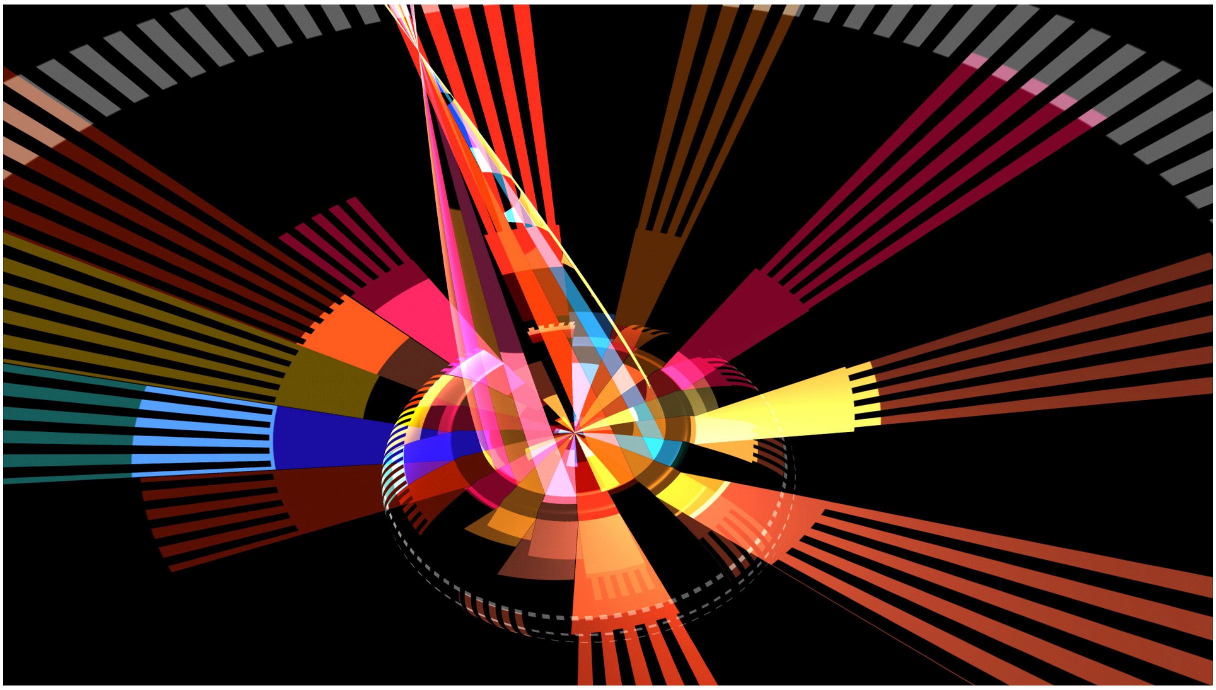


Fig. 3 Chromophore (Still screenshot).

2. PROCESS: ACOUSMATIC SCRYING & IMAGINED NARRATIVES

While many synchronised audio-visual performance works are created by composing sound to pre-made visual material sequences, or conversely by authoring a generative visual system to work with a completed audio composition, Chromophore was created by developing audio and visual materials in synchronisation from the outset. Moving back and forth between between domains using a strict sequential process provided a feedback loop, and dialectical relationship, between sonic and visual domains allowing compositional decisions to be made based on aesthetic and narrative syncretic qualities. The initial task was to gather a library of field recordings based on industrial and postindustrial acoustic ecologies. Recordings were made of the industrial and technological landscape – the ambient noise of construction sites, waste materials and broken mechanisms. There was also a focus on the recording of technological noise with emphasis on the quasi-musicality of electronic machines, computer and data transfer systems. At a later date these field recordings were listened to, often several layered simultaneously, without reference to their original source. This form of veiled listening allowed the recordings to insinuate new associations, metaphors and narratives dissociated from their original material and locative contexts. These insinuations were logged in note form as lists of visual events – the result being an acousmatic sound scrying exercise that enables the triggering of a set of imaginary narratives and poetic speculations. These noted fictions, conjectures and narratives then formed a storyboard for the creation of visual sketches programmed in the video synthesis tool-kit VVVV. Dense parametrized visual sketches, which contain movements, behaviours, triggers, based on the storyboard were then output to a fixed media video file for reference. Then follows a form of sonically veiled viewing of the video without reference to the original sound triggers with the aim of composing a soundtrack to the video in order to build a sound object library for the final performance work. This latter process I refer to as a form of visual scrying for sonic objects, with the aim generating a sonic palette combining field recordings and synthesized sounds. In this sense the generative video document acts as an animated score, creating interesting constraints on the audio composition process. These constraints drive the selection of specific sound objects for the final performance artwork often confounding expectations, creating dynamic ambiguities between modalities and enabling new electro-acoustic sound-video relationships. An important part of the creative and compositional process throughout is in the processing of both modalities, sound and video, divorced from one another. Perceived alone they can be checked for narrative cohesion, and then recombined to create the final audio-visual performance artwork where external MIDI control can effect spatial dynamics and narratives of the generative system.

XENOGLOSSIA/LEISHMANIA

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Keywords: Improvisation, Intermedia, Generative Systems, Audio Analysis, Realtime Systems

Xenoglossia/Leishmania **is a structured audio-visual improvisation, utilizing live electronics and interactive animations. The musical and visual performances are highly interdependent, guided together through the actions of the performers, automated real-time analysis of the audio, and the exchange of networked messages between the audio and animation systems.**

1. XENOGLOSSIA / LEISHMANIA

- audiovisual improvisation structured through software and network implementations
- audio and video display both independence/autonomy and interdependence/coordination
- Xenoglossia: generative audio system
- Leishmania: interactive particle/cell animation system

2. GENERATIVE STRATEGIES FOR XENOGLOSSIA AUDIO

- layering
  - six parallel audio channels which can run independently or be (partially/totally) coordinated
- behavioral variety
  - eighteen strategies for generating rhythmic values
  - eleven strategies for generating synthesis/signal processing parameter values
  - one governing rhythmic strategy and one governing parametric strategy at a time per channel
  - most strategies are implemented using state machines

- directionality
  - most rhythm/parameter generation behaviors are designed to produce clear trajectories
  - various forms of linear/gradual transition
  - accelerando/decelerando
  - focussing in on a specific parameter or set of parameters
- polyrhythm
  - independently generated rhythmic values for each synthesis/signal processing module
- performer activity emphasizes evolutionary behavior/high-level control
  - stochastic/autonomous generation of low-level parameters/detail
  - three primary roles for the performer
    - intervene in rhythmic, parametric, and sonic behavior for each audio channel when needed
    - clone and reproduce the behavior of interesting sonorities and textures,
    - generate contrast, variation, and synchronization between processes (for large-scale form)

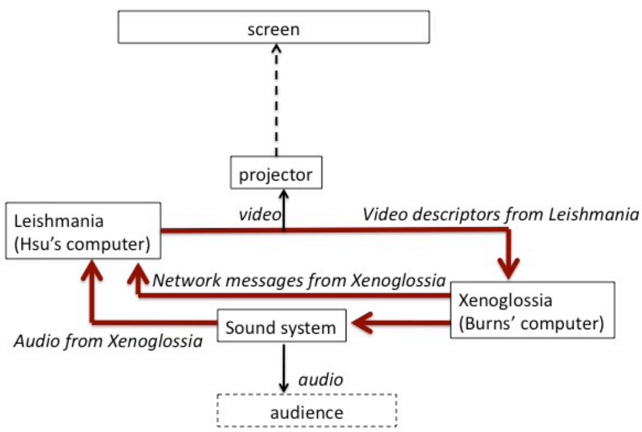


Fig. 1 Stage setup and signal flow for Xenoglossia / Leishmania

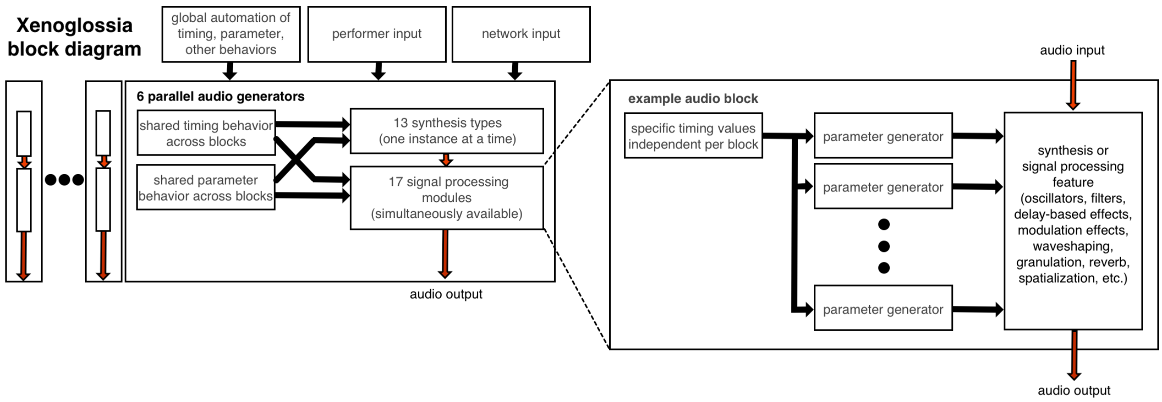
3. GENERATIVE APPROACH FOR LEISHMANIA ANIMATION:

- colonies of single-cell organisms in fluid substrate
- each cell-like component has hidden connections to other components
- colonies evolve in structure and "swim" through substrate
- flows in substrate may be:
  - controlled by gestural input
  - influenced by random or generative processes,

depending on current distribution of cells

- flows may:
  - resolve into stable patterns (for example, cycles)
  - disperse into chaos

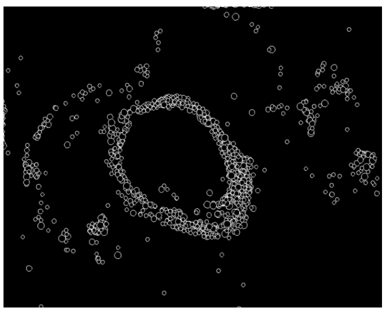
Fig. 2 Block diagram for Xenoglossia



4. NETWORKING / INTEROPERATION OF THE TWO SYSTEMS

- Leishmania audio analysis:
  - tempo
  - spectral features
- Leishmania -> Xenoglossia networking
  - Leishmania performer actions (“stir”, “scatter”, “faster”, “slower”) affect evolution parameters
  - Leishmania behavior modes (“blobRing”, “spiral”) change rhythmic behaviors
- Xenoglossia -> Leishmania networking
  - indication of large-scale contrast
  - initiation of “lock mode” parametric feature (sustained use of single values)
- coordination between performers

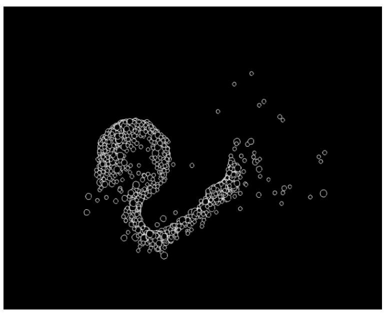
Fig. 3 Screenshot 1 from Leishmania



5. AESTHETIC IMPLICATIONS OF THE WORK

- complexity, richness, detail
- restricted palette of textures (sounds and shapes) and behaviors
- mixture of coordination and independence within and across visual and auditory domains
- genuine sense of improvisation within and between generative systems

Fig. 4 Screenshot 2 from Leishmania



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QUASICRYSTAL SOUND FIELD 1 APERIODIC ORDER AND NON-LOCAL HARMONY OF MATHEMATICAL QUASICRYSTALS: AN INTERACTIVE SOUND INSTALLATION AND CONCERT

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Keywords: Mathematical Quasicrystals, Sound Art, Aperiodic Order

Quasicrystal Sound Field 1 is a live sound-art installation based on a new formulation of mathematical quasicrystals first published in 2009 by Grundland, Patera, Masakova and Dodgson. Quasicrystals are characterized by Aperiodic order. A structure with rotational symmetry but no translational symmetries. The particular algorithm, called the Quasicrystal Phase Function, is proposed for image sampling, but offers as well interesting possibilities for sound synthesis. This sound-work is a first example of bringing the algorithm as waveforms out in the open air.

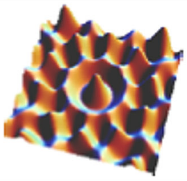
1. INTRODUCTION

Quasicrystals is a research topic of contemporary mathematics. Keywords to mention are: the Penrose tiling, aperiodic order, substitution sequences and substitution sets. The cut-and-project-method which is about projecting higher dimensional lattice points into lower dimensional spaces using an irrational "slope" and a window. In the early eighties there were groundbreaking discoveries within crystallography and electron microscopy when rotational symmetries of hitherto unseen order were seen in metallic alloys (Senechal 1996). This has interwoven the physical and the mathematical interests for the quasicrystals. Further it must be mentioned that islamic art has created such patterns since medieval times.

2. THE QUASICRYSTAL PHASE FUNCTION

This sound-work is exclusively based on the expression of the Quasicrystal Phase Function formulated in 'Image Sampling with Quasicrystals' (Grundland *et al*. 2009) The authors employ the root lattice of the non-crystallographic Coxerter group H2. I suggest to refer to the publication for the background. Figure 1 shows an excerpt from the publication giving the expression for the function f(z). The Quasicrystal Phase Function is in the publication proposed for image sampling, but it can naturally be explored for sound synthesis. The 10-term sum of complex exponentials can be rewritten as trigonometric functions, enabling fabulous cancellations. and one can arrive to the following expression which is easily programmable:

Fig. 1 The Quasicrystal Phase Function, excerpt from 'Image Sampling with Quasicrystals'



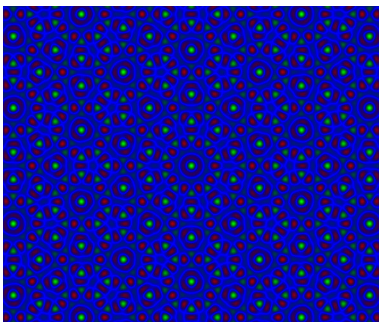
Quasicrystal phase function: $f(z) = \sum_{j=0}^{9} \exp\left(2\pi i(\zeta^j)\cdot(2\tau^4 z)\right)$ defined for regular decagon vertices $\zeta^j = \exp\left(\frac{2\pi i}{10} j\right)$ and golden ratio $\tau = \frac{1}{2}(1+\sqrt{5})$ with dot product $u \cdot v = \frac{1}{2}(u\overline{v} + \overline{u}v)$ and complex conjugate $\overline{u_1 + u_2 i} = u_1 - u_2 i$.

f(z) = 2*cos(k*x)+4*cos(k*x*cos(pi/5))*cos(k*y*sin(pi/5))+4*cos(k*x*cos(2pi/5))*cos(k*y*sin(2pi/5))

where z=x+iy and k=2pi*(7+3*sqrt(5))

All imaginary terms have cancelled and f(z) is a continuous function from the complex plane to the real numbers. It can be visualized in 3 dimensions or every point in the plane can be mapped to a color as in figure 2.

Fig. 2 . f(z) : -1 to 1 and -i to i, red is minimum (-10), blue is 0 and green is maximum (10)



3. QUASICRYSTAL SOUND FIELD 1

The Quasicrystal Phase Function is the core of all structures and synthesis giving form to this sound work.It creates the movement of this work on all levels from sample-rate level perceived as tone and spectrum to time-structures perceived as rhythm and dynamics. After the first period of exploration I found that the function gave fine and richly varied outputs for movements in simple straight lines through the plane. As such it is dependent of an angle and a speed through the plane. The 10-fold rotational symmetry can easily be heard.

(e.g theta radians sounds alike (theta+n*pi/5) radians where n=1,2,3... and theta is any angle) Further for the sound mapping one must naturally consider a framework for scaling and speed so that artifacts due to aliasing are avoided. In the references there is a link for a basic sound mapping of a single Quasicrystal Phase Function written in the sound programming language ChucK. For the realization of the "Quasicrystal Sound Field 1" I have more that 20 functions running simultaneously as I found that the harmonies arising from the interferences between these were a rich and unexplored vast terrain.

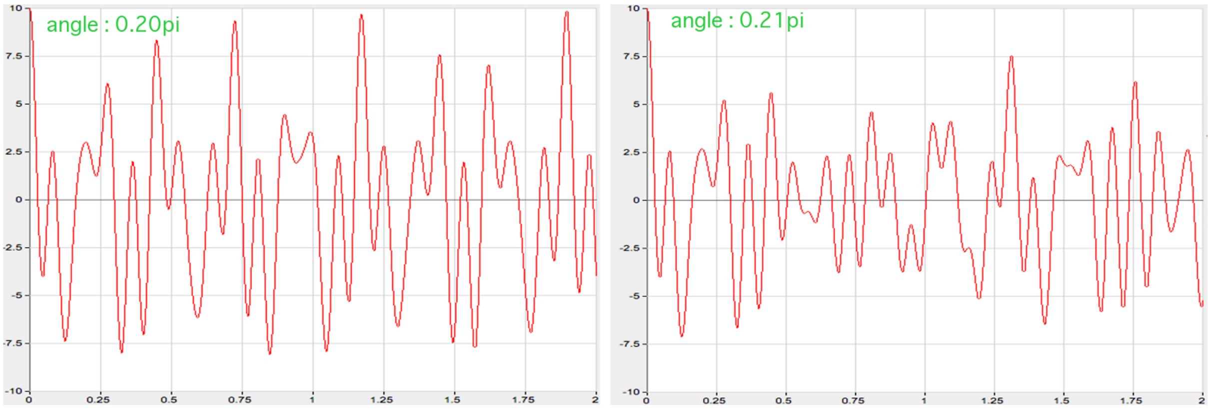


Fig. 3 f(z) along a line of length 2 from 0 at two different angles with 0.01pi radians difference.

4. REALIZATION

"Quasicrystal Sound Field 1" can be realized as a concert for live musicians and electronics or an installation which is interactive with the sound produced by the visitor and any background sound exceeding a tunable threshold. This threshold is set so that the installation does not interact with itself. It is not "loud" – it remains comfortably under acoustic level. The computer-generated sound is mapped to 1–5 speakers. The sound-space is monitored by 6 microphones which are mounted in a half circle – pointing outwards with pi/5 between each direction – and as such mirroring the internal 10-fold rotational symmetry of f(z).

From the input of each microphone the energy is calculated over a suitable window. Between each microphone and its nearest neighbor a vector is calculated from the two energy-calculations when the energy of the incoming sound exceeds the tunable threshold in that particular direction. In total there are 5 vectors in play between the 6 microphones. Each vector sets the angle and the speed through the complex plane of a synthesis unit based on the f(z). In total 5 synthesis units are running independently. Inside each of the 5 synthesis units several incidents of the f(z) are running at sample rate. Each incident with the same angle determined by the control vector. The speed values of the different incidents of f(z) are scaled with powers of the golden ratio. ((1+sqrt(5))/2) From negative powers down to –30 (~0.00000053779543) to positive powers around 10 (~122.968619026332). With these incidents of f(z) signal output, phase modulation, modulation depth and output envelope are controlled.

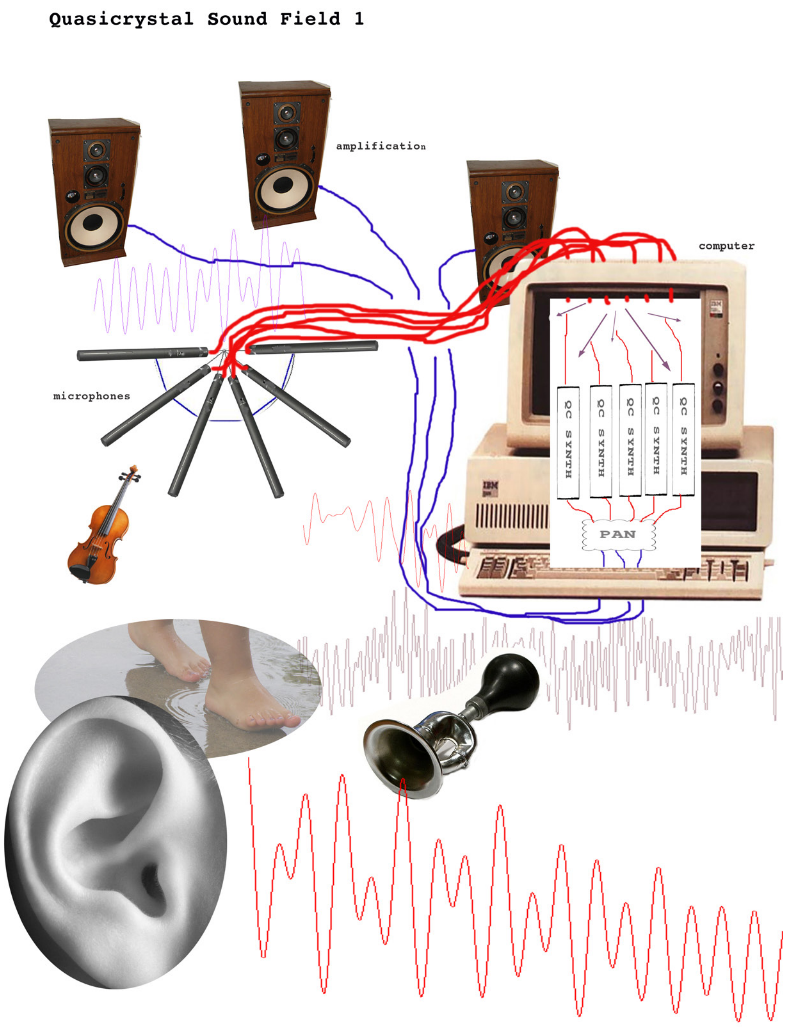


Fig. 4 Quasicrystal Sound Field 1

5. ACOUSTIC REALITY

It must be said that the current version of the installation is not at all realized with a precision conforming to a scientific experiment – it falls into the category of art for sure – Still it has become my impression that the installation functions as an extension of the real acoustic space and is sensed intuitively by the musician while playing therein. A synergy of material, space, sound and computation through the perception of the performer. In this installation the exploration of the possible harmonies between the 5 synthesis units are done automatically in a sense. Without conscious control of the composition. The interaction happens on a faster intuitive level. In future sound work on the mathematical quasicrystals such compositional choices might very well be actuated otherwise. And possibly include new ways of thinking about spectral interaction.

Certainly this algorithm opens up for new sound and rhythmical structures. One could call it vast sound-surfaces of aperiodic order. The name of the current project – Quasicrystal Sound Field 1 – is given for the reason that I already have several other setups in mind for the future involving quasicrystal algorithms. This rather simple setup for version one, has proved itself worth exploring for a while though, before rushing further for the next.

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link to ChucK code for a sound mapping of the Quasicrystal Phase Function http://antidelusionmechanism.org/chuckCode.html#QCphF

CONTRIBUTIONS FOR A MORE AWARE CITIZENSHIP — A STUDY DEDICATED TO THE DESIGN OF TOOLS TO READ AND ANALYSE POLITICAL INFORMATION ONLINE

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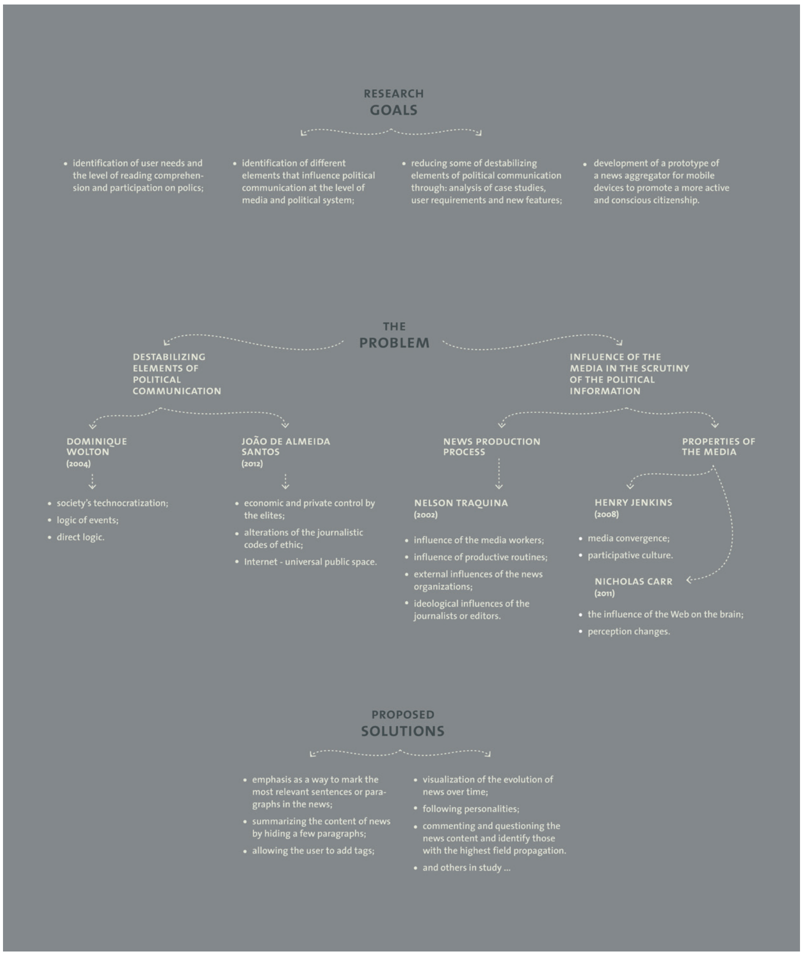
Keywords: Interaction Design, Design, News, Web, Politics, Social Media

This poster presents the problems that led to the development of a news aggregator that allows users to explore the political information distributed by the media. Through the study of techniques for Natural Language Processing, interaction design, information visualization and the analysis of case studies, the research presents the first ideas prototyping features to implement in the aggregator. The ongoing research within the Doctorate in Design, at the Universities of Aveiro and Porto, aims to bring citizens closer to and more interested in political matters.

2014.xCoAx.ORG PORTO, PORTUGAL COMPUTATION, COMUNICATION, AESTHETICS AND X

This study focuses on the difficulties presented by the destabilizing elements that political communication and media properties create in the transmission of information, in order to assert the needs in the design of tools that help citizens to become more aware of these issues. As a practical project, the research proposes the design of a news aggregator that offers a set of features capable of reducing the power of these influences while making the users more active and interested in political affairs. In addition to the identification of the problems, the research will also present some of the features identified in case studies as possible solutions for noise reduction, distortion and information concealment.



While still in an initial stage of the development of the practical project, we propose a series of possible solutions, resulting from the analysis of case studies. These functionalities were considered possible solutions, capable of being adapted and implemented in a news aggregator and emerged from different media and projects, such as mobile applications, Web, interactive manuals and projects of information visualization. These functionalities demonstrated that the following ideas and functions may turn an aggregator in a tool capable of reducing some of the problems here identified.

The media play an important role in the development of a common conscience. However, there are influences that hinder the communication process of political information and yet others that interfere with the ability of the citizens to scrutinize that information. It is fundamental to develop tools that reduce the capacity of these destabilizing elements and promote the interest of the citizens for these matters.

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TIMEMACHINE

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Keywords: Ambient Computing, Context-Aware Computing, Data Visualisation, Location-Based Computing, Mobile Devices, Media Art, Temporality

TimeMachine is a mobile phone application which aims to capture the elasticity of time experienced in everyday life and translate it into a meaningful image. The practical goal of the project was to devise a computational system to infer personal temporal relations, and create a visual interface to evoke an understanding of the experience of temporality for its user. The challenge was to concretise our views on the ambiguity of quotidian events – time-based occurrences at the intersection of space and time – and to express them as a piece of freeware people could use to transform the reality of lived experience into a visual form.

1. INTRODUCTION

TimeMachine is an Android application which aims to capture the elasticity of time experienced in everyday life, and translate it into a meaningful image. It asks the question ‘Why do some days feel longer than others?’.

2. SYSTEM

Designed to measure oneself against oneself, the project deploys a self-referential system to emphasise the co-dependent relation of user and experience. It assumes that despite their significant differences in human perception, space and time are indissociable, and that context and activity are inseparable – places to which one has never been simply don’t exist. The only external cultural assumption it makes is that the place where users spend more time is “home”. TimeMachine tracks one’s individual GPS coordinates with a timestamp, and continually processes this data to infer their spatio-temporal patterns, in realtime. Personal habits are created over time and only correlated to those collective norms that cannot be controlled by humans (length of day). One’s unique temporal pattern is built from zero and trained by repetition over time, and while this *template* undergoes changes, it maintains enough self-identity to plot differences in relation to it.

An individual temporal pattern is an entity defined by two asymmetric axes: one which distinguishes whether the user is in, or outside, their normal routine, the other reflects one’s current activity rate, the acceleration and deceleration of the number of places visited. A temporal pattern is the result of constant interactions between the difference in one’s routine and rate of activity. The system is designed to measure deviation from the norm and express novelty. For instance, sitting at home watching TV, for someone who spends their life flying around the world, would be an extraordinary event, and clearly outside their pattern. To answer the question “Why do some days feel longer than others?”, TimeMachine proposes that changes in the temporal dimension of each day, its intensity, the perception of its expansion or contraction, depends upon the relations between events, the differences in one’s individual time pattern.

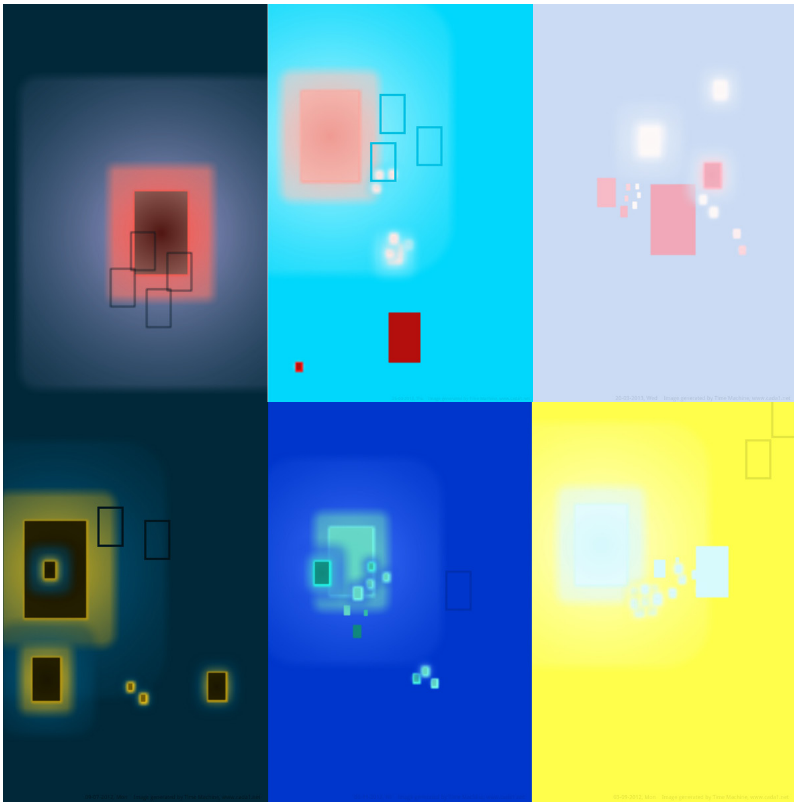

Fig. 1 TimeMachine examples of visual output. Extended visual system description and more images *http://www.cada1.net/TimeMachine_Applica-*

3. VISUAL INTERFACE

The aim of the visual interface is to present a productive model of difference. It attempts to visualise relationships between events through an experiential graphical display capable of being read while simultaneously asking for interpretation. It uses the metaphor of light and exploits the ambiguity of colour to give each day and singular events a chromatic tonal value.

The *background* colour is a combined value for each day, correlating both axes. Singular events – temporal relations associated with geolocations, places – only describe their distance from the routine axis. An event's position on the screen does not relate to its geophysical location. Thus, in this event-based network, showing clusters of difference to routine, the ground-figure relationship is much more interconnected and nuanced than is perhaps first apparent: distance from routine marks each event, and their sum also feeds the *background*. Displayed events form a temporal pattern, based on distance from routine, grouped when similar, and divergent when dissimilar.

TimeMachine's visual interface translates personal temporal patterns into a visual form, and exploits colour as a quality which can be read and interpreted.

CONTACT: A CONCERT FOR INTERACTIVE SOUNDS IN THE HANDS OF THE AUDIENCE

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Keywords: Distributed, Interactive, Audio Devices, Remove, Live Coding

In the work *Contact*, the categories of performance device, loudspeaker system and compositional structure are jumbled and merged: the members of the audience are invited to be a part of the piece, and find themselves holding in their hands the loudspeaker system itself, which they can interact with via physical and digital affordances. A population of 10 "sound balls" is distributed amongst the performance space. Each ball contains a small WiFi-enabled computer, with loudspeaker and sensors (accelerometer and gyroscope). Following Bown *et al.* (2013), the balls can

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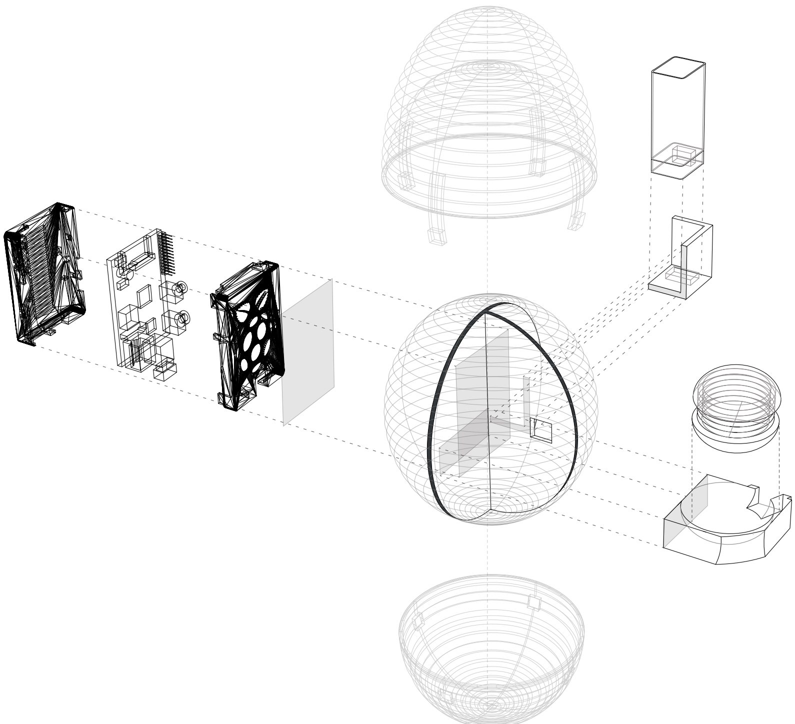
be 'live coded' from a host computer, running synchronised realtime generative audio software that incorporates the sensors' activity into the sonic behaviour. They are fully portable and interactive, and are encased in generatively designed, digitally fabricated "elastoplastic" shells by architects reinhardt_jung.

The work continues ongoing research into the use of physical computing technology to produce fully portable and adaptive sound systems and explore the affordances of this technology in how we experience sound in our environment. Although the phones in our pockets already provide the required technology – speaker, onboard computer, WiFi, sensors – the creation of dedicated devices introduces new design elements such as the creation of custom cases.



The piece provides a tactile-acoustic experience that renders musical performance in a way that directly involves the acoustic properties of the delivery system (Stuart, 2003). The small speakers are far from high-definition, but the music is composed with their resonant qualities in mind and the distributed sound produces a rich sonic effect. When presented in concert at the 2013 International Computer Music Conference (a piece composed by Oliver Bown and Miriama Young, Bown *et al*. 2013), they were hidden under the audience's seats. A number of attendees indicated afterwards that they had believed the sound was coming from the high-end 8 speaker PA installed in the venue. This is certainly not a sign of the quality of the speakers involved or of any advanced acoustic trickery, but an indication of how the shift of sound source from standard in-house PA to alternative devices can provide novel opportunities for surprise and enchantment. The composition can also utilise the vibrotactile potential of the speakers through contact with the body, and interactive gestures such as rolling or throwing can be used to produce further sonic effects such as Doppler shift.

Such affordances allow the work to extend game-based approaches to composition and performance, such as the work of artists like The Hub (Gresham-Lancaster, 1998), Nick Didkovsky (Didkovsky, 1992), Jon Rose (Rose, 2007) and John Zorn (Zorn, 2004). As with Jon Rose's experimental works, this involves the audience in the gameplay.

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FACELESS PATRONS – AN AUGMENTED ART INSTALLATION EXPLORING 419-FICTIONAL NARRATIVES

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Keywords: Overpayment Check Scam, Augmented Reality, Scambait

Scamming is a global phenomenon and victims can be found everywhere with no difference in gender, age or race. To persuade the victim into paying money up-front, the scammers create story worlds with *get rich quickly* schemes. The different narratives are situated in the grey area between reality and fiction (Hotz-Davies, 2011). These stories reflect the dystopian side of computer mediated communication where the Internet enables a world of false representations, abuse of trust, humiliation and desperation for opportunities.

1. MATERIAL

We want to take a closer look to the *overpayment check scam* that is still largely used although digital payment methods are a common practice. In this type of scam a scammer shows interest in a product offered online by contacting the auctioneer. Once the deal is closed the scammer sends a forged check to the victim. The check is issued for far more money than agreed and the scammer convinces the victim to immediately cash the check and after deducting the costs of the product wire the rest of the money back. The scammers are using a loophole that the check transfer system affords (Stabek, 2010). Normally wire transfers are done within a couple of minutes, whereas it can take up to several days for the bank to refuse to honor the check with the result that the victim loses the money and additionally can be charged for money laundering.

2. METHOD

The story takes the form of e-mail correspondence where two characters are involved; one art patron created by the scammers and our fictional artist *Anna Masquer*. The scammers posed identity is often based on either identity theft or a confusing mix of several existing individuals, giving them the opportunity to remain faceless and anonymous. Our character *Anna Masquer* represents an average contemporary artist in her late 30s. Her story is backed up by a virtual identity presenting herself and her artwork on a Wordpress blog and a Flickr channel (Masquer). The crucial point for the scammer is to convince the artist why the payment can only be delivered in the form of a check payment. In our example, a wealthy person interested in the arts wants to buy an artwork. Since he is busy with his professional job, he demands to pay by check. In an email sent to *Anna Masquer*, the patron *Mac Nuel* states:

Email excerpt

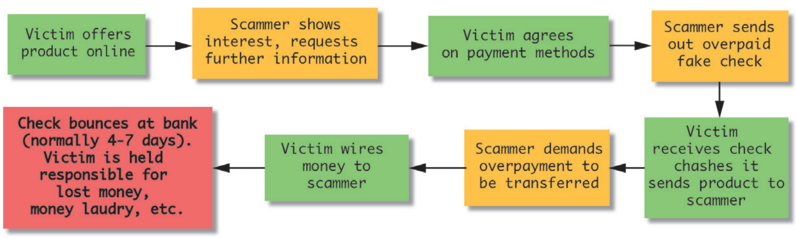
> *From: Marc Nuel*
> *To: Anna Masquer*
> *Subject: Re: Faceless*
> *I can only prepay the total amount of this gift product by cheque payment only. This is as a result of my deployment to the gulf of Mexico since we are presently engaged in a Deep-water project at our offshore location hence I am presently not in the UK and cannot make a bank transference from this location offshore.*

Tensions between the characters start to emerge when the check arrives. The scammers' character starts to put pressure on our victim to receive the advance payment before the check bounces and the plot is revealed. Our character Anna who is a victim in disguise aims to linger and keep the correspondence up as long as possible without transferring money back to the scammer. The received checks are considered a trophy (Zingerle, Kronman, 2010) and were reported to law enforcement.

The installation setup consists of five photo-frames hanging on a wall. Each frame connects to a correspondence with a scammer and holds a photograph and a fake check that was received as an advance payment for Anna Masquers' photos. By using a smartphone or a tablet the visitor can scan each photograph via a third party AR-browser. Each physical photograph is then overlaid with an AR layer containing a video compilation of images. These images are the result of an online search in an attempt to confirm or invalidate the authenticity of the scammer's character and his online representations. This search result tries to give a face to the faceless scammer, yet fails while the posed art buyer can be anyone or no one of the persons found within the search. Additionally to the images the video contains a voiceover narrating parts of the email correspondence, enabling the visitor to follow the whole narrative paths of the *overpayment check scam scheme*.

3. CONCLUSION AND DISCUSSION

- The art project uncovers overpayment check scams.
- By understanding the story structure, checks can efficiently be gathered and reported to law enforcement.
- The ongoing research on 419-fiction: testing various scambaiting methods to point out its info activist potential.



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XEPA – AUTONOMOUS INTELLIGENT LIGHT AND SOUND SCULPTURES THAT IMPROVISE GROUP PERFOMANCES

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Keywords: Generative Art, Computational Aesthetic Evaluation, Physical Computing, Sculpture, Sound Art

The live XEPA anticipates a future where machines form their own societies. Going beyond mere generative art, future machines will exhibit artistic creativity with the addition of artistic judgment via computational aesthetic evaluation.

The XEPA intelligent sculptures create animated light sequences and sound. Each XEPA "watches" the others and modifies its own aesthetic behavior to create a collaborative improvisational performance.

No coordination information or commands are used. Each XEPA independently evaluates the aesthetics of the other sculptures, infers a theme or mood being attempted, and then modifies its own aesthetics to better reinforce that theme. Each performance is unique and widely varied.

1. BACKGROUND

Artists exercise critical aesthetic judgment in all phases of their work. Aesthetic evaluation comes into play when studying other artists, while applying microdecisions while creating a piece, in learning from a newly created piece prior to beginning the next piece, and so on. It also comes into play when trying to categorize art as to genre or movement. And as especially applies in this work, the assignment of a certain feel or emotion to a given piece, or put another way the extraction of semantics from abstract aesthetics, is another kind of evaluation.

Over the years generative artists have created art using complex systems such as genetic algorithms, reaction diffusion systems, cellular automata, artificial life, deterministic chaos, fractals, and Lindenmayer systems. While these systems can offer a seemingly unending stream of visuals and sound, they typically do so without discrimination, and they lack any self-critical functionality.

Many writers such as Boden emphasize that novelty is a necessary but insufficient criteria for creativity. Creativity also carries with it the implication that the results are useful or otherwise of value. To fully qualify as creative artists computers will have to at least combine generative systems with computational aesthetic evaluation (Boden 2004).

Computational aesthetic evaluation (CAE) remains an unsolved problem. Only when computer-based systems are both generative and self-critical will they be worthy of consideration as being truly creative (Galanter 2012).

More generally, while a great deal of work has been done to produce all manner of man/machine interfaces, machine-to-machine interaction remains in the realm of brittle fine-grained protocols. Person-to-person interaction is, of course, different. It does not involve the direct connection of brain signals. Rather person A will observe the behavior of person B, infer their intent, anticipate their future actions, and then person A will adjust their own behavior. Note that in this context speech, for example, can be considered behavior and is obviously not direct neural transmission.

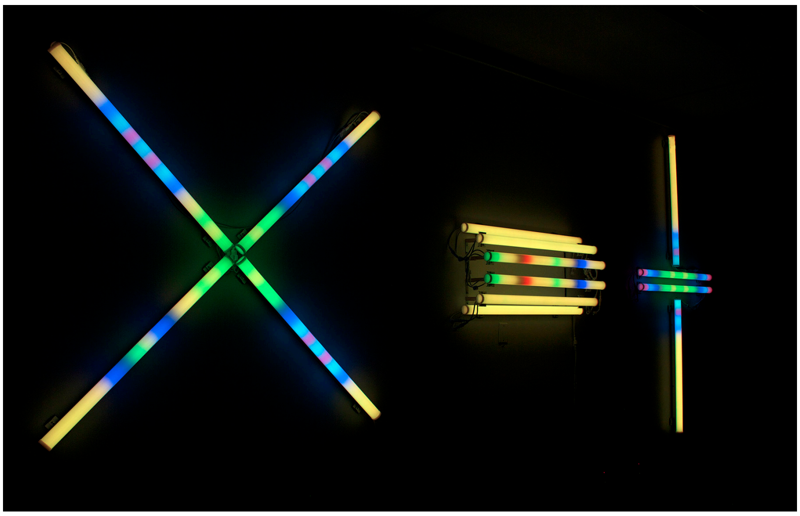


Fig. 1 Three XEPAs in alpha testing during software development

2. XEPA

XEPA is the name of both the art project and individual intelligent sculptures that display animated colored light and produce music and sound. XEPA is an acronym for "XEPA Emerging Performance Artist"; the performance is emergent; the "young" XEPAs are emerging artists (Galanter 2014).

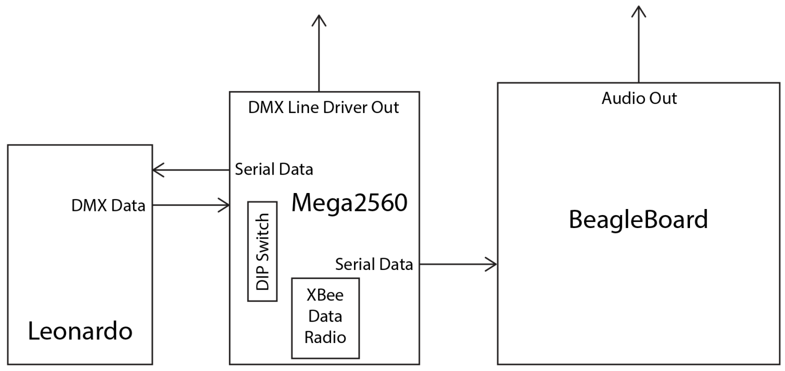


Fig. 2 The XEPA "Brain" interconnection design

Each XEPA "watches" the others (via data radio) and modifies its own aesthetic behavior to create a collaborative improvisational performance. In doing so each XEPA independently evaluates the aesthetics of the other sculptures, infers a theme or mood being attempted, and then modifies its own aesthetics to better reinforce that theme. Each performance is unique, and a wide variety of themes and moods can be explored.

It's important to note that while data radio is used, it is in principle the same as each XEPA watching the behavior of the others. The radio messages sent are merely descriptions of what that particular XEPA is doing at that particular time. No actions occur by command, and there is no script to follow.

While XEPA is fundamentally an artwork, it provides a robust platform for experiments in CAE. As suggested by human relations, XEPA A will evaluate XEPA B's aesthetics and then modify it's own behavior. While XEPA is not science per se, it can stimulate and contribute to a science of CAE by way of visceral and pragmatic example.

And since XEPAs, in principle, are interacting on the fuzzy level of observation and reaction, the artwork suggests and illustrates how future intelligent machines may form their own societies and cultures.

Fig. 3 Much generative art has a bias towards cool colors due to the use of an RGB color system (left). XEPA uses a variation of the more painterly RYB system (right)

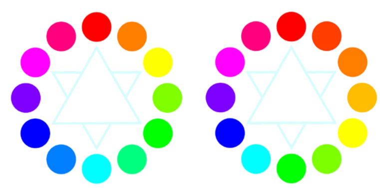
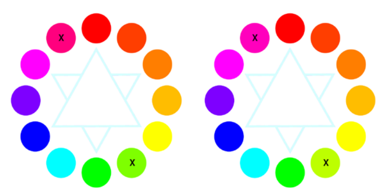


Fig. 4 XEPA adds corrections to the RYB system (left) to smooth the transition from cool to warm colors with the RYB Plus system (right)



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BABEL'S MONKEYS (2012)

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Keywords: Combinatorial Writing, Twitter, Processing, Genesis 11:1–9

Babel's Monkeys is an art work by Luís Sarmento Ferreira that consists on the cyclical rewriting of the biblical episode of The Tower of Babel (Genesis 11:1–9 – King James Version) using words from the real-time stream of Twitter public feeds. The work is presented on a wooden plinth with a built-in monitor on its top face. The object evokes both the shape of a pulpit or lectern and the one of a reading table with a book rack. This relates to the religious nature of the text being displayed in the monitor and to the influence of Jorge Luis Borges' *The Library of Babel* to this work.

1. ORIGINS

In The Library of Babel, a short story by Jorge Luis Borges, a library is imagined which consists of books containing all possible combinations of twenty-five symbols (a twenty-two-letter alphabet, the space, the comma and the stop) "namely, all which it is given to us to express: in all languages." (Borges, 2009, 71). This all comprehends everything that is possible: every historical fact and fiction; every prediction of the future, including the correct one; everything written in extinct or still to be invented languages as well as their translations. In his prologue to Fictions, Borges (2009, 9) points at the origins of a ran-

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dom combinatory mode of thought, which in its turn cannot be dissociated from a timeless mode of thought about the origins of all things.

Fig. 1 *Babel's Monkeys* (more media at http://spiritbit.com/web/projects/babelsmonkeys)

Borges' choice of Babel as the setting for a space with its limits in infinity is very probably related to the biblical episode The Tower of Babel (Genesis 11:1–9). This narrative tells of a human attempt to approach God by means of a tower designed to reach Heaven. God's reaction to this human enterprise takes the form of attributing different languages to the people and their dispersion over the whole span of the Earth.

An increasing portion of our time is spent nowadays clicking on digital device's keyboards, which continually generates a huge amount of short texts. This reminds us of the 'infinite monkey' theorem, which, in one of its many formulations, states that an immortal monkey pressing a typewriter's keys at random would eventually produce Shakespeare's complete works. The probability of achieving a significant text through a random combination of characters is so low as to be considered impossible by human standards. However, as one or more of the variables is made to approach infinity, the probability of obtaining such a text not only increases, but tends to inevitability.

That contemporary massive text production feeds a collective human memory, built of scattered fragments, lacking an index and often left unread: A memory of Babel, written in a potential infinite process by a massive amount of human beings and stored not in a library but in internet servers.

2. HOW IT WORKS

In Babel's Monkeys, Genesis 11:1–9's text is cyclically rewritten, using as a basis a continual flux of words and sentences collected, as nearly as possible in real time, from what is being written at any given moment in the public listings of the Twitter internet platform. The program is made in Processing using Yusuke Yamamoto's Twitter4j library.

The algorithm replaces, one by one, the displayed words of the text for the ones in newly collected twitter sentences. These sentences may be written in any language. Whenever, in this universe of words, a word appears that is also contained in the Genesis 11:1–9's text, the word is highlighted and stays unchanged and in its place. The "unfound"words remain in constant mutation. As time progresses, the number of words originated in twitter decreases as the words of the text that is being "written" slowly replace them. At the instant the last word is found, the complete Genesis' text disappears and is replaced by a new amalgam of twitter sentences that restarts the process of text construction. Approximately twice a day, Babel's Monkeys reproduces the Tower of Babel narrative in an infinite cycle.

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GLITCHER

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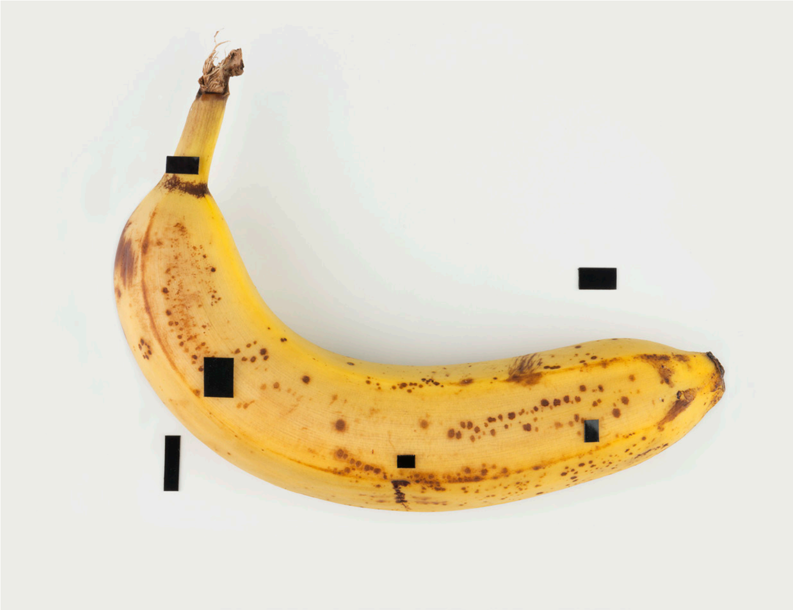
Keywords: Glitch, Decoration, Aesthetics

Glitcher is glitter for glitch: tiny pieces of colored material used for glitch-like decoration. Not only glitcher is nice to look at and fun to play with: it raises interesting questions on the nature of glitch in visual art.

Glitter consists of tiny pieces of sparkling material usually used to decorate objects, accessories and clothes. We designed a very special type of glitter; we are proud to introduce glitcher: glitter for glitch.

When it comes to visuals, glitch is confined to the monitors connected to computing devices or to prints on paper (Moradi *et al.* 2009). For those who have always loved the aesthetics of glitch and always searched for a way to bring it to the world of concrete objects, glitcher is here to help.



Glitcher is extremely simple to use: just grab some and sprinkle appropriately on anything to create an edgy statement in glitch art. Here follows an example of a still life with a banana.

It is obvious that in "Still life with banana and glitcher" glitcher has not been sprinkled randomly: black glitcher has been carefully placed on the banana and the background surface so that the edges of the rectangles are either vertical or horizontal.

This care is needed if we want to reproduce the glitch effects in a convincing way. Faithfulness to the original glitch has also guided us in the design process: glitcher is comprised of rectangular pieces because the shape of the hardware components in monitors (i.e. arrays of pixels) determines the visual form of glitches in digital images.

Do glitcher's shape and appropriate placement enable us to convey glitch seamlessly from its traditional environment to ours? Not completely: the photograph above is not the artwork itself, but merely a picture of it. The real "Still life with banana and glitcher" is indeed a sculpture that provides a convincing glitch visual effect only from a restricted set of points of view, outside of which the result is rather different, in that the rectangles in perspective appear like parallelograms and the connection with the phenomenology of traditional glitch becomes weaker and weaker. This is also why glitcher cannot be used to accessorize people: their bodily movements annul the glitch effect.

We do not know whether these limitations are a definitive statement against the conveyance of glitch into the world of concrete objects. Naturally, 3D-printers are on their way to the mass market and will allow for new experiments, but the aesthetic nature of glitches in that context lacks the abstract and essential elegance of glitches in flat images, which glitcher aims at embodying.

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NON HUMAN DEVICE #002

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Keywords: Interactive, Gesture, Audiovisual, Installation

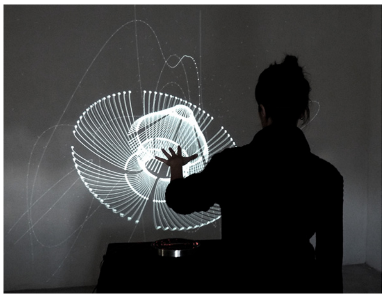
“Non Human Device #002” is part of series of interactive installations where experimental audiovisual devices/instruments are explored. In this installation the audience interacts with sound and vision content through a gesture based interface. By moving the hand over a device the user manipulates in real time a three dimensional virtual creature and interacts with the sound generation. It is an interactive system in the borderline between an exploratory sound and vision instrument, an art installation and gaming experience.

1. INTRODUCION

“Non Human Device” is a spinoff from the project Boris Chimp 504, an audiovisual live performance that tells the adventures of a chimp cosmonaut in space. Every version of the “Non Human Device” installations are based on an alien object/device found by Boris Chimp 504 during his missions through the deep space. Sharing the same narrative and sci-fi aesthetics of Boris Chimp 504 the installations are used as a laboratory for possible future stage instruments for the live performance. It is also an opportunity to present audiovisual content in a different format and to get in touch with the audience on a different level.

In this version a gesture based interaction is explored. A luminous cylinder object is presented to the audience. Inside it has a “LeapMotion”[1] device, a infrared sensor that captures hand and finger gestures. When the user moves his hands over the device he will interact with the audiovisual content, manipulating a virtual creature and defining sound parameters.

Fig. 1 Pictures from “Non Human Device #002”’s demonstration



2. INSTALLATION DESCRIPTION

A table, where the surface is placed, and a frontal projection surface compose the installation setup. In the screen we see a virtual creature built by several lines. This creature, which resembles a jellyfish, he is continuously rotating and lies on a dark background with some flickering dots connected by lines.

When the user moves the hands over the device a series of parameters are detected (rotation X/Y/Z, and height). These data is captured in Max with the “aka.leapmotion”[2] patch, and then sent as OSC message to Quartz Composer and used to control specific parameters in the visual interactive content. The rotating parameters control the position of the structure in space and the “height” changes the shape itself (openness of the creature’s legs, width). At the same time the same parameters are being sent as MIDI messages to Ableton live where they control audio filters. Some of the visual parameters, like specific elements on the background and parts of the creature shape, depend not on the tracked data but on the audio frequencies that are being constantly analyzed inside Quartz Composer.

Fig. 2 Pictures from “Non Human Device #002”’s demonstration

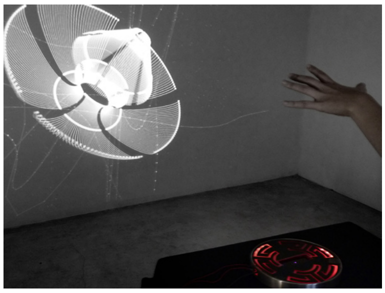
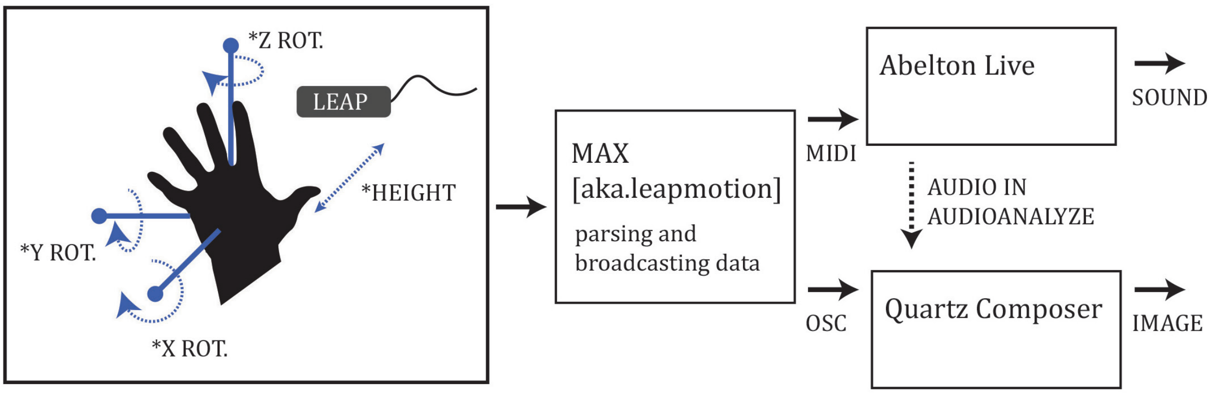


Fig. 3 Scheme of the Interactive System



3. FUTURE WORK

As future work our goal is to improve the interaction with the digital creature, creating more controllable parameters and mappings in a way to create a more expressive experience.

1 *https://www.leapmotion.com/*

2 *https://github.com/akamatsu/aka.leapmotion*

4. RELEVANT MEDIA ASSETS

A video from the installation can be watched here: *https://vimeo.com/81994347*. An article telling the story of the BorisChimp504 performance and the related interactive installations can be read here: *http://thecreatorsproject.vice.com/blog/boris-504s-non-human-device-challenges-viewers-to-take-a-trip-into-space-with-a-soviet-chimpanzee*

THE NEOLUCIDA PROJECT

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Keywords: Drawing, Drawing Aids, History of Art, Crowdfunding, Media Archaeology, Optical Tools, Analog Technology, Dead Media

This art and design project is simultaneously a product and a provocation. By producing the NeoLucida – a modern reinterpretation of the camera lucida – we are stimulating interest in media archeology, art history, and the long relationship between art and technology. After an overwhelmingly successful crowdfunding campaign, the NeoLucida went out to almost 15,000 users. What happens when that many people start drawing like they did in the 19th century? What happens when thousands of people look at drawing differently? And what happens when they adapt it to their own, 21st century uses?

The NeoLucida is an optical drawing aid that lets you trace what you see. It's a modern reinterpretation of the camera lucida, an indispensable drawing tool popular in the days before photography. It uses a prism on a flexible stand to superimpose an image of your subject onto your paper. You see your subject and your hand at the same time, giving you control to draw with great accuracy.

When artist David Hockney proposed that the great masters of art used aids like the camera lucida, drama ensued. Some called it heresy to suggest the masters were "cheating." Others supported Hockney in his historical investigation, swayed by his personal recreation of antique drawing techniques.

As two art professors, we weren't interested in making a product. We thought about asking a provocative question: What if we could give a camera lucida to artists, historians, and students? What if people could decide for themselves if Hockney was right?

Fig. 1 The NeoLucida allows you to

The problem is that camera lucidas are antiques, and priced accordingly – typically over $200. So we figured we would make our own inexpensive version using authentic optics with contemporary manufacturing techniques.

We looked to crowdfunding to support the manufacturing minimum order requirements. In short order, the NeoLucida was funded at nearly 3000% over the original $15,000 goal. 11,406 people backed the project to be part of this provocative question.

In the end, the product is not particularly innovative. After all, the prism is a replica of optical technology available nearly 200 years ago. But the wider NeoLucida Project suggests innovative ways for products to enter and exist in the world.

First, contemporary manufacturing techniques makes for a device that used to cost hundreds of dollars to a 19th century artist now under $50. The NeoLucida is the least expensive camera lucida ever made.

The project also reconsiders what crowdfunding can be. Rather than launching a product for the marketplace, we used Kickstarter as a way to engage the world and offer a chance to be part of an experiment. The product-as-provocation model we created works well with crowdfunding: there is no financial risk to developing a product and the backers build a community of like-minded investors with a small personal stake in the project.

Fig. 2 The Neolucida eyepiece: a prism housed on an adjustable gooseneck stand.

Fig. 3 Look straight down into the prism to see your subject superimposed onto your paper.

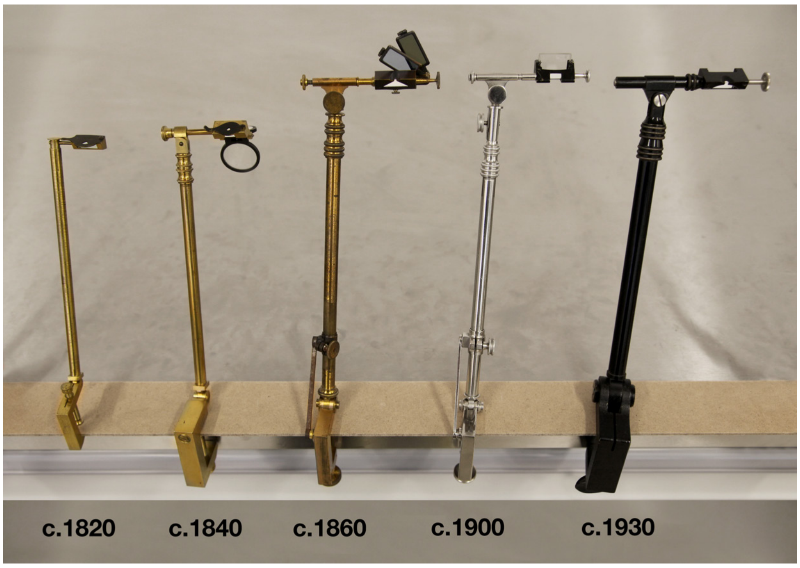

Fig. 4 The NeoLucida was designed based on first-hand research with vintage camera lucidas.

Fig. 5 The NeoLucida was designed based on first-hand research with vintage camera lucidas.

The overwhelming and rapid success of the Kickstarter made us more ambitious about the project. When some backers referred to us as "professors", we noticed that what we had built was not merely a hunk of metal and glass people were buying, we were building a community of students wanting to learn about, and engage with, art and technology. We suddenly realized: "With 11,400 backers who read our updates and ask us questions, this is not a crowd-funding campaign, this is a Massive Open Online Course (MOOC)!" We then put together some of the aspects of the project to see that we were actually engaging in a massive open-source experiment. The NeoLucida Project is simultaneously:

- Crowd-Funding (Kickstarter campaign)
- Crowd-Learning (Through updates about history and concepts as well as the growing website with original essays and "lessons")
- Crowd-Empowering (Open source details given away for everyone to better understand their tools)
- Crowd-Laboratory (DIY and Makers will improve and hack and re-imagine our work and share it with other makers and our community).

SELF-KARAOKE PATTERNS: AN INTERACTIVE AUDIO-VISUAL SYSTEM FOR HANDSFREE LIVE ALGORITHMIC PERFORMANCE

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Keywords: Live Algorithms, Audiovisual, Improvisation, Intermedia

Self-karaoke Patterns, is a proposed audiovisual study for improvised cello and live algorithms. The work is motivated in part by addressing the practical needs of the performer in 'handsfree' live algorithm contexts and in part an aesthetic concern with resolving the tension between conceptual dedication to autonomous algorithms and musical dedication to coherent performance. The elected approach is inspired by recent work investing the role of 'shape' in musical performance.

1. OVERVIEW

1.1. LIVE ALGORITHMS

The Live Algorithms for Music framework (Blackwell and Young, 2004) aims to support the analysis and development of music performance systems which exhibit some degree of musical autonomy. Shown in Fig.1, Blackwell and Young offer a modular PfQ model, dividing the performance system into three functionally distinct components: P, the audio analysis system (ears); Q, the audio synthesis elements (voice); and f, the transformative and/or generative patterning process which links them (brain).

These components represent distinct fields of research: analysis (P) modules deploy machine listening and learning algorithms; synthesis (Q) modules deploy computer music and sound design techniques. The framework is intentionally agnostic toward the design of the patterning process (f) and approaches to this range

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from AI-like simulation of human musical behaviours (e.g. Cope, 1992, Biles, 2001) to manipulation of idiosyncratic musical contexts (e.g. Di Scipio, 2003). The last decade has seen a trend for investigation of dynamical, self-organising systems which aim to capture some of the organizational forces in play in non-idiomatic group improvisation (e.g. Blackwell, 2004)

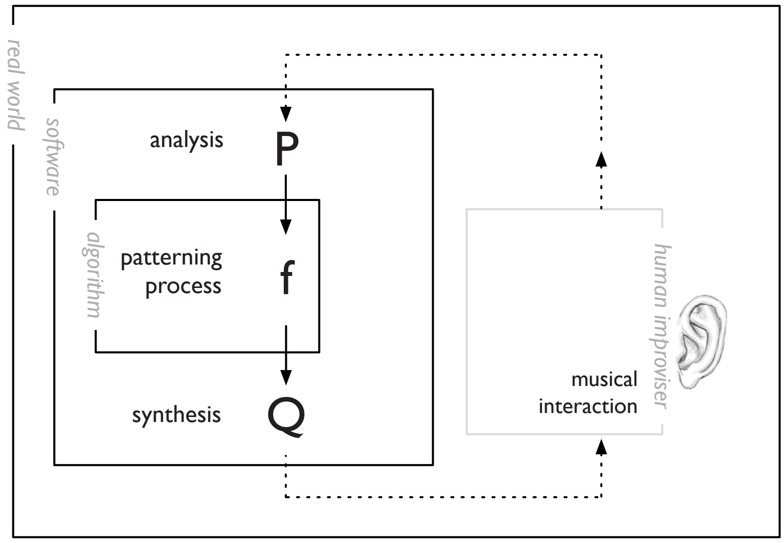

Fig. 1 Elements of the *PfQ* model for a Live Algorithm. Interaction is via real-time audio data in shared acoustic environment.

As research interactive performances move from the confines of conference halls to more mainstream venues, it becomes relevant to address some of the associated practical and aesthetic performance issues. The current project aims to address two issues:

1. PRACTICAL DIFFICULTIES OF HANDSFREE PERFORMANCE

As a cellist, I can't hover of my laptop in performance: I can't tweak input levels, synthesis parameters nor prod the system out of stasis or curb runaway behavior. At the same time, a desirable sense of security on stage requires some means to monitor system state, beyond that which is acoustically available in the moment.

2. BASIC AESTHETIC CONSIDERATIONS

Amongst human improvisers, endings are rarely planned, but are negotiated, or appear and are recognized (or not).[1] Programming an algorithm capable of recognizing an ending in open form improvisation is a non-trivial task. A related issue in algorithmic composition in general is achieving a balance of generative autonomy and

1 Evan Parker, personal communication.

musical coherence (Pearce and Wiggins 2002). A highly constrained system may guarantee a well-formed result but lack variation or surprise: Greater algorithmic freedom can result in delightful, challenging or at worst, offensive surprises.

1.2 INSPIRATION FROM CURRENT RESEARCH INTO SHAPE IN MUSICAL PERFORMANCE

There is a growing musicological interest in understanding the significance of the pervasive use shape in musical discourse, formal and informal (Leech-Wilkinson and Prior, forthcoming). We use linguistic metaphors of shape in rehearsals, teaching, programme notes and reviews; we shape music physically with our bodies as we play and represent music in visual shapes on staves or graphic scores. The basic premise of this interdisciplinary research programme is that shape (in a slightly nebulous and multifacted way) seems to be core to musicking, but is little studied or understood.

The predominant focus to date has been on classical musicians (e.g. Prior 2011). In an online survey (Eldridge, 2014), we recruited responses from improvisers in order to explore their phenomenological experiences of shape. Many improvisers described a marked distinction between how they think about music offline (planning, learning, practicing) versus online (improvising). Many talked about explicitly 'shaped' strategies in their pre-performance activities – a saxophonist practicing specific rhythmic and melodic patterns or a livecoder literally drawing out the shape of their set in 2D before performance. Whilst performing however, most described a more subconscious mode, or flow state (Csikszentmihalyi 1997), in which they are engaged in and supported by, but not consciously analyzing, their musical environment.

> *When I listen I'm outside the shape looking at it. When I'm playing I'm inside it, travelling, with no overall sense of its size or layout. I've worked with African musicians who, when we've been working out arrangements, use the phrase "you can come inside" when it's your turn to play.* – *Stephen Hiscock (Percussionist)*

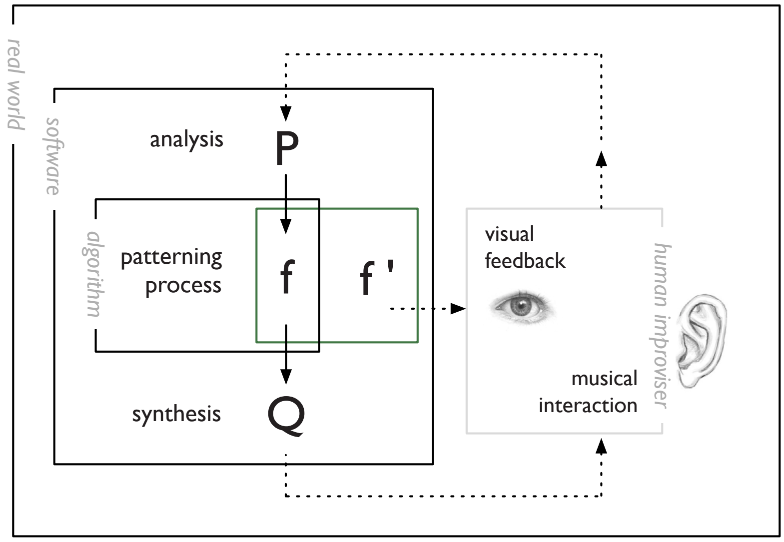

Fig. 2 The PfQ model with added visual component. The visual patterning process (**f'**)may be distinct from, but coupled to the audio algorithm (**f**). Audio interaction is augmented by visual feedback, allowing further insight into current state of system as well as history.

2. SELF-KARAOKE PATTERNS

These initial findings inspire an approach to live algorithms in which a structured, generative visual module becomes a core functional component of the patterning process. This has the potential to provide feedback to the instrumentalist during performance – allowing them to be 'inside' the shape. The design of such a process provides a vehicle for structuring performances on a longer time scale, leaving freedom for short-term interactions.

A two tier model of 'intermedia' composition is developed: on a short timescale interactions are designed between human performer, generative algorithm and digital animation system, mediated by machine listening; on longer timescale, the form is 'narrated' by a visually presented structure.

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CHINESE WHISPERS – FOR TWO LAPTOP PERFORMERS AND MEGAPHONE ARRAY

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Keywords: Collaboration, Live, Networking, Livecoding, Hacking, Field Recordings, China, Megaphone, Appropriation, Recontextualisation

Chinese Whispers is a collaborative performance for two laptop performers and an array of networked megaphones. The project emerged from Rebellious Devices, a series of concerts and workshops presented by the authors in China in summer 2013. These events explored the use and misuse of Chinese consumer electronic devices for collaborative musical performance.[1] Chinese Whispers received its premiere performance at Manchester Metropolitan University, Crewe on 14th of November 2013.

1. MEGAPHONE CULTURE IN MAINLAND CHINA

Chinese Whispers homes in on one device in particular, the handheld megaphone, used in Chinese culture for automated announcement by state enterprises and street vendors alike. Inspired by their use "in the wild", we spent time recording these devices in train stations, shopfronts and markets in Guangzhou, Xi'an, Shenzhen and Beijing. In the weeks that followed, we also developed a network of megaphones that could record and recapture each other's output. This array was then placed under the control of two laptop performers, who aimed to draw out, replicate, highlight and juxtapose aspects of the original field recordings. Divorced from their original cultural context (and from literal interpretation by most Western ears), the character of these recordings become sonic signifiers of contemporary China, representing aspects of large scale people management, entrepreneurship and competition, as well as individualism and opportunity.

Fig. 1 The array at the concert with Graham Booth and Jonas Hummel (back right).

2. EQUIPMENT AND STAGING

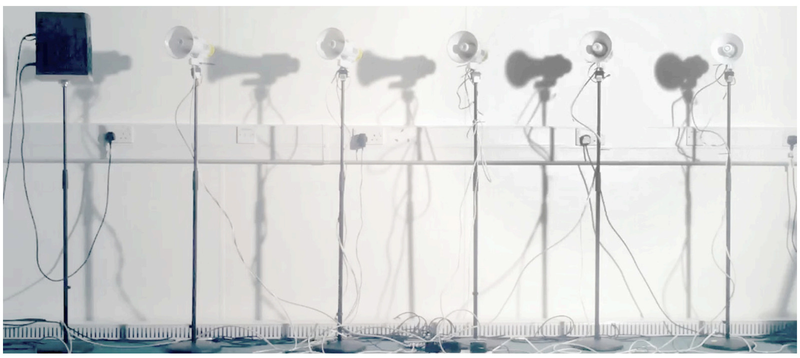
The project uses:

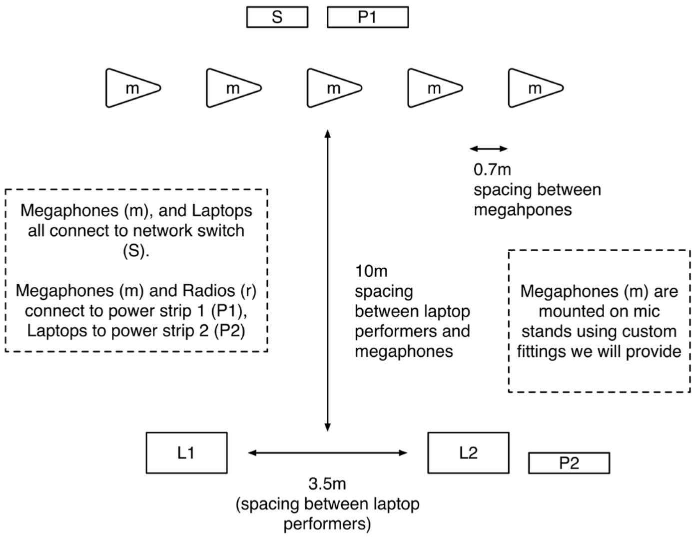
- 5 hardware hacked megaphones
- 5 BeagleBone black minicomputers (housed insided the megaphones)
- 2 laptops (running SuperCollider)

Each megaphone in the array is screw-mounted to a microphone stand and connected via ethernet cables to a network switch. The laptops are also connected to the same switch via longer cables. In terms of software, the project is powered by a modified version of the Utopia network library for SuperCollider,2 which runs on both the Beaglebones and the laptops. The Beaglebones themselves also run SuperCollider for sound playback and networking, as well as Python for actuation of the devices.

Fig. 2 An example megaphone used for the project (unhacked)

Fig. 3 The array at the concert with Graham Booth and Jonas Hummel (back right).





The project requires a space of at least 8m×8m where the laptop performers can situate themselves at some distance from the megaphones. The spacing between megaphones is adapted to the acoustics of the venue. Where possible, the project is presented offstage, where the audience can roam within the space between the performers and megaphones.

3. INTERACTION

The megaphones used are low-cost devices with simple recording and playback capabilities. By circuit bending and augmenting each device with a minicomputer, we are able to network them, exposing a layer of higher level control (e.g. playing back one device while recording from another), whilst at the same time retaining control over low level aspects (e.g. physical rotation of the megaphones).

Treating the array of megaphones as a single entity proposes challenges for collaborative interaction, as each property of each megaphone is only accessible to one player at a time. To address this we combine a rigid but intuitive graphical user interface with flexible algorithms,

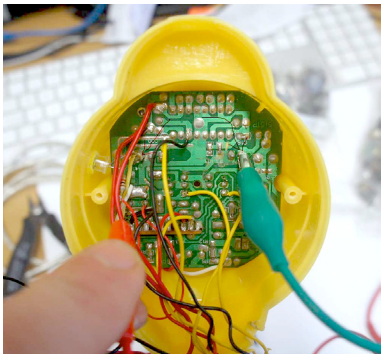


Fig. 5,6 and 7 Elements of a hacked megaphone: the bent circuit of the megaphone itself (left), the servo motor used to rotate a megaphone horizontally (middle) and the BeagleBoneBlack computer with DIY shield, housed inside the megaphone (right).

which are manipulated using live-coding techniques. For this purpose we wrote dedicated classes for SuperCollider which take care of the low level of programming interaction.[3] The code example below shows how these classes are used in performance and some of the possible method calls. This combination of malleable choreographed material and direct control lies somewhere between a chess game and interactive CCTV surveillance.

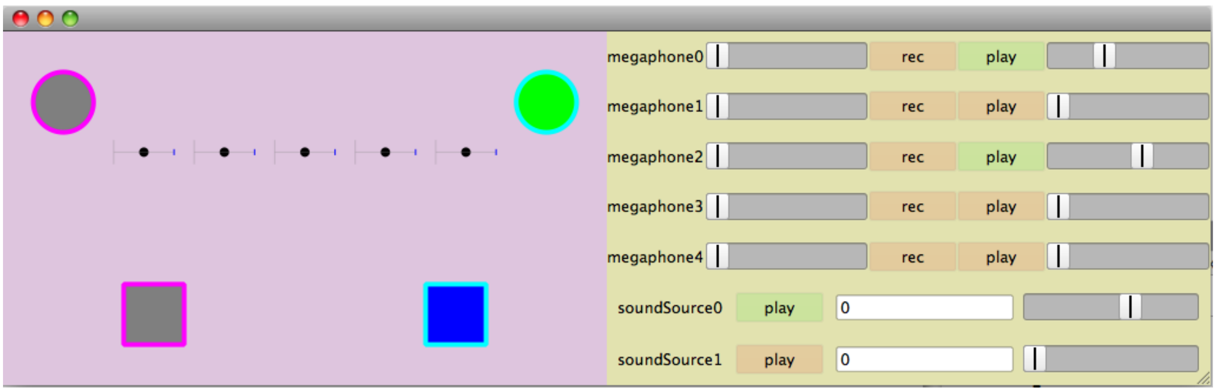
Fig. 8 SuperCollider Code Examples: some single commands and a Routine to move, record and playback with the array. All of this can be livecoded

```
// Single command examples to control the array
l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.faceLeft;};
// ALL face left
{l.remoteMegaphones.do{arg remoteMegaphone;remoteMegaphone.startPlaying}; // All start playing;
l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.stopRecording}; // ALL stop recording

// The Parrot Routine
(
Tdef(\parrotAll, {
	// turn forwards, record from the sound source, repeat the sound forwards
	var soundFileNumber, waitTime, endTime;
	endTime= 15;
	waitTime = {0.0.rand}; // change to more than 0 for phasing
	soundFileNumber = 1;
	l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.stopRecording; remoteMegaphone.faceForward;};
	l.mySoundSource.startPlaying(3, 0.5); // max volume
	l.remoteMegaphones.do{arg remoteMegaphone;
		fork{
		waitTime.value.wait;
		remoteMegaphone.startRecording;};
	};
	4.wait; // or the full length of the soundfile - would be good to have these in an array
	l.mySoundSource.stopPlaying;
	l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.stopRecording;};
	1.wait;
	1.do{
		var volume;
		volume = rrand(0.5, 1);
		// play them back forever, until the Tdef is stopped or restarted, when a new sound will be triggered
		l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.startPlaying(volume)};
	};
	endTime.wait;
	l.remoteMegaphones.do{arg remoteMegaphone; remoteMegaphone.stopPlaying};
}).play;
)
```

Refining the collaborative interface used in the project is the current focus of our work. To see the project in action, please view the video under the following link: *http://vimeo.com/93748488*

Fig. 9 The array at the concert with Graham Booth and Jonas Hummel (back right).



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2. https://github.com/muellmusik/Utopia/
3. https://github.com/sidechained/ChineseWhispers/

ALGORAVE SET

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Keywords: Algorave, Live Coding, Algorithmic Composition, L-Systems, Haskell

The performer generates rhythm patterns and their variations through stochastic methods and L-systems using a custom live coding library called Conductive and the Haskell programming language in this performance for the xCoAx algorave. Several concurrent processes trigger a custom sampler according to those generated rhythms. Through interactive programming, the performer manages those concurrent processes and generates and selects data to be read by those processes, resulting in musical output. The performance is projected.

In this solo performance, improvised programming generates danceable percussive music emphasizing generative rhythms and their variations, and all of the performer interaction with the system is projected for the audience to see. Figure 1 shows a recent performance.

The custom live coding system, a Haskell language library called Conductive (Bell 2012), was written to deal with time constraints when live coding. It triggers a software sampler built with the Haskell bindings (Drape 2010) to the SuperCollider synthesizer (McCartney 1996) and loaded with thousands of audio samples. Through live coding, the performer manages multiple concurrent processes that spawn events, including the number of processes, the type of events spawned, and other parameters.

This performance uses revised methods described in (Bell 2014). The previous system, documented in (Bell 2013) and (Bell 2011), lacked flexibility. In particular, the style of rhythm patterns produced was more static than desired. In the revision, the interface to the rhythm-pattern generation routine was rewritten as a higher-order function to increase flexibility, allowing for pattern generation with L-systems (Lindenmayer 1968) or other techniques.

An example of an L-system from (Supper 2001) can be seen in figure 2. The revised function also allows for a variety of methods for increasing the rhythmic density of patterns. Those patterns and their variations are stored in a type called an IOI Map, where IOI stands for interonset interval. An IOI is the time between the onset of two events adjacent in time. The revision can be seen in figure 3.

Fig. 1 Renick Bell performing with the described system at the Linux Audio Conference 2014 in Karlsruhe, Germany on May 3, 2014

Fig. 2 An example L-system from (Supper, 2001)

rules: a -> b
b -> ab

input: a

output: b
ab
bab
abbab
bababbab
abbabbababbab
bababbababbabbababbab

At least two methods of generation of base rhythms are used: stochastic methods and L-systems. In the former, sets of rhythmic figures are generated stochastically. From them, figures are selected at random and joined to form larger patterns. In the latter, L-systems are coded live and used to generate patterns. These patterns are then processed into a stack of variations with higher and lower event density. That stack is traveresed according to a time-varying value, described by a data type called a TimespanMap, to create dynamically changing rhythms. This is illustrated in figure 4.

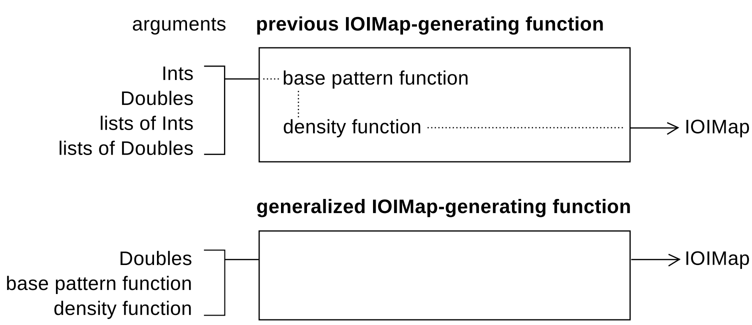

Fig. 3 A recent revision to the rhythm

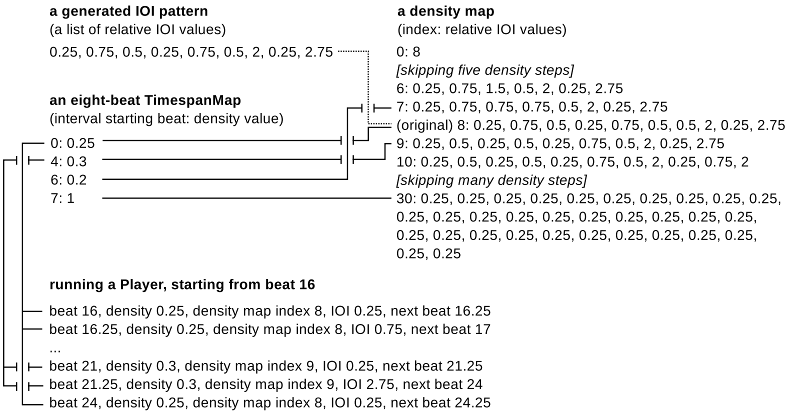

Fig. 4 An illustration of how IOI patterns result in rhythms via density maps

Simultaneously, patterns in which audio samples and other parameters are assigned to sequences of time intervals are generated through similar methods. The concurrent processes read the generated data and use it to synthesize sound events according to the rhythm patterns described above.

The performer's interaction involves activities such as generating such data, continuously reselecting which data to use throughout the performance, changing the number of running concurrent processes, and determining when changes occur.

The projection shows all of the performer's activities, including code editing and execution of code in the interpreter. When the performer presses "Enter" on the keyboard, the line under the cursor is sent to the interpreter and immediately executed. Pressing F11 causes the code block under the cursor to be sent and executed. Text output of functions is printed in the interpreter.

The primary technologies used include:

- Conductive, a library for live coding in Haskell (Bell 2012)
- the Haskell programming language, through the Glasglow Haskell Compiler interpreter (Jones *et al*. 1993)
- the SuperCollider synthesis engine (but not its programming language) (McCartney 1996)
- hsc3, the Haskell bindings to SuperCollider (Drape 2010)
- the xmonad window manager (Stewart and Sjanssen 2007)
- the vim text editor (Moolenaar 2008)
- the tmux terminal multiplexer (Marriott and others 2013)

- the tslime plugin for vim (Coutinho 2010)

Other tools that are essential for the performance include:

- the Calf Jack Host (Foltman *et al*. 2007)
- jackd (Davis and others 2014)
- patchage (Robillard 2011)
- an Arch Linux computer (Vinet and Griffin 2014)

ACKNOWLEDGEMENTS

I would like to thank my advisors Akihiro Kubota and Yoshiharu Hamada for research support.

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MICO REX

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Keywords: LiveCoding, AlgoRave, Network Music, Interface, DIY, FLOSS, SuperCollider, Processing, Arduino, Live Performance, Algorithms, Audiovisual, Music, Performance, Dance, Vocals

Mico Rex is a Mexican experimental electro-pop duo formed in 2010 by Ernesto Romero and Jorge Ramirez, pioneers of live programming in Mexico.

It is a meal of unjustifiably harsh electronics, seasoned with catchy, melodic, schizophrenic and danceable ingredients. Exploring styles including bolero, 8bit, glitch, old school electro, old romantic, punk, geek, breakz, fresh, vocal, finura and the future, they will take care of you (if you let them) with smooth waves of deep wild-eyed braids. With a mix of deterministic algorithms and joystick-in-card-board controlled expressiveness, concatenated within a master two-synched-laptop-brain, Mico Rex play with the precise and the indeterminate.

After performing in cheesy and gritty joints, they reached international festivals in Mexico and went all the way to a successful European tour across Zürich, Nantes, Barcelona, and closing the 2012 SuperCollider Symposium in London also releasing out their first E.P "Rico Mex" on the ChordPunch label.

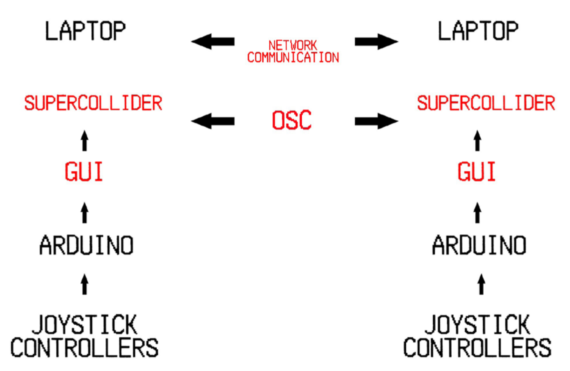
In 2013, after a pre-heat streaming concert to Birmingham's Network Music Festival, they were back in Europe for the LiveCode Festival as part of their Algorave tour: Brighton, London, Karlsruhe, Cologne, Düsseldorf, The Hague and Amsterdam.

The live performance is a combination of networked structured pieces and improvisation with code accompanied with voice and home-made joystick controllers in pain and reactive algorithmic visuals. The sound design, visuals, structure and composition are made upon programming code for hardware and software developed by the group members themselves (Fig. 1).

```
{1.do{~net.sendMsg("/Bong", 0); }}
~fadeOutPalomaTutti.set(\gate,0);

Pdef(\bongo).play;

(

~net= NetAddr("169.254.49.196", 57120);

Pdef(\bajoCero, Pbind(\instrument, Pn(Pxrand([\acidBong,\acidBong,\BajoBongMute,\acidBong],
84/2),1),
\tempo, 120/60,
\midinote,Pstutter(84/6,(Pseq([59,61,59,55,53,51]-12,84*1))),
\legato, Pwrand([0.01, 0.08],[0.9,0.1],inf),
\gate,1,
\amp,Prand([0.18, 0.23,0.25,0.34,0.25]*1,inf),
\pan,Pn(Pshuf([0,0.1,0.21,0,-0.21,0.4,-0.4,-0.1,-0.5,0.4,], 1), inf),
\dur,Pseq([0.25],84*1),
\attack,0.18,
\trigger, 1,
\sustain, Pkey(\dur)*1.15 ));

Pdef(\bajoConstante, Pbind(\instrument, \acidBong,
\tempo, 120/60,
\midinote,Pstutter(84/6,(Pseq([59,61,59,55,53,51],84*1))),
\legato, Pwrand([0.01, 0.08],[0.9,0.1],inf),
\gate,1,
\amp,Prand([0.18, 0.23,0.25,0.34,0.25]*1,inf),
\pan, Pn(Pshuf([0,0.1,0.21,0,-0.21,0.4,-0.4,-0.1,-0.5,0.4,], 1), inf),
\dur,Pn(0.25,84),
\osc, Pseq([Pfuncn({1.do{~net.sendMsg("/Bong", 1); }},1).trace, Pfuncn({1.do{~net.sendMsg("/
nada", 0); }},inf).trace],1),
\attack,0.018,
\trigger, 1,
\sustain, Pkey(\dur)*1.15 ));

Pdef(\bajoConstanteSinMsg, Pbind(\instrument, \acidBong,
\tempo, 120/60,
\midinote,Pstutter(84/6,(Pseq([59,61,59,55,53,51],84*1))),
\legato, Pwrand([0.01, 0.08],[0.9,0.1],inf),
\gate,1,
\amp,Prand([0.18, 0.23,0.25,0.34,0.25]*1,inf),
\pan, Pn(Pshuf([0,0.1,0.21,0,-0.21,0.4,-0.4,-0.1,-0.5,0.4,], 1), inf),
\dur,Pn(0.25,84),
\attack,0.018,
\trigger, 1,
\modTime, 0.56,
\modLine,0.9,
```

Fig. 1 Example of MicoRex's Code

They consider code as the most flexible media for live electronics performance. Code+networking+gui+physicalInterface.



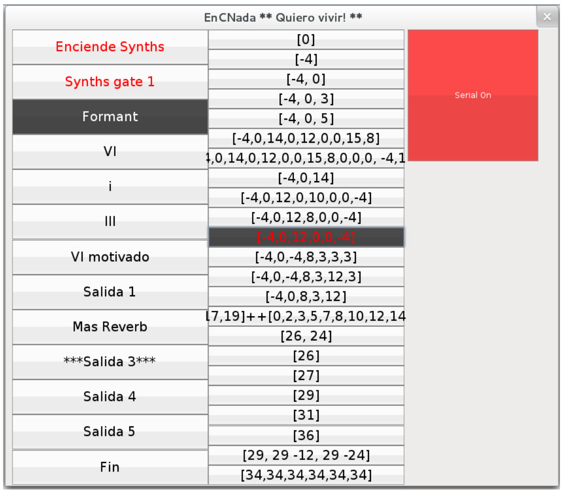


Fig. 2 and 3 Diagram and GUI.

The execution of the music compositions is developed in real time in accordance to the requirement of each piece of music taking advantage of a network that communicates the members musical gesture palette and the reactive visuals.

Fig. 4 and 5 Physical Interface

KEYNOTE

THE RAGGED MANIFOLD OF THE SUBJECT: DATABASENESS AND THE GENERIC IN CURATING YOUTUBE

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Digital cultural production oscillates between singular instances and massive scale occurrences, the individual and the collective, unique and generic, where such tensions are constitutive, as paradoxes, of modes of production and operation of subjectivity today. These tensions are exemplified in art work, and are sustained by computational machines, some of which are database management systems. Generic here relates to measurement, seriality, similarity, and relationality, where the operation of relating itself contributes to the new articulations of the singular and multiple. This talk discusses such relationality in computational cultural forms. The position of the subject that Kittler claimed to be occupied by the Turing machine, is in fact constructed in more complex ways, by computational ensembles that contribute to the maintenance of the subject, rather than replacing it completely. The subject is produced not through an exercise in writing but through the relationality of data which, in the example of an art project, such as Curating

YouTube, handles singularities and establishes relations between them as a multiple or as a ragged manifold. It is somewhere in this computational maintenance of the operationalised singular and multiple and the movement between them that the new kind of the subject arises. I explore the generic, a number of art projects on YouTube and curatorial tools, and NoSQL databases to arrive at an understanding of the new forms of multiplicity and relationality that cut to the core of the changing conditions of possibility of the subject.

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 recent albums are published by Crónica and Audiobulb.

MARCUS LEIS ALLION

Typographer and graphic designer **Marcus Leis Allion** currently lectures at both Kingston University and Central Saint Martins. From 2001–2009 he was a key member of the internationally renowned Barnbrook studios where he designed numerous typefaces, identities, and publications. During that period Marcus was also engaged in a number of projects that sought to develop and expand critical approaches to creativity – including partner/art director of the first copyleft label, LOCA Records, and collaborations with The Libre Society. Recent work builds on these connected interests and experiences.

www.*u-n-d-t.com*

RAPHAEL ARAR

Raphael Arar is an award-winning artist, designer and technologist whose work seeks to trace the trajectories of interpersonal and intrapersonal interaction in light of progress. These works manifest themselves in a variety of forms encompassing a synthesis of nostalgia and novelty often informed by scientific systems and humanistic research. His artwork has been shown at museums, conferences, festivals and galleries internationally including the Espoo Museum of Modern Art (FI), The Boston Cyberarts Gallery (USA), Dark Horse Experiment (AU) and the Athens Video Art Festival (GR). His design work has been awarded through MITX and The Webby Awards and has been featured in sources including Communication Arts Magazine, Forbes, New York Times and The Boston Globe. Arar holds a BA from Boston University and is currently completing his MFA at the California Institute of the Arts.

ÁLVARO BARBOSA

Álvaro Barbosa (Angola 1970) is an Associate Professor and Dean of the Creative Industries Faculty at University of Saint Joseph (USJ) in Macau SAR, China. Until September 2012, was the acting director of the Sound and Image Department at the School of Arts from the Portuguese Catholic University (UCP-Porto), co-founding in 2004 the Research Center for Science and Technology of the Arts (CITAR), in 2009 the Creative Business Incubator ARTSpin and in 2011 the Digital Creativity Center (CCD). Holding a Ph.D degree in Computer Science and Digital Communication from Pompeu Fabra University in Spain and a Graduate Degree in Electronics and Telecommunications Engineering from Aveiro University in Portugal, his academic activity is mainly focused on the field of Audio and Music Technology, in which he worked for five years as an Resident Researcher at the Barcelona Music Technology Group (MTG). His creative projects, in collaboration with other artists and researchers, have been extensively performed internationally, with special emphasis in Sound and Music Design, Collaborative Interactive Installations, Live Electronic Music, Computer Animation, Design Thinking and Systematic Creativity.

www.abarbosa.org

NUNO BARRETO

With a MSc. Degree in Informatics Engineering from the University of Coimbra, **Nuno Barreto** is currently enrolled for a Ph.D in Science and Information Technology, from the same Institution. His research includes Artificial Intelligence applied to behavior modelling, and more recently, the support of creativity through Procedural Content Generation mixed-initiative design tools, all in the context of Digital Games and Simulations. Currently, he is also a game developer and promoter for a game development studio startup named Titan Forged Games.

RENICK BELL

Renick Bell is a doctoral student at Tama Art University in Tokyo, Japan. His current research interests are live coding, improvisation, and algorithmic composition using open source software. He is the author of Conductive, a library for live coding in the Haskell programming language and runs the net label the3rd2nd with Jason Landers. He has a masters degree in music technology from Indiana University and an interdisciplinary bachelors degree from Texas Tech University. He has performed internationally on four continents. He is from West Texas but has lived in Tokyo since 2006.

renickbell.net

MIQUEL BERNAT

Miquel Bernat received his musical education at the conservatories of Valencia, Madrid, Brussels and Rotterdam, and at the Aspen Summer Music Festival (USA). Being a musician of great versatility, he has played with the Orquesta Ciutat de Barcelona and with the Royal Concertgebouw Orchestra of Amsterdam, as well as in the contemporary music ensembles Ictus, Ictus Piano and Percussion Quartet, Trio Allures, Duo Contemporain, among others.

Formerly a professor at the Rotterdam and Brussels conservatories, he is currently engaged intensively in pedagogical activities at the "Escola Superior de Musica de Catalunya" in Barcelona, and the "Escola Superior de Musica do Porto" and Aveiro University (Portugal). As Lecturer and Master Class Professor he has been invited to Darmstadt Summer Course (Germany), Instrumenta de Oaxaca (Mexico), the International Summer Course of Brasilia, among many other universities in Argentina, South Africa, the USA, UK and Australia.

In Porto, he founded DRUMMING: Grupo de Percussão, that has become one of the leading percussion ensembles in the world, uniquely expanding interactions between music and other art forms. A passionate performer of new music, Miquel Bernat has worked with numerous composers (many works have been dedicated to him) thus contributing to the expansion and evolution of the contemporary repertoire for percussion.

PETER BEYLS

Peter Beyls is an interdisciplinary artist exploring computer programming as a medium of artistic expression; he develops generative systems in music, the visual arts and hybrid formats. Beyls studied at the Royal Music Conservatory Brussels, EMS Stockholm, Ghent University and the Slade School of Art, University College London. He published extensively on the application of Artificial Intelligence for artistic purposes. Beyls holds a Ph.D in Computer Science from the University of Plymouth, UK and is currently a researcher at CITAR, Universidade Católica Portuguesa, Porto and visiting professor of Media Art at the School of Arts, University College Ghent.

www.beyls.org

JIM BIZZOCCHI

Jim Bizzocchi is a filmmaker currently working in video art and installation. His research interests include the aesthetics and design of the moving image, interactive narrative, and the development of computational video sequencing systems. He is interested in the effect of new technologies on cinematic visual expressions such as split-screens, layered imagery, image transitions, and stereoscopic cinema. His work in interactive narrative includes ongoing extension of the computational capabilities of his Re:Cycle video presentation and sequencing system.

GRAHAM BOOTH

Graham Booth and Jonas Hummel are musicians and Ph.D researchers based at the Sonic Arts Research Centre, Northern Ireland and Manchester Metropolitan University, England respectively. They formed the partnership Co:Lab in early 2013 to develop new social and technological systems for co-operative musical interaction. In September 2013 they presented their first project Rebellious Devices in China with a series of concerts and accompanying workshops.

Their research interests include collaboration in network music situations, group improvisation with custom-built interfaces and instruments and the affordance of technology in live music performance. Previous projects include ensembles of networked radios (Translocal Rundfunk Orchestra) and laptop computers (Huddersfield Experimental Laptop Orchestra, Republic111, PowerBooks UnPlugged).

OLIVER BOWN

Ollie Bown is a researcher, programmer and electronic music maker. He creates and performs music as one half of the duo Icarus, and performs regularly as a laptop improviser in electronic and electroacoustic ensembles. He has worked with musicians such as Tom Arthurs, Lothar Ohlmeier and Maurizio Ravalico of the Not Applicable Artists, and Brigid Burke and Adem Ilhan of Fridge. Icarus' 2012 album Fake Fish Distribution was released in 1000 unique digital variations. The band have produced remixes for electronic music pioneers such as Four Tet, Murcof and Caribou and recently produced software for an experimental live performance by Aphex Twin, premiered at the Barbican Hall in London in 2012. Ollie has performed at international festivals such as Sonic Acts (Amsterdam), the Sonic Arts Network Expo (UK) and AudioVisiva (Milan). He has designed interactive sound for installation projects by Squidsoup and Robococo, at venues such as the Powerhouse Museum in Sydney, the Oslo Lux, the Vivid Festival, Sydney, and the Kinetica Art Fair, London.

In his research role he was recently local co-chair of the 2013 International Conference on Computational Creativity and on the organising committee of the Musical Metacreation Workshop and events series, and is on the program committee for a number of conferences concerned with computers and creativity. He has a special interest in the evolution of human musical behaviour.

He developed and maintains the Beads computer music library, a set of low-level tools for creating interactive and generative audio for Processing/Java.

VICTORIA BRADBURY

Victoria Bradbury is a visual artist weaving programming, physical computing, body and object. She is based in Newcastle UK and studies the performativity of code as a researcher with CRUMB. Her work has been shown at the Albright Knox and Hallwalls Galleries (Buffalo), Harvestworks and Cuchifritos (NYC), and Globe Gallery (Newcastle). She participated in the Shanghai Biennial IMMERSION: Art and Technology workshops (2012) and was a resident artist at Imagine Gallery, Beijing (2008). Bradbury has presented research at ISEA 2013 (Sydney) and Re:Wire (Liverpool 2011). She is a collaborator with Attaya Projects and a member of the New Media Caucus board.

www.victoriabradbury.com

VILBJØRG BROCH

Born in Denmark, studied dance and improvisation at the SNDO in Amsterdam in the early nineties and have been based in Amsterdam since then. Studied voice by members of the Roy Hart Theatre and classical voice for more than a decade by coloratura soprano Marianne Blok. I was working in various improvisational and collaborative setting during the past 25 years in theatre, performance and music. I started computer-music some 10 years ago. This has brought with it an ongoing selfstudy of mathematics, which is a great source of inspiration.

antidelusionmechanism.org

ANDREW BROWN

Andrew R. Brown is an educator, musician, digital artist, and computer programmer. He holds a Ph.D in Music and is Professor of Digital Arts at the Griffith University, in Brisbane, Australia. His work explores the aesthetics of process and regularly involves programming software as part of the creative process.
In addition to a history of computer-assisted composition and audio-visual installations, Andrew has in recent years focused on real-time art works using generative processes and musical live coding; where the software to generate a work is written as part of the performance. He has performed live coding and interactive music in many parts of the world and his digital media art works have been shown in galleries across Australia, USA and China.

andrewrbrown.net.au

CHRISTOPHER BURNS

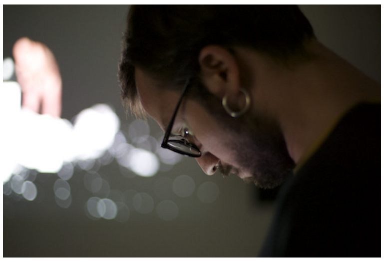
Christopher Burns is a composer and improviser developing innovative approaches to musical architecture. His work emphasizes trajectory, layering and intercutting a variety of audible processes to create intricate forms. The experience of density is also crucial to his music: his compositions often incorporate materials which pass by too quickly to be grasped in their entirety, and present complex braids of simultaneous lines and textures. A committed educator, Christopher teaches music composition and technology at the University of Wisconsin-Milwaukee. He has studied composition with Brian Ferneyhough, Jonathan Harvey, Jonathan Berger, Michael Tenzer, and Jan Radzynski.

sfsound.org/~cburns

TOM CALVERT

Dr. **Tom Calvert** is Emeritus Professor in the School of Interactive Arts and Technology at SFU Surrey. He has degrees in electrical engineering from University College London (B.Sc.), Wayne State University (MSEE) and Carnegie-Mellon University (Ph.D). His research interests focus on computer animation and computer based tools for user interaction with multimedia systems; his work on computer animation has resulted in the Life Forms system for dance choreography and SFU spin-off company Credo Interactive Inc. markets and develops this software

BAPTISTE CARAMIAUX



Baptiste Caramiaux is a researcher in the EAVI group, at Goldsmiths, University of London, since 2012. His work focuses on Human Motion, Interaction Design, Computational Systems and Sound Perception.

He received a Ph.D in acoustic, signal processing and computer science applied to music from University Pierre et Marie Curie (UPMC), in December 2011, completed at IRCAM – Centre Pompidou. Before joining IRCAM, he was trained in applied mathematics and music.

His work has been published in international peer-reviewed journals (ACM Transactions, Computer Music Journal, etc.), conferences (NIME, CHI, SMC, etc.) and festivals (Transmediale, etc.).

www.baptistecaramiaux.com

ALEXANDRA CÁRDENAS

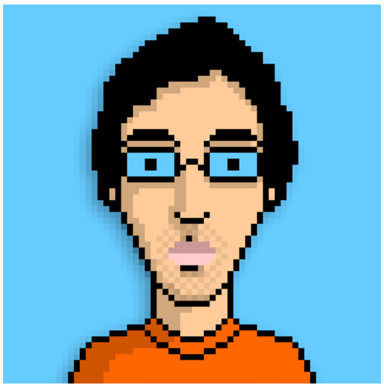
Composer and improviser of music ranging from writing orchestral works to improvising with electric guitar and laptop. Using mainly the software SuperCollider to turn her computer into another musical instrument, her work has focused recently in creating pieces with Live Electronics and exploring the musicality of coding and the algorithmic behaviour in the music. An important part of this exploration is the practice of live coding. Currently she lives in Berlin, Germany and studies the masters Sound Studies at the University of the Arts.

www.tiemposdelruido.net

MIGUEL CARDOSO

Miguel Cardoso (1978) has a degree in Communication Design at Faculdade de Belas Artes do Porto (2003) and is currently studying for a Ph.D on Computer Music at Escola das Artes da Universidade Católica do Porto. Since 2006 he has actively collaborated with Bestiario (Barcelona) on the creation of data visualisation projects. He is also assistant professor at Faculdade de Belas Artes da Universidade de Lisboa, lecturing on the Master in Communication Design and New Media.

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.

www.pedrocardoso.pt.vu

MARIA CARMONA-MARTÍNEZ

M. Mercedes Carmona-Martínez is associated professor in Econometrics and Statistics at the Catholic University of San Antonio, Spain. She holds a Ph.D in Economics, from Universidad de Murcia, and has a wide research and teaching experience in applied statistics and data analysis. She has presented numerous communications to national and international conferences and has published several research papers in indexed journals. She has also guided several Doctoral Thesis which make use of a quantitative methodology applied to various phenomena in the field of social sciences, and she coordinates the Research Methodology Module at the UCAM-FOM Doctoral School.

personas.ucam.edu/maria-mercedes-carmona-martinez

MIGUEL CARVALHAIS

Miguel Carvalhais is a designer and musician. He holds a Ph.D. in art and design by the University of Porto, 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
at-c.org
cronicaelectronica.org

RODRIGO CARVALHO

Rodrigo Carvalho. (Porto, 1983) Designer & new media artist from Porto/Portugal. Graduated in Design (Aveiro–PT.2005) and with a Master Degree in Digital Arts (Barcelona – ES.2009). He is nowadays a Ph.D student in Digital Media in the University of Porto/FCT under the UT Austin/Portugal Program. His work is focused in the relations and the synergies between sound, movement and image in audiovisual real time systems and environments.

www.visiophone-lab.com
s-v-m.tumblr.com

RICARDO CLIMENT

My research focuses on the articulation of structure in interactive game-audio and music composition. For the last six years I have concentrated on the use of audio-graphic-physics in game engines and the use of meta-data retrieval. I created 3D game-audio interactive environments (game-audio.org), which strongly connect with my works employing dynamic scores for acoustic instruments and live electronic media in compositions, such as “Xi”, “Russian Disco” or “Drosophila”.

I currently serve as director of the NOVARS Research Centre, University of Manchester in UK and previously taught at SARC, Belfast. I have also served as resident composer Mexico, Spain, Ireland, Germany and Sweden. I hold a music Ph.D and MA from Queen’s University and a degree in Economics, University of Valencia, Spain.

electro-acoustic.com
sonorities.org

ginger coons

ginger "all-lower-case" **coons** has been variously called a designer, artist, academic-in-training, technician and talker-about-things. When not building, writing, drawing, editing or holding forth, ginger is also Ph.D candidate in the Critical Making Lab and the Semaphore research cluster in the Faculty of Information at the University of Toronto, studying the movement of born-digital methods to physical production processes through rapid prototyping.

gingercoons.ca

NUNO CORREIA

Nuno Correia (CITI)
Nuno Correia is a Professor at Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, where he works in the area of Interactive Multimedia. He participated in the creation of a Digital Media Ph.D and coordinates the
Computer Science Ph.D program. He is representative in IFIP TC14 (Entertainment Computing). Nuno Correia participated in national and European projects. He was a researcher at Interval Research Corporation, Palo Alto, in 1996/97. Previously, he was at INESC, Lisboa. Nuno Correia supervised 6 doctoral and 30 master theses. He is (co-) author of more than 90 publications and was co-chair of international conferences (ACE, MobileHCI).

img.di.fct.unl.pt

LAURA CORTÉS-SELVA

Laura Cortés-Selva is associated professor in Media Studies at the Catholic University of San Antonio, Spain. Bachelor in Media Studies and cinematography, her main interests is visual style, cinematography and methodology.

She has work as a director of photography in several short movies, documentaries, music videos and spots and is author of: *The influence of cinematography in the visual style of films; Analysis of Dick Pope´s visual style in Mike Leigh´s films; The influence of celluloid digitization in the visual style of films, El director de fotografía, co-autor de La obra cinematográfica* and *La influencia del estilo visual cinematográfico en las series de ficción televisivas.*

to-build-up.blogspot.com.es/
personas.ucam.edu/laura-cort%C3%A9s-selva

CÁTIA COSTA

Cátia Costa is a multimedia designer and researcher. Has an Undergraduate and Master degree in Design and Multimedia from University of Coimbra. Since 2012, she has been working, as freelancer, to FBA – Ferrand, Bicker & Associados (www.fba.pt). Her interests include infovisualization, typography, photography, editorial, graphic and generative design.

cdv.dei.uc.pt

GUSTAVO COSTA

Born in Porto, 1976. Studied percussion, music tecnology, sonology, composition, music theory and is currently attending a Ph.D in Digital Media at FEUP, Porto on the subject of expressiveness and interactivity in computer music. His work as a musician and composer is based around underground counterculture, improvised and electroacoustic music. He has toured and recorded extensively around Europe, United States, Japan, Brasil and Lebanon.

www.gustavocosta.pt

PEDRO CRUZ

Pedro Cruz is a data visualization specialist and explorer. Since 2010 he is an invited assistant professor in Design and Multimedia at University of Coimbra and a Ph.D student there. He passed through Cambridge, MA as a Ph.D visiting student for MIT Senseable City Lab. In 2010 he won the SIGGRAPH Student Research Competition. He also contributed to works that won a Webby Award in 2013 and distinguished in Cannes Lions 2012. His work was featured in several exhibitions such as CES, MoMA's Talk to Me, Ars Electronica as well as in magazines such as Fast Company, Wired and in specialized books.

pmcruz.com

JULIO D'ESCRIVÁN

Julio d'Escriván (b. 1960) is a composer working in creative technologies and moving image through laptop audiovisual performance, livecoding and *soundpainting* with instrumental ensembles. Julio is active as a laptop artist in the UK and internationally. His *FUSIL* project combines, live coding and visual loop remixing along with found-objects amplification with Spanish Saxophonist Iñigo Ibaibarriaga and more recently British composer Monty Adkins. A 2013 album, 'flix' was published in Spain by Zawp Records of Bilbao. 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.

RUI DIAS

Born in Braga – Portugal in 1974, where he studied classical and jazz piano.

BA in Composition at the Music and Performing Arts School (ESMAE, 2005) in Porto, and MA in Multimedia at the Engineering Faculty of Porto University (FEUP, 2009), where he is currently a student in the UTA/Portugal Digital Media Ph.D program.

Teacher since 2005 and program director since 2007 of the Electronic Music and Musical Production program at the Applied Arts School of the Polytechnic Institute of Castelo Branco – Portugal.

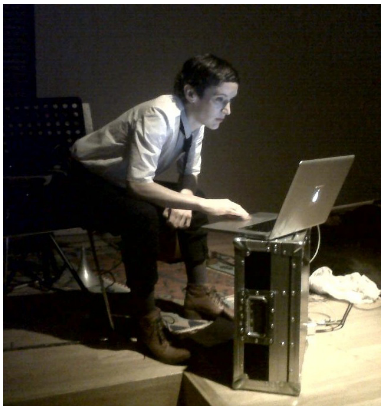
www.ruidias.pt

ARNE EIGENFELDT

Arne Eigenfeldt is a composer of live electroacoustic music, and a researcher into intelligent generative 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. He has presented his research at conferences and festivals such as ICMC, SMC, ICCC, EMS, EvoMusArt, GECCO, and NIME. He teaches music technology at Simon Fraser University, and is the co-director of the MAMAS (Metacreation Agent and Multi-Agent Systems) Lab.

www.tiemposdelruido.net

ALICE ELDRIDGE



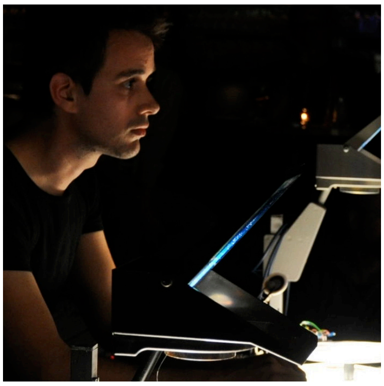
Alice Eldridge is an interdisciplinary researcher and cellist/improviser interested in biological systems and sound. She currently lectures in Music Informatics and Generative Creativity at the University of Sussex where she is carrying out research into the potential for soundscape as a proxy for biodiversity.

As a performer, she is one-quarter of the all-female award-winning collective, Collectress and a vibrant member of the Brighton (safehouse) and London Free Improvisation scenes, recently joining Evan Parker in his 70th birthday Big Band.

She is very sad not be at xCoax this year, but had an opportunity to collect audio data in the Amazon.

ecila.org

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 Ph.D 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.

interface.khm.de/index.php/people/lab3-staff/christian-faubel/

SAM FERGUSON

Sam Ferguson is a musician, researcher and programmer who is a lecturer at the University of Technology, Sydney. His research focus is to understand the relationship between, and effects of sound and music on human beings.
His research covers areas as diverse as spatial hearing and loudness research, to sonification, emotion, and tabletop computing.

LUÍS SARMENTO FERREIRA

Luís Sarmento Ferreira teaches since 2006 at Portuguese Catholic University's School of Arts and practices his research work at CITAR (Research Center for Science and Technology in Art) since 2005. He is a Ph.D candidate at the same institution's Science and Technology in Art Ph.D program. Holds a Graduate Degree in Sound and Image, with a Digital Arts specialization, which was concluded in 2004.

Currently his interests lie on the generic field of adaptive/generative interface development in the context of artistic production and in particular on the potential of web interactive systems and mass participation in Art.

spiritbit.com

INGMAR S. FRANKE

Ingmar S. Franke is a research associate at the Technische Universität Dresden. His main research topic is focused on the cognition of digital 3D imagery, especially regarding projection and perspective in interactive computer graphics. This includes the adaptation of algorithms and principles from traditional painting to modern computer graphics, based on findings from art and psychology. In conjunction with modern technologies for tracking and visualization, virtual environments can be improved and optimized for human perception.

mg.inf.tu-dresden.de/mitarbeiter/ingmar-franke

PHILLIP GALANTER

Philip Galanter is an artist, theorist, and curator. As an Assistant Professor at Texas A&M University he conducts graduate studios in generative art and physical computing. Philip creates generative hardware systems, light sculptures, video and sound art installations, digital fine art prints, and light-box transparencies. His work has been shown in the United States, Canada, the Netherlands, Peru, Italy, and Tunisia.

Philip's research includes the artistic exploration of complex systems, and the development of art theory bridging the cultures of science and the humanities. His writing has appeared in both art and science publications

philipgalanter.com

JOSÉ ALBERTO GOMES

José Alberto Gomes born in Porto in 1983.
In 2007 completed a degree in Composition at the School of Music and Performing Arts. Created strong bonds with new technological possibilities and the role of music in music theater, film, installations and electronic improvisation.

He taught in the courses of Electronic Music and Music Production – ESART, Audiovisual Communication and Multimedia – Lusófona University of Porto and Composition – ESMAE-IPP.

He is the curator of the project Digitópia of Casa da Música Foundation. Currently is doing his Ph.D in Computer Music at Catholic University. He is creator in music and sound design for theater plays and videos; creation and programming interactive sound installations; and composing for electronic and instrumental ensembles.

www.jasg.net

THOMAS GRILL

Thomas Grill (b. 1972) works as a composer and performer of electroacoustic music, as a media artist, technologist and researcher of sound. His works range from audiovisual installation, to electro-instrumental improvisation, to acousmatic music for loudspeakers. Cooperations with renowned artists from the fields of music, literature, theater, dance and video. Doctorate in composition and music theory at the University for Music and Performing Arts, Graz. Lectureships at the University for Applied Arts and the University for Music and Performing Arts, Vienna. Senior researcher at the Austrian Research Institut for Artificial Intelligence (OFAI). Thomas Grill lives and works in Vienna.

RAINER GROH

Prof. Dr.-Ing. habil. **Rainer Groh** is teaching media and interaction design at the Technische Universität Dresden. His main research areas are the theory and methodology of interactive imagery and Visual Engineering. The interdisciplinary research addresses the rapid development of hardware and software systems by establishing novel kinds of interfaces between human and computer. The focus is on user and situation aware data visualization with the help of innovative technologies such as gestural interaction, autostereoscopy, and gaze tracking.

mg.inf.tu-dresden.de/mitarbeiter/rainer-groh

THOMAS GRÜNDER

Thomas Gründer is a research associate at the Technische Universität Dresden. Working in the research group "Cognitive Interface Technologies" (CogITo), his main research topics include the Development, Evaluation and Methodology of user interfaces. One core research area is related to the interaction in augmented reality scenarios using gestures, gloves and wearables and the expressiveness of diversity human motion.

mg.inf.tu-dresden.de/mitarbeiter/thomas-gründer

ERNESTO ROMERO

Ernesto Romero Mariscal Guasp, Mexico 1975. Composer, performer, programmer. Studied Music Composition, Choir Conducting, Mathematics. Focused in real time electronic music, live coding, physical interfaces development for the performance. Performed in U.S. Latin America, Europe. Explores algorithmic composition/performance, generative music, sonification, popular music forms re-utilization. Member of "Mico Rex" experimental electro-pop music duo, closing the SuperCollider Symposium (London 2012), artists in ChordPunch net label, performing in Algorave tour 2013, going for their 3rd european tour (2014). Led the National Center for the Arts Audio Workshop Mexico (2007-2013) researching, developing and promoting live electronics and FLOSS. Important livecoding promoter in Mexico.

ernestoromero.netii.net
www.micorex.net

JINGYIN HE

Jingyin "Jon" He (1986, Singapore) is an experimental sound and integrated media artist, and researcher. His artistic focus is driven by the investigation and discovery of new directions in aesthetics. He works within a hybridized culture of art and technology, exploring the frontiers of digital creativity in contemporary sonic and visual arts practices.

Jon is currently pursuing his Ph.D in Sonic Arts and Engineering at Victoria University of Wellington (New Zealand), re-visioning Chinese antiquity with modern technology towards extension, preservation and pedagogy. He recently completed his M.F.A. in Music Technology: Interaction, Intelligence & Design with Integrated Media at California Institute of the Arts.

j-he.net

BILL HSU

Bill Hsu works with electronics and real-time animation systems. He is interested in complex generative systems, inspired by natural processes, that interact with live performers. He has built systems, tools, installations and compositions in collaboration with Peter van Bergen, Chris Burns, John Butcher, James Fei, Matt Heckert, Lynn Hershman, Jeremy Mende and Gino Robair. He teaches and does research in he Department of Computer Science at San Francisco State University.

unixlab.sfsu.edu/~whsu/art.html

PATRICIA HUIJNEN

Originally from Luxembourg, artist, educator and museum professional **Patricia Huijnen** holds a BFA (Université des Sciences Humaines de Strasbourg, France, 1999) and an MAA (Emily Carr University of Art and Design, Vancouver, Canada, 2012) in Visual Arts. She is a trained art educator (Université du Luxembourg, Luxembourg, 2002) and has international museological experience. Her research and art practice investigates the mouth, speech and affect from a physiological, historical and feminist perspective. Her sculptural, object-based and graphic work has been exhibited in Luxembourg, Switzerland and Canada. Huijnen is currently living and working in Switzerland and Luxembourg.

patriciahuijnen.wordpress.com

JONAS HUMMEL

Graham Booth and **Jonas Hummel** are musicians and Ph.D researchers based at the Sonic Arts Research Centre, Northern Ireland and Manchester Metropolitan University, England respectively. They formed the partnership Co:Lab in early 2013 to develop new social and technological systems for co-operative musical interaction. In September 2013 they presented their first project Rebellious Devices in China with a series of concerts and accompanying workshops.

Their research interests include collaboration in network music situations, group improvisation with custom-built interfaces and instruments and the affordance of technology in live music performance. Previous projects include ensembles of networked radios (Translocal Rundfunk Orchestra) and laptop computers (Huddersfield Experimental Laptop Orchestra, Republic111, PowerBooks UnPlugged).

TROY INNOCENT

Dr. **Troy Innocent** is a world builder, iconographer and reality newbie. His artificial worlds – Iconica (SIGGRAPH 98, USA), and Semiomorph (ISEA02, Japan) – explore the dynamic between the iconic ideal and the personal specific, the real and the simulated, and the way in which our identity is shaped by language and communication. He has received numerous awards, including Honorary Mention, LIFE 2.0: Artificial Life, Spain (1999); Foreign Title Award, MMCA Multimedia Grand Prix, Japan (1998); First Prize, National Digital Art Awards, Australia (1995); and Honorary Mention, Prix Ars Electronica (1992). Innocent co-founded the digital arts collective Cyber Dada in 1989 and through pioneering works such as Idea-ON>! contributed to the Australian new media arts practice during the 90s. His most recent works are urban art environments: an interactive sculpture garden entitled Colony in the Melbourne Docklands and Urban Codemakers, an Alternate Reality Game that reinvents the history of Melbourne. Innocent is currently Senior Lecturer in Games and Interactivity, Faculty of Life and Social Sciences, Swinburne University, Melbourne. Innocent is represented by Hugo Michell Gallery.

troyinnocent.net

BIPIN INDURKHYA

Dr. **Bipin Indurkhya** did his BE (Electronics) in India, ME (Electronics) in the Netherlands and Ph.D (Computer Science) from University of Massachusetts, Amherst (USA). He spent twelve years teaching at universities in the US, most of them at Boston University. He was at Tokyo University of Agriculture and Technology, Japan for eight years. He has been with IIIT-Hyderabad since 2004, where he started a Cognitive Science Lab, secured industry and government funding for various research projects, and started a Ph.D program in Cognitive Science. Since 2011, he has moved to Krakow (Poland), and is a visiting faculty at the Computer Science Department at AGH University; and at the Computer Science and Cognitive Science Departments at Jagiellonian University.

His current research includes modeling creativity, underlying metaphors and designing creativity-support systems; usability studies involving perceptual and cognitive aspects, and developing IT and robotics tools for assisting cognition and communication for autistic and dyslexic children.

JARED HAWKEY

& SOFIA OLIVEIRA

CADA is a Lisbon-based art group that makes mobile software. Its computational systems are playful and slow, exploring the interrelationship between the variable character of human beings and the spatio-temporal dimensions they create and negotiate in everyday life. Its visual interfaces can be read and interpreted, leaving space for the imagination and the ambiguity of the real.

www.cada1.net

BEN JARRETT

Ben studied Product & Interaction Design at Unitec, in New Zealand. Recently he completed a Master of Design, and is lecturing in both disciplines, researching, as well as pursuing his own business interests. He has two main areas of professional expertise and passion that seem to intertwine – high-end audio and experience/interaction design. He is most interested in creating deep value design that brings people into conscious process and state of sustained delight and immersion. Creating systems and products that are magically positioned in a physical reality, rather than mere digital immersion.

www.metier.co

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 100 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.

www.ajaykapur.com
akapur@calarts.edu

TEJASWINEE KELKAR

Tejaswinee Kelkar holds a bachelor’s degree in production engineer, a diploma in North Indian classical music and Western music theory and composition She is currently pursuing a master’s degree by research in computer science, and works in the cognitive science lab at IIIT Hyderabad, studying the interaction between music and motion, focusing on North Indian classical music. She also performs and teaches music. Her research interests include generative models of composition, multimodality and cross modal interaction.

LINDA KRONMAN

Linda Kronman (MA) is a media artist and designer from Helsinki, Finland. She has worked as an Art Director for media production companies and taken part in several multidisciplinary art and design projects. In her artistic work she is interested in exploring various participatory art&design practices, specially in connection to creative activism. Currently she is completing the postgraduate program in MediaArtHistories at the Danube University Krems, Austria.

www.mycupofcoffee.info
www.kairus.org

CATARINA LEE

Catarina Lee (1988) is a Portuguese communication designer. She has recently concluded a Master Degree in Communication Design and New Media (2014) and holds a Degree in Communication Design (2010) from FBAUL (Faculty of Fine Arts, University of Lisbon). Her current research seeks to explore data-based and software-driven audiovisual systems, with a particular interest on the theme of the transmutability of digital data.

GOLAN LEVIN

Golan Levin is an artist/engineer interested in the exploration of new modes of reactive expression. His work focuses on the design of systems for the creation, manipulation and performance of simultaneous image and sound, as part of a more general inquiry into formal languages of interactivity, and of nonverbal communications protocols in cybernetic systems.

Through performances, digital artifacts, and virtual environments, Levin applies creative twists to digital technologies that highlight our relationship with machines, make visible our ways of interacting with each other, and explore the intersection of abstract communication and interactivity. Presently he is Associate Professor of Electronic Art and Director of the STUDIO for Creative Inquiry at Carnegie Mellon University, Pittsburgh.

flong.com

LIA

Austrian artist **LIA** is one of the early pioneers of software and Net art and has been creating code-based art since 1995. LIA's main tool to create software artworks is code.

LIA's works combine various traditions of drawing and painting with the aesthetic of digital images and algorithms. They are characterized by a minimalist quality and by an affinity with conceptual art. Her work takes on various forms such as video, realtime visual performance, net art, sound and visual installations, iPhone/iPad applications, facade projections and more. Her work focuses on the translation of certain experienced principles into abstract forms, movements and colors (and sometimes sound) to allow the observer to explore these principles on a subconscious level. LIA works and lives in Vienna.

www.liaworks.com

LIAN LOKE

Lian Loke is a design researcher and performance artist, who places the lived body at the core of inquiry into contemporary issues and emerging technologies. Loke's research and creative practice is interdisciplinary and spans the arts, design and human-computer interaction. One of her primary interests is in creative approaches to physical activity and bodily self-awareness, mediated by interactive technologies. She has an established research program of working with somatic practitioners and dancers to inform the design and human experience of body-focused interactive systems (Australia Council for the Arts funded projects Thinking Through The Body 2008/09, Luscious Apparatus 2010/11).

Complex Corporealities and Distributed Choreographies is a current design research collaboration with architect Dagmar Reinhardt, investigating novel spatial environments for stimulating sensory experience and creative engagement. This research introduces the body as a generative concept for understanding and creating new relationships between complex spatial structures, body and computation. With the shift to programmed materiality where computational design processes generate new physical forms and computation becomes embedded in material objects, our research is innovating new interdisciplinary design approaches combining architecture, interaction design, physical computing and choreography.

FILIPE LOPES

Filipe Lopes is an awarded composer, performer and an academic. His practice focuses on music composition, frequently encompassing electronic music, digital media, audiovisual installations, interactive digital systems and software development. He has composed music for performers and ensembles but also music for films, dance and theatre. In addition, he has also developed significant of work related to music education and new technologies.

At the moment Filipe is doing a Ph.D in Digital Media at FEUP and UT|Austin. His research is focused on sound, space and identity.

www.filipelopes.net

PENOUSAL MACHADO

Penousal Machado, Ph.D, is Assistant Professor at the Department of Informatics Engineering of FCTUC and the scientific director of the Computational Design and Visualization Lab, of the Centre of Informatics and Systems of the University of Coimbra. His research interests include Nature-Inspired Computation, Artificial Intelligence, Computational Creativity, Computational Art and Design. He is the author of more than 100 refereed journal and conference papers in these areas and has co-edited the book "The Art of Artificial Evolution". He is member of the editorial board of the "Journal of Mathematics and the Arts" and of the "Genetic Programming and Evolvable Machines Journal", chair of several scientific events, and member of the Programme Committee of numerous conferences. He is also the recipient of several scientific awards, including the prestigious award for Excellence and Merit in Artificial Intelligence granted by the Portuguese Association for Artificial Intelligence. Recently, his work was featured in Wired magazine UK and included in the "Talk to me exhibition" of the Museum of Modern Art, NY (MoMA)

cdv.dei.uc.pt

MANUSAMO & BZIKA

Manusamo & Bzika is an interdisciplinary group created by Manuel Ferrer Hernandéz (visual artist) & Alena Mesarosova (architect) and focused on the creation of interactive installations involving the use of Augmented Reality (AR) and 3D modelling. Started in 2006, the group has produced AR creative work for numerous festivals and projects in Slovakia, Italy, Spain and Portugal. Manuel Ferrer holds a Fine Arts degree by Miguel Hernández Univeristy, Alicante and a Master in Fine Arts by the Polytechnic University of Valencia where he is currently pursuing a Ph.D. He has lectured at San Gregorio de Portoviejo University, Manabí. Ecuador. Alena holds a degree in Ingenier-Architecture (Inzinier architekt) at the Fakulta Umení, Technická Univerzita v Košiciach, Eslovaquia as well as the Bachelor (Bakalár). She also graduated from the Curso del bienio especialistico de scenografia en la Accademia di Belli Arti Catania ,Sicilia–Italia and is currently pursuing Ph.D at the Polytechnic University of Valencia. She has lectured at San Gregorio de Portoviejo University, Manabí. Ecuador.

manusamoandbzika@gmail.com
www.manusamoandbzika.webs.com

TIAGO MARTINS

Tiago Martins is a cross-media designer by training who smoothly mutated into an "algorist", while interacting with computer scientists during his studies. He is particularly interested in the convergence of multiple disciplines such as graphic design, art and computation. He creates his own tools to develop experimental artefacts and design solutions through the exploration of the expressiveness of computational, parametric, generative and emergent processes.

He is a researcher of the Computational Design and Visualization Lab. of the Centre of Informatics and Systems of the University of Coimbra, where he is enrolled in the Doctoral Program of Information Science and Technology, working on his thesis project "Author Tools in Design". He did his Bachelor and Master in Design and Multimedia at the same institution, completing the master in 2013 with the thesis "Algorithmic and Computational Approaches in Art and Design".

cdv.dei.uc.pt

CHRIS MCCORMICK

Chris McCormick is a hacker, musician, and artist who dabbles in the procedural, lo-fi, and retro computing arts. He has been working as a freelancer since 2000, running Linux on the desktop since 1996, and writing code since 1986. He rides a bicyle.

mccormick.cx

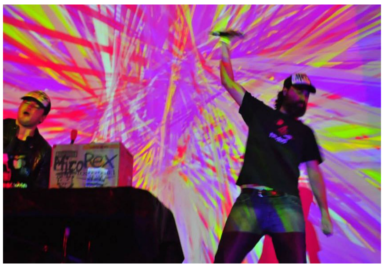
JOÃO MENEZES

João Menezes is a sound and media artist, working at the intersection of sound and digital media. Having digital means as the core of his artistic process, João's work ranges from music for theatre/dance performances, Installations; to the development of audio and musical software. He is a regular collaborator on art-technology environments, such as Max MSP and the Jamoma platform. Furthermore, João has been lecturing workshops and presentations in universities, conferences and festivals.

Born in 1989. Concluded his MA in 2012 in Interactive Music and Sound Design (with high distinction – FEUP, Porto). Is a member of the Digitópia Collective at Casa da Música.

cargocollective.com/joaomenezes

MICO REX



Mico Rex. Experimental electro-pop duo formed in 2010 by Ernesto Romero and Jorge Ramirez, mexican live programming pioneers. After performing in mexican international festivals they went to europe touring across Zürich, Nantes, Barcelona, closing the 2012 SuperCollider Symposium in London and releasing out their first E.P "Rico Mex" (ChordPunch).

After a streamed concert to Birmingham´s Network Music Festival in 2013 they did their second european tour for the LiveCode Festival as part of their Algorave tour.

With a mix of deterministic algorithms and joystick-in-card-board controlled expressiveness, concatenated within a master two-synched-laptop-brain, Mico Rex play with the precise and the indeterminate.

micorex.net

MATHIAS MÜLLER

Mathias Müller is a research associate at the Technische Universität Dresden. Within the research group "Cognitive Interface Technologies" (CogITo), his research area includes gesture-based and tangible interaction in virtual environments.
The focus is on unrevealed potentials of real-time computer graphics and novel tracking technologies to improve the user experience of interactive 3D visualizations by utilizing concepts from art and photography for innovative visualization techniques and psycho-physiological principles to adapt the machine to the needs and abilities of human beings.

mg.inf.tu-dresden.de/mitarbeiter/dipl-medieninf-mathias-mueller

MIGUEL NETO

Miguel Neto (Lisboa,1979) Musician, producer and new media artist living in Santiago de Chile has a degree in Psychological Sciences, studied Studio Recording, Advanced Music Production and a Digital Arts Master. Nowadays he is interested in creating musical interactive interfaces and exploring new musical languages, using computers and the new digital technologies. He is the musical side of real-time audiovisual performance Boris Chimp 504.

www.borischimp504.com

PHILLIPE PASQUIER

Philippe Pasquier is Associate Professor and Graduate Program Chair at Simon Fraser University's School of Interactive Arts and Technology. He is both a scientist specialized in artificial intelligence and a multidisciplinary artist. His contributions range from theoretical research in artificial intelligence, multi-agent systems and machine learning to applied artistic research and practice in digital art, computer music, and generative art. Philippe has co-authored over 100 peer-reviewed contributions, presented in forums ranging from the most scientifically rigorous to the most creatively arty.

SUSANA PATO

Susana Sanches Pato (Portugal, 1989) studied at the Faculty of Fine-Arts of the University of Lisbon (FBAUL) since 2007, where she developed her interests in new media art and design. She holds a degree in Multimedia Arts (2011) and a MA in Communication Design and New Media (2014), for which developed a dissertation concerning the subjects of computation, interactive systems and generative and performative practices.

BRUCE PENNYCOOK

Bruce Pennycook is Professor of Music in the Department of Theory and Composition in the Butler School of Music, Director of Digital Arts for the College of Fine Arts and Faculty Panel Chair for the Digital Arts and Media Bridging Disciplines Program at the University of Texas at Austin. He has been responsible for developing advanced pioneer programs in Music, Media and Technology and innovative research in new media including the famous The Music Library of The Future.

Born in 1949 (Toronto, Canada). Master in Music in Theory and Composition (1974, University of Toronto). Received a Canada Council Doctoral Fellowship for graduate work at the Center for Computer Research in Music and Acoustics (1976, Stanford University).

blogs.utexas.edu/bpennycook/bio

OLIVIER PERRIQUET

Olivier Perriquet (b. 1974) is both a visual artist and a research scientist. After an initial training in pure mathematics (MA) and computational biology (Ph.D), he graduated from Le Fresnoy, National Studio of Contemporary Arts, and was subsequently invited as a Fulbright fellow to Duke University after he spent several years as a researcher in artificial intelligence in Lisbon. He currently teaches at the media art school e|m|a|fructidor in France. His artistic work is focused on image, language and cognition, and draws references from various fields, including experimental and expanded cinema, video, live performance, contemporary dance.

www.linkedin.com/in/operriquet

NUNO PINHO

Nuno Peixoto de Pinho, born in São João da Madeira (Portugal) in 1980. In 2003 he started is composition bachelors degree at the Escola Superior de Música e das Artes do Espectáculo (ESMAE) in Porto. Recently Nuno is doing is Ph.D in Composition at Universidade Católica do Porto (U.C.P) where he explores the musical data processing in a more specifically field "The Musical Reuse as a Creative Process Compositional" under the supervision of Erik Oña and Sofia Lourenço.

FRANCISCO PROVIDÊNCIA

Francisco Providência (Coimbra 1961-), graduated in Communication Design, taught design and drawing in Architecture School of Porto University, having joined Aveiro University, where collaborated on the structure of training Design. Francisco defended Ph.D in his own work, directs the 3rd cycle in Aveiro University. With professional design practice (in his own studio) since 1985, has been dedicated to the transfer of design in companies and Museography, as synthesis domain and interdisciplinarity, today cross closest to a creative function directed to social innovation. Francisco is a researcher co-founder of the research unit ID+ that understanding the poetics in design as a locally contaminated ethos considers its manifestation required for cultural diversity and health condition of the global system.

PAUL PRUDENCE

Paul Prudence is an audio-visual performer and live-cinema artist working with computational and generative environments. His work, which had been shown and performed internationally, focuses on the ways in which sound, space and form can be cross-wired to create live-cinematic visual-music experiences. Paul is known for his complex time-based geometric narratives which are precisely synchronised to electroacoustic sound design and sound art compositions.

Paul has given lectures and workshops on computational film making techniques to a wide range of audiences and venues – from MFA students to art-science conferences and through to digital arts festivals. He has presented his personal work and his inter-media research at venues such as The Royal Institution and The Science Museum in London, The School of Visual Arts in New York City, as well as other academic institutions internationally.

Paul maintains the research weblog Dataisnature in which he writes about the interrelationships between natural processes, computational systems and procedural-based art practices. He has authored chapters in a number of books covering visual effects and interface design using code and programming. He is a contributor to both Neural magazine and Holo magazine – both deal with media art, electronic music and computational creativity. He is a guest contributor to creativeapplications.net reporting on innovation and emerging currents at the intersection of art, media and technology.

JORGE RAMÍREZ

Jorge Ramírez (GDL,México, 1981) Architect, composer, sound artist. Transfere marginal processes between music and architecture, in the imminence of the intractable.

The precise and the indeterminate, error, repetition and exception and the perceptual repercussions of time and space are all questioned in the manipulation of material from its essential physical characteristics.

Creating anomalous microdetails and using error as structure provides an analogy to tectonics, where the precision of accidents, the order in the midst of chaos, creates a dialogue that envisions landscapes beyond sound.

www.jorge-ramirez.com
www.micorex.net

DAGMAR REINHARDT

Dagmar Reinhardt is the director of reinhardtjung, a widely published architecture practice that received numerous recognitions and awards. Lecturing internationally, Reinhardt is a Program Director at the Faculty of Architecture, The University of Sydney, and Co-chair of the ROB|ARCH2016 International Conference for Robots in Architecture, Art and Design. Reinhardt's research on performativity in architecture spans from creative works that interface choreographed human and material behavior, to developing robotic manufacturing for affecting aound through complex curved geometries. As founder of the biome research cluster, Reinhardt extends creative design for a mathematical language derived from laws of the natural world, and shared between generative design, sound, digital fabrication, interaction design and architecture.

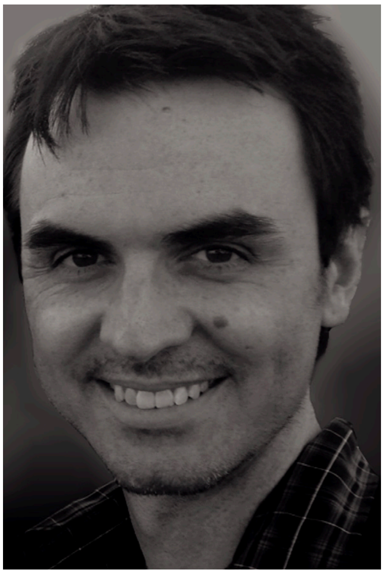
reinhardtjung.de
biome.cc

LUÍSA RIBAS

Luísa Ribas holds a Ph.D 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 in digital interactive systems. As a professor at FBAUL (Faculty of Fine-Arts, University of Lisbon) she teaches Communication Design, focusing on print and digital computational media, namely in the domains of editorial design and audiovisuality. She contributes to events and publications with articles on digital art and design.

lribas@fba.ul.pt

MATTHEW RILEY



Matthew Riley is currently lecturing in Animation, Games and Interactive Media at RMIT University and is a Ph.D candidate at Swinburne University researching interactivity in mixed-reality artworks. His practice has received recognition in international and national publications, galleries and events. He has been invited to speak at numerous conferences, festivals and institutions including the London College of Communication, FreePlay Independent Games Festival, the Society for Animation Studies, CODE – A Media, Games & Art Conference, ABC Television, The Australian Centre for the Moving Image, ISEA, NHK Japanese Broadcasting Corporation and France's Milia Conference.

www.matthewriley.net

LICÍNO ROQUE

Licínio Roque obtained a Ph.D in Informatics Engineering from the University of Coimbra while developing "Context Engineering", a socio-technical approach to Information Systems Development.
He teaches studio and project-based post-graduate courses on Human-Computer Interaction, Game Design and Sociotechnical Systems Development at the University of Coimbra.
He researches in HCI and Digital Games, focusing on Participatory Media Design, studying player-author transitions and the emergence user-generated content in games.
Currently, he researches the design of playful contexts in learning and other fields, and the design of media for supporting creativity.

MÉCIA SÁ

Mécia Sá, was born in Oporto in 1985. She graduated in Design from the University of Aveiro. Finished her master's thesis at the Faculty of Fine Arts of Oporto with a study on Information Visualization as a mean to promote an easier and more understandable access to online news about politics, with the goal of fostering a more participative citizenship.

Currently at the University of Aveiro, she is developing her Ph.D thesis on the destabilizing elements introduced by political communication and the media on the political discourse and how design tools can help citizens become aware of these critical aspects of democratic life.

ADRIANA SÁ

Adriana Sá is transdisciplinary artist, musician, performer/composer. Her work has been supported with many grants and commissions. Around 1995 she started using sensor technologies to explore music connected to light, movement, architecture and weather. Currently she explores disparities between human perception and digital analysis as creative material. Adriana performed and exhibited worldwide, e.g. at Calouste Gulbenkian and Serralves (Portugal), Experimental Intermedia and PS1/MoMa (US), Caixa Forum and Arteleku (Spain), ICA–Institute of Contemporary Arts (UK) or Aomori Contemporary Art Center (Japan). She is a researcher in Arts and Computing Technologies at Goldsmiths, with publications in Leonardo, Leonardo Transactions, and NIME

adrianasa.planetaclix.pt/

CRISTINA SÁ

Cristina Sá (Portugal 1973) is an Invited Assistant Professor at the School of the Arts of the Portuguese Catholic University (UCP), where she teaches courses in the Media Art, Interactive Art and Digital Culture areas. She holds a Ph.D degree in Communication Science/Audiovisual and Interactive Media from Lisbon's Nova University. In 2001 she finished the Sound and Image Master, specializing in Digital Arts, at Portuguese Catholic University (UCP) and graduated at the Faculty of Engineering of University of Porto in 1997. Her main research area is in Interactive Art at UCP's Research Center for Science and Technology of the Arts (CITAR), specifically in the study of the impacts of Digital Culture in Portugal and in interfaces as complex mediation elements that govern our experience. She collaborates with Nova's Centro de Estudos de Comunicação e Linguagem (CECL) in the area of Art and Communication and has also collaborated with Barcelona's Pompeu Fabra University in 2005. Strong commitment to interdisciplinary fields such as Art and Technology due to a hybrid formation in Engineering, Art and Communication

labs.artes.ucp.pt/ftp/csa

ROB SAUNDERS

Rob Saunders is a Senior Lecturer in Design Computing at the Faculty of Architecture, Design and Planning, University of Sydney. Rob's research engages with creative agency, computational curiosity, and robotic art. Using techniques from machine learning, robotics and surveillance he has explored the role of curiosity in creative processes and developed models of creative systems at individual, social and cultural levels. Rob collaborates with artists and designers to apply his research in design customisation systems, interactive installations and robotic artworks.

web.arch.usyd.edu.au/~rob

HANNA SCHRAFFENBERGER

Hanna Schraffenberger is a Ph.D student and researcher at the Media Technology Research Group at Leiden University and at the Augmented Reality Lab based at the Royal Academy of Art in The Hague. Her research interests include interactivity, interactive art and Augmented Reality. She is particularly interested in multimodal Augmented Reality and its artistic applications. Besides doing research, Hanna is interested in communicating scientific topics to a broader public. She is the Editor-in-Chief of AR[t], an inspiring magazine series about Augmented Reality, art and technology.

www.creativecode.org

ATAU TANAKA

Atau Tanaka creates musical instruments using sensing technology to capture movements and gestures of musicians. His first inspirations came upon meeting John Cage during his Norton Lectures at Harvard. Atau then studied at CCRMA Stanford, and conducted research in Paris at IRCAM, Centre Pompidou. He has been artistic ambassador for Apple, was the first artist to be engaged as researcher at Sony Computer Science Laboratory (CSL), and has been mentor at NESTA UK, and Artistic Co-Director of STEIM Amsterdam. His work is funded by the European Research Council (ERC). He is Professor of Media Computing at Goldsmiths.

eavi.goldsmithsdigital.com

MILES THOROGOOD

Miles Thorogood is a doctoral researcher at the School of Interactive Art and Technology, Simon Fraser University, exploring relationships between machine learning, artificial intelligence, soundscape, and creativity. His works have encompassed sound installation, locative media, and variety of generative a/v manifestations shown in Australia, Europe and North America. He has developed and run workshops and classes for creative coding in Canada and Australia. Published works include thematics of mutli-agent systems, electronics hacking, artificial life, and generative systems. As well, he has been published internationally in leading technology and arts magazines.

HORÁCIO TOMÉ-MARQUES

photo by Carlos Azevedo.

Horácio Tomé-Marques is a visual artist, musician and researcher in 3D and 2D digital image synthesis, digital media, multimedia technologies, music, interactivity, virtual and immersive environments. At present he pursues a Ph.d based on the relationship between Music, Reason and Emotion using emergent human computer interfaces (e.g. BCI–Brain Computer Interface) and innovative performative arts approaches. He has a long and established career as a designer, performer (music), teacher, creative and artistic director and curator.

Born in 1960 (Portugal). Has a degree in communication design and teaches at the School of Music and Performing Arts–ESMAE, Porto, Portugal.

horacioarts.com

MARTIN TOMITSCH

Dr. **Martin Tomitsch** is a Senior Lecturer at the University of Sydney. He is the Director of the Design Computing program, research member in the Design Lab, founding member of the Media Architecture Institute, state co-chair of the Australian Computer-Human Interaction Special Interest Group (CHISIG), and visiting lecturer at the Vienna University of Technology's Research Group for Industrial Software (INSO). His research on interaction design and media architecture has been published in three books and over fifty conference and journal articles.

web.arch.usyd.edu.au/~mtomitsch

GRAEME TRUSLOVE

Graeme Truslove (Ph.D) is a composer and performer based in Glasgow, Scotland. His output includes: electroacoustic and instrumental compositions, film and theatre sound design, audio-visual art installations and improvisation (performing on guitar and/or laptop). His work is largely concerned with conflicts between intuitive performance and the fixed-medium, often exploring how fixed-medium expressive and structural possibilities can be integrated into improvised performance and vice versa. Truslove's work is regularly performed at international centres and festivals for contemporary music, and has attracted various awards, including 1st prize in Métamorphoses 2010, Belgium.

graemetruslove.wordpress.com

EDWIN VAN DER HEIDE

Edwin van der Heide is an artist and researcher in the field of sound, space and interaction. He extends the terms composition and musical language into spatial, interactive and interdisciplinary directions. His work comprises installations, performances and environments. In his pieces, the audience members are placed in the middle of the work and challenged to actively explore, interact and relate themselves to the artwork. Besides running his own studio, he is a part-time Assistant Professor at Leiden University (Media Technology MSc programme) and heading the Spatial Interaction Lab at the ArtScience Interfaculty of the Royal Conservatoire and Royal Academy of Art in the Hague.

www.evdh.net

PAULA VARANDA

Paula Varanda is a specialist in contemporary dance that graduated from Escola Superior de Dança (ESD, Lisbon, 1994), concluded the MA on Choreography from Middlesex University (London, 2003), and is a Ph.D researcher in this same university since 2008. She was associate teacher at ESD (2010/2011), and was a consultant in the Institute for the Arts of the Portuguese Ministry of Culture (2004–07). Since 2004 she writes dance reviews and articles for several editors *Público*, Alkantara 2010, Daniel Tércio 2009, *Animated and Le Monde Diplomatique*; she is author of *Dançar é Crescer* (Caleidoscópio, Lisbon, 2012). Her doctoral research has been presented in several international conferences in Portugal and England.

paulavaranda.net/research

MARIO VERDICCHIO

Born in Milano, Italy in 1975. Master's degree in Computer Engineering in 2000 and Ph.D in Information Engineering in 2004 at Politecnico di Milano, Italy.

Researcher at the University of Bergamo since 2005, where he teaches Theoretical Computer Science and Computer Science for Communication.

His main research topics stem from his background in Artificial Intelligence and have always been related with the task of finding computational models of human activities and characteristics, including identity, communication, reasoning, experimentation and aesthetics

http://cs.unibg.it/verdicchio/

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 teaches at FHNW University, Switzerland and is an Adjunct Professor at Simon Fraser University, Canada. With industry experience as a designer and programmer, he holds an MSc in Physics, an MAA in Visual Arts, and a BA in Visual Communications.

His work has been exhibited in major exhibitions such as SIGGRAPH, IDEAS 10, New Forms, Re-new, Hyperkult and other international venues. He has chaired the arts track of the Computational Aesthetics conference 2011.

www.pixelstorm.ch

JAMES WYNESS

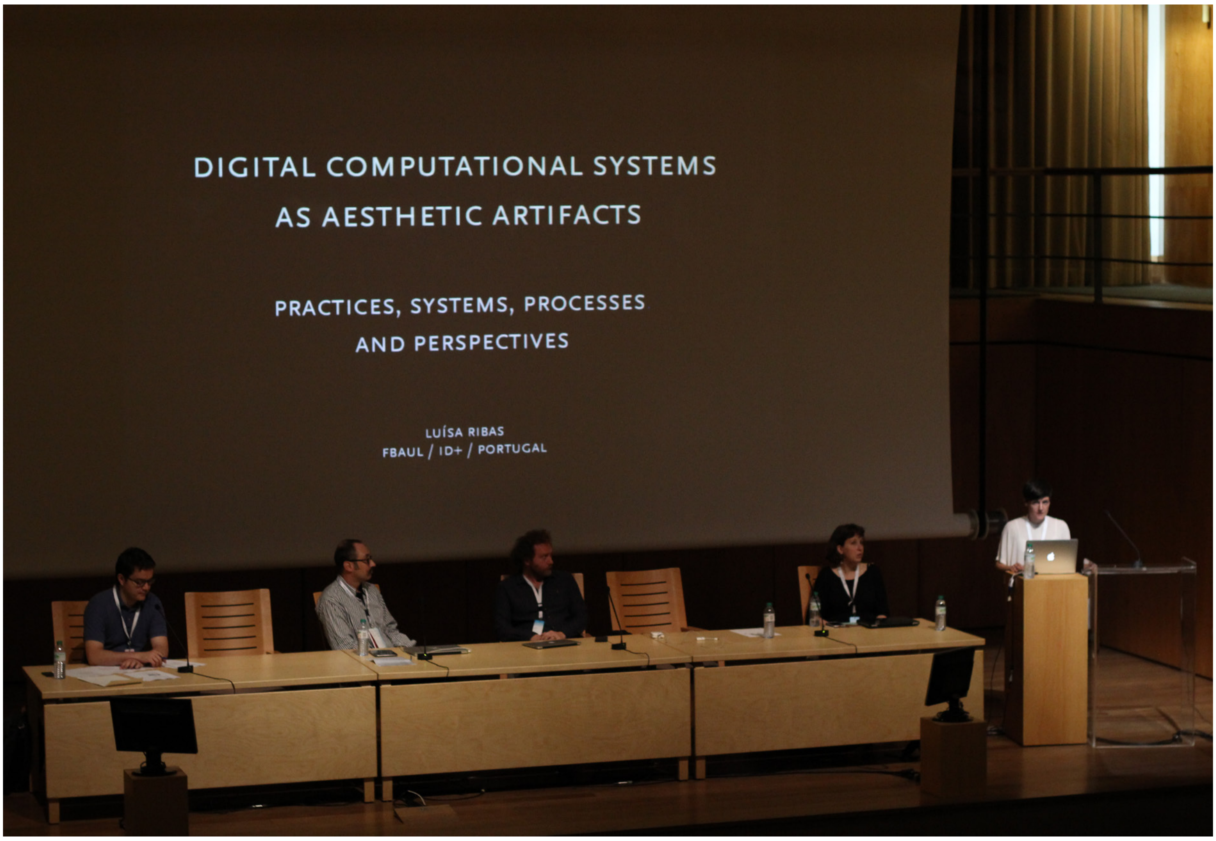
James Wyness is a composer and performer who works with recorded sound, hand-made instruments, found objects and materials. He has an MA Honours degree in French Studies and a Ph.D in electro-acoustic composition from the University of Aberdeen.

ANDREAS ZINGERLE

Andreas Zingerle is a media artist from Austria. He is a Ph.D candidate and assistant at the Timebased and Interactive Media Department in Linz (Austria). He is researching scambaiting strategies and implements their mechanics in interactive narratives and media competence trainings.
In the last years he worked on several installations exploring a creative misuse of technology and alternative ways of Human Computer Interaction. Since 2004 he takes part in international conferences and exhibitions, among others Ars Electronica Campus, SIGGRAPH, Japan Media Arts Festival, File, WRO Biennale.

www.andreaszingerle.com
www.kairus.org

PHOTOS

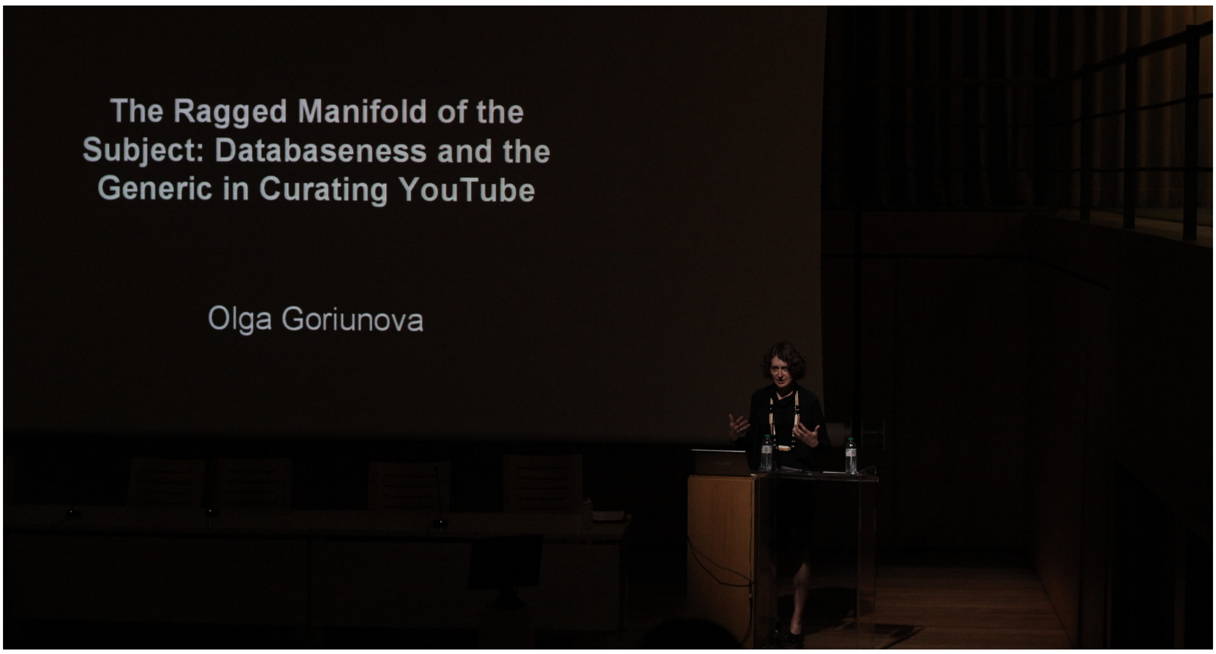

DIGITAL COMPUTATIONAL SYSTEMS
AS AESTHETIC ARTIFACTS
PRACTICES, SYSTEMS, PROCESSES
AND PERSPECTIVES
LUÍSA RIBAS
FBAUL / ID+ / PORTUGAL

1

2


What happened
on St. John's
day

3


The Ragged Manifold of the
Subject: Databaseness and the
Generic in Curating YouTube
Olga Goriunova

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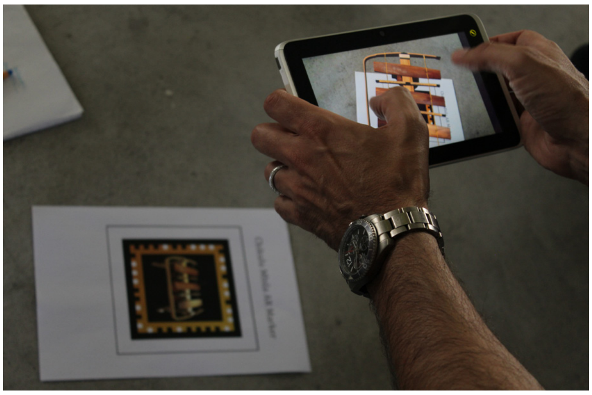

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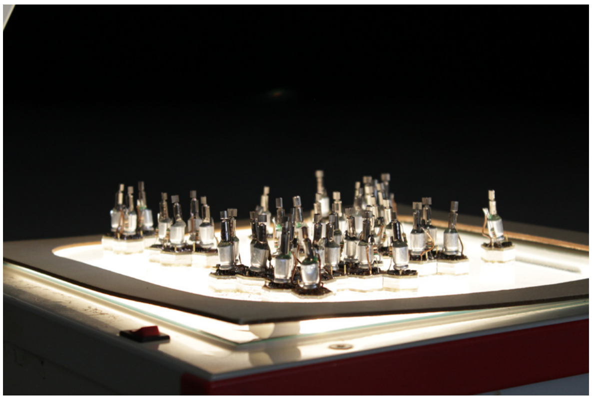

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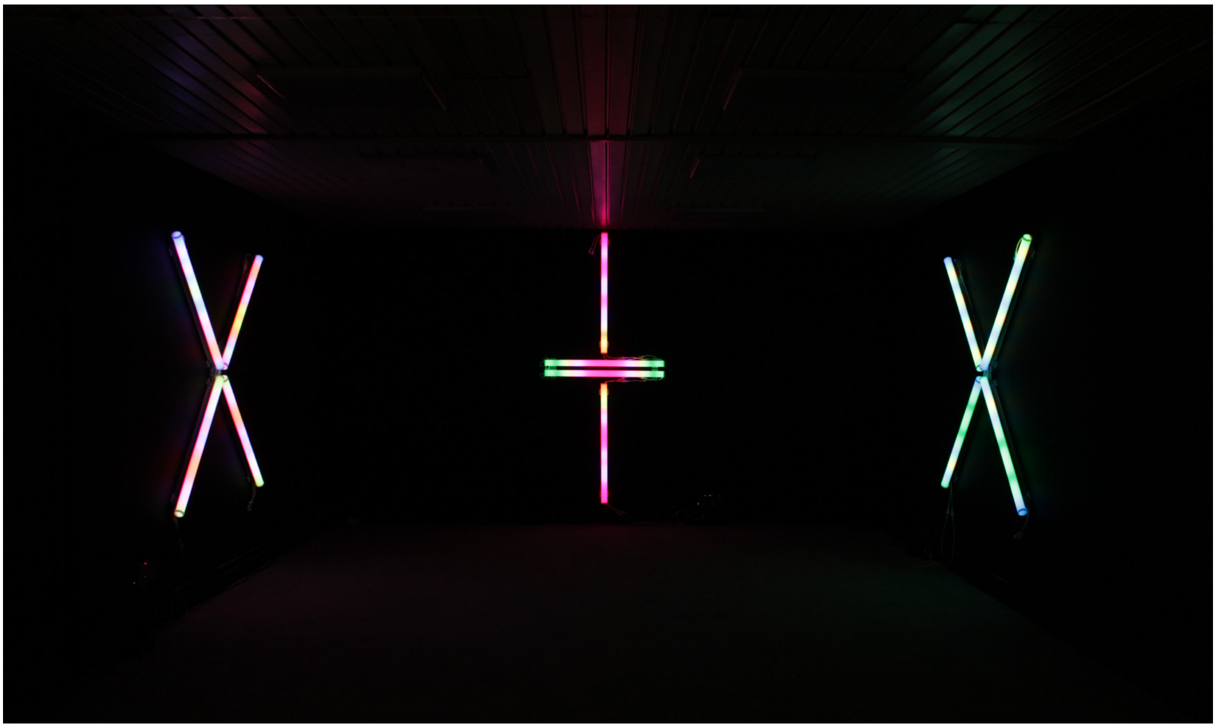

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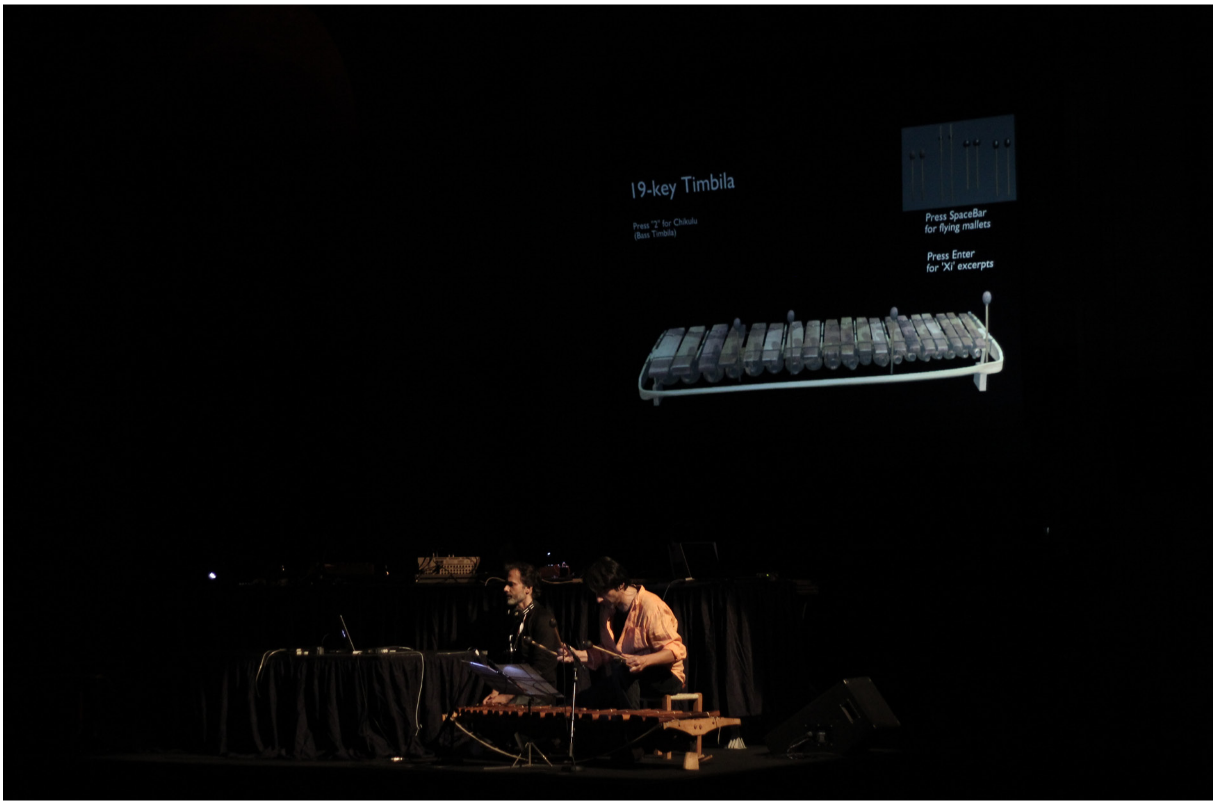
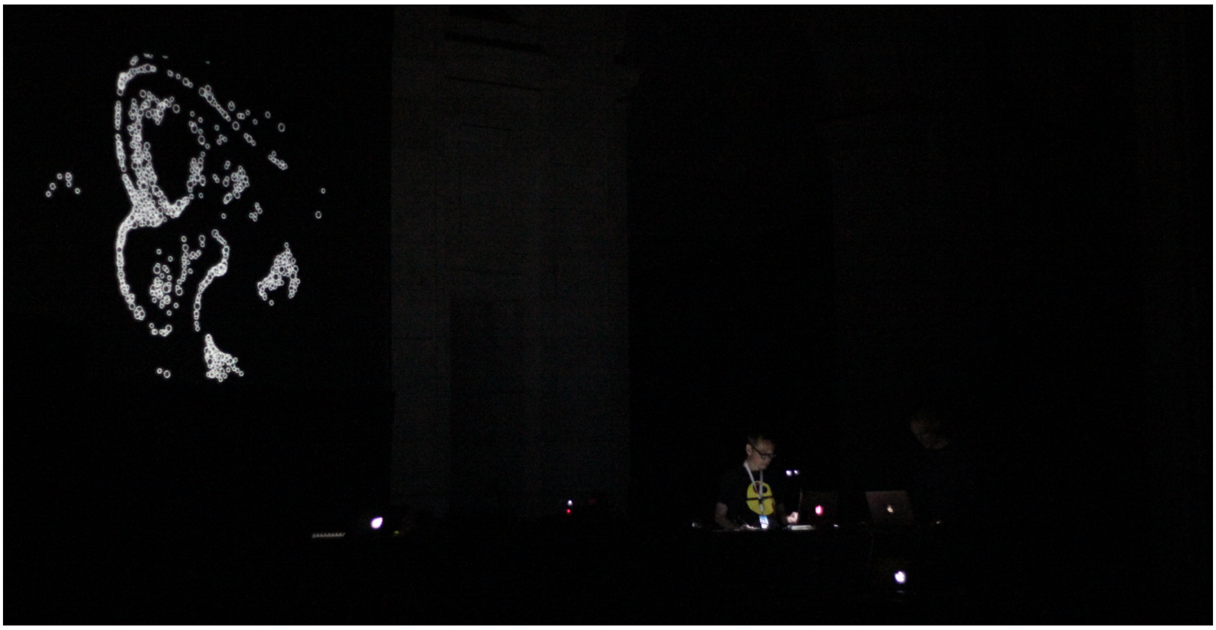

19-key Timbila
Press "2" for Chikulu
(Bass Timbila)
Press SpaceBar
for flying mallets
Press Enter
for 'Xi' excerpts

25


26


27


28


SuperCollider
aa -> lkl
dd -> lkl
bb -> lkt | ^9^
xx -> lqwetreyl
xx -> lQwETReyl
yoyo xx

29

30

1 Luísa Ribas presenting, in the panel (left to right) Mario Verdicchio, Andres Wanner, Ollie Bown, Victoria Bradbury.

2–3 Ginger Coons.

4 Olga Goriunova.

5 Julio d'Escriván.

6 Pedro Cardoso.

7 Thomas Grill, Tejaswinee Kelkar.

8 Pablo Garcia, Andres Wanner, Patricia Huijnen, Christian Faubel & Paula Varanda.

9 **Exhibition**
Vilbjørg Broch:
Quasicrystal Sound Field 1: Aperiodic Order and Non-local Harmony of Mathematical Quasicrystals

10 **Exhibition**
Ricardo Climent, Miquel Bernat, Manusamo & Bzika:
'Xi' – for Timbila of Mozambique and Interactive 3D Models

11 **Exhibition**
Andreas Zingerle & Linda Kronman:
Faceless Patrons – An Augmented Installation Exploring 419-fictional Narratives

12 **Exhibition**
Mario Verdicchio:
"Glitcher"

13 **Exhibition**
Pablo Garcia & Golan Levin:
The NeoLucida Project

14–15 **Exhibition**
Christian Faubel:
Crystal Forming Robots on Overhead

16 **Exhibition**
Philip Galanter:
XEPA – Autonomous Intelligent Light and Sound Sculptures that Improvise Group Performances

17 Jason Reizer moderating the poster session.

18–21 Ollie Bown.

22 Mario Verdicchio presenting the performances.

23 The Scottish School of Flower Arranging:
Ikenobo Ikebana

24 Vilbjørg Broch + Susana Santos Silva:
Quasicrystal Sound Field 1: Aperiodic Order and Non-local Harmony of Mathematical Quasicrystals

25 Ricardo Climent, Miquel Bernat, Manusamo & Bzika:
'Xi' – for Timbila of Mozambique and Interactive 3D Models

26 Chris Burns & Bill Hsu:
Xenoglossia/Leishmania

27 Paul Prudence:
Chromophore

28 Jingyin He:
Sonic Evocations

29–30 **Algorave**
Julio d'Escriván

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 projects PEst-C/EAT/UI4057/2011 (FCOMP-Ol-0124-FEDER-D22700) and PEst-OE/EAT/UI0622/2014.