xCooAx
2016

4th Conference on Computation, Communication, Aesthetics & X
xCoAx: Proceedings of the Conference on Computation, Communication, Aesthetics and X.

xCoAx 2016, Bergamo

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Published by
Universidade do Porto
Praça Gomes Teixeira
4099-002 Porto
Portugal

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ISSN 2183-9069

October 2016

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For the first time since its inception, xCoAx has not been brought to a new city: this year the conference on computation, communication, aesthetics and X has gone back to where it all started, the city of Bergamo.

Still, in our quest to offer always something new, fresh, and exciting to our participants, we organised the event in a different venue than the university: we took the presentations, the artworks, and the performances to the city’s modern and contemporary art museum GAMeC (Galleria d’Arte Moderna e Contemporanea).

The first and foremost benefit of bringing a discourse on art, technology and their ramifications to such a venue was the opportunity to share our endeavors with a larger audience, namely, the people who usually attend the exhibitions at GAMeC. xCoAx has also made waves in the press, not only in various listings of events of the week, but also with an extensive interview article in the largest newspaper in Bergamo.

The connection to the local context had also a more structured side in the form of a special call for artworks open to the students of the Carrara Academy of Fine Arts, which is situated just on the other side of the road from the xCoAx venue. The selected work, a piece of video art, was shown alongside the other entries, and we are very happy and proud to have given a young local artist at the beginning of her career the opportunity to show her work in an international venue.

We mentioned in the opening of the conference that going back to the same city but in a different venue reminded us of the trajectory of a helix: its circular motion brings us back towards the starting point, but the linear component of its movement takes us a bit further at each round, so that we revisit the places where we were before, but always with a different, new perspective. We think that this metaphor may also fit the topics of xCoAx.

The quest to comprehend the impact of technology on art is indeed an attempt to understand what happens when we revisit existing endeavors, such as communication and aesthetics, with new tools that technological progress has given us. The questions regarding the old and the new when we use computational artifacts still hold. Are we simply going back to where we started?
Are we revisiting places from the past with a new perspective? We are undoubtedly moving forward from a technological point of view, but does this mean that the artistic discourse is also progressing?

It is very hard to imagine a better person to ask than our keynote speaker, Frieder Nake. The computer art pioneer delivered a talk that is still resonating with us after months, and to make this effect last even longer, we asked him to give it to us again in written form, and he kindly agreed. Thought provoking to say the least, we are sure Nake’s discourse will be able to disrupt many of your preconceptions on what it means to make digital art.

It is very likely that not all the questions will be answered, and that new ones will rise, but this is exactly why xCoAx goes on along its own helix. Wherever it will take us, we are excited and ready.

Mario Verdicchio
Keynote
The digital image does not exist. (Pias 2003) But don't we speak of exactly this, the digital image, nearly all the time? We do, indeed, speak of it and we do it in a way that is similar to our speaking about a number of other phenomena surrounding the algorithmic world of computing: by mystifying the phenomenon in one way or other.

When we speak of the digital image, we definitely speak of images. All of us are familiar with them. There is nothing much exciting about speaking about them. But our case is the image in a special state or mode: the digital mode of the image. Here we go! Whatever we may think of images, when we think of them, we think of a visible phenomenon. The digital image, by being an image, must be visible. Otherwise, if not visible, we would not usually call it an image.

Well, yes, but careful! There are, as some claim, also mental images. Or images of imagination. They are, beyond doubt, not visible. When the mental image came up in psychology and cognitive science, some voices doubted that it could exist in the sense of an image. So, perhaps, in a metaphorical sense there might be a mental image. And we can, of course, use the name of any phenomenon in a metaphorical way. That's the reason behind the power of the metaphor without which much of our language and speech would disappear.

But is this the case with the digital image? Usually it's not. Naively we talk about digital images without thinking much about what we say. It's on a computer, it is stored there, and it is being processed. So isn't it digital by necessity? Oh yes, it is. In a way. But no, it is not. For, as already indicated above, images must be visible in order to be images; and the digital is invisible. The digital image is the invisible visible. Contradiction! So it does not exist.

1. Pias' publication is the text of an oral presentation in German. He summarizes in four statements the first of which says: "Das digitale Bild gibt es nicht, ...", and he continues: there is only a paradoxical relation between information and presentation of an image, and this relation may be called "digital".

2. For, if mental images were visible, they would not be mental.
Images as digital images are not visible. They are, in some way still to be determined, two-in-one! The image in postmodern times, in times of algorithms and computations exists in a double mode. I usually call it algorithmic sign. But, in the course of this essay, I am going to use a simpler expression. I will say, the so-called digital image is a surface-and-subface. We can deal with it as a digital image only if we consider it to be a pair of a visible surface and a manipulable subface. The surface is analog, the subface is digital.

This phenomenon of duplication is, of course, a characteristic of the entire plethora of things and processes as they become subject matter of algorithmic treatment. That is, as I see it, what the Algorithmic Revolution is doing to our world. In effect, the algorithmic revolution makes things and processes disappear from their existence as perceivable by our senses. And it lets them re-appear perceivably but only after having spun their other that will from then on become their permanent companion. Their digital (algorithmic) shadow.

We will return to the Algorithmic Revolution towards the end of this essay. For the time being we announce that between the concepts of surface-&-subface and the Algorithmic Revolution, this essay will be concerned with how the subface wins: It drives the masterpiece out of the world of art. The art in the work of art now is established as a set (or class) of images. Membership of the specific and individual image in a general set of images becomes more important than the appearance of the image itself. This constitutes the algorithmic revolution in the arts. In the end, the digital domain appears as the great trivializer.

**COMPUTER ART & ALGORITHMIC ART**

What, in its beginnings, was called computer art, were drawings calculated by computer programs and made visible by some kind of drawing machinery: drum plotter, flatbed drawing machine, or microfilm plotter. In the latter case, such graphic images were brought to decent size by photographic processing. Fig. 1 shows three examples that appeared in the first three exhibitions of this new kind of artistic generation. Only for the record, there were three such exhibitions in 1965: Georg Nees in Stuttgart (Germany), in February, 1965; A. Michael Noll and Bela Julesz in New York, in April, 1965; and Frieder Nake and Georg Nees in Stuttgart, in November, 1965.
Even though these three simple drawings may look, in their superficial visual appearances as rather different, they share two common features: they explore polygons, and the vertices of those polygons are determined randomly.

On an abstract geometric level, the simplest form of a polygon is a sequence of points in an area of the plane. Those points become the “vertices” of a single line when the polygon is drawn. To draw the sequence of points that make up a polygon, is an act of interpretation. The sequence of points is visually interpreted by starting to draw a line from the first to the second point, continue drawing from there to the third point, etc., until the last point is reached. If, from there a last line segment is drawn back to the first point, the polygon is called closed; otherwise it is open.

The three examples we see in Fig. 1 display twice a single polygon (left and right), and once a grid of small polygons (center). Michael Noll’s algorithm (left) randomly choses the next point by determining its horizontal coordinate according to a Gaussian probability distribution, whereas the vertical position was determined by quadratically increasing the distance and entering again into the image format when the chosen distance took the polygon outside the image size.

Frieder Nake’s algorithm is based on a random choice of the next direction, and a distance along that direction. Only a discrete set of directions was permitted: horizontally left or right, diagonally in 60 or 120 degrees, both up and down, or more or less vertically within a small range of directions around the vertical. Lengths were also to be taken from a short distance range, a middle, and a long distance range.

Finally, Georg Nees’ algorithm is repeated for each cell of the grid that the viewer may discern. Each individual polygon consists of 23 vertices, alternatingly chosen in horizontal or vertical directions within the grid cell. The first and the last vertex are connected in whichever direction is determined by their positions.
Concerning the simplistic aesthetics of these three results from the very first days of algorithmic art, there can hardly be any doubt about the following observations. Even an algorithm so trivial that it shrinks down to the command, “Select a sequence of points in the plane and draw their connecting line, allows for enormous differences in visual appearance by giving various meanings to the innocent word “select”. Already here, we encounter in a definitely trivial way the deep principle of all algorithmic art. It is the principle that algorithmic art is interesting and revolutionary because it requires the description of an infinity of cases of a certain kind. The individual cases described appropriately, are similar (or even the same) in terms of structural features, but they differ in all their specifics. Call such a set structurally similar cases (“instances”) a class. The realization of one, or a few, or even many instances of a class is then left to the computing machine. The human's task, duty, and contribution is the description of the structure, and the specification of the kind of randomness.

The latter is done by specifying probability distributions for each if the parameters that such an algorithmic work may depend on. So the artist's work becomes the description of structural features of the members of an infinite set of (in the end) visible objects, plus probabilistic rules for the selection, or determination, of one particular instance of the class.

Several far-reaching conclusions can be drawn here. They constitute the fundamental aspects of the algorithmic aesthetics we are talking about.

First, the art in algorithmic art is fundamentally found in the class, not in the individual work. This is of greatest importance for algorithmic aesthetics. It is the revolutionary departure from all other forms and modes of art.

The dialectics, maybe the tragedy, of this predicament is that you can not and will never see (perceive) a class. A class, by being constituted as an infinite set, can never appear. The human can only conceptualize a class. The class can make itself perceivable only in instances, never in total. We may have the whole only in some of its parts. Algorithmic art is implicitly abstract, even if the subject matter of the work contains figurative components. Since we may experience the work only in one or the other of the instances of the class, only such cases can be purchased.

Second, the artist's activity is remote and removed from touching the work. It is drawing and painting with eyes wide shut. You do not see, you think. I like to rephrase this as “Think the image, don’t make it.” We leave behind modernism as (still) occupied by material object. We enter postmodernism as occupied by semiotic processes.
The theory of the work of art has always had a semiotic component: the work is the material carrier of complex signs. But in the postmodern algorithmic approach to art, semiotic processes become fundamental and essential. The thing evaporates into signs.

Third and finally, the work now appears as duplication of itself. I have come to call this, many years ago, as the surface-and-subsurface character of the artistic work. This work consists materially in two modes: as a perceivable surface, and a computable subsurface. We do not usually have access to the subsurface. It is hidden, internal to the computer or the software system. The artist’s activity, his or her skillful operations generated that subsurface. In ordinary terms, we may say that the subsurface is the algorithm, the description of the class, the program-and-data. In the same manner of describing the situation, the surface is the image on screen, in projection, be it still or dynamic, passive or interactive.

Important, however, from the point of view of theory and history of art is the following fact. No work can become a work of art, if it is not perceivable by our senses. But this fundamental aspect of the work, in algorithmic art, is of secondary character only. Perceivability remains necessary. But this necessity is taken for granted and is giving way to computability. Computability in action is “executing the code”. The computer processor is doing this. What it is doing is of the character of an interpretation of the code.

Due to space limitations, I do not go deeper into the question of randomness. How to do anything random on a computer when the computer is the machine to compute and, thus, not to do anything randomly. Indeed, the computer’s computations deliver nothing that is not computable. But from a behavioristic perspective, a kind of pseudo-randomness can be achieved that, superficially is random even though it can be precisely defined in an algorithmic way.

Conceptual artist, Sol LeWitt, beautifully wrote about “the idea becomes a machine that makes the art”. (LeWitt 1967) Two years before he said so, others had already started to exhibit works that corresponded or satisfied precisely this prediction. Conceptual Art and Computational Art (to use another term, again) share a lot. Algorithmic art is a branch of conceptual art: it is a conceptual art taken seriously, or come true³.

THE DIGITAL & THE ANALOG

We tend to believe that the digital is something absolutely new, of very recent origin. However, when we think about it for a moment, we realize that counting must be an activity based on
The digital. We say “1”, and then “2”, and we can go on like this for ever. So counting appears to be a process giving answers to the question: how many are these? We stand in front of a pile or heap or sequence of things of like or dislike qualities, and ask that question: how many?

All we must be capable of when we want to answer that question is, how to distinguish one of the entities from another one. The digital is concerned with the fingers (digitus, Latin for finger). We know they are different. Their difference is evident. We associate them, one after the other, with the entities in the set under consideration. With some care, we establish the association and get an answer to the question: do both sets contain the same number of things? This starts our experiencing the concept of number. It is based on difference and distinction. When every quality of the entity is abstracted away, and when comparison is reduced to distinction, the concept of number starts appearing.

In culture, this must have been an early and basic process. On the walls of caves, not only animals and humans have been discovered, but also groups of short strokes similar to those we still use when we count by creating a record of the entities already counted. Drawing and counting — if you like: art and arithmetic — are two basic cultural techniques. Even though the concept of number as a very abstract sign develops only later, the activity of counting by comparing two sets of different things seems to have been already with caveman (cf. (Ifrah 1985)). The flock of sheep belonging to a cave and a set of pebbles were matched in the morning when the sheep left the cave, and again in the evening when they returned. They thus saw if one had been taken by a predator.

The digital is the discrete, the analog is the continuous. Each letter in the alphabet, as a form, is analog. But as one specific of all the different letters in the alphabet, it is digital. The alphabet is a discrete set of continuous letters. Each of the letters is visible.
Their set, as set, is not visible. If we draw them in the sand, one beside the other, we see the letters, we don’t see the set of letters.

The world is not digital. Nothing is in the world that is digital. If it makes any sense, then the world is analog. Digitality is a mental concept. To gain it and to use it, pre-supposes historic development of culture. Only now, with computing machinery, digitality has gained prominence. That’s okay and fine, but not very exciting. Exciting is the machinery based on discreteness. Digitizing the things around us is nice again. But more exciting are the algorithms to deal with the digital stuff.

**SURFACE & SUBFACE**

Take a look at Fig. 3. There you see (not true to scale) four pictures that were generated by different runs of a program. Actually, the three small pictures to the right come from the version of the algorithm *Walk through raster* that I had programmed in 1966, whereas the larger picture is from the 2005 programmed version of the same algorithm.

![Fig. 3. Frieder Nake: Walk through Raster. Four realizations with different repertoires, transition probabilities, modes, 2005 (left), 1966 (right).](image)

You see a flowchart description of the algorithm *Walk through raster* in Fig. 4. Let me indicate the logic or action of the algorithm. It starts from the assumption that an image plane of a certain size is given, invisibly covered by a homogeneous rectangular grid. Given is also a repertoire (set) of “signs”; they are totally arbitrary but given in computable form, i.e. such that they can be executed. Furthermore, “transition probabilities” are given.

4. In the examples, the signs are very simple geometric shapes. This must not be.
This says that, if one specific sign occupies the location of one of the grid cells, there are specified probabilities for each of the signs to be chosen as the successor sign. In other words, there are conditional probabilities for each of the signs to occur next under the condition that one specific sign has occurred before. If we have five signs, we need $5 \times 5 = 25$ such conditional probabilities. The empty grid cell may be used as a sign. — Our pre-condition is even more powerful: the transition probabilities may depend on the location of the currently last sign, not only on its visual appearance. So the algorithm allows for non-stationary transition probabilities.

Given all these ingredients, the algorithm generates an image by visiting, step by step, each of the grid cells. Its walk through the grid (the “raster”) is relative to one of six possible modes. (You may discover the modes in the realizations of Fig. 3.)

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**Fig. 4.** Frieder Nake: flowchart for “Walk through Raster”, 1966.
The so-called flowchart description of this algorithm is, first of all, independent of any concrete programming language. It is (and must be) unambiguous, nevertheless. Its form (from (Nake 1974)) makes it independent of any concrete conditions, by being as abstract as possible: it is a permanent record of the algorithm. The difficult question—now often debated, and necessarily debated—of how to document, archive, and preserve this kind of works (“art”) is solved here in the simplest and clearest and most flexible way possible.

The 1966 version of the program was written in Algol 60, a marvellous, highly influential, but now forgotten programming language. The later version of the same algorithm was done in Processing. The later version generated an edition of 44 drawings, each one a unique original realized as digital print. The edition was offered in 2005 by Museum Abteiberg in Mönchengladbach (Germany).

My estimate of the production of the 1966 version is between 60 and 80 drawings. They were realized as China ink drawings on paper, some of them repeatedly because people wanted to buy them. I did another version of the algorithm in 1972 for the portfolio “Ars ex Machina” that Gilles Gheerbrant printed in Montreal as screenprints (edition of 250). The portfolio contained six prints by six artists plus seven texts.

These facts about the algorithm Walk through raster shed a light on “surface-&-subface”, my abstract concept of algorithmic art in its earliest and simplest form. You will have concluded already that Fig. 4 stands for the subface, Fig. 3 brings together a few surfaces. To remind you: the surface represents the visible components of the work, the subface stands for the computable component. Both tightly belong together. We cannot (never!) separate the two.

We may think of the digital image as the piece of paper, we hold in our hands, covered by colored lines and areas that were applied in a more or less mechanical way to the paper. We may also think of the digital image as the light appearing on screen and generated by the processor on the graphics processing unit of your computer. But these are only the surface components. They would not exist without their computable counterpart hidden away somewhere in computer storage and running in a machinic attempt to generate another instance of the specific algorithmic image.

The unit of surface and subface builds the algorithmic image. Only in the realm of analytic thinking can we separate the surface from the subface. Ontologically they belong together. The al-
algorithmic image is a double. You may think of it as if it contained its own operational description. In fact, algorithmic images constitute, in their double existence, a new kind of image. It is okay to think, in ordinary practical thinking, of the algorithmic image as an image that is realized and produced by a computer running a program on certain input data. But, more rigorously, this is not correct. The theoretical perspective on algorithmic art tells us that the image is constituted only in this new double form of surface-&-subface. That’s what is excitingly new.

Any aesthetics of algorithmic art must start from here, from this peculiar ontology of the subject matter. It is an ontology strongly influenced by the technological aspect of existence of these works. More precisely, the technology here is predominantly a technology of algorithms. We are dealing with art in its algorithmic dimension. Algorithms exist as descriptions and are, therefore, semiotic entities, that is signs.

The images used in this section as examples are in some way old-fashioned: done as ink on paper. From the point of view of media history, they belong to the McLuhan phase of algorithmic art. I call McLuhan phase that phase of a new medium where Marshall McLuhan’s proverbial phrase of “The medium is the message” (McLuhan 1964) holds true. Applied to the current case, this means that, a generative art whose medium is revolutionary (algorithms on computers) but whose contents (drawings in ink on paper) is not new at all, is still in the phase where the drawing says, look, I’m done by computer — as if this was so terribly new. A medium in its McLuhan phase is trying out new ways of doing the traditional. Only when the products gain the specifics of the new medium, do they leave the McLuhan phase.

In the present case, this requires leaving behind the static state of works in frames put up on the wall. Algorithmic art possesses in inherent drive towards a dynamic existence. It may be realized in animation or any interactive installation. In cooperation with Matthias Krauß, I have done a dynamic version of Walk through raster for the exhibition “Die präzisen Vergnügen” at Kunsthalle Bremen, 2004/05.

Four monitors were linked to one PowerMac on which the algorithm computed sequences of signs as described above. Such a sequence was fed to four graphic processors, each of which was driving one of the monitors. They prepared the sequence in different modes available in the algorithm. The visual appearances thus were completely different on each monitor although the visual material displayed was the same in each of the four monitors.

8. In older publications, I have written about this view of the algorithmic image as an “algorithmic sign”. This is the semiotic version of the same general observation, but theoretically better justified and richer developed. (Nake 2001)
This installation was running all day, slowly generating images on the monitors without ever repeating. A sense of the infinity of the class of images could thus be approached.

Let us conclude this section by looking at Mondrian's painting of Fig. 5, asking the question “Is this an algorithmic image?” We know, Mondrian has painted it in 1930. So it cannot possibly come from an algorithm run on a computer for computers did not exist by the time. But this remark does not exclude that algorithmic thinking and elements went into its construction.

Studying the repertoire of visual elements, the situation is simple: there are horizontal and vertical black bars of almost same width (not exactly the same, an extra analysis would have to be carried out). This web of bars generates a number of rectangular areas, seven in this case. Some of them remain white, a few may be colored by red, blue, or yellow in primary color saturation.

We know that Mondrian has done a considerable number of these neo-plastic paintings, as he called them. We would take that entire set and apply a large number of statistical and topological analyses to the individual works. The topological analysis would be particularly interesting. You see in Fig. 5 that there is one cross and three T-junctions. Anthony Hill in London and myself have (in 1968/69) investigated these bar-structure topologies quite precisely. I still believe that along such paths a new kind of aesthetic research may be ventured. With generative methods results found this way could be tested. However, what Mondrian was after was some kind of harmony or balance. He was very sure about what that meant to him. I doubt that there is an algo-

Fig. 5. Piet Mondrian: Composition II in Red, Blue, and Yellow, 1930.
rithmic definition close enough to Mondrian’s intuition. There are definite limits to algorithmic imagery.

**THE MASTERPIECE & ITS END**


The chapter starts by stating that “our respect for what has been written, formulated, or painted, what has been given form, as if all expression were not at last exhausted” is the cause of the “asphyxiating atmosphere” we all (then, after the end of World War II) live in. It is not quite clear whether Artaud refers to culture and society in general, or especially to art and the theatre. However, he explicitly mentions painting, and he is more likely staying within the realm of art. For in the next paragraph, he says: “We must have done with this idea of masterpieces reserved for a self-styled elite and not understood by the general public; ...” And let me end these explicit references to Artaud’s radical judgement on this quote: “Masterpieces of the past are good for the past: they are not good for us.” (Artaud 1958: 74)

**Fig. 6.** Leonardo da Vinci: Mona Lisa, ca.1503-1506.

Must I, when writing about painting and raising the question whether there are still, or can still be, masterpieces, first define what makes a painting a masterpiece? And if not define, at least
describe it? The artist makes a work. In the algorithmic field, he or she does not even make the work in the full sense of the word. They think it more than make it when they develop an algorithm as an operative description of the class of works which those works belong to they actually care to have generated automatically. Society in intricate and interwoven processes, full of unpredictability and uncertainty, may turn the work into a work of art. Of such pieces, in the course of time, some are elevated to the rank of a masterpiece. Avoiding definitions of a set of minimal conditions a masterpiece must satisfy, if we ask a random group of persons for examples of masterly paintings, they will quite likely answer, “Mona Lisa” (Fig. 6). This image stands out beyond all doubt. Everybody seems to know one or more examples of masterpieces, even if they might be hard-pressed to give reasons for their choice.

Perhaps, the three candidates of Fig. 7 would also appear in such a poll, or another similar selection from the rich world of art. Quite likely, the more people we ask, the more hopeful candidates would appear on the list. After some time we would have to stop this. The discussion would now start again of the necessary features for the label of a masterpiece.

My claim in this essay is that the masterpiece is disappearing, independent of the criteria we may require as necessary conditions for that quality label. If I want to uphold such a claim, I must offer characteristics unique to algorithmic art that prevent such works from being lifted up into the category of masterpiece. Such a characteristic property is the algorithmic image’s double mode of existence. Its very nature of surface-&-subface destroys all master-likelihood.

Fig. 7. Sandro Botticelli: Birth of Venus, 1494-86 (left); Vincent van Gogh: Starry night, 1889 (center); Edvard Munch: The Scream, 1893 (right).

I have argued that the art in the algorithmic work is to be seen in the class, not in the individual member of the class. The class stands for the abstract whole of all its members. It is, as a class, not perceivable. We cannot take it to a room, observe it, discuss
it, admire it. It would not have an aura. It totally lacks bodily features—in all its distant, abstract, alien, ephemeral nature, in its mental and logical instead of material and graspable existence. This lack of any thingliness, its existence as sign only, is necessary for the class to be a class, and makes it the opposite of what we expect of a work of art.

But is this bad? Must we be sad about this predicament? No, we must not! The algorithmic work, in its own domain, is the source of an endless stream of works. It exists in time much more than in space. It happens, is fluid, comes and goes, and thus corresponds to something other that was important to modernity, but no longer is: truth. With the disappearance of truth, with its replacement by events, the masterpiece also vanishes. It leaves us behind with sad eyes and a secret tear in them.

THE ALGORITHMIC REVOLUTION

We are living, you could suggest, in times of “the end of ...” or of “post-...”. The end of art. The end of ideology. The end of communism. The end of history. Post-industrialism. Post-histoire. Post-modernism. There are more ends and posts. But in all that ending and giving up, we still feel that one fact, development, or process has been happening and has still not come to its end, one strong tendency is still with us, turning everything upside-down: a revolution under which we suffer and which we enthusiastically embrace.

The US-American sociologist, Daniel Bell, published a book in 1973 in which he suggested that industrial society would come to its end. He had studied statistics about the structure of the labor force and found a dramatic development. Societies are identified by the most prominent feature characterizing its processes and structures. Western bourgeois societies were, therefore, called labor society. For productive labor was the constituting feature influencing all societal processes. It was also called “industrial society”, the term Bell starts from. Industrial production is the bourgeois form of re-generating their society as a whole.9

Bell’s studies convinced him that classical industrial society was bound to come to its end and be superseded by a post-industrial society. Instead of industrial labor producing material goods for the capitalist market, service labor was becoming the largest component in the structure of the labor force. Bell could already find this shift in his analysis.

Bell’s findings of the early 1970s have been confirmed and refined in the decades that followed.10 It is interesting to observe that around the year 1970, computers already play a great role in many matters of management, even though in comparison to
2015, such influence is still singular, home- or custom-made, and specific. Computer science has just been established as a separate academic discipline for university studies in all Western countries as well as those of the Eastern Block. But no private person possesses a computer, the Internet does not exist for people, communication is still by wired telephone devices. The first great wave of automating manual factory work is in preparation, leading in the 1970s to fierce strike movements in Western European countries. What we think of in the second decade of the 21st century, when we think of “computing”, quietly appears in 1984 (first Macintosh) and 1994 (Internet break-through with the first graphic browser).

But Bell’s post-industrial society foreshadows postmodern culture, and is implicitly aware of the fantastic and astounding turnover of every facet of the technological infra-structure of society that the semiotic engine (which is the computer) brings about, has brought about, and is still continuing to establish irrevocably, as it seems.

Within a time-span of just about thirty or fifty years, everything we do during an hour, a day, a month, or a year, takes on a new form. Therefore, sociologists, historians, philosophers, psychologists, or journalists suggest new names for the society we live in. A name is a sign, and the sign originates in magic and myth. In uttering the name of an absent entity, we let the entity be present at least to some extent. In the name we ban the unknown danger.

Deep and severe changes of the structure of society are usually prepared in slow developments, along gradual tendencies. But when such tendencies have reached a critical level, the main forces behind the change dare the revolution. Slow change of the technological infrastructure then explodes in disruptive change of the political superstructure.

We have heard people talk of the information revolution, computer revolution, knowledge revolution, the third industrial revolution, the digital revolution, and we have read about corresponding societies: information, knowledge, postmodern, digital, or media society. Each of those terms contains some convincing aspect. I still suggest and prefer to call what is happening the algorithmic revolution. Why?

New in a surprising and convincing way about the developments we have experienced and have become active or passive agents of, are the following main aspects. The revolution is a cultural, a technological one. It is not a political one. Therefore, it is deeper. It is also broader, it is ubiquitous, encompassing the entire world. It is international and global. There is no turning back.

This revolution has lasted for already about forty years, and
it is still continuing. It started quietly. Almost nobody became aware of it before it had changed so much that there was no return. It spread and crawled into the individual psyche and into international surveillance. It usurped all modes of communication, and now is with the young individual by day and night, awake and asleep, at home, in school, at work.

This revolution is about computability. It is not about computers. It is not about mobile gadgets. It is not about digital media, not even about digitality, although the digital principle of coding things and processes plays an enormous role. But it could not play that role without computable functions. The major and always first question when the accelerated attacks are levelled towards another section or realm of culture is: is it computable? How can it be transformed into computable?

The computable has a second name: the algorithmic. Therefore, Peter Weibel and others, including myself, prefer to speak of the algorithmic revolution. This name says what is going on.

And algorithmic art was a very early form the algorithmic revolution took. Isn’t that nice.

REFERENCES


Although the concept of algorithms has been established a long time ago, their current topicality indicates a shift in the discourse. Classical definitions based in logic seem to be inadequate to describe their aesthetic capabilities. New approaches stress their involvement in material practices as well as their incompleteness. Based on the distinction of form and medium, as known for example in Luhmann’s work, we propose that algorithms are actual forms taken out of a medium we tentatively call algorithmicity. We attempt an observation of defining aspects of such a medium by drawing a trajectory across a number of sound pieces. The operation of exchange between form and medium we call reconfiguration and it is articulated along this trajectory.
1 INTRODUCTION

Algorithms are now ubiquitous, everywhere we look they made their way into the titles of exhibitions, movies, books and conferences. Even when discounting a certain fad factor, we still find them newly in job descriptions. The timing is at first surprising, given that the modern use of the term began in the first half of the last century (Blass and Gurevich 2003). But as computing power increases and computers become cheaper, we can now employ algorithms virtually everywhere and with increasing complexity — resulting in a heightened awareness of their “intelligence” and ethical implications. The best design effort is made so machines do not get in our way (Weiser 1993), nevertheless we feel their presence.

Although algorithms have inspired the electronic art for a long time, the understanding of their aesthetic consequences has changed over time and currently is undergoing another shift, possibly the reason for the renewed interest in their artistic use. The aim of this article is to explain this shift and to attempt to describe a medium of algorithmicity from which algorithms may obtain their forms.¹ The method is an examination of how forms move between a number of specific sound works. By doing so, we propose that artistic strategies can be built based on such motions that cut across the alleged boundaries of “pieces” and, secondly, that this mode of observation may enrich the methodological repertoire of artistic research.

2 WHY ALGORITHMS MATTER

The discourse on algorithms and “artificial intelligence” often carries utopian or dystopian undertones. They are provoked by the distinction between human and machine agency, allowing for such perceptions as the “uncanny valley” (Mori [1994] 2012). This distinction is upheld by the image of coding/decoding, often including the ideal of perfect reconstruction. It is assumed that something real—an experience, a thought, a movement—can be transformed into a finite set of elements that may then be transported or “machine learnt” and unfolded or predicted as an evocation of that original experience or movement. People are worried when the reconstruction is not complete; when the distance between the endpoints of control and communication, i.e. conceptualisation/perception or intention/interpretation, is not annulled: somebody, something did not understand.

The antagonism in the relationship between human and machine stems from the idea of cognitive delegation. Algorithms are

¹. Medium here does not denote a physical medium, but the pair medium/form refers to their common understanding in systems theory, as represented for example in Luhmann’s work. One could also think of the distinction epistemic thing/technical object in Rheinberger’s work.
supposed to embody the products of our thinking processes. For instance, computer music pioneer Gottfried Michael Koenig stated that at the beginning of a composition there is a set of rules which originates from an “act of invention”, and the computer system is merely concerned with the question “given the rules, find the music” (Koenig [1978] 1993). To this effect, computer scientist Robert Kowalski succinctly defined “Algorithm = Logic + Control” (Kowalski 1979). In the tightness of language and cybernetics, no space was left for excess. The algorithm was thus characterised by rigidity, purity, stringency, and in fact, immateriality: After all, algorithms—and even their control components—were abstract procedures for which a concrete implementation still had to be found before they could be actually executed. Likewise, algorithmic art shared the same reservations as conceptual art towards craftsmanship and the preference of the immaterial act of symbolisation. For example in Frieder Nake’s *Paragraphs*, very similar to the manifests of Sol Lewitt or Lawrence Weiner, one finds: «Computer art is concept art insofar as it describes an idea and does not show the material work» and «Computer art shares with conceptual art ... a neglect of materiality» (Nake 2010, §10, §21). Max Bense’s generative aesthetics refers to the material carriers required for aesthetic objects, but they remain the passive receivers of rules, theorems and semiotic arrangements (Bense [1965] 1971).

This view is recently being challenged by various artists and scholars in fields such as software studies or cultural theory. Algorithms now bear a crucial relationship to material reality, they can have unintended consequences, they can crash machines, etc. Algorithms have become *performing entities*. This has profound aesthetic consequences. The classical algorithmic aesthetics were formal. For example, the ideal of form was given by computer scientist Donald Knuth as an elegance expressed through conciseness, clarity, efficiency and suitable representation (Fuller 2008). A variation of this is cognitively defined, whereby the more compressible and predictable a code is for an observer, the more beautiful it is (Parisi 2013, §1.4). One might argue that Bense made the opposite statement, where the aesthetic value lies in order defined as an irregular (unpredictable) distribution, but nevertheless this conception is based on efficiency in terms of information and entropy coding. Against interactive and generative aesthetics based on prediction and probabilities, Luciana Parisi argues instead that novelty does not arise through external forces (e.g. integration of real-time environmental data or Bense’s random number generator) but is the result of a speculative tendency at the heart of computing, such that end results are alien to the initial conditions. In her theory, an algorithmic
object not only possesses a finite material form, the particular implementation and set of instructions. It is complemented by an abstract reality that makes it possible to produce and transform novel data. This *surplus* value is non-written and non-implemented, “incompressible” in the sense that it cannot be formulated.

If we say that algorithms are characterised by imperfection, we thus understand this not as glitch—the celebration of failure—but as the resistance to become determinate; imperfection in the sense of a durational and iterative, a constant reconfiguration. One can now see that, as abstract writing, algorithms exhibit a congruency with compositional processes as forms of becoming. And with them they share the difficulty if not the paradoxicality of observing and describing that which is non-written and un-realised. The task then is to find strategies of “de-paradoxicalisation” (Luhmann 1993), of engagement and entanglement to nevertheless obtain a glimpse of the blind spots and to incorporate findings into future practice. In other words, we have to take a fresh look at the agency in these processes.

### 3 SPACES

One way to conceive a medium is by analogy of space. This was done for example by George Spencer-Brown who qualified an unmarked space (medium) and a marked space containing all distinguished forms (Spencer-Brown 1979). In our case, the two types of spaces could be named the space which enables algorithmic practices, and the space produced by the very same practices.

If one accepts, at least for the moment, a comparability between the scientific epistemological process and the aesthetic epistemological process, several findings from science and technology studies and the history of science may be incorporated into a theory of the marking of space, the transition from medium to form. To understand the agency that realises this boundary, one might start with the interaction of human and machine which Andrew Pickering describes as a dance:

As active, intentional beings, scientists tentatively construct some new machine. They then adopt a passive role, monitoring the performance of the machine to see whatever capture of material agency it might effect. Symmetrically, this period of human passivity is the period in which material agency actively manifests itself. Does the machine perform as intended? Has an intended capture of agency been effected? Typically the answer is no, in which case the response is another reversal of roles: human agency is once more active in a revision of modelling vectors, followed by another bout of human passivity and material performance, and so on. (Pickering 1995, 21f)

2. The question whether art as such or artistic research in particular deals with the production of knowledge, and what the nature of that knowledge is, is beyond this article. There are entire monographs on this topic (Mersch 2015). Here we rely mostly on a notion of “epistemic semiosis” as expressed by Rheinberger and which seems a good fit for the aesthetic field as well.
While the two actors are still clearly separated here, in the next step Karen Barad’s concept of intra-action might be adopted. Human and machine are now inextricably connected in their production of space, time and matter. More importantly, there is no predetermined separation between the object and the apparatus of investigation. “The apparatus enacts a cut delineating the object from the agencies of observation” (Barad 2007, 114). In a very similar manner, Hans-Jörg Rheinberger describes the “epistemic thing” as incrementally delineated through interaction with and emergence from technical objects, an interaction taking place in a special space called an experimental system (Rheinberger 1997). Like Barad’s mattering, meaning is produced through a semiosis that is primarily material and only secondarily linguistic. If this seems in contradiction to Parisi’s insistence on an abstract reality of algorithms, it must be added that Rheinberger defines this semiosis as a relation between the produced material traces and “invisible entities”.

The two reviewers of this article have asked that I give a precise definition of algorithmicity. The problem is this: in Spencer-Brown’s (and subsequently Luhmann’s) perspective, the space of the medium, although being “pervasive”, can only be indirectly observed by marking it and obtaining specific forms. Similarly, in Rheinberger’s perspective, the epistemic thing does not have an ordinary reference. If we give a name to it, algorithmicity, such a reference “is always alleged, and it must remain, at least if one is taking the matter seriously, without precise meaning” (Rheinberger 2008, 41). What Rheinberger suggests, is that one tentatively stabilises technical sub-routines because the two spaces codependent on each other and without such stabilisation the unmarked side would simply “dissipate”. The agency then appears in the, perhaps small, differences from iteration to iteration, and by getting involved in material explorations we approach the unstable concept.

4 TRAJECTORY

The remainder of this article is therefore used as a case study in relating changes in an apparatus with the properties or characteristics of a medium of algorithms. It chooses a particular trajectory cutting across a number of pieces based on the use of similarities or imperfect reconstructions. It is the nature of such trajectories that one can only artificially determine starting and ending points. The use of sound similarity approaches to elucidate the dance of agency between composer and computer had previously been investigated (Rutz 2012), and the three pieces included in that study will be taken as points of departure from which we can now iterate with a more precise toolbox.
The idea to work with similarity can be traced back to a notion of “sound mobile” (cf. Rutz 2014b, §4.2), i.e. a structure that both guarantees an identity and object-form (recognition) but also produces ever varying changes so that the object is experienced always from different angles. A notation is fixed but the performance is variable. For example, we may have a description: ‘In the second section, lasting between one and two minutes, the recording of the sound of a rock sliding repeatedly across the floor of the room is heard.’ Then what I am interested in is that as each visitor or audience member is exposed to the piece, the same but different sliding rock is produced, for instance by selecting a slice from a much longer recording of these sounds. This is illustrated in Fig. 1.

This is an extremely simple algorithm, making it a good case to start with. If we return to Kowalski’s definition, we may find the situation shown in Fig. 2. Although the distinction between “data” and “parameters” is somewhat arbitrary, I have associated the corpus or source material with the logic component since it will most directly engage with the definition of data structures, and the performance parameters with the control component. The agency of algorithms is closely related to the exchange processes with their “environment”, what has been labelled data, parameters and implementations here. For example, the duration parameter will be the result of experimenting with an implementation of the algorithm, and on a finer grid we will encounter more parameters. Then the distribution function (linear, exponential, ...) to choose randomly from the duration interval may be written into the control component or may be visible as a parameter from the outside.
The double arrows should make clear that an algorithm is neither a given nor a static structure but something that comes into existence through these exchanges and is prone to drift and iteration, once we start to use it as a “sub-routine” in a successive project. It therefore makes more sense to talk about the configuration of all the elements of Fig. 2 along with their relations. We can then observe re-configurations, the addition or removal or exchange of elements and relations, each of which contributes to an understanding of what could be called the medium (Luhmann 1995), the unmarked space (Spencer-Brown 1979) or the epistemic thing (Rheinberger 1997) of algorithms—what we want to call algorithmicity—and how through iteration a specific form (Luhmann), marked space (Spencer-Brown) or technical object (Rheinberger) emerges.

Iterations may happen at the local level, within a piece. Observing them requires either strong discipline while composing or a second instance, conflicting with the “extimate” unity of artist and computer. A solution is to make this second instance an automatic tracing system integrated into the apparatus, an attempt that we have undertaken with a software framework (Rutz 2014a). But iterations also happen when we move from piece to piece, as the boundaries of pieces are organisational demarcations providing useful gaps that may bring the re-entry of algorithms to the front, to use Spencer-Brown’s term for the production of forms. Through these gaps we may then detect the medium in between the pieces, as drafted in Fig. 3.

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5. The term describing the blending of intimacy and exteriority was originally used by Lacan (Pavón-Cuéllar 2014), and was applied by Rheinberger to the experimental situation (Schwab 2013b).
So if we cross such a gap, the “sound mobile” is instantiated again in the live-electronic piece *Inter-Play / Re-Sound* (2011). One reconfiguration here is that instead of an existing corpus, live material is captured from a microphone. The function that preserves the piece’s identity is fulfilled by analysing this material in terms of its spectral content, aligning it with pre-composed structures for specific types of detected sounds or condensing the live signal into various buffers by keeping only those chunks that are similar to a template sound. The stable handle of “similarity” as our compositional strategy now introduces new algorithmic elements that may connect to existing ones. Here, such an element is the signal process that extracts and cross-correlates the spectral content. In other words, an important aspect of algorithmicity is the ability to compose algorithms.⁶

Across the next gap, the automatism that was introduced through the spectral analysis provides the basis for the fixed media piece *Leere Null* (2012). Here we leave the metaphor of the sound mobile, and similarity—now taken as a centrifugal force away from identity—is used as a motor to produce unforeseen sequences of sounds, scanning a huge corpus of heterogeneous input sounds. Fig. 4 shows a timeline view of the second part of the piece. Even without seeing the detail of the spectra, one can grasp the ability of a simple proposition to organise the material. Here the algorithm is duplicated and follows two strategies for the selection of sounds: while subsequent sounds are always chosen based on strong similarity to one another (now taking into account both spectral and temporal development), one strategy tries to equally maximise similarity between concurrently heard sounds and the other tries to maximise dissimilarity between concurrent sounds. The result is two different forms, one defined by a coherence with concurrent sounds contributing to a fused spatial gestalt, the other defined by a Tudoresque ecology in which we can perceive many different elements transparently.

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6. The creation of new machines through ‘orientation’ and ‘composition’ has been examined by Heinz von Foerster (2003) and Dirk Baecke (1996). If we think of a duplication of Fig. 2, the two copies of the system will be rotated and asymmetrically connected through their respective environmental transitions. In our example, the data structure of the algorithm that makes a random time selection within a corpus is filled with data provided by the algorithm that analyses the spectral frames of the input sound.
Fig. 4. Timeline showing sonogram arrangement of sounds in *Leere Null*. Time passes horizontally and concurrent sounds are vertically distributed.
One simple switch in polarity leads to two irrelative qualities. What is the source of this irrelativity? It must lie outside the binary polarity switch. A plausible explanation is that we witness a phenomenon according to Barad’s definition, that is the emergence of an entity through the interweaving of observations and the whole experimental arrangement. It would be false to simply attribute it to the complex interaction between individual components of the Kowalski algorithm, such as the specific type of spectral feature vector or the weighting function between subsequent and concurrent similarity. Instead it must be understood as the result of our experimentation with the algorithms, the whole trajectory, our investment that led to the particular constellation that we take now as its end point. Trajectory means we can always take another step: how the corpus of possible sounds came into existence. How sounds are “drained” from the corpus once they have been used, injecting thus a tiny reactive component into the algorithm.

The next node in the chosen trajectory is a joint. The first source is the previously used similarity measurement function based on audio feature extraction. The second source stems from my engagement with genetic algorithms (GA) in a research project on instrumental algorithmic composition. The potential of GA as asymptotic form generators is fascinating, but I was looking for a way to employ them in the domain of electronic music and sound art. I was interested in approaching synthetic sounds as a new material I had rejected so far. I began experimenting with the genetic programming (GP) of synthetic sounds by evolving a graph of signal processing blocks (UGens) and evaluating it based on the audio similarity with a given target sound. The convergence of this process is incredibly slow if the number of UGens is large and no combinatorial heuristics are given, as the space of possible graph topologies is immense. Instead of introducing such heuristics and constraints to shrink the solution space, I decided to observe the intermediate products of the search irrespective of their proximity to the target sound. Several interesting aesthetic properties appear: there is a multitude and variety within the individuals of each population, especially considering those “less fit”. The algorithm exhibits its peculiarities through the way DSP blocks are mutated and combined. Although the target sound has a fixed duration, the sound structures are temporally unlimited, furthermore they are parametric models that can now be further composed and even extended to arbitrarily high numbers of channels.

With this technique, I developed both a sound installation *Configuration* (2015) and a fixed medium piece *Grenzwerte* (2015). In the installation, the formal elements are triggered by and ren-
dered through the specific space, the layout and atmosphere, the objects found in situ. Room recordings from the boat in which the installation took place where used to drive the genetic programming. But how to organise the sound individuals coming out of this programming? The algorithm is composed with two other algorithms. On the basis that an installation is foremost a spatial form with no musical-dramatic linearity, the individuals—all those falling within a given interval of fitness—were fed into a two-dimensional self-organising map (SOM) based on a spectral feature vector, providing a plane for look-up or traversal. But what kind of traversal? The classic Boids algorithm from Craig Reynolds provides a simple mechanism to scan a field with adjustable balance between coherence and disjointness. Each swarm particle picks up the sounds (using nearest neighbour search in the SOM) for one of the nine sounding objects in the installation. Often the particles are close to each other, producing perceptually close forms, sometimes the swarm breaks apart into groups, providing spatial contrast (Fig. 5). In Grenzwerte, which is a stereo piece, the Boids did not make sense. The configuration was changed to unwind the map, beginning at one point and then finding the nearest neighbour, deleting the data point and repeating. One such path is shown in Fig. 6.

**Fig. 5.** Traversal of sounds (left) in Configuration (right). Each red dot is a sound synthesis graph obtained through GP and placed in the SOM. Superimposed is a swarm of nine agents scanning the map, each connected to a sound transducer in the installation.

**Fig. 6.** Section from a path unwinding in Grenzwerte. Each data point is visualised by the corresponding UGen graph, the colour gradient describes the temporal succession.
5 LATERAL CUT

For the sake of brevity we will stop at this point with the “similarity” trajectory, although there would be more nodes. Instead, this article finishes by adumbrating a lateral cut. We can imagine the space of algorithmicity as an ether in which trajectories such as the one described before can be precipitated. A last important property to highlight is that these paths are not isolated fibres, but they are actually interwoven. Evidence will be given through a short second fibre that crosses the preceding one in the installation Configuration.

This is a visual fibre, and therefore an illustration is helpful again to explicate what is difficult to verbalise (Fig. 7). On the left side a rendering from a graphical user interface is shown that is used both to visualise processes during the development of a sound installation and to act as an interface for live improvisation. Both in the “unsupervised” display and the live operation the problem of screen space occurs. The number of processes and their parameter structure change, so an intelligent partition of the display is sought. We also need to be able to pan and zoom at different levels of detail. The system derives from an information visualisation toolkit and a particular forced-directed layout algorithm for graphs. An $N$-body force defines the gravity or repulsion between all vertices along with a Barnes-Hut coefficient, a drag force simulates friction, and a spring force controls the edges in the graph. As a result, processes will self-organise their use of the screen estate. Together with a convex hull rendering for groups of parameters, the interface obtains an aesthetics resembling amoeba on a specimen slide.\textsuperscript{8}

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\textsuperscript{8} This impression is limited in the figure as it misses the animation.

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\textsuperscript{8} Ever since this system became operational, it was self-evident that the visual beauty constitutes an autonomous quality beyond the functional design. The gap we cross in the transition from the left to the middle image of Fig. 7 is the withdrawal from the context of an auxiliary display and the construction of a pure video
In Configuration, one of the rooms contains a video triptych. The image shown here is a frame from one of the three videos, following the evolution of selected sound structures as they mutate and crossbreed through the genetic programming—the point of intersection of the two fibres. To procure a vertical alignment, experiments were conducted with the algorithm, finally arriving at two custom “torque” forces that bring the structure into the desired vertical layout.

The second and last gap shown here occurs within this installation piece. The third of the video triptych attempts to find a visual form for text. (The movement of text components through my work would indeed be yet another fibre that finds a crossing point here.) From the augmented layout used to produce the GP video, an experimental system was constructed where all parameters could be adjusted. Although just a dozen in number, the dynamics become very complex and the spectrum of possible shapes and gestures extremely large. The reconfiguration that took place encompasses the exchange of UGens for text letters as vertices, the addition of a second edge type for connecting text lines, and most importantly the introduction of key frame snapshots for the parameter set. Interpolations are performed between key frames while the interaction between the parameters is all but linear, bringing the structure from stable plateaus to clusters and chaotic oscillations and back again.

6 CONCLUSION

We have suggested that algorithmicity is the medium or unmarked space of algorithms which are its specific forms. Rather than focusing on a predominantly technological determination, for example when Lev Manovich contends that an independent software medium configures the mental model of the “user” (Manovich 2013, 204), and rather than applying a psychological underwriting of creativity as is often the case in cognitive science, we propose that this medium is more acutely located by the ensemble of positions presented here, from the speculative and incompressible nature of computation (Parisi) to the intra-action of human and apparatus (Barad) to the experimental spirit (Rheinberger). If we move experimentation to the foreground, the boundary that extends beyond Kowalski’s definition becomes the main focus. We suggest that the boundary operations are best described as reconfiguration, operations where many elements and relations, representations and concepts remain intact but a few critically change. We propose that reconfiguration happens on several time scales and that it will be especially useful to extend the observation beyond individual pieces and instead look macroscopically at series of pieces. This way we amplify the gaps that allow us to study the nature of marking the space. Pieces
become resting points; we select a stable reference, such as the “sound mobile”, and map out the possible moves of algorithmicity, such as the catenation or nesting of algorithms, the reimplementation of a concept, the movement from a formerly internal detail of a program to a more exposed governing position. This project is also an invitation to artist-researchers to participate in the mapping process, since experimental systems have likewise been identified as an insightful perspective on artistic research (Schwab 2013a).

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Digital interactive systems have systematically been designed in order to cater to the user’s desires, through user-friendly and user-centred design methodologies, privileging pleasurable and effective experiences. While this may be necessary and a worthy pursuit in many cases, it led to the rise of convergent systems focusing mainly on efficiency, productivity, and optimisation not only in those areas of our lives that require this mindset but to all areas regardless, relegating the interactor to the role a client experiencing a product, while limiting the creative and exploratory potential of the digital medium. In order to introduce divergency, we propose the concept of defamiliarisation as a method to reduce the predictability of interactions with digital technology, and suggest possible methods to accomplish it in interactive systems.
1 INTRODUCTION

With the ubiquitous of computing and the pervasiveness of digital media, we are now faced with pervading interaction with digital information. These are capable of being part of virtually all of our daily activities: of our work, naturally, but also of our leisure, our meals, our commute, our social interactions, exercise, rest, and so on.

As we further allow these systems\(^1\) into every aspect of our “connected everyday” (Giaccardi 2015), the more influence the design philosophies inherent to these systems have on ourselves and our behaviours.

Regardless of what we may have learned from Marshall McLuhan, in a post-app world we often neglect that the medium that delivers the digital information we interact with has an inherent ideology, even if not consciously designed, and that that ideology has an impact on us, the interactors. Even user-centred/user-friendly design, which aims to have the design process guided by users, is implicitly stating a design philosophy that conditions the product and our usage of it, gradually adapting our own actions to better accommodates the generalised user that these objects are centred around, and attempting to be friendly to (Dunne 2005).

While designing to please the user, these methodologies, logically and unavoidably exclude all possible experiences that are unpleasant and “user unfriendly” (Dunne 2005), even if these unpleasant interactions could expand the experience. Steven Fokkinga and Pieter Desmet make the case for negative emotions “as a key element of rich product experiences, instead of an unwanted side effect of product interaction” (2012), such emotions as well as those arising from frustration and aggravation from unfriendly designs could be explored in a way to produce novel and valuable experiences.

Naturally, there is a financial incentive to create interactive systems that create pleasurable experiences and respond to the interactor’s expectations. Likewise, the design of systems that aid the discovery and encountering of digital information, in their attempt at relevancy, condition the possibilities of the interaction. As the available information grows, information seeking and discovery systems, in an effort to better answer to the information needs of the user, began to adopt methods of information personalisation, catering content according to the individual needs and preferences. In what can be described as another form of user-friendliness (one that modifies not the interface delivering the information but the information itself), the system attempts to predict the user’s intention and present the result which it believes to be best suited.\(^2\) The intention is to create a “serendipity

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1. In this article, and for the sake of brevity, by systems we are encompassing all methods of conveying digitally-based information, be it a smartphone (and smartphone application), a smartwatch, a video game or a website. Further research will be necessary to frame this discussion within specific media.

2. The intention is to create a “serendipity
machine”, as Eric Schmidt once described his vision for Google Search (Siegler 2010). This, however, is, at best, pseudo-serendipity, as these systems do not cater to us, but to a machine-created caricature of ourselves, the sum of our clicks, likes and shares. While these may represent the interactor to some extent, they are not us, and they do not accommodate growth, as we are constantly ‘consuming’ the same ideas, letting ourselves fall into an echo-chamber, constantly feeding the machine with the reverb of ourselves.

As we continue to create systems built on a functional mindset, which privilege optimisation and productivity, promoting pleasurably knowable experiences built upon best practices of user-friendliness, we fail to explore the potential of these increasingly smarter devices and of the digital medium itself as a means for creative and unexpected experiences which may deliver actual serendipity.

2 CONVERGENT ME AND DIVERGENT US

In his book Being Digital, Nicholas Negroponte (1995) foresaw a future newspaper in which the individual reader could fine tune the relevancy of the content according to what interested her the most at a particular day, through user-configurable filters with which one could “crank personalisation up or down” (2015, 154). This “Daily Me”, as Negroponte called it, would be our main source of information during work days. When, however, we felt the need for more “serendipitous” discoveries (during a relaxed weekend, Negroponte suggests), we would opt instead for the “Daily Us”, which would enable us to expand our concerns beyond what is familiar and discover new, surprising information.

Twenty years later and the Daily Me is a reality. We can see it in Facebook, Twitter, Google News, YouTube and Spotify. It is ever present in the attempts to better accommodate the interactor’s expectations and interests, since “a squirrel dying in front of your house may be more relevant to your interests right now than people dying in Africa”, as Facebook’s founder Mark Zuckerberg famously stated (Pariser 2011, 1). The quest for relevancy becomes ever more crucial as these systems’ business model is largely dependent of it. Through exploring our natural homophilic proneness, these systems keep us engaged in the content which lie into our declared interests.

While there are abundant examples of Daily Me-like systems, the same can’t be said for the Daily Us, beyond academic and artistic experimentations³. And while some systems have the potential to be examples of a Daily Us that takes advantage of the potential of the web and the digital medium, most fail to do so due to either by implementing content personalisation methods or being circumscribed to the audience of these systems.⁴

3. One good example of an attempt at a Daily Us is Catherine D’Ignazio’s Terra Incognita: 1000 Cities of the World, a “serendipitous global news recommendation system designed to help people out of their personalised media filter bubbles”. While D’Ignazio’s study didn’t show a significant shift in user behaviour in aggregate, 87.5% of the users reported to have learned about a new city and 63% of users consider that Terra Incognita “prompted them to reflect on the geography of their news reading”, helping to broaden users’ horizons while piquing “their curiosity and helped some feel ‘more connected’ to unknown places” (D’Ignazio 2015).

4. Such is the case with the crowd-curated news aggregators such as Digg, Reddit and Slashdot. While the democratic “upvote” and “downvote” mechanics of these platforms can lead to the most interesting or commented upon content at a particular moment rise to the to, in practice, however, due to the particular demography of these platforms (mostly US males between the ages of 18 and 29) what ends getting up-voted the most is the type of content that fits to the audience interests.
This Daily Me/Daily Us dichotomy can be juxtaposed with J. P. Guilford’s *Convergent* and *Divergent* intellectual processes. In Guilford’s model, *Convergent* thinking is productive, goal-driven and intended in discovering a single solution, while *Divergent* thinking concerns itself with creativity, with generating multiple solutions to a problem (Guilford 1967). When translating this to interactive systems, *Convergent* systems are those that attempt to provide the right information at the right time, *Divergent* systems are those that expand the interactor’s world, promoting unexpectedness and surprise. *Convergent* systems are user-friendly and user-centred, *Divergent* systems challenge the interactor. What is happening is that we are seeing convergence without first diverging, decreasing chance, surprise and unexpectedness, making our interactions with digital information safe, friendly and utter predictable.

3 DIVERGENCY THROUGH DEFAMILIARISATION

*Defamiliarisation* is, quite literally, to make objects unfamiliar. To Viktor Shklovsky, who introduced the concept, to *defamiliarise* an object means to increase the difficulty and, therefore, length of contemplation and perception of that object “because the process of perception is an aesthetic end in itself and must be prolonged” (1917) and as a method to “counter-act the familiarisation encouraged by routine modes of perception” (Dunne 2005).

By considering defamiliarisation as a technique in interaction design, we are able to explore the creative/divergent potential that interactive systems can have in our lives, drawing attention both to the interaction and the medium.

In the following section we will explore methods for designing defamiliarisation in interactive systems, divided in defamiliarisation of information, interface and emotion and drawing from examples in the state of the art. These originate from various types of applications and were chosen due to their singular approaches which we believe can be applied in other categories of interactions and lead to new and surprising forms of engagement.

3.1 INFORMATION DEFAMILIARISATION

By information defamiliarisation we consider methods that transform or reconfigure digital information (the information objects themselves, what is commonly referred to as *content*) in order to make them strange and unfamiliar. This can take shape through manipulation and transformation of the information, its juxtaposition and through randomness.
MANIPULATION AND TRANSFORMATION

Information defamiliarisation can be achieved by changing the formal qualities of the information artefact. One example is found in photographic filters commonly used in mobile photography through applications such as Instagram (2010) and Hipstamatic (2009). In the particular case of Hipstamatic, the user is able to activate a random filter (representing a combination of simulated film and lens) that’s automatically applied to the captured photograph. This can lead to unexpected results that introduce novelty in what has otherwise become a routine banal activity.

JUXTAPOSITION

Juxtaposing apparently unrelated information can lead to defamiliarisation, as it invites the interactor to draw connections between the different information being transmitted. This was observed by Tuck Wah Leong in his study of listening to music in shuffle. Leong observed that “when familiar tracks are presented to listeners unexpectedly [...] listeners perceive the evocations of these familiar and personal associations as being slightly different, unfamiliar or even strange.” (Leong 2009) This is also observable in image search engines and explored to great effect on the website fffound.com where a user uploaded image is associated to three other images, often apparently unrelated.

RANDOMNESS

Randomness is often explored as both a mechanic for defamiliarisation of information as a method for other mechanics, as observed in the cases of Hipstamatic and shuffle listening, both relying on randomness. One example of randomness as a means for defamiliarisation can be observed in chatroulette.com and randomyoutube.net. In both these platforms, randomness is the key mechanic, and defamiliarisation occurs due to the uncertainty of what will be shown. In Explosm’s Random Comic Generator 2.0, defamiliarisation is the consequence of the random (often non-sensical and occasionally fortuitous) combination of comic panels.

Fig. 1. Randomly created comic strip from Explosm’s Random Comic Generator 2.0.
3.2 INTERFACE DEFAMILIARISATION

One can also design defamiliarisation through the system’s interface. By challenging conventions and eschewing best practices, the designer is able to draw attention to the interaction and explore new methods of communicating information. These can be done through interface abstraction and interface complexity.

ABSTRACTION

Through interface abstraction, the designer reduces traditional interface elements to the non-figurative, rejecting the notion of interface “transparency” (Murray 2012) and embracing opaqueness, encouraging exploration of the interface, allowing for surprise and delight when the interactor is able to understand a specific functionality. This can be observed in Argeiphontes Lyre, a synthesis program developed by Akira Rabelais with a graphic user interface consisting of a translucent, cloud-like shape that displays cryptic messages in different languages. The author offers no documentation for the software, leaving the interactor to learn it through experimentation alone (Bailey 2012).

COMPLEXITY

With this defamiliarisation method, the designer purposefully and overtly hampers the interaction by introducing complexity. While similar in result, complexity differs from abstraction since the interface can be completely descriptive. One example of this kind of complexity is in the video game Papers, Please (2013), in which the designer purposefully created a “clunky” interface in order to better approximate the repetitiveness of the bureaucratic process (Cullen 2014).

Fig. 2. Papers, Please user interface, from http://papersplea.se
3.3 EMOTION DEFAMILIARISATION

These are systems that, while offering a specific function to the user, do so while intentionally provoking a particular emotion, not necessarily related to the system's proposed goal. These can be through poetic, whimsical or mischievous interfaces.

POETIC INTERFACES

In poetic interfaces, the system is imbued with expressive, figurative or metaphorical meaning beyond the implicit in the interface. This can be exemplified in Jörg Piringer’s *gravity clock* (2010) in which the passage of time is symbolised “by the permanent destruction and reconstruction of the clock-face.” Here, defamilialisation occurs through the desconstruction and abandonment of the functional premise of the software, in this case, to tell time.

WHIMSICAL INTERFACES

Whimsical interfaces combine functionality with a playful, joyous tone, engaging with the interactor beyond the user/tool paradigm. This can be found in Mark Sheppard’s *Serendipitor* (2010), a GPS navigational system which occasionally makes suggestions such as “follow a cloud”.

By breaking with the functional, impartial expectancy of software, whimsical interfaces encourage the interactor to reflect on the interaction itself. In the particular case of *Serendipitor*, this is done through the tongue-in-cheek notion of using a GPS navigational systems to help one wander.

MISCHIEVOUS INTERFACES

Mischievous, or abusive (Wilson and Sicart 2010) interfaces are those that intentionally break with the interactor’s expectations, behaving inconsistently and unpredictably, lying to the interactor or being extremely challenging. This can be seen in the video games *Unfair Mario* (2013) which uses the players expectation of a *Mario* video game against them, regularly resulting in death of the video game character and player frustration. Overcoming mischievous interfaces can, however, empower the interactor, giving her the feeling of ‘beating the designer’.

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5. While emotion has long been a design goal, it is mostly focused on user’s pleasure and delight or “fun” (Norman 2005, 100), which we believe to be reductive.

4 CONCLUSIONS AND FUTURE WORK

Convergent, user-friendly systems reduce the complexity of human experience into goal-driven interactions in which a successful interaction is productive, and a successful interface is one that either disappears or is pleasurable to engage with. This artificially limits the potential of interactive digital interfaces as a creative medium for novel, surprising experiences beyond the functional and pleasurable. In this paper we have highlighted the need for divergent systems that provide new methods of interaction. We have suggested that the artistic technique of defamiliarisation could be used as a means to create divergent systems, and offered possible methods to do so, through defamiliarisation of interface, information or emotion.

While this paper is exploratory in nature, we have started to prototype systems that explore each of the suggested methods and evaluate their potential to create defamiliarisation, having started with a smartphone application for mobile photography—which manipulates and transforms the captured images randomly and without the interactor’s control—with promising preliminary results. Future work will consist of further experiments of the enunciated methods for achieving defamiliarisation. Through them, and their respective evaluation, we aim to discover the principles and mechanics that are necessary to create divergent systems that enable creativity and serendipity, and can contribute to reclaim chance, unpredictability and surprise into our daily interactions with technology.

Acknowledgements. This research was made possible by a grant from Fundação para a Ciência e a Tecnologia.
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Under the concept “from the archive to the new” this paper explores the impact of digital computational technology in the way we store, share and transform information in a technologically mediated society. It starts by developing a theoretical investigation on the topic, while addressing a “brief history” of the digitalization of the archive and its consequences. Secondly, it proposes a practical approach to the subject through the development of a digital web-based platform divided in two key moments—archive and program. The digital archive gathers projects related to the theoretical investigation. We then create small computational programs in order to transform the stored information into new meaningful pieces of information. Finally, we present a framework used as a design methodology to guide the development of these computational programs, seeking to produce results whose expression, meaning and reflection contributes to a renewed view of the archive.
1 INTRODUCTION

Our research explores the theme “from the archive to the new” aiming to reflect on the impact of digital computational technology in the way we store, share and transform information in a technologically mediated society. Assuming that the archive is a place where we store information that we want to preserve in the future, it can also be understood as a space of memory, or as Charles Merewether (2006, 10) asserts, “the archive, as distinct from a collection or library, constitutes a repository or ordered system of documents and records, both verbal and visual, that is the foundation from which history is written.”

In this sense, the archive is a governance space where various types of power are exercised when its narratives are re-built in different times and places. It is a technical apparatus (dispositif) whose structure defines what it will “say.” Therefore, in the context of transition from analogue archives to digital archives, the archive is no longer a place where we just store and share information, given that, as a digital medium, it is able to transform information through computational processes.

According to this view we explore the archive under different perspectives. Firstly as a theoretical concept, while providing a “brief history” that summarizes how the digitalization of the archive has allowed it to spread throughout all dimensions of our experience, reshaping the way we deal with information.

Secondly, this reflection on the archive is put into practice through the development of a digital web-based platform divided into two key moments: the archive and the program. We created an archive to store projects that reflect the theme of this study and then developed small computational programs in order to perform transformations on the information stored in the archive. This allowed us to reflect on, and put into practice, the new condition of the archive. In order to develop these computational programs we used a framework devised as a design methodology, or a means to structure and systematize processes that more evidently contribute to a renewed view of the archive and its potential for novelty.
2 FROM THE ARCHIVE TO THE NEW: “A BRIEF HISTORY”

2.1 THE TRANSITION FROM ANALOGUE ARCHIVES TO THE DIGITAL ARCHIVES

According to Michel Foucault (1972, 129), “the archive is first the law of what can be said the system that governs the appearance of statements as unique events”. In order to define the concept of archive, Jacques Derrida (1995, 9) stated that this concept shelters in itself the memory of the name *arkhé* and its double meaning of commencement and commandment. Thus, the archive, in its principle of commencement, is the place of domiciliation, or localization, and in its principle of commandment is the place of consignation.

However, according to Derrida, with the introduction of digital technology, an archivist technical revolution happened leading to the transition from analog archives to digital archives and transforming these objects in algorithmic devices where all the documents, regardless of their nature, are coded in the same language and placed in a non-hierarchical structure called database. Given these changes, José A. Bragança de Miranda (1996, 97) states that “if before and, since always, the archive was located, corresponding to a specific institution and therefore was controlled, today it has relocated itself, spreading throughout all the experience.”

2.2 THE NEW DIGITAL ARCHIVES

The digitalization of the archive has resulted in the fragmentation of memory and consequently the fragmentation of experience. In these new technical devices it is not the data but the meta-data that are the archival element (Ernst 2013, 92). In other words, it is no longer in the data itself that relays the principle of what is said by the archive but in the gap between the data. Therefore, it is the relationship that is established between the data that determines and builds new significant fields: “the new archive’s task is to meaningfully link up different information nodes—a variable archive art. (...) Here it is no longer a question of reactivating objects but of relations.” (Ernst 2013, 83)

In this sense, these new archives are structured by databases which Manovich (2001, 194) defines as “collections of items on which the user can perform various operations: view, navigate, search”; and because they are not linearly readable they clash with the narrative principle of the archive. As Manovich
adds, the databases and the narratives are enemies. As a result of this new fragmented construction, according to Ernst (2013, 82), we live in a dynamic memory culture which is always updatable. Bernard Stiegler (2009) considers that we pass from the mnemotechnics—technical objects as bearers of memory—to mnemotechnologies. These new devices have the ambiguous role of simultaneously empowering us with an immense memory that is always retrievable and, at the same time, remove our knowledge, given that instead of bearing the memory inside our body we can upload it in external prostheses. Thus, according to Stiegler (2009, 27), by being external to us, these prostheses are more permeable to be controlled by others, and this fully installs “a question of biopolitics, psychopolitics, sociopolitical and technopoliticalization of memory.”

2.3 THE TECHNOLOGICALLY MEDIATED SOCIETY AND ITS CONSEQUENCES

In the “Cyborg Manifesto”, Donna Haraway (2000, 295) said that “a slightly perverse shift of perspective might better enable us to contest for meanings, as well as for other forms of power and pleasure in technologically mediated societies.” It seems that the terminology “technologically mediated society” is the perfect translation of this era in which we upload our memory in technological prosthetics and trust in these technologies to mediate our social, economic, political and emotional structures.

Considering the recent history of the evolution of societies, Foucault identified the existence of a disciplinary society in the last century, as a model born from an economy focused on production and in which the government is concerned with managing bodies as a mass and normalizing it through surveillance. Foucault termed this type of government biopolitics and presented as architectural metaphor the Panopticon of Jeremy Bentham, where the subjectivity of the bodies is silently overwhelmed by the feeling of vigilance. Within the crisis of confinement institutions, and as a result of the technological revolution, Deleuze announced the substitution of the disciplinary society by the society of control. In contrast to the Panopticon, this new model replaced the disciplinary exercise on the confined individual, by controlling the individual in open-air through a super-structure named Synoptic by Thomas Mathiesen. So, according to Deleuze, there is no longer about a regulated mass but about a set of divided individuals governed by a numerical language built by codes and passwords that allow access or cause exclusion. In this sense,
Byung-Chul Han (2014) refers to *psychopolitics* as the new exercise of power where technological seduction puts us in a position between being users or being used by the technologic apparatus. Thus, the *psychopolitics* is no longer concerned with shaping the bodies to produce but with seducing the psyches to explore themselves in a voluntary and passionate way.

Therefore, at a time when virtually every field of our lives is mediated by these digital technologies we can raise the question of how this new language and this new order shape individuals and contemporary societies, as well as by whom is the information captured by these technologies being used. Taking Bragança de Miranda’s (2001, 32) definition of control as “the ability to dominate the update procedures”, and being aware that these technologies are also increasing their procedural features, we can say that they become more and more able to act on information. This ability raises issues of agency and control, becoming increasingly undefined by who controls whom.

These issues become more evident when we face a world where technology pervades our communications, our bodies and our lives and, at the same time, we find ourselves under a state of surveillance through a massive capture of information which presets our identities and our decisions, using systems as statistic and predictive analysis performed by complex algorithms. The fact that these technologies are able to transform information through models built by humans but performed by machines, which have an unimaginable capacity of processing and abstraction, raises questions about the neutrality of these technologies. In the end, as William S. Burroughs (1978) asserts, all control always needs time, opposition, concession and ultimately to be controlled.

### 3 FROM THE ARCHIVE TO THE NEW: THE PROJECT
#### 3.1 PRINCIPLES

As a result of a theoretical investigation that led to this brief history, and in order to test the potential of transformation of digital media, a practice-based investigation was developed as a means to perform actions that explore the transition “from the archive to the new”. So, broadly speaking, this is a project where the information gathered in a given archive is transformed into new information through computational processes, with the aim of promoting a reflection on the way we store, transform and share information. According to this idea, the A—P (Archive—Program) is a web-based digital platform divided into two key moments of action: the *archive* and the *program*.

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4. Translated from: “O controlo é introduzido no esquema como a capacidade de dominar o processo de actualização” (Miranda 2001, 32)

3.2 DIGITAL CONTEXT

In order to define an understanding of this digital environment, let us start by addressing the possibilities of computation that Alan Turing revolutionized when he conceived a machine capable of simulating all others machines and, above all, a machine capable of simulating itself. This “Turing machine” gave rise to modern computers which, according to Wardrip-Fruin (2009, 1) “are designed to make possible: the continual creation of new machines, opening new possibilities, through the definition of new sets of computational processes”; or as stated by Florian Cramer (2002):

If one defines as a medium something that it is between a sender and a receiver, then computers are not only media, but also senders and receivers which themselves are capable of writing and reading, interpreting and composing messages within the limitations of the rule sets inscribed into them.

In this regard, computers exceed the primary condition of being a medium to become what we might call a procedural medium. That is, they no longer just receive and send a specific signal but have the ability to operate or execute processes that can transform this same signal. So these digital machines, according to Broeckmann (2005), “force their signals to pass through the barely material interface of electrical current and algorithmical calculations” changing the way the machines mediate our understanding of the world.

Manovich (2001) also highlighted that “the identity of the media has changed even more dramatically” and summarized the key differences between old and new media based on five principles: numerical representation, modularity, automation, variability and transcoding. Taking into account that what is often referred to as “new” media, like Cramer explains, is not so much a matter of a temporal relation, but rather a matter of procedural nature, we have chosen to use the term “digital media” in the sense defined by Wardrip-Fruin (2006, 25), meaning that “for something to be digital it need only be represented by discrete values”, a characteristic that transforms a digital object into a mathematical structure that can be algorithmically manipulated:

(...) we are increasingly experiencing media that not only say things and show things—but also operate. These media have internally-defined procedures that allow them to respond to their audiences, recombine their elements, and transform in ways that result in many different possibilities. These human-designed processes separate such media from fixed media, which
have only one possible configuration. (Wardrip-Fruin 2006, 2)

Digital media then differ from fixed media by being “media for which digital computation is required at the time of audience experience” (Wardrip-Fruin 2006, 7). That is to say, the result—a digital work—is defined, not merely in relation to its digital format, but by involving computational processes, given that what we experience, even as static displays, are the results of ongoing computations.

We can take as example the digital poem, as addressed by Katherine Hayles (2006), who emphasizes that its “digital characteristics imply that the poem ceases to exist as a self-contained object and instead becomes a process.” In this manner, Hayles raises the issue of a new temporality, stressing that with digital media the poem becomes “eventilized”:

“Less an object than an event, the digital text emerges as a dance between artificial and human intelligences, machine and natural languages, as these evolve together through time.” (Hayles 2006, 187)

Among the various types of digital work, we can find web-based works that are developed in the context of the Internet, as an infrastructure where a protocol system regulates a network of technology composed by browsers, servers, and connections, establish by a relationship based on the model of client-server. Therefore, web-based applications or programs are only active with an Internet connection, as they run in web browsers that, instead of being connected to a device's memory, are fed via servers connected by a network that uses the HTTP protocol. These works can be configured as websites, web-applications, web-add-ons or web-platforms.

3.3 ARCHIVE

In our project the web-platform is initially configured as a digital archive that acts as a systematic repository of projects with online available documentation related to the themes addressed in the theoretical investigation. This archive is always updatable and its information does not necessarily follow a linear narrative, since it is fragmented in a non-hierarchical space where its order is always subject to change. Accordingly, this archive is divided into two folders: the projects and the entities. The projects are included if their theme, their design, their information, context, or any other aspect is considered valid or relevant regarding the

6. On Wikipedia we can find a definition of the Internet as “the global system of interconnected mainframe, personal, and wireless computer networks that use the Internet protocol suite.”
aim of the archive. There is no limitation in terms of format or time periods. The *entities* folder gathers information available online about the authors or participants in the projects included. As a result, we have an online digital archive that is never accessed in the same way since its order can be changed when updated or even altered by the user, who can perform various operations such as view, navigate and search.

3.4 PROGRAM

Secondly, the platform becomes a program. It is conceived as a cultural program built with computer programs that perform
processes to transform the information stored in the archive into new significant pieces of information. We consider the “cultural program” as a selection of projects by a certain entity, according to a thematic or a conceptual aim, and the “computer program” (software) as a set of instructions that describe a task to be performed and involving computational processes running in real-time, web resources and online information. In order to guide the development of this project, we used a framework that allowed us to systematize processes according to their potential for novelty and expression, so that the aim of the cultural program can be achieved; that is, to promote a reflection on the way we store, transform and share information in a digitally mediated culture.

4 FROM THE ARCHIVE TO THE NEW: THE FRAMEWORK

4.1 PRINCIPLES

Taking on Hunicke et al.’s (2004, 1) idea of using a framework as design methodology to “guide the creative thought process and help ensure quality work”, we developed a framework in order to structure processes. In order to create this framework, we articulated different models and views on digital media. As a starting point, we considered digital computational systems as aesthetic artifacts (Ribas 2014), while articulating the MDA (mechanics, dynamics, aesthetics) by Hunicke et al. (2004) and combining it with the “model of digital media” proposed by Wardrip-Fruin (2009) with its focus on processes, as well as aspects of the “framework for understanding generative art” by Dorin et al. (2012). We particularly focused on the time dimensions as treated by Hayles (2006) in the shift from “object to event”, keeping in mind Manovich’s “principles of new media (2001)”.

According to this, we address the conceptual, mechanics and experience dimensions, and within these dimensions we highlight the role of different agents: author, computer and audience. This framework is conceived as a methodology for structuring our project, regarding its constituent elements and the views from which it can be considered, as well as its specific steps of development.
4.2 DIMENSIONS

Conceptual

According to Broeckmann (2005), a “recent re-evaluation of Concept Art” defines it as a “precursor to digital media art”, indicating that “the concepts of media art have evolved into a broader cultural environment.” This idea evokes Sol LeWitt’s words about Concept Art, meaning, “the idea becomes a machine that makes the art”. In this sense, the author’s decisions concern the conceptual choices, regarding the themes and principles, to be expressed by the work as computationally implemented at the level of its mechanics; as structures of processes that with be automatically executed by a computational device as a performance.

Mechanics

As Hunicke, et al. (2004, 2) assert the “mechanics describes the particular components of the game, at the level of data representation and algorithms.” At this level, and when considering process-based work, we are addressing the computational implementation of an idea as the definition of the components (units)
and the description of processes (structures of processes) necessary for the process to run.

In this context, a unit is what can be considered individually, drawing on Dorin et al.’s (2012, 244) conception of entities as “constituents that are (conceptually) unitary and indivisible, and whose functional relationships are not typically expressed in terms of internal mechanisms.” However, they “may exist in structured or hierarchical relationships with one another, leading to the creation of new composite entities.” Therefore, we consider that multiple units can compose a new unit of another scale, i.e. in the case of a text, a word would be a micro-scale unit and a sentence macro-scale scale unit. The units may also vary in diversity, being homogeneous or heterogeneous; in quantity, by being single or multiple; and they also may vary in meaning, if they have semantic value.

The structures of processes or algorithms can be seen as a description of instructions to be performed. Dorin et al. define the basic characteristics of processes, which include the “initial conditions—the state and configuration of the entities before the process begins—or initialisation procedures—the actions or conditions necessary to start the processes” (2012, 245). When thinking in terms of time, Hayles (2006, 245) states that in fixed media such as print “writing and coding often coincide and become virtually the same activity from the author’s point of view (…). With electronic poetry, by contrast, writing and coding become distinct and often temporally separated events.” That is, when Hayles (2006) refers to the temporal dimension of the operations of the poem-machines, the structures of processes corresponds to the “time of code,” as the time to “decide on behavior.”

Experience

The experience dimension views the process as performance or as an element of the experience that concerns the run-time behavior of the work as automatically executed by the computer on which it runs. In this sense, the surface “includes what is made available to the audience for interpretation (and interaction) as well as instructions to the audience, physical interface devices, and so on” (Wardrip-Fruin 2006, 10). The elements of experience of digital computational systems as aesthetic artifacts then concern “not only their surface but also their dynamics, or the variable behavior tied to their processual and performative qualities” (Ribas 2014, 61). So, rather than focusing merely on surface elements, we also focus on the dynamics—the performance of processes as an element of experience—since the surface may
be static or variable in time according to internally defined procedures.

5 CONCLUSION AND FUTURE WORK

The primary aim of this research was to explore the theme “from the archive to the new” while reflecting on the impact of digital computational technology in the way we store, share and transform information. Taking on the idea of the archive as a place of memory as well as place of control and governance, this study sought to clarify the consequences of the digitalization of the archive and understand its new condition. Under this view a theoretical investigation was developed in order to explore the questions of agency and control that arise as digital archives and databases increasingly mediate all aspects of our lives.

Seeking to give concrete form to this reflection, we developed a web-platform guided by two main purposes: creating a digital archive of projects that deal with these questions, and performing transformations on the information stored in order to create something new. In order to emphasize the alignment between concept, mechanics and experience of this work we resorted to the design methodology proposed, seeking to develop processes that can become expressive in defining the experience of the archive. However, we acknowledge that at this stage of development, the archive and the program do not necessarily accomplish the full potential of these processes, since they were devised as indices or as starting points for a further study of complex and expressive processes.

According to this, our aim is both to feed the archive as a way of consolidating this investigation, acknowledging the limitations of the program, and establishing as a priority the development of additional experimental transformations of information. Another aspect that deserves our attention in terms of future research, is the further development of the framework by detailing its dimensions, elements and also the temporal aspects implied in these different views of processes.

In conclusion, with this approach this work sought to explore and reveal how digital archives can spread through almost all aspects of our lives, being no longer understood as mere storage spaces but rather as sites of transformation, under the control of processes that are capable of generating new meaningful information.
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Can we effectively describe artworks in informational terms? This paper discusses this question and its ramifications by analysing Mikhail Volkenstein’s (2009) characterisation of art as ‘informational systems’ and contrasting it with contemporary understandings of information and aesthetics. Overall, the paper argues that contrary to Volkenstein’s description, the kind of information conveyed by artworks is not only of an aesthetic kind, since artistic value depends on various other (cultural and economical) aspects. Nonetheless, it concludes that Volkenstein’s description of artworks as ‘programs’ that not only convey but also generate information is a powerful metaphor for addressing current developments in artistic practices.
1 INTRODUCTION

As computational technology assumed all the functions of previous information technologies (ITs) the (ontological) differences between “media” collapsed. The modernist conception of the “medium” as the sole guarantor of the identity of audiovisual expression was called into question by digitisation. What were previously conceived as materially distinct entities are now simulations; dynamical representations of data, or information. This new regime brought significative opportunities and challenges for art. On the one hand, it forced art scholarship to rethink its (traditionally wary) attitude towards technology, and to engage computation as a domain no longer exclusive to engineering and science. On the other hand, the possibility of simulating and hence freely mixing the tools, techniques and “vocabulary” of pre-computational audiovisual expressions within the same environment led to the development of a “hybrid” and constantly changing “new media” (Manovich 2013). The questions of how artworks and artistic practices should be understood under this new informational parading thus remains one of the most pressing concerns for art scholarship.

When it comes to understanding the impact of information technology on art and “media”, scholarly approaches may be loosely distinguished by their theoretical priorities. There are those who consider analysing technology is the most effective way to understand current shifts in artistic practices; theirs may be called the “engineering” approach (Mitcham 1994). There are others for whom the human factor generally determines the impact of technology; this is the traditional approach we find in the humanities. As a representative of the engineering approach, Software Studies argue the qualities of “new media”—e.g. “hybridisation” and “deep remixability”, (Manovich 2013)—are a direct consequence of the modularity and permanent extendibility software. Which, in turn, owes such qualities to the interchangeability of its “building blocks” (Manovich 2013). Thus, according to this view, in order to understand contemporary audiovisual manifestations we should focus on the history and technical nature of its medium, i.e., software. Conversely, current humanistic approaches (heavily inspired in Merleau Ponty’s phenomenology) argue that in order to comprehend the effects and nature of Information Technology we should rather focus on how they manifest within our cultural practices.

In this paper I discuss Mikhail Volkenstein’s (2009) little known characterisation of artworks as “informational systems” and contrast it with current understandings of information and aesthetics. I begin by briefly recalling the origins of the concept of
“information” while highlighting some key aspects of its meaning in the context of Claude Shannon’s Mathematical Theory of Communication (MTC). Afterwards, I summarise Volkenstein’s model, before outlining a definition of information based on semantic content. The latter provides a means to circumvent the limitations of Volkenstein’s grounding of “artistic information” on aesthetic value, while retaining the most thought-provoking aspects of his model. Namely, the notion that artworks may be regarded as “programs” capable not only of conveying but also of generating new information.

2 INFORMATION

To paraphrase Adriaans and Benthem (2008), the word “information” has an extremely high frequency but a comparably low content; even though we constantly hear and use the term, we rarely ponder what exactly we are referring to. This is hardly a surprise, since information can be associated to such a multitude of meanings that it sometimes appears to be a “conceptual labyrinth” (Floridi 2010). In this everyday usage, information serves as an umbrella term for everything we exchange when we engage in acts of communication. Therefore, as philosopher Luciano Floridi (2004) suggests, the question “what is information?”—like the question “what is being?”—belongs to a category of enquiries that one cannot expect to answer through dictionary definitions. Instead, Floridi argues, one should use them as a pretext for philosophical enquiry.

2.1 THE ORIGINS OF THE CONCEPT

Information comes from the Latin in formare, which both Cicero and Saint Agustine reportedly used when discussing Plato’s Theory of Forms and, in particular, it was used by Cicero when he referred to “representation[s] implanted in the mind” (Adriaans and Benthem 2008, 8). Centuries later, during the early Renaissance the French word information began to be used colloquially to refer to such things as “‘investigation’, ‘education’, ‘the act of informing or communicating knowledge’, and ‘intelligence’” (Adriaans and Benthem 2008, 8). By the end of 17th Century, the technical use of information had anything but disappeared, as British Empiricists who returned to Platonic sources opted to coin the term “idea”, from the Greek word for Platonic Form, eidos (Dusek 2006). Only in the first quarter of the 20th Century did information start to attract scholarly attention again, when engineers and researchers Harry Nyquist1 and Ralph Hartley2...
speculated on the possibility of quantifying the transmission of information or even “intelligence” (see Byfield 2008). The work of these two pioneers would later serve as inspiration for Claude Shannon’s (1980) groundbreaking *Mathematical Theory of Communication* (MTC), the first successful method for describing communication in probabilistic terms and the stepping stone of contemporary “information theory”.

### 2.2 INFORMATION AS A QUANTITY

Contrary to some interpretations, Shannon’s MTC does not provide an all-encompassing definition of information, but rather a formal description of the physical constraints governing every instance where “not-yet-meaningful” data are transmitted (see Floridi 2016). Shannon’s goal was to determine the ultimate level of data compression, and what the ultimate rate of data transmission was. He was, in his own words, attempting to measure “the accuracy of transference from sender to receiver of a continuously varying signal” (1980, 8). Conceived as a mathematical function, Shannon’s formalisation ought to apply to any instance of communication. Thus he had to regard what was being transmitted (i.e., “the message”) under purely quantitative terms. This implied ignoring the semantic contents of the message and treating the information it carried solely as a “raw” (Floridi 2004, 51), “dimension-less” (Ben-Naim 2008, 203) quantity. It follows that MTC is fundamentally a study of communication limits and of information purely at the syntactic level, meaning that it was conceived to deal with the transmission of data—the symbols and signals that carry information, and not with “information” itself. That is why in contexts where semantic value is not a priority, such as in computation—computers are after all syntactical devices—MTC is a more than adequate method of analysis.

### 3 THE ARTWORK AS AN INFORMATIONAL SYSTEM

At the end of his little-known 1986 book, *Entropy and Information*, late Russian biophysicist Mikhail Volkenstein (2009) delineated an informational approach to artistic creation. Essentially, Volkenstein claimed artworks not only convey but also create new information, hence they represent open “integral informational systems”. Integral because—as with living organisms—all of the their features are essential for their proper functioning, and any change in their internal structure can potentially damage their meaning. Artworks are not isolated systems; once “liberated” they acquire a “life” of their own (Volkenstein 2009, 187),
establishing new relationships with the world and with their potential audiences while, simultaneously, maintaining a constant relationship with their creators. Volkenstein (2009, 187) points out that regardless of the medium, “artistic information” is open and available to anyone, therefore every person is entitled to say if they like or dislike a given artwork. In order to evaluate an artwork in a “competent” and “serious” manner, a person requires what Volkenstein (2009, 188) calls a “thesaurus”, that is, certain background knowledge and aesthetic sensibility that allows her to adequately process the information contained. Therefore, the value of artistic information is “of an aesthetic kind”, and it is ultimately determined by the way it influences a sufficiently prepared audience.

3.1 LOSING AND PRODUCING ARTISTIC INFORMATION

Reception of artistic information involves both a partial loss and an “enhancement”. Every instance of communication is potentially subjected to the interference of noise11, often due to the physical and environmental conditions surrounding the transmission. Given the unsurmountable gap between the mind of the artist and the minds of her audience, a certain amount of information conveyed by an artwork is bound to dissipate in the process of being received. For Volkenstein (2009, 187) such loss is “inevitable” and “trivial”. What is not trivial is the fact that the artwork “activates or programs [emphasis added] a stream of associations, thoughts, and feelings in the consciousness of the receptor” (Volkenstein 2009, 188) thus stimulating the creation of new information by him or her. It is here that, according to Volkenstein, rests the value of an artwork.

3.2 THE VALUE OF ARTISTIC INFORMATION

How valuable the information created by an artwork is depends largely but not entirely on its singularity and irreplaceability. In other words, it lies in its informativeness. The more novel and unexpected the information an artwork generates—i.e. the less redundant it is—the more valuable it will be. But regarding this point Volkenstein (2009, 188) makes an important caveat: whereas for information theory redundancy is normally equated to repetition, in the context of art the equivalency cannot stand, since many artworks use repetition precisely as an aesthetic device. Conversely, a uninformative and hence redundant artwork will be one that exhibits cliche and banality, or whose existence is due solely to technical prowess. Nonetheless, Volkenstein does

11. That is, ‘unwanted data’ (Floridi 2016) received along with a message and with the potential to impede its adequate apprehension.
concede that public reception of artworks is subject to historical and even personal fluctuations. In other words, that yesterday’s mediocrity may become today’s masterpiece and vice versa. Hence, great artworks are those to which we “return” repeatedly over the course of our lives and that always seem to offer something new, for true “genius”, argues Volkenstein (2009, 190), “is unlimited informativity”.

4 INFORMATION AS SEMANTIC CONTENT

What makes MTC such an effective tool in the context of information technologies (namely its disregard for semantic content) makes it comparatively limited from the point of view of art, the humanities and even biology (see Volkenstein 2009). Scientific (quantitative) models tend to neglect granular detail because operating at a higher level of abstraction allows them to explain phenomena in more general terms. In the context of art, however, the assumption is that every artwork constitutes a unique instance regardless of the fact that it may share some qualities (physical or otherwise) with other artworks. When we approach works of art we do it with a hermeneutical intent attuned to granular detail. Thus the question is, what benefit does talking about art in terms of information when the very formulation of this concept seems to disregard its most crucial aspects—namely, semantic content and its reception? Luckily, as Shannon (Shannon and Weaver 1980) himself recognised, MTC’s reductive characterisation of information is by no means the only one available.

4.1 THE GENERAL DEFINITION OF INFORMATION

Most fields related to information science now tend to agree upon an operational definition of information based on semantic content (Floridi 2011a). According to this “General Definition of Information” (GDI) semantic contents may be considered information if and only if they are composed of “well-formed meaningful data” (see Floridi 2004; see also Floridi 2011a). Along with rejecting the possibility of data-less information, GDI requires data to have some form of representation (e.g. binary digits) and also—given the nature of current computational technology—physical implementation. Now, regarding the question of how or why data are able to carry meaning in the first place is, according to Floridi (2004), one of the most difficult problems for semantics. Nonetheless, he also notes that in fact the issue “is not how but whether data constituting information as semantic

12. The definition of ‘data’ is itself contentious. Data is the Latin translation of the Greek word, dedomena; it is the utmost unit to which information may be reduced. In its singular form, ‘datum’, is a fact concerning some difference or lack of uniformity within some context, e.g. the perceptible difference between two letters in the alphabet, or the difference between the presence or absence of an object (see Floridi 2004; Floridi 2011a). That is why sometimes information is characterised as ‘a difference that makes a difference’ (see Byfield 2008).

13. It is important to note, however, that physicality does not necessarily entail materiality (see Floridi 2010).
content can be meaningful *independently* of an informee” (Floridi 2004, 45). Examples such as the Rosetta14 stone and the growth rings in tree trunks show the answer is that meaning is not—at least not exclusively—in the mind of the human subject (see Floridi 2004).

### 4.2 TWO TYPES OF SEMANTIC INFORMATION

Seen as semantic content, information comes in two major types: instructional and factual. Instructional information—also known as “imperative” information—is the kind one might find in stipulations, orders, recipes or algorithms. Certainly, all these instances have a semantic dimension, since they have to be interpretable and therefore meaningful. But, unlike those categorised as factual information, they cannot be correctly qualified as being true or false, only perhaps as being correct or incorrect15. Instructional information does not convey specific facts, nor does it model, describe or represent ideas; it merely helps to “bring about” (Floridi 2016) (factual) information. For its part, factual information (also known as “declarative” information) is the most important of the two kinds of semantic content, but it is also the most common way in which information as information “can be said” (Floridi 2004). Factual information “tells the informee [agent] something about something else” (Floridi 2004, 45), for example, the location of a place, the time of the day, an idea, a fact, etc. To borrow a metaphor from Floridi (2004), factual information is like the “capital” or centre of the “informational archipelagos”, since it provides both a clear commonsensical grasp of what information is, and links all other concepts related to information.

### 5 EXPANDING VOLKENSTEIN’S CHARACTERISATION

#### 5.1 NOT JUST “AESTHETICS”

Volkenstein’s equation of “artistic information” with aesthetics is problematic for two reasons: first of all, it presupposes the definition of the latter—which he does not provide; secondly, as a contemporary phenomenon, art has become too complex to be understood solely under the category of “the aesthetic” (Stecker 2010). Oversimplifying, aesthetic objects or phenomena may be described16 as those whose formal qualities or “meaningful features” trigger experiences (pleasurable or otherwise) which may be appreciated “for their own sake” (see Stecker 2010, 289). Argu-

14. Prior to its discovery, Egyptian hieroglyphics were indecipherable; the discovery of the stone provided an ‘interface’ to access their meaning; this however did not affect their semantics (see Floridi 2004).

15. Consider a musical score or a piece of software, neither of them may be successfully described as being true or false.

16. Aesthetics, of course, is a problem in its own right and no single definition can be an all-encompassing one.
ably, having aesthetic value continues to be a necessary requirement for something to be considered “art”, but it is by no means a sufficient one. Contemporary understandings no longer regard art as the necessarily autonomous and self-contained dominion High Modernism portrayed (see Greenberg 1999), but as a transversal endeavour concerned with the whole range of human experience, from socio-political to cognitive and metaphysical preoccupations. It thus follows that the kind of information conveyed through art cannot be merely “aesthetic” or even “artistic” for these are only a couple of layers or levels at which any given artwork may be observed. By substituting “artistic information” with “semantic information”, Volkenstein’s characterisation receives a significative update, offering a more general—more “model-like”—understanding of artworks.

5.2 ART AND SEMANTIC INFORMATION

Arguably, artworks are at the very least instances which “point at” or call our attention towards “something” interesting in the world. Whether that “something” is interesting or relevant, is always open for debate and interpretation. Many works of art are content with merely conveying their sheer presence—their “aboutness”—without attempting to offer any specific kind of “discourse”. Other artworks assume (or at least purport to assume) an open position; their aim is to make a direct or indirect commentary about a state of affairs, or to provide a number of elements for the audience to reflect upon said state of affairs. All of the former are instances where some form of semantic information—to repeat: well-formed and meaningful data—is conveyed; but they are also instances where more information may (hopefully) be produced. Volkenstein’s model offers a useful way to characterise this process: the metaphor of the artwork as a program.

5.3 THE ARTWORK AS A PROGRAM

Volkenstein describes artworks structurally as complex integral informational systems, but functionally as programs which, upon being read trigger the generation of information that was not previously contained in them. This simple metaphor allows us to imagine our relation with art in a more contemporary manner. We may perhaps describe the artwork as a “bootstrap loader” that launches our “thesaurus” (see section 3), thereby allowing us to generate ideas and connections that we could not.
have imagined otherwise. We may also think of an artwork not as a pre-compiled program, but more like a complex “script” which may be run through a myriad of interpreters and produce an equally different number of outputs. Which could include value judgements ranging from total lack of interest to considering the artwork a true masterpiece, or perhaps feeling the need to utter the proverbial “my two-year old child could have done this”. Nonetheless, like all metaphors, this one has limitations too. Unlike computers, our interpreting abilities are not limited to performing numerical calculations and remembering their results; we humans establish complex semantic associations without even trying. As interpreters, we “choose” which information present in the artwork we pay attention to and which we ignore. Our interpretations are shaped by our mental and emotional states, by our intellectual and personal backgrounds, and by the very historical and cultural circumstances surrounding our engagement with artworks.

CONCLUSIONS

We have seen that Volkenstein’s model is a good example of how artworks may be portrayed in informational terms. We have also seen that GDI offers a useful way to avoid circumscribing artistic information to aesthetics and therefore making Volkenstein’s model more compatible with current understandings of art. Regarding artworks as complex systems which, at the very least, “say something about something else” does not by itself explain how or what kind of information a given artwork might convey, nor does it solve all problems presented by aesthetic experiences. But it does help us remember that artworks are not magical objects, and that they bear similar organisational properties as other complex systems. From an ontological perspective, Volkenstein helps us to think of artworks as particular configurations of information, but also as hermeneutical “programs” with potentially endless outputs.

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Algorithms primarily belong to the fields of mathematics and computer science. Certainly, the best-known application of algorithms is computer programming. However, algorithmic methods—in the sense of instruction to follow certain rules—have been also used as creative artistic instruments, for example, in modern art movements, such as Fluxus, Conceptual Art or Happening. With this background in mind, this paper aims to explore how algorithmic logic can be implemented in the realm of artistic production by both computer and analog artists. Artists chosen for this investigation include Manfred Mohr, Sol LeWitt, and Hans Arp. Based on the analysis of their works, this paper attempts to establish differences in dealing with algorithms within artificial and human creativity.
With the emergence of computers, many artists began employing these media for the creation of artworks. The main operating principle behind computer programming is the algorithmic approach, since all computer programs are based on algorithms. An algorithm can be described in broad terms as a set of instructions developed to solve a problem or accomplish a given task in a finite number of steps (Barth 2013, 4).

However, an algorithm must not be executed solely by computers. As Peter Weibel (2005, 2008) notices, algorithmic methods had been used long before computers were invented. For example, in the form of “instructions for use and action”, algorithmic principles had been already applied in traditional arts as manuals or musical scores since centuries. In this context, Leon Batista Alberti’s architectural tractate *De re aedificatoria* (1452), Piero della Francesca’s script on perspective in painting *De prospectiva pingendi* (1474) and Albrecht Dürer’s book on geometry *Underweysung der Messung* (1525) were written as manuals for artists, giving instructions for making buildings, paintings and sculptures (Weibel 2005, 3). In modern art, Weibel distinguishes between two applications of algorithms: an intuitive and an exact application. The art historian points out that the intuitive use of algorithms happened in such art movements as Fluxus, Conceptual Art or Happening where one should act according to given instructions.

On a related note, Conceptual artists formulated conceptual schemas to create their artworks (Taylor 2014, 47). One of the most influential artists of this movement, Sol LeWitt, outlined his methodology as the selection of “basic form and rules that would govern the solution to the problem” (LeWitt 1967), what reflects the main principle of an algorithmic procedure. The artist developed his concepts based on strictly formulated rules, so that “arbitrary or chance decisions would be kept to a minimum, while caprice, taste, and other whimsies would be eliminated from the making of the art”, instead “the plan would design the work” (LeWitt, 1967). This principle is best demonstrated in his *Wall Drawings* (see Fig. 1) that represent explicit instructions for execution of several geometric shapes. Sol LeWitt hired his assistants to carry out these drawings by following the given rules, such as “vertical lines, not straight, not touching”. In doing so, it was possible to execute several variations of these workspieces.

While Conceptual Art explores the idea of instructions-based art following the logic of algorithmic procedures intuitively, computer-aided art is based on the exact application of algorithms.
In computer art, an algorithm is firstly developed by an artist, then executed by a computer, and, finally, displayed on an output device, such as a computer monitor or plotter.

The following paper aims to explore in case study approach how algorithmic logic can be implemented in the realm of artistic production by both computer and analog artists. The first artist chosen for this investigation is Manfred Mohr—one of the most influential computer-art pioneers—as he makes his art through the exploration of computer algorithms. Mohr’s works will be analyzed in a comparative perspective with Conceptual Art and Dadaism. It is necessary to introduce the main artistic principles of these art movements in the current discussion, since they—following Weibel’s exploration of algorithms—similarly to computer-generated works, are based on the underlined algorithmic logic. Through this comparison, the paper attempts to figure out differences between “intuitive” and “exact” algorithmic approaches.

2 CASE STUDIES

Manfred Mohr is one of the most influential computer artists. However, he began his career as a jazz musician and abstract expressionist, but later turned from traditional painting to computer-generated art (Mohr 2002, 111). In doing so, he was strongly influenced by the theories of the German philosopher, mathematician, and semiotician Max Bense, developed in the 1950-60s (Von Mengen 2007).

Bense attempted to establish objective scientific approach in the realm of aesthetics. His main purpose was to construct a theoretical platform that would enable a rational evaluation and creation of artworks, as opposed to traditional theories oriented to subjective and emotional interpretation. The most influential area of Bense’s theories is the concept of Generative Aesthetics (Taylor 2014, 88-89). Bense formulated it as follows:

Generative aesthetics [...] implies a combination of all operations, rules and theorems which can be used deliberately to produce aesthetic states [...] when applied to a set of material elements. [...] Generative aesthetics is an ‘aesthetic of production’, which makes possible the methodological production of aesthetic states, by dividing this process into a finite number of distinct and separate states which are capable of formulation. (Bense 1971, 57-58)

Generally speaking, Bense believed it is possible to generate aesthetic objects according to exactly formulated rules. For Bense (1965, 151), Generative Aesthetics proceeds in three steps.
Firstly, the artist defines the elements of the repertoire that will serve to generate a work of art. For example, the repertoire of a literary work consists of a certain vocabulary, the repertoire of a musical work—of the quantity of notes, the repertoire of a painting—of individual forms and colors. In a second step, the artist formulates the rules for connecting the elements of the defined repertoire to a complex composition. For example, in a literary work, the words are combined to sentences and phrases according to grammatical and stylistic rules; notes in a musical composition are governed by the rules of harmony; in art, such rules are determined by an artist or a group of artists. Finally, the artist selects certain elements from the repertoire and combines them to a composition according to predefined rules. Nevertheless, as Bense noted, despite the existing rules, an artist often makes decisions unpredictably. This depends, for example, on his health condition or mood during the act of creation. According to Max Bense, when an artist begins to create his work, he has only a general concept, but he does not know exactly how all details will look like until his work is completely finished. Thus, the creative process is for Bense closely linked to random intuitive decisions (Bense 1965).

In the late 1960s, Mohr started exploring computer algorithms for the creation of his computer-generated works based on Bense’s scientific aesthetics. The geometrical form of a cube is the primary motif of Mohr’s computer-based works since then. Mohr introduced the cube into his works, as its structure is based on a mathematical logic, and therefore can be well adapted to a computable configuration. Nonetheless, Mohr never aimed to visualize mathematical properties of the cube. Instead, his research is rather focused on the exploration of new visual and aesthetic expressions that result from abstract relations between structural elements of a cube (Maiocchi 1994, 35).

Using the cube as his primary motif, Mohr created series of computer-generated works. His black-and-white plotter drawing P-154-C (see Fig. 2) belongs to his early work phase Cubic Limit I (1972-1975). This computer-generated work shows a sequence of three-dimensional cubes. These figures are evenly distributed over the image surface 10 across by 7 down, forming straight rows. There is however no cube of all edges. Mohr removed a number of contour lines by each of them. In the lower part of the picture, cubes are missing only one or two edges, so that the three-dimensional shape of the cubes is still recognizable. From the bottom to the top of the picture, the number of removed edges by each cube, however, gradually increases, until the figures of the upper rows possess only one or two edges. These cubes are
no longer identifiable as such. Mohr deliberately aims at disturbing the symmetrical balance of the cubes. In this way, he seeks to create a visual tension. His main goal is to create new aesthetic forms with the visual language that has never been seen previously. Concretely, by removing the edges of the cube, Mohr breaks the illusion of three-dimensionality, forming instead new two-dimensional structures (Mohr 1975).

Mohr (2002, 111) developed the algorithm for this work in accordance with Bense's Generative Aesthetics. In doing so, the artist firstly defined the elements of the repertoire. Geometrically defined, a cube is a three-dimensional form constructed by means of twelve contour lines or edges, respectively. Consequently, Mohr used twelve edges of a three-dimensional cube as a repertoire for creation of his computer-generated piece. More precisely, Mohr's repertoire consists here of straight lines of equal length that can be placed only at an exactly predetermined order, and can appear only once. In a second step, Mohr established the rules that determine the main futures of the graphic: to combine the predefined twelve straight lines into cubes, and to distribute them evenly in the grid. The local structure of each cube was determined by a random number generators that program chance in the selection of certain parameters based on Probability Theory. In P-154-C, random numbers decided which edges exactly must be removed (Von Mengen 2007). The use of random decisions guaranteed here the unpredictability of aesthetic production, which Bense regarded as a necessary criterion for being an artwork. In other words, what occurs in artistic-creative processes through intuitive spontaneous decisions in a natural way is simulated here by random number generators. Moreover, the involved chance demonstrates here the innovative character of the production process — which would be impossible in a purely deterministic program, where only a predictable outcome can be produced.

On a related note, the algorithm for P-154-C predefines the amount of straight lines and the instruction to connect them in the way that introduces the form of a three-dimensional cube, while the decisions to eliminate certain edges of the cube is determined by random generator. The result is a cube, known in advance in its general structure but unpredictable in all its detail.

It is important to notice that generation of different combinatorial possibilities of structures emerged through the removing edges of a cube is only possible if the program constantly begins with a new random number. In P-154-C, to avoid the same random number and, therefore, the same output, each random number was calculated by computer so that the same occurrence was
excluded. In doing so, the algorithm generated a fixed sequence of different numbers. Each time the program ran, the sequence repeated itself, guaranteeing thus the non-repeatability of numbers. Consequently, the result here is not truly random; it is only generated by means of randomness, and appears to the observer as being random. For this reason, the term pseudo-random is rather to be applied here (Klütsch 2007, 116). The sole use of random number generators would lead to chaos. Due to the fact that random was partly controlled, the complete arbitrariness was avoided, and the chaos was escaped. The result is the perceptible aesthetic information.

An essential feature of this method of image generation is that one can produce a great number of characters using the same program without repeating the same figure twice. In P-154-C, there is indeed no figure showing the same combinatorial possibilities of structures emerged from the removing edges of a cube. This means that such programs do not create individual figures, but rather classes of figures that share common features defined by the algorithm (Nierhoff 2005).

Certainly, it was also theoretically possible to develop an algorithm for the generation of differently shaped cubes, exactly determining how each individual figure will look like, without involving any random numbers. However, such algorithm would not create a class of figures. A strongly deterministic program would rather generate concrete graphical outcomes or, in the case of the graphic P-154-C, exactly 70 individual combinatorial possibilities of a three-dimensional cube. A class of figures consists, on the contrary, of endless chains of variations. More precisely, in all, there are \((n) \times (n-1) \ldots (n-m+1)/m\) combinations possible with the cube edges, where \(n = \) the twelve edges of a complete cube, and \(m = \) the number of missing lines. Following this mathematical formula, if two lines are removed from a cube, there are \((12 \times 11)/2 = 66\) possible line-combinations (Mohr 1975). This means that Mohr investigated here some of \((12 \times 11)/1, (12 \times 11)/2, (12 \times 11)/3 \ldots (12 \times 11)/11\) possible structures. In other words, the graphic P-154-C could also display other combinatorial possibilities of a cube.

The decision to investigate the structure of the cube immediately brings Mohr’s works into line with those artists who also aimed at the exploration of the three-dimensional cube. For example, the cube was an important motif in Conceptual Art. In this context, Sol LeWitt created a cubic work Variations of Incomplete Open Cubes — a series of three-dimensional cubes each missing one or more its sides. Similarly to Mohr, Sol LeWitt also developed rules for the production of his project: to create all
possible three-dimensional structures of a cube by systematically removing its edges without repeating identical forms. In his investigation, the artist started with the variations consisting of three edges (the minimum number needed to identify a three-dimensionality), and ended with a cube with one of its sides eliminated (the last possible variation of an incomplete open cube) (Lee2001, 51). Following these rules, LeWitt figured out 122 possible variations of incomplete open cubes, which are illustrated in the schematic drawing, where variations are arranged according to the numbers of removed edges (see Fig. 3). Based on this drawing, LeWitt created large series of wooden sculptures that show some of identified variations (see Fig. 4).

The project *Variations of Incomplete Open Cubes* is linked by formal criterion to Mohr’s *Cubic Limit* series, and particularly to the graphic *P-154-C*. In fact, both artists Manfred Mohr and Sol LeWitt used the cube as the primary motif of their workpieces. Furthermore, both applied to equal methods of art production, namely, repetition, seriality, mechanical rationalism and algorithmic logic. Finally, both aimed to show potential infinite different states emerged from the construction and deconstruction of the cube. Generally speaking, the aesthetic of both art objects, by a mere observation, appears exceedingly identical (Taylor 2014, 48-49).

Nevertheless, there are also essential differences between them. Although both artists are focused on the investigation of the cube, they treated this geometrical form from different perspectives. While Sol LeWitt was primarily concentrated on the three-dimensional realization of the cube, Mohr, in contrast, was mainly interested in a two-dimensional expression of this multidimensional geometrical structure. Moreover, although Sol LeWitt, similarly to Mohr, removed edges of cubes, their structure always remained identifiable as such. In doing so, the artist clearly emphasized the principle of symmetry, whereas Mohr primarily aimed to destroy it (Lähnemann 2007).

The most significant differences, however, become particularly evident by comparing production methods involved by the artists. Although LeWitt was able to identify the correct number of possible variations, he couldn't figure out a logical way to identify repetitions. In order to verify that there are no repetitions, the artist simply built a three-dimensional model of each structure, and then rotated it (Baume 2001b, 24). In contrast, Mohr applied to a mathematical approach—that is, pseudo-random numbers—that guaranteed the non-repeatability of variations. Additionally, due to this method of image-generation, all variations of Mohr’s work are to be considered random decisions,
while all executed variations of *Incomplete Open Cubes* are chosen deliberately. When looking at LeWitt’s wooden sculptures, all of them contain one complete side on the ground. Indeed, LeWitt confirmed deliberately making such a choice, since a production of an installation without horizontal structures would be rather unstable (Baum 2001, 25).

Certainly, the use of randomness in the processes of art creation is not the invention of computer artists. For example, Dada artist Hans (Jean) Arp also involved the principles of randomness in his rule-based works. Nonetheless, he applied to random mechanism differently from computer artists. On a related note, Arp created series of compositions with the title: *Objects Arranged According to the Laws of Chance*. In this context, the group of wooden reliefs known as *Constellations* illustrates different arrangements of five white and two smaller black biomorphic forms on a white ground (see Fig. 5,6). When creating these works, Arp’s rule was to produce the required number of the forms, then randomly, without thought, drop them onto a flat surface, and finally attach each of them wherever it fall (Glimcher 2005, 56). This means that Arp used chance in its pure form, as opposed to Manfred Mohr’s computer art that refers to the mechanical random which is incapable of creating a true chance.

3 CONCLUSION

Based on a case studies approach, this paper has provided insights into how algorithmic logic—simply understood as instruction to follow certain rules—can be implemented in both computer and analog art. Artists chosen for this investigation included Manfred Mohr, Sol LeWitt, and Hans Arp.

The analysis started with the exploration of Manfred Mohr’s computer-generated work. This investigation has demonstrated that Mohr attempted to achieve aesthetic results on computers through a combination of strictly planned logic and mathematical chance within computer programs. That is, the artist firstly predetermined rules that defined the general composition of his graphic. The local structures of the graphic, however, were constituted by random number generator. In doing so, it was possible to create the whole class of works where graphical outputs have common ground characteristics but are different in their details. Moreover, this method of image-generation allowed Mohr to produce unpredictable works, without repeating twice the same figure. Concluding, it can be said that all steps within Mohr’s process of creation are mathematical operations.
Although Conceptual art is similar to computer-generated art mathematically oriented, it shares, as Grant D. Taylor (2014, p. 65) observes, only a “spiritual relationship” to mathematics. In one of his theoretical works, Sol LeWitt confirmed that Conceptual Art does not have “much to do with mathematics, philosophy, or any other mental discipline” (LeWitt, 1967). Moreover, LeWitt maintained that Conceptual Art does not necessarily proceed in a logical order. In this context, he pointed out that conceptual artists are “mystics rather than rationalists. They leap to conclusions that logic cannot reach” (LeWitt, 1967). In fact, as the analysis of Sol LeWitt’s work has illustrated, the underlying algorithmic logic of his conceptual schema is far from being a mathematical concept. For example, in order to avoid the repeated execution of the same variation, LeWitt simply verified it by rotating a three-dimensional model of each structure, as opposed to Mohr who created variations based on computational, i.e. mathematical logic. The use of chance within Dada-art is also to be distinguished from random numbers of computer art algorithms. While the chance of Dadaism refers to a pure chance, random numbers of early computer works are used in terms of computational logic, namely in the sense of so-called pseudo-random, where the chance is partially controlled.

Concluding, it can be, therefore, outlined that the use of algorithmic procedures in Mohr’s computer art is clearly grounded on a scientific base, while algorithmic approach within Conceptual Art and Dadaism is to be considered rather pseudoscientific.

REFERENCES


In this paper, two key features of a framework for active matter (programmable, or rather, “processual” material) that is, programmability and process, are explored via a theoretical and practical discussion. More generally, this paper investigates the concept of materiality and material performance: analysing the experiences of humans in terms of their interaction with the environment, with artefacts and with material within a design context. Finally, the authors propose the conceptual project “Chrysalis Gemini”, applying their perspective on the discourse, meaning and contextualisation of interactive materiality. The aim of “Chrysalis Gemini” is to present the relational potential implied in active materials and their ongoing process of transformation - suggesting a world in a state of flux.
1 INTRODUCTION

Within architecture and design, form has grown to the point where the condition of its materialisation has become standardised; material is, within the logic of the modernist tradition, secondary to form. The digital revolution, marking the change from analogue to digital technology, transformed the designer’s drafting board into a digital canvas. Form, it seemed, was then much more divorced from physical reality. These new design spaces provided liberation regarding formal expression, but they also expanded the difference between matter and form and made the separation of the modeling, analysis and fabrication processes more pronounced.

Today, perhaps because of the recognition of the ecological failures of modern design, design culture is witnessing a new materiality. Society and the way materiality and materials are understood are mutually conditioning one another. Materiality and material performance are no longer a subordinate question of detailing, but instead, one of vital significance. The notion of materiality provides us with a first clue regarding the renewed importance of subjectivity. Materiality, unlike matter, can never be considered as entirely objective. Materiality corresponds to a certain category of experience which is a socially constructed one. The point becomes more evident when considering its opposite, immateriality. Nothing is in itself immaterial. We call something immaterial when we cannot relate to it in certain ways. Materiality corresponds to a range of experiences which give us the impression of being in genuine contact with the physical world. Some of these experiences are based on immediate sensory evidence and others involve instruments and machines. Whatever the case, materiality possesses a relational character. It implies an encounter between a subject and the material world. From this perspective, materiality appears as a mix of permanent, ahistorical features with cultural factors. It articulates physical constraints as well as social constructs, such as the value we attach to certain types of observations.

But even in its permanent interplay with its surroundings, material itself has been regarded, in the last few decades, mostly as mutually passive and static. Only the very recent progress in the fields of active matter and programmable material is challenging this assumption. Suddenly the formerly mutually exclusive worlds of seemingly immaterial processual software and static hardware start to intertwine, evoking what the Self-Assembly Lab at the Massachusetts Institute of Technology considers a “material revolution,” succeeding the “hardware” and “software revolutions” (MIT 2015).
Within this discourse, the meaning and contextualisation of materiality and the future relationship with it are being renegotiated. The trace of the inert material left behind suggests a world in a state of flux and determined by relation rather than subject and object separation. This ongoing process is calling for a close examination with the aim of revealing the potential implied in this revolution. Therefore, the following paper highlights significant aspects of this shift. Reaching from the questionable term of “programmability” to Martin Heidegger’s understanding of “leaky” things, and looking at the condition of changing states and the potential meaning of ornament, an extensive field of thought is established. The proposed conceptual project “Chrysalis Gemini” derives from and illustrates these principles, stressing the potential of material in a processual relationship with humans and their environment.

2 THE AMBIGUITY OF PROGRAMMING MATERIAL
The term programmable material might sound paradoxical at first. Programming for the last few decades has been strongly associated with the so-called immaterial; software appears to run the same process on different hardware seemingly regardless of the material the machine is made of. The plastic or aluminium cases that enclose these processes appear as nothing but static decoration protecting the magic occurring inside. Although a closer look at this magic might reveal how desperately dependent it is on specific material resources, from the outside, the material aspects of programming appear to be fully negligible.

The emerging term programmable material and the work that is being done in that field suddenly bridges this traditional dichotomy between software and hardware. Generally, the term refers to matter with the inherent ability to change its physical properties. This ability may then become part of an information process similar to that which takes place within hardware-software platforms. Prominent examples include shape memory alloys, polymers that can assume different shapes at different temperatures and chromogenic systems that change colour in response to electrical, luminous and thermal stimuli. But even basic materials may reveal similar intrinsic qualities when observed carefully; this has been amply demonstrated by professor and architect Achim Menges at the Institute for Computational Design at the University of Stuttgart. “HygroSkin”, the pavilion built in 2010 in collaboration with his colleagues Steffen Reichert and Oliver David Krieg, possesses several openings covered by paper thin wooden flaps (Menges 2013). In response to the surrounding humidity, these either expand and flatten or curl and open. Skilfully triggering the intrinsic behaviour of timber, the design of these flaps is such that they process the given environmental input and produce an output relative to this. Unlike conventional hardware-software platforms, which aim at producing the same output regardless of the particular materiality, in this case, matter and process coincide seamlessly.

2.1 RECONSIDERING PROGRAMMABILITY

The radical turn of ascribing the adjective programmable to material itself, the traditional silent slave of programming, calls for the re-evaluation of the definition of what is meant by programmability. Professor Georg Trogemann refers to a machine as programmable, in the most essential meaning of this term, if its behaviour can be changed without the reconfiguration of its inner structure (Trogemann and Vierhoff 2005). Therefore, all future responses are, in fact, inherent to the machine, and programming becomes the art of triggering, combining and
manipulating the possibility of these responses. Other authors demonstrate further the very material reality of programming and data-flows (Blanchette 2010, Kirschbaum 2007). Still related to computer-based programming, conventional expectations are the repetition of executed commands and the processing of unambiguous states irrespective of the material platform. Although these expectations cannot be substantiated as accurate even in the specific reality of computer-based processing, they are certainly significant elements of the term’s connotation.

Thus applying this term to the material environment and to material-human relations on various scales is a challenging and, in some cases, unfortunate aspiration. It has to be stressed that working with the intrinsic behaviour of matter is a continuously varying process influenced by a large number of factors, unlike the distinct and exact repetition computer-based binary code offers. Furthermore, the different working cycles of hardware and software become intertwined. The behaviour of shape memory alloy metals, for example, is altered through high-temperature forces that change the internal crystalline structure. Programming the behaviour of these metals is therefore achieved by altering the material’s inner coherence. This process can be rewound and repeated multiple times, creating continuously shape shifting states. At this point, programming is no longer fixed to commanding unambiguous states to be executed by the materialised hardware, but rather both happen in an inextricably intertwined fashion. To further underline this continuous interdependency and to withdraw from the deterministic connotations of programming, the term *processual material* shall be pursued in this paper.

2.2 PROCESSUAL MATERIAL

Replacing the concept of *programmable* by *processual* shifts the primary interest towards the alterability and the temporal qualities of materials. While *programmable* implies code dictating to passive matter, *processual* defines a relationship between maker, syntax, user, form and material as an open process of influencing agents. Abandoning the static meaning of materiality clears the way for an understanding of material itself which holds the potential of behaving in an active and adaptive way towards environmental processes (Hensel and Menges 2009). Processual materials are, therefore, not a substitute for existing hardware-software platforms but rather represent a new range of interdependent interactivity. It is not about a program allegedly commanding material to act, but about the potential interplay
between matter and agents. In this case external and internal forces engage in the form-finding process much along the lines of Gilles Deleuze and Félix Guattari's theory, enabling interwoven fluid interdependencies between agents within a continuous meshwork (Ingold 2010).

Processual refers, in the first place, to material that can react, either gradually or spontaneously and immediately, to its environmental and to external interactions. A connection can be drawn to the processual art movements and, in particular, to Robert Morris' pamphlet “Anti Form” (1968). Moving this understanding into the everyday exchange with the material world may genuinely alter the human relation towards materiality. Processual material may reveal the traces of the dynamic meshwork it is embedded in; it may turn inside-out its inner state and become part of an open-ended interplay with its surroundings. The idea of static form is contrary to this understanding. It is important to consider that material seldom presents itself in its purest form, detached from the environment. In this sense, it can be regarded as questionable to look at the concept of processual materials as isolated from other materials. New materials in this field are often presented as samples in laboratory settings. Though this might be an efficient way to demonstrate their capabilities such a presentation falls short of considering the complex real-world interplay they must be embedded within. Outside the laboratory, there are many more links and paths than the understanding of a material in isolation can capture.

3 POTENTIAL OF PROCESSUAL THINGS

The problem of considering materials as samples is the lack of context, social semantic and culture. Tim Ingold intervenes into discussions of material theory with his critique of the conceptual reduction of things to objects. His ideas might be applied to our concept of processual materials and how they become processual things. In this context, processual things are much more than the material that unfolds the form of the object. Things are understood, not as lifeless matter, but, to pick only a couple of Ingold's descriptions, as “a particular gathering together or interweaving of materials in movement,” (Ingold 2010, 214) or a “knot whose constituent threads, far from being contained within it, trail beyond, only to become caught in other threads in other knots” (Ingold 2010, p.4). Following this idea, threads of forces and interaction are what distinguishes things from objects. Objects can exist in a vacuum, but things are in a permanent relationship with the environment, in a continual process of becoming, as a result of internal and external forces.
The thing, in opposition to the object, is a becoming, a process of interaction whereby several becomings undertake a reciprocal process with each other. Its identity is not limited by external forces, but enhanced by the osmotic character of the thing - what creates its appropriation of the environment and make its drives internal. Ingold's writing finds its basis in the later works of the German philosopher Martin Heidegger (Heidegger 1968; Heidegger 1971). The fourfold - the gathering of earth, sky, mortals and divinities - is what constitutes the thing, according to Heidegger. The thing is desubstantialised: no longer a self-enclosed entity but instead the intersection of these four constitutive elements. It extends beyond itself along the relation presented, and becomes the particular node for such relations that contextualise it. The processual character of the thing does not consist in an isolated fixed state, but can be defined in regard to the thing's fluidity within a social process.

Processual things carry the potential of individualisation within utilisation. The success of this development not only creates an adaptive artefact but enhances the emotional bonds between people and things. The generative potential of processual materials, where growth and flexible mechanisms have an essential role in the delineation of form, may have the capability to promote emotive connections. These connections may emerge from a deeper understanding of the artefact's morphogenesis and the proximity and time required for their development. There we can find Christopher Alexander's (Alexander 1977) work regarding parametric design, by which a particular artefact can be generated in response to people's needs. In his perspective, an adaptive process will be successful only if it is unfolded and takes into consideration all kinds of possible interactions. The local uniqueness of an artefact cannot arise unless each part has an absolute autonomy so that it can adapt to specific conditions. However, this autonomy should be organised and systematised under some sort of deeper regulation. The adaptation will not only make the local part correctly adapted to its own processes, but it will also be shaped to form a larger whole.

This process seeks to develop artefacts which exist in a permanent evolving position. The things which are becoming during this transformation are the result of a close relationship between the various constituent forces which provide individual singularity. The uniqueness of the artefact is related to the experience of its use, but that experience cannot be designed directly but only through affordances. Affordances are simply the possible interactions with, and uses of, an object based on the properties of the object and capabilities of the user (Norman 2013). In the
case of processual materials, affordances can provide the framework for a new class of interactive systems which can adapt to interaction and context, so sustaining more open-ended design practices. The qualities of the materials should be considered in designers’ decisions to create products based on the behaviour of the users, their environment, and the possibilities of engagement and interaction.

The fluidity needed in the interplay around processual things triggers a fully deep and boundlessly open set of experiences. A responsive environment cannot be adequately modeled by any small finite number of experiential trajectories through that environment. A growing literature in the fields of material computing points to non-digital processes that do not follow the organisation or logic of a finite state machine (Glanville 2007; Kretzer and Hovestadt 2014; Krippendorf 2007; Pask 1969). The proposition inherent in the concept of processual things is that artefacts are created simultaneously both from the point of view of humans and from the perspective of the behaviour of materials. This conceptualization demands a shift in attitude about computation, and an extension of views on material qualities to a much broader base. Characteristics such as weight, elasticity, endurance or stiffness, belong to the world of seriality and sequential-processing thinking. In this argument, it is proposed to think spatially, introducing elementary topological concepts with which material and cultural change can be articulated using relational notions of proximity, limit, and adjustment (Sha 2013).

### 3.1 SHIFTING PHASES

The development and reconfiguration of processual things imply a physical category characterised by the combination of events-effects. Events refer to the deformations and transformations that occur when flows reach the beginnings of transitional phases and state-changes. Effects apply to the absolute qualities that consist in each state, defining the capacities and differential relations of an assemblage at a particular moment in space-time (Deleuze and Guattari 1987).

Things are dynamic, not because they are controlled by spirit, but because the material of which they are composed continues to circulate in the surrounding media, and this forecasts their dissolution or ensures their regeneration (Ingold 2011). We can consider Deleuze and Guattari, who insist that “matter-flow can only be followed” (Deleuze and Guattari 1987, 409). According to this theory, vases are no more stable than human bodies but are constituted and held in place within flows of material. By the
time materials have turned into objects, they become hidden to us: they disappear in the manufacturing process. Degradation, corrosion or wear and tear, however, changes this scenario. Despite the best efforts of designers and manufacturers, no object has a fixed state, neither can it last indefinitely.

A functional application for material flow is the capability of self-healing materials to repair damage to themselves, at early stages. This process is inspired by the sophisticated organisational structures of biological organisms. A living body has many simultaneous and complementing mechanisms with which to perform partial or complete self-restoration at many different stages. For instance, when the skin is cut, the body instantaneously responds, and the wound is clotted via “platelets” in the blood flow. By this mechanism, the tissue is sealed, allowing it to repair itself. However, the majority of artificial materials deteriorate with time irreversibly, due to wear, and this limits the life of many components. The implementation of self-healing techniques in inorganic materials is a new field of research. When self-healing materials are broken or injured, a healing process can be triggered; for instance, an agent flows into the cracked section to seal and repair it. Whereas the artificial system will not be able to create identical material to replace the damaged area, nevertheless the self-repair function could serve to provide new material in this area, and this is similar to the way in which skin damage results in the formation of scar-tissue.

There are two basic types of self-healing systems: autonomous and non-autonomous. Autonomy indicates that there is no external intervention; on the other hand, non-autonomous repairing designates that a particular external mediation is necessary to initiate the process: for example, heat and/or humidity. The self-healing methods currently proposed use a repair agent implanted into the matrix of the material. When activated by damage, the agent is released and seals the void or crack by solidifying or through other chemical reaction. In this process, a collection of regeneration strategies in the format of a trigger, a rule and an action must be specified; thus creating a self-healing loop. This notion includes the detection of failure, its diagnosis and the subsequent recovery. In this loop, the most general states are the entire, when the thing displays intentional functioning and all requirements are met as expected, and the broken which could be identified by an unacceptable response that most probably is the result of a failure or error. The possible transitions between states are stored in the code of the material; the system is unstable and inhabits a fuzzy processual zone until it reaches the next state in the loop.
3.2 PERFORMATIVE ORNAMENTATION

Visual organisation of form communicates information to people through the surfaces and geometry it presents. Experience is based on an intimate interaction of human beings with surfaces and spaces which influences emotions and physiological states and consequently, actions. Ornamentation may be understood to be concerned with a particular way of arranging information and presenting it to the user: connecting space and time, and thus structuring human experience. The ornament can create a dialogue, and be further developed by that conversation between man and artefact.

In the context of self-healing materials and processual materials in general, the ornamental can be understood, not as decorative applied to the logical and organisational structure, but instead as the element which takes care of sharing information: information about material, ways of interaction, cultural values and the society the thing is immersed within. *Kintsugi* is the traditional Japanese technique of mending broken pottery, using plant resin lacquer as an adhesive and powdered gold. The unintentionally broken vessels reveal the, hitherto potential, vulnerabilities, flaws and imperfections that these things possess. The gold seams of *kintsugi* enhance the unique pattern generated by this relationship-centred human-thing-environment, thus creating a new component for appreciation. The intermediate character of ornament, between ideal and material, places reciprocity in the relation between matter and concept. Both representation and meaning occur at the ornament. The aesthetic form of knowledge is not optional: every artefact is available only by way of appearance, the inner structure of an artefact and its materiality are evident by aesthetic mediation.

Processual materials generate ornamental effects that are not simply added at the end of the design process; instead, they are inherent to rhythmic forces that activate dynamic changes in space, reflecting mutations and transitions. Ornaments reveal an internal organisation, a consistency against which experience and knowledge can be tested and questioned. To this extent, an ornament emerges if material, form and structure are able to interact with each other, and most importantly, if they can be interrelated by, and so establish a conversation with, the user. Conversations affect and impulse the transitory states of social beings. Ornament is the figure that emerges from the material substrate, the expression of embedded forces through processes of construction, assembly and growth. In this way material, and finally the thing, transmits effects.
4 PROPOSED PROJECT: “CHRYSALIS GEMINI”

Reconsidering the shift of material from its static perception to a state of flux requires a strong focus on contextualisation. From a design perspective, this renewed view on processual material and its bundling as a processual thing propose a new level of interactive and autonomous form finding. Therefore, it is important to leave the laboratory setup, wherein new materials are usually presented, and look at their embedded purposes.

“Chrysalis Gemini” is an interactive materiality concept for ceramics with self-healing abilities. Technical concepts for ceramic components with self-healing abilities are currently being developed by scientists and engineers (Ponnambalam 2012). This kind of material carries microcapsuled healing agents; when exposed by crack or rupture, these fill the gap. The laboratory concept proposed for mechanical endurance serves as a starting point for our design scenario as it is immersed in the everyday use of ceramics. When the surface of “Chrysalis Gemini” is cracked, voluntarily or by accident, the embedded healing agent is exposed, and this then closes the crack. Furthermore the agent is imbued with the capacity to absorb the flavour and colour of the dish or liquid contained after healing. Therefore, breaking the bowl does not only change its appearance but also creates a sensual memory which is added to its experiential realm. Initially, the vessels are identical, but through time and experience, they become individual active traces of their interaction with humans and their environment.

Continuing the line of thought of current technological achievements in the field of self-healing materials, this scenario alters, not only the relationship between the lifespan of things and the things themselves, but also the connotations, the meaning, of the act of breaking something. “Chrysalis Gemini” considers breaking or cracking as a form of interaction, a changing of the state of a thing and of its material. As the French philosopher Bruno Latour points out, in our everyday experience the act of breaking might reveal the complex network within which things are entangled (Latour 1999). A broken car may unveil the unforeseen trajectories of insurance companies, car repair shops and spare part supplies which have initiated an in-line process of repair (ibid., p. 237). The (successful) result of this process is often the complete re-concealing of these trajectories.

The Japanese craft of kintsugi introduces a different handling of brokenness and repair. Here the unique reaction of the material to its breaking, the usage of gold for repair and the craftsmanship involved, actually increases the value of the piece. In
the process of repair, its unique brokenness is valued, putting the craftsman into close relation to the material. In the end, instead of becoming hidden, the trajectories of repair come into focus and the final piece is a constant emotive reminder of this process. Considering autonomous self-healing materials, understandings of the act of breaking and repairing are altered further. One can describe the traditional procedure that a car or a potential kintsugi piece undergo in terms of separate states and decisions (see fig. 3). With autonomous self-healing, these states can no longer be separated distinctly but rather melt into a continuously looped process (see fig. 4). Changing from the active-passive term of repairing to healing implies a constant alteration. This reposition transforms the relation between human, thing and environment into an interconnected process.

For “Chrysalis Gemini”, this is key to the relational individualisation of everyday objects and how one might interact with them. Healing is not considered as reestablishing the exact initial condition, but a process leaving traces of its occurrence - scar tissue of a sort. The process of breaking and healing is actively or by accident initialised by the user and then takes place in correspondence with the environmental settings. The haptic experience of continuous breaking and healing discloses the processual change within the material, rendering a complex and unforeseeable interplay between multiple factors.

One can think of this in terms of a (re-)generative design which exists as an evolving system: the dynamic substance remains alive, the surface is reconfigured as it matures. The code of the material is implemented in the design process but then left to unveil itself through the interplay of forces. The designer does not determine the final outcome, but rather creates an experiential setting.

The concept is meant to visualise how processual things, when placed into a context, reveal potential beyond their mere functional use. It exposes how processual things carry the inner potential to rearrange the interactions with, and connections towards them. This approach proposes a radically new way of thinking about the meaning of material in design, bridging the gap between software- and hardware-thinking, offering a fuzzy system approach that determines materiality as a continuous characteristic by allowing relative degrees between 0 and 1, between broken and entire.
5 CONCLUSION

In investigating the potential of processuality, it becomes evident that its continuous temporal and interconnected qualities are vital. Manifold aspects of performative and generative design already correlate to this understanding. Considering processuality, the significant potential of interactive material merges the knowledge spaces of computer-based programming and real-world material interaction. This combined knowledge opens up an understanding of co-acting, in which thing, human and environment continually influence each other. In addition, the proposed concept “Chrysalis Gemini” highlights the contextual appeal of this idea. Interaction is not only allowed in functional terms but represents a constant repositioning of actors. In their materialised form, the otherwise hidden processes become a tangibly integrated part of thingness.

Furthermore, processual materials may hold the potential of being process-starters rather than just being considered as design output. Hereby the intrinsic qualities of the material are of
core value in determining the potential of interaction and the unique relation it may hold. This idea asks for more flexibility and precision in materiality evaluation and greater insight regarding testing and investigation in contextualised scenarios. It can only be stressed how important this research is since the human-world relation is continually being re-negotiated at this particular point.

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WATSON GETS PERSONAL: 
NOTES ON UBIQUITOUS 
PSYCHOMETRICS

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Keywords
Cognitive Computing
Machine Learning
Qualification
Cultural Techniques
Psychometrics
Public Computational Media

Novel computational methods and platforms have opened a new front in psychometrics, the search for measurable personal traits in artefacts created by humans. In particular, texts produced on social media channels have been queried for insights into behavior patterns and sentiment.

This text describes an experiment in querying computing platforms that offer psychometric text evaluation. The aim of the project is to reveal some of the dynamics and assumptions hidden in the code underlying computational text analysis. The project suggests “asymmetrical coding” as a practical intervention to build interfaces for opaque deep-learning systems that act outside the direct reach of individuals, yet produce conditions that effect multitudes.
1 BACKGROUND

In 1991 Mark Weiser suggested that technologies weave themselves into the fabric of everyday life and disappear into the background (1991). Computers, like automobiles before them, would be perceived as everyday objects and not technical devices once they became ubiquitous. Callon and Law later coined the term *qualcalculation* to describe the mutual territory and dependencies between calculative and noncalculative actions (2005). Thrift expanded the concept of disappearing technology and qualcalculation as the product of ubiquitous computing events at the infrastructural level (2004). With massive deployment and aggressive distribution, these ubiquitous systems become constitutive; they pervade not only physical but also mental spaces and yet remain largely undetected when in operation.

Deep (machine) learning attempts to model high-level abstractions to detect or extract features hidden in large datasets. While feature extraction technologies have been in operation for many years, new efforts within big data research proposes to find features that were not anticipated, promising the discovery (not just the recovery) of knowledge and even the production of prediction (Mckenzie 2015). The activities of deep machine learning produce a new dimension of the qualcalculative condition. As opposed to the Thriftian framework in which computing and its infrastructure is hidden and operates in the background, the mental modes produced by machine learning enter into the foreground; their existence is acknowledged and celebrated by the engineering industry.

Cognitive computing is a catch phrase used to describe large-scale deep machine learning research applied to IBM business analytics. Cognitive computing is an offspring of several parents, expanding specifically on previous neural network research that, in turn, borrows from research into biological information processing systems and their ability to detect patterns within large quantities of unstructured information. Cognitive computing operates on an industrial scale; it is a platform level activity, dependent on and flourishing in cloud-scale centralized computing environments with access to vast amounts of data from distributed and changing sources. Cognitive computing no longer exists as a background flow but operates as a foreground fact that actively intervenes into everyday life, offering new approaches to problems of general interest and commercial value.
2 PUBLIC COMPUTATIONAL MEDIA

Computational systems have long been recognized as cultural territory (Agre 1997), and artists have responded in various ways to this condition. My own practice has produced contributions to the field in the past. Recently, I have become interested in specific responses to computational systems at scale. This inquiry is part of an ongoing research agenda of public computational media (PCM), the study of various aspects of computation systems and their ramifications for public life. The goal of PCM is to contribute to the debate through experiments that materialize ideas and test procedures in ways that text-centric methods do not. Machine learning and its corporate derivative, cognitive computing, are part of a new active computing infrastructure that acts on data of public interest, and as such are territory for PCM.

3 STATE OF THE ART COGNITIVE COMPUTING: WATSON

Cognitive computing is conceptually premised on cognitive science research that attempts to explain how thought occurs in the human mind. While the quest for synthetic consciousness remains evasive, and misgivings about the project’s grandiose goals openly questioned (Marraffa 1999), the goal of synthetic problem solving has made rapid advances in recent years. In particular, data-centric deep learning systems have been created that are able to reliably detect patterns from a corpus of data.

Watson, a computation framework created by IBM Research, is one of the most prominent examples of corporate machine learning today. The Watson palette consists of a variety of subsystems that can be applied to different types of data analysis problems. Watson was designed with the aim of processing structured and semi-structured information more efficiently than a human being. The project has a long history and has achieved prominent success. In 1997, a Watson predecessor, Deep Blue, won a six game match against the then World Chess Champion, Garry Kasparov. In 2011, a first version of Watson, designed specifically as a question-answering system with the full text of Wikipedia loaded into its four terabytes of disk memory (Ferrucci 2012), emerged as the winner of the quiz show Jeopardy!

Watson is a curious name for a system seeking superhuman intelligence. While the system’s makers link the name to the founder of IBM, Thomas J. Watson (Ferrucci 2012), the name is also reminiscent of the fictional character John H. Watson, Sher-
lock Holmes's faithful and reliable assistant who can never quite match up to his master's superior deductive abilities.

But silicon Watson has loftier goals. The synthetic Watson has been created to find reliable answers in unstructured data more effectively than standard computational search solutions. According to IBM internal evaluations, Watson meets or exceeds performance metrics of other state-of-the-art search technologies (Saon 2015).

4 PSYCHOMETRICS AND COMPUTATION

Psychologists have historically sought measures that reveal the secret, hidden, or distorted real self. The theory of values posits that every person has a set of values or goals that motivate their actions (Schwartz 1994). This construct, referred to as the theory of Basic Human Values, maps desirable, trans-situational goals of people's lives independent of cultural boundaries onto 10 basic values: universalism, benevolence, conformity, tradition, security, power, achievement, hedonism, stimulation, and self-direction. Similarly, the Five-Factor Model (Big 5) categorizes human personality traits into five categories: neuroticism, extroversion, openness to experience, agreeableness and conscientiousness (Norman 1963), (Goldberg 1981).

The field of psycholinguistics sees in language a window into hidden self-valuation systems. From that perspective, the use of language is the conduit through which these hidden values become exposed. This idea has a long history (Galton 1884, Allport 1936), and has led researchers to seek personal traits by comparing texts first with value orientation surveys, and then later by harnessing computational linguistics to perform the comparisons (Fast 2008, Fleishman 2009, Chen 2014). The increased use of social media and computing platforms has made it easier to (attempt to) detect human values in social media textual artefacts, and to (attempt to) automatically understand people through their use of social media production. More recent research has sought to expand the list of basic values, inferring even darker traits from social media text production, such as narcissism (Sumner 2012). By including more direct indicators of interests such as “liking”, some researchers have claimed to detect explicit personal traits such as sexual and political orientation (Kosinski 2013).

One of the most popular text analysis packages is LIWC: Linguistic Inquiry and Word Count. LIWC has two central components, a processing node and a set of dictionaries with categories. When a LIWC based procedure is applied to a text, it calculates
the percentage of words for each LIWC category. Each of the 64 categories contains dozens to hundreds of words. LIWC has been employed in hundreds of studies to tally words in psychologically meaningful categories (Tausczik 2010, Matthews 2015).

Procedurally, the relationship between text and value is established by associating a specific trait with words that describe aspects of the sought trait. An input text is scanned and its words are parsed into the existing set of categories, as in a traditional linguistic parsing for pronouns and verbs, etc. The parsing becomes problematic when tallying qualitative features, such as emotion, for example. Which words should fall into the category of anger? While numerical tallying within a given category can be automated, the creation of categories themselves cannot. The LIWC system creates its own lists gleaned from dictionaries compiled by human helpers, and employs human word judges to categorize tricky entries (Tausczik 2010).

Qualitative features such as cruelty can be articulated in a text in many subtle ways, as any reader of Primo Levi will know. LIWC, however, is blind to sarcasm, irony and context in general. Systems such as LIWC are currently limited to detecting qualitative events on a per word level. Emotions are assessed by the detection of declared emotion words, and sadness might be found in the occurrence of words such as “hurt, sad, depressing, and disappointing”. In addition to key words, sentence structure and language elements (such as pronoun and auxiliary word use) have been found to correlate with language emotionality, suggesting, according to psycholinguists, “a deeper importance of the expression of emotion and thinking styles” (Tausczik 2010). Other categories such as social coordination, honesty and deception are assessed in a similar process of combining detectable words and specific linguistic constructs. Some of the combinations are less convincing than others, however. One study makes the rather odd observation that an increased use of causal and insight words can be associated with—somehow—greater health improvements (Pennebaker 1997).

Despite the ongoing popularity of trait analysis, fundamental issues with the field persist. Boyle points out that there is no established theoretical basis for the Big-Five, that these features cannot be replicated consistently in different samples, and that even when detected, they provide only a static account of behavior regularities (Boyle 2008). Furthermore, there is surprisingly little attention devoted to differentiating the category of text within computational trait analysis. While a literature-centric approach to trait inquiry might consider poetry, legal proceedings and fictional accounts as vastly disparate territories, text
forms tend to be lumped together where text quality is secondary to text content. Recent research has started to investigate this deficit and inquire as to how different social media platforms influence the assessment of traits. Haber, for example, reports that pronouns are less frequent in wikis as opposed to blogs, and profanity is much more frequent on Twitter than in business-oriented media (Haber 2015). Consequently, media specific variations in word use are reflected in models created based upon those word use patterns.

5 WATSON DOES PSYCHOMETRICS

According to published IBM reports, Watson is premised on the same theoretical assumption as standard computational psycholinguistics, namely that human traits can be detected in language use, and that this process can be automated with software. Watson staff (IBMWatson) cite in their justification prior efforts in the field (Fast 2008, Chen 2014), and describe how the research team expanded this existing framework into social media data sets and new personality features. The Watson team developed its own models to infer scores for the Big-Five with several additional dimensions from other models, including the aforementioned Basic Human Values (and Needs) system. The model for the Big-Five personality characteristics was trained on data from blogs, while the model for Values was trained on forum posts, and the Needs model from Twitter data. With these augmented models in place, the Watson service infers characteristics from textual input by tokenizing the input and matching the tokens with the LIWC psycholinguistic dictionary in order to compute scores for each of its categories.

Depending on the particular set of characteristics, Watson uses a weighted combination from the LIWC category scores to form its own final score. For example, the Big-Five uses coefficients reported by one source (Yarkoni 2010), whereas the coefficients for the Values were gleaned from another source (Chen 2014). Interestingly, the domain specificity of the models has less of a negative effect than one might imagine. IBM organized a study (Gou 2014) in which models from different sources were applied to Twitter data. The researchers found that for a large majority (> 80%) of the Twitter users, scores for personality traits that were inferred for these models correlated significantly with survey-based scores.
According to Watson engineers (Ferrucci 2012), the Watson system has been exposed to books “from the Gutenberg Project”. But precisely which texts Watson was exposed to is not known. Watson, as is the case with all machine learning systems, will be challenged to deal with ill-defined input, unusual samples and small data sets. As other researchers have lamented (Scott 2014), outsiders rarely have access to the innards of commercial algorithms. Recent work in black box auditing has shown that it is possible to investigate how a classification model takes advantage of features in datasets without knowing how the models themselves are constructed (Adler 2016). While this line of research is extremely promising for algorithm auditing in general, my goal here is not to detect the predictive qualities of a given algorithm but to observe artefacts of classification created through exposure to unusual materials.

With developer access to Watson’s Personality Insights analytic engine API, one can observe how Watson performs the assessment of character traits on arbitrary text input. As opposed to working with textual materials from current social media platforms, I have confronted Watson with media texts from old platforms, which are not influenced by the dictates of social media text production. In this experiment, Watson is asked to respond to input text it might not have been exposed to previously. The selection of texts includes: Sun Tzu’s *The Art of War*, 5th century BCE, Plato’s *Republic*, around 380 BCE, Lucretius’ *On the Nature of Things*, 1st century BCE, Ovid’s *Metamorphoses* of 1CE, Orwell’s *1984* of 1949, Carroll’s *Alice in Wonderland* of 1865, de Sade’s *120 Days of Sodom* of 1785, Shelley’s *Frankenstein* of 1818, Austen’s *Sense and Sensibility* of 1811, Marx’ *Communist Manifesto* of 1848, Kaczynski’s (aka Unabomber) *Industrial Society and Its Future* (Manifesto) of 1995, as well as IBM’s *Annual Report* of 2014.

While the current version (March 18, 2016) of the Personality Insights module supports Arabic, English, Spanish and Japanese, the texts in this experiment are mostly originally written in English or have been translated into English. The choice of text materials is guided by the measure of enduring cultural impact, with a corporate annual report the exception to the rule. The goal is not to see how well Watson classifies the documents, but to collect and reflect on unexpected relationships between business language and literature that Watson might generate. Or: how do the classics fare under Watson? Can (author) character traits from sophisticated textual production be differentiated from ephemeral writing? Figures 1 and 2 show an attempt to ad-
dress the questions. The figures show code-generated views into Watson-generated similarities between (the authors of) texts that could hardly be more dissimilar: the Communist Manifesto and the IBM annual report. Both sources get high marks in “achievement striving”, and a maximum score for “imagination”, for example.

Watson’s Personality Insights assumes that the input text is produced by a single person. Arguably this is not the case for annual reports where a cohort of anonymous writers put together documents spanning hundreds of pages. Yet the voice that emerges from the annual report is singular. It represents the corporation and, at least in the USA, corporations enjoy many of the same important rights and responsibilities of individuals. While other countries do not explicitly support the US model of corporate personhood (Blair 2013), features such as corporate social responsibility (May 2015) and the unified entity they suggest have become person-like actors across the global business landscape. While the applicability of personhood to the annual report production team may appear spurious at first, it fits the historical pattern of the making of the corporate persona (Blair 2013) though the mechanism of the “artificial person” that, like a cyborg, can be similar to a living person yet completely different “inside”. This is the rational for applying personality analysis to a corporate annual report.

Annual reports are an odd combination of frank assessment and reflection created by corporations around the world. Companies report on their activities, successes, investments and future plans in their annual reports. Annual reports define a unique form of language and language use; a mixture of hype, promotion and bureaucratic write-easy that is inspirational, self-congratulatory and obfuscating at the same time. Like blogs and wikis, the annual report is at home on social media. Yet the annual report is not an established textual category in the way that blogs, wikis and posts are, and hence it has not yet been declared worthy of model creation for text analysis. Here it serves as an example of a new global text production category, one well-suited to be read by machines; a reference point by which to compare an algorithm’s responses to earlier textual production categories.

The Watson team is continuously tuning and refining the Watson code base and training materials. The publicly available changelogs track the sequence updates but do not describe the technical details and operational changes. While this visualization allows one to see the current state of the algorithm, it is not sufficient to show changes between updates. However, re-applying the visualization to generate a time-series sequence of the
outputs of the invisible algorithm might show when changes occur and how the evaluation of the stable texts changes over time. As these texts remain fixed, the differences in the positions of the text markers will be due to changes in the Watson code itself. Such changes give a low-resolution lumped view of the temporality of code modifications over time, giving these texts a new role as markers for change and progress in otherwise inaccessible algorithm design. Figures 4 and 5 show an unsuccessful attempt at finding such differences. From these graphs, we can see that the system V2 did not change between November 2015 and April 2016 as far as the evaluation of the category “Melancholy” is concerned.

Fig. 1 and 2. Watson personality assessment engine applied to the IBM annual report of 2014 and the Communist Manifesto of 1848.
**Fig. 3.** Watson personality trait Melancholy (Personality Assessment algorithm version March 2016, filtered with a sampling error < 0.075) across a selection of text sources. Values are differential scores using the IBM Annual Report of 2014 (pale red at 0.0) as a reference. All results are normalized with regards to a sample population “based on a corpus of more than a quarter of a million Twitter users” (IBM Watson 2015).

**Fig. 4 and 5.** No change detected in the evaluation of a subset of the sample texts between November 2015 (left) and April 2016 (right) within version 2 (v2) of the Personality Insights module.
Yet the principle is more important than the example. By generating code of codes, algorithms of algorithms, it is possible to perform more discerning observations of algorithm effects in practice (Scott 2014). While the current version of this code of codes is only a start, the principle suggests a new kind of contribution to investigations into large and inaccessible software systems that evaluate text production.

7 TEXT ANALYSIS, ASYMMETRIC CODING AND CULTURAL TECHNIQUES

Recently, researchers have begun to question the results produced from automated trait analysis of social media artefacts. Models created in one domain and applied to another can introduce spurious artefacts. Specific features such as style and message length vary between domains, and can make comparison of traits observed across platforms difficult. For example, character-count limited Twitter showed in one study the least Big-Five variability for a given sample size while email showed higher variability (Haber 2015). Neuman describes how the Watson analysis framework completely misses the mark on a text produced by a recent mass murderer, and then proposes adding semantic similarity measures to existing text analysis methods (Neuman 2015) to counter the detected deficiency.

The accuracy of Watson’s Personality Insights has also been tested in less formal settings. Contributors to QUORA, for example, have tested the system with a variety of personal and nonsense texts, finding a tendency for flattery in the generated output (QUORA).

However, in this investigation, the goal is not to assess how correctly or incorrectly Watson performs, nor to improve the Watson engine, but rather to find new ways of observing system status. How does it change, how does it see the materials at any given moment? What kind of relationships are created between ephemeral and canonical texts, and how might even minor glitches scale, given the industrial level deployment of ubiquitous text analysis? The codes that produce such observations and relationships are a code-based form of cultural technique (Siergert 2013); they are new kinds of difference-producing operators.

The impetus to query this territory leads us back to the start of the paper; it is given by the ubiquity of machine learning and cognitive computing. The Watson system – as are other corporate machine learning frameworks - is being deployed in industries ranging from travel planning to weather monitoring and, most
recently, health care. Gaining insights, even in small measures, into how these systems operate is important, both to appreciate what they can accomplish but also to understand their shortcomings and failings.

The focus of text analysis systems such as the Watson personality trait assessment is indicative of the obsession with social media production that is altering the definition of text. The fact that an annual report and the Communist Manifesto both achieve top scores in “imagination” tells us that the system is blind to the contexts in which the texts operate. Political vision and business innovation become similar only through the system that evaluates them; a new category of machine learning enabled semantic glitch.

Training text classifiers on ephemeral text materials such as tweets elevates tweets to the status of formal text, previously held by literature. Will we find ourselves in the position of deciding to write (and think) the way computing platforms expect us to in the future, simply in order to minimize classification errors? Once cognitive computing becomes ubiquitous and scans electronic correspondence for signs of mental instability, thus impacting health insurance, we just might be inclined to do so.

As the reach of machine learning expands into new territory, the problem of ill-defined input will develop two along two different trajectories. First, it will be a concern for algorithms faced with normalizing new data sources such that results are computationally sound. Second, it will be a concern to people who do not want to be reduced to a computational compatibility issue. One response to this situation might be to offer additional training materials to classifiers in order to educate them on variations in texts and people in meaningful ways. Let the machines take over, finally, but perhaps we could have them read a few good books first.

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Hans Richter’s famous piece *Rhythmus 21* is considered to be the first abstract film in the experimental tradition. The *Webdriver Torso* YouTube channel is composed of hundreds of thousands machine-generated test patterns designed to check frequency signals on YouTube. Could it be argued that, given certain necessary provisions, there exists a lineage connecting *Rhythmus 21* and *Webdriver Torso*? What would it be called? Are we at liberty to discuss the *Webdriver Torso* channel as an artistic marvel emerging from mathematical abstraction?
Featuring a succession of shapes in black, white and grey, Hans Richter's famous piece *Rhythmus 21* is considered to be the first abstract film in the experimental tradition. Throughout its runtime of approximately 3 minutes, the constituent spatial elements of the work are comprised exclusively of the interaction of geometric forms—thereby drawing attention to the material properties of the medium of film: light, movement, and the screen as surface.

The *Webdriver Torso* YouTube channel\(^1\) consists of about 500,000 videos, all of them featuring the same aesthetics—seemingly familiar red and blue rectangles randomly changing location, proportion and size. An asynchronous soundtrack of piercing, high-pitch pulse tones accompanies these. Initially the purpose of the channel was unknown, as was the identity of its operators. Various rumors circulated on the Internet and the channel attracted dozens of thousands of subscribers and millions of views. It was then discovered that the channel is operated by Google engineers, supposedly using it for testing the technical quality of image and sound on YouTube. In other words, these videos are intended as nothing but chroma and frequency test patterns. Moreover, it was also revealed that the videos are all automatically generated and automatically uploaded to the channel.

The aesthetic affinities between *Rhythmus 21* and the *Webdriver Torso* videos are easily discernible, even to the untrained eye. But what lies behind them? What do they disclose? Do they extend beyond the surface formalism of the projected images we recognize as abstract film or video? At first blush this claim seems difficult to prove. To start, *Rhythmus 21* was created almost a century before *Webdriver Torso* was launched. It also goes without saying that Hans Richter was human, as were the viewers of his film (then and now). Furthermore, Richter also pre-mediated *Rhythmus 21* as an artwork. On the other hand, the numerous videos in the *Webdriver Torso* channel have been ‘created’ by computers and not by humans. They are similarly intended for ‘viewing’ by computers rather than by humans. Finally (and perhaps most crucially), they were not designated as artworks. Thus, according to traditional aesthetic criteria, *Rhythmus 21* can be understood and categorized as a work of art whereas *Webdriver Torso* cannot. How then should it be understood and categorized? Is it more than an endless series of meaningless technical information?

Nonetheless, the affinities in question here are, in many ways, quite damning. Could it be argued that, given certain necessary provisions, a lineage can be drawn to connect *Rhythmus 21* and *Webdriver Torso*? And if we follow with this ‘thought experiment’,

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1. “Webdriver Torso Youtube Channel,” https://www.youtube.com/channel/UCsLiV4WJfkJfTEH09PmRklw/videos
what would this lineage be called? *Rythmus 21* can be considered as a work of geometrical abstraction, that is a work whose pictorial language is based on the use of simple geometric forms placed in non-illusionistic space and combined into nonobjective compositions. Are we at liberty to discuss the *Webdriver Torso* channel as an *artistic* marvel emerging from another sort of abstraction?

The assertion we set out to examine here is thus twofold: 1. *Webdriver Torso* is an indicative artifact of a process (or family of processes) called *mathematical abstraction*. Arguably, even if mathematical abstraction does not yield artworks in the traditional sense, it does bring about a set of circumstances that pertains to some fundamental definitions of art. The persistence of these circumstances suggests that the framework they operate within ought be considered as relevant, if not pivotal, for thinking creatively about art *today*. 2. If we take into account the core principles of conceptual art and computer art (as they have been defined by Frieder Nake) mathematical abstraction *can*, in some cases, be considered an extreme form of art.

However, before we delve into the locus of our inquiry, a few words about early abstract art are in order. There are various historical roots and philosophical presuppositions that eventually lead to the gradual rise of abstraction in various places in Europe. Accordingly the emergence of ‘pure’ abstraction in the 1910s is narrativized in several ways, but most often with one of three protagonists: Kazimir Malevich, Wassily Kandinsky or Piet Mondrian. The different traditions of abstraction also echo a variety of philosophical, political and aesthetic positions. Nonetheless, no matter the particular tradition of abstraction, or how one understands the positions it grew from, the underlying principle of all such traditions is one. It is the desire to gradually strip away from the picture (and henceforth from art) the visible traces of reality until all discernable elements of worldly phenomena are eliminated.

Put plainly, abstraction is a process of reducing expression into the most essential of forms. It is therefore possible, even appropriate, to name reduction, removal and elimination as the core concepts of modernist abstraction—common to all its lineages and differentiating them from 19th century realist painting. But, if abstraction is defined as a mode of strict restraints, then arguably it is not the outcome that deserves attention but the methodology. Abstraction may be spiritual (a search for ‘essences’) but it also procedural—it is the technological breaking of action into constituent, operative components. In other words it is the reinvention of artistic expression as a series of operations that are (or
can potentially be) streamlined. (Later we shall even argue that abstraction can also be understood in terms of quantification.) Furthermore, when these operations are notated they can form ‘new’ matter or new information. This capacity, we believe, is not only the root of abstraction in art; it is also the very same capacity that underscores artificial intelligence.

Put differently, abstraction and technology are not unrelated; neither do they follow divergent principles. Rather they are inextricably entwined. In the context of the early 20th century this is observable when thinking about modern art within the broader history of modernism. The rise of modernism, we should bear in mind, was concurrent with the rise of industrial and reproductive technologies. This given, technology itself often became the subject of modern art. Modernism, in other words, should be recognized as, at least in part, responsible for the advent of abstraction in the visual arts.

What’s more, the artistic goals of what we now call modernist abstraction are also simultaneous and comparable with many cutting edge scientific quests that took place around the turn of the century. Physics, chemistry, experimental psychology, and other sciences were all similarly engaged in the deconstruction of the inanimate, biological and psychological realms into simple, further indivisible elements. Thus, it can be easily established that the gradual move toward abstraction in art echoes the same zeitgeist, argued Lev Manovich convincingly. Just as physicists, chemists, biologists and psychologists strived to break down reality to its basic constituents, so did the artists of the time. They too attempted to articulate the basic elements that constituted their field of inquiry.

Using motion as his means of investigation, Hans Richter challenged the cinematic experience by applying musical principles to it. Arguably it is the ‘music’ created by the transition of its elements that lends Rhythmus 21 its geometrical abstract quality. (Of course similar concerns can be identified not only between separate fields of inquiry but also within them. In other words Hans Richter obviously took inspiration for the title and theme of his film from other abstract artists who similarly titled their works with musical terms—for example Kandinsky or František Kupke.)

In fact, abstraction in this film is more than a successful attempt to do away with a mimetic image of the world. The disavowal of the direct connection to the external world and the elimination of narrative constitute this piece as a self-sufficient, ‘closed’ ecosystem. Or, to use Philip Allain Michaud’s words: “everything that appears on the screen proceeds from the shape of
the screen itself: the rectangles that grow or shrink are screens parallel to the screen; the lines sweeping horizontally or vertically across the projection’s surface are screens perpendicular to the screen. There is thus no more difference between the nature of the screen and the nature of the images projected onto it.”

*Rhythmus 21* thus becomes, perhaps similarly to Malevich’s black square, an investigation into the circumstances and conditions of its own existence. These circumstances and conditions are: material (the screen as surface), cognitive (the movement and transition of elements on that surface and their ‘imprint’ on human eyes and minds) as well as ontological (the logical transformation of world into rhythm). Thus, for the time of its creation, this gesture was radical—an attempt to undercut the suspension of reality that usually underpins the cinematic experience, and, concurrently, the revolutionary suggestion that some aspects of that reality may be replaced by radical abstraction. Today, almost 100 years since the gesture of *Rhythmus 21*, the same methodology is at play.

It can easily be said that the videos posted on the *Webdriver Torso* channel also examine and expose their own conditions of production. In that sense they are a link on the same continuum that dates back to the early 20th century. In other words (and in stark contrast to Manovich who identifies contemporary forms of abstraction with “the sciences of complexity”) we are not only arguing that *Rhythmus 21* and *Webdriver Torso* are comparable in many superficial aspects. We further posit *Webdriver Torso* as descending from similar concerns as well as continuing the same structures that yielded *Rhythmus 21*. Thus, the inclusion of Webdriver Torso in the tradition of abstract art is, in our view, a foreseen stage in the transformation of art from visible, to procedural, to conceptual, and then to the exclusively algorithmic. We shall shortly delineate this transformation with the aid of Sol LeWitt and Frieder Nake.

Are we then at liberty to scrutinize *Webdriver Torso* in exactly the same ways as we did with *Rhythmus 21*? Yes but with extreme caution—because such scrutiny, as will soon be made clear, not only confirms that *Webdriver Torso* videos share many traits with abstract art, it also, at the very same time, breaks away and makes redundant the overarching principles of what we are accustomed to identifying as art in the first place.

Nowadays artists are routinely expected to question and explore their own processes, to be able to tie their concerns to broader narratives and metanarratives. Moreover, it almost goes without saying that an artist must problematize the lineage and contexts he or she belongs to, if they wish to expand them.
Yet this was hardly the intention of the Google engineers behind *Webdriver Torso*. And so we ask: does the continued interest in these videos, even after the mystery surrounding their origins has been dispelled, hail a new metanarrative for art? Can it be argued that these machine-generated videos are not an anecdote but a long overdue expansion of the epistemological frameworks of art? Do they have aesthetic qualities unique to them? Can it be proven that strangely these videos are comparable to man-made artifacts that are considered art? Could this channel be considered as an artistic genre, or even medium, of a unique kind? Perhaps it can.

In an article discussing the development of test patterns on different media, Adam Rothenstein suggested that the *Webdriver Torso* videos promote a “new aesthetic test pattern for contemporary technology.” And so, even if the videos call to mind artifacts of the geometric abstraction tradition (which were all carefully, and manually, crafted by human artists), labeling them as art objects still requires extreme caution (or a modest leap of faith) because such labeling clearly challenges our familiar conventions of what art is. This is due to the clear lack of authorship here, and the apathy towards their ontological standing.

As part of such inquiry we must also discuss another important quality of *Webdriver Torso*—that it is not only virtual and immaterial, almost-entirely independent of location or time, but that it also exists, and will continue to exist, regardless of whether it ever ‘has’ an ‘audience’ to ‘view’ it and irrespective of whether that audience is comprised of humans or machines.

This characteristic of *Webdriver Torso* places (or rather abandons) complicated questions on the doorstep of art. For we not only know that that creator of these videos was not human, we also do not know the ratio of human (as opposed to machinic) viewers. This, to reiterate, is an entirely new phenomenon. Furthermore, the fact that an open channel of quality assurance process has become a modest attraction, in and of itself, reveals the extent to which the workings of the post-industrial technical apparatus (which underlies most artistic media production today) are, to most of us, entirely opaque and unknowable. Otherwise, as Daniel Rubinstein notes, why the ongoing tendency to refer to them with bucolic metaphors such as clouds, shadows, streams, farms and flows?

Earlier we explained that the abstinence that produced modernist abstraction was closely linked to the dominant scientific paradigms of its time. We shall now name the broader symbolic actions, or layers of asceticism, that brought rise to this paradigm. These, we argue, are still the backdrop for the scientific
paradigm of *our* time. This will support the claim that some autonomous computer-generated media outputs are, in many ways, a radical manifestation of the same conditions that, at least since the mid-twentieth century, have defined art.

To do so we now turn to the late media philosopher Vilém Flusser who consistently dissected and discussed the evolution of humanity in terms of abstraction. The symbolic role of sculpture, argued Flusser, was to abstract the four-dimensional continuum of space and time into a three-dimensional sign. This sign then stood for the continuum but, because of its dimensional reduction, it could also be manipulated. Some early examples for that are gravestones, the pyramids and obelisks of various cultures. A further symbolic (or ascetic) act consisted in signifying a three-dimensional scene, object or sign through a two-dimensional surface-sign. This way a dying person, or an existing gravestone, could be signified by a painting of a pieta, for example. This once more increased the possibilities of manipulation. A third symbolic act according to Flusser was the replacement, or denotation of the two-dimensional through the alleged one-dimensionality of the written text. Linear writing, as Flusser often referred to it, thus represents even further recession into the non-concrete, into the form of code we call ‘the alphabet’. Importantly, it also endows humans with a new capability, the capability of ‘conceptual thinking’.

Then came the fourth symbolic act, which was the replacement of the one-dimensionality of linear writing by what Flusser and also Friedrich A. Kittler identify as ‘zero-dimensionality’ of numbers or bits. Flusser calls this zero-dimensionality ‘the universe of technical images’. Kittler calls it ‘the world of the symbolic’ or ‘the world of the machine’. Either way, and no matter the terminology one opts for, the movement of human communication towards extreme abstraction, can, according to this overarching narrative, be alternatively defined as the gradual cultural abolition of all natural dimensions.

What all phases described in the previous paragraph have in common is what Kittler called the $n-1$ dimensional signifier. What we must bear in mind in this context is that the $n-1$ dimensional signifier does not only reduce one dimension in every phase. More importantly, it *conceals, disguises*, and *distorts* the signified, that is, the $n$ dimension. Thus, the last 40,000 years of man can also be defined as the process by which all human modes of expression have been abstracted, ephemeralized and finally replaced by electronic modes of code.

We shall now go one step further to suggest that not only modes of expression but also other cerebral functions can be, and in fact have been, replaced by electronic functions. By ‘other cere-
bral functions’ we now mean the human penchant for mysticism that is commonly called creativity — in other words the desire to ‘make’ art. But in order to claim that an algorithm that automatically spits out ready-to-air videos is ‘artistic’, or even ‘an artist’ we shall have to leave the inner contradictions of Flusser and Kittler for a different occasion. Instead we shall briefly define the ‘art’ in ‘computer art’ to bring the arguments of this paper to a close. This will be done with ideas that are by now familiar from another form of art that similarly appeared after the emergence of electronic code — that is conceptual art.

It is all-too-rarely acknowledged that early computer art had much in common with other art forms that emerged around the same period: high-modernist hard-edged abstraction and, more importantly, conceptual avant-garde art. The brotherhood between these artistic genres, all born around the 1960s, a time of turmoil and calls for social-change, is marked in the immanence of concepts. Crucially both conceptual art and computer art can be understood as ousting traditional artistic values — most notably the (manual) craft required for the physical execution of the individual work of art. Instead both place emphasis almost-exclusively on the process and on the ideas that govern it. In fact, this ideological similarity is made apparent and accessible in a manifesto published in 2010 by Frieder Nake — a mathematician and a pioneer of computer art. Importantly, Nake’s “Paragraphs on Computer Art, Past and Present” borrows its style from an earlier manifesto — Sol LeWitt’s 1967 “Paragraphs on Conceptual Art.” This earlier title is acknowledged, quoted and some of its core principles are elaborated.

In his manifesto, Nake names 3 great principles of computing machinery. These are: computability, interactivity, and connectivity. Computability, he argues, appears in the arts as algorithmic art, Interactivity appears as interactive installation and connectivity appears as net art or software art. We shall utilize some of his intriguing arguments on algorithmic art to support our definition of mathematical abstraction.

Computer art is “art from a distance” argues Nake. The computer is necessary for the art process by mediating and fulfilling the artist’s ambition. It then automates the production of the perceivable, material component of the work. In algorithmic art the artist can potentially create (in fact they must create) an entire class of art works (not just an individual work). The artist thus works in the realm of possibilities and potentialities, not just of in the realm of realities. The work of art in algorithmic art is, in other words, the description of infinitely many possible works.
Computer art is conceptual art states Nake, but insists that concepts in computer art are somewhat different from concepts in conceptual art. In computer art concepts appear as operational descriptions. This is significant because algorithms are descriptions: “finite descriptions of infinite sets.” Moreover, algorithms are descriptions of dynamic processes. However, these descriptions have a unique standing: they are operational and executable. That is, they are text and machine, at the same time. To recall, LeWitt proposed that in conceptual art “the idea becomes a machine that makes the art.” Here the machine is the text and the text is the idea — idea and artwork become one. Nonetheless it is important to clarify that computer art is conceptual art insofar as it describes an idea and does not show the material work. Since its description must be operational or computable, the concept can be carried out immediately without mediating media. If the conceptual artist ever wanted to realize his description of an idea, he would need an appropriate kind of media to do so.

Nake’s underscoring of the process of reduction as elemental for conceptual art is especially relevant to our argument because it makes clear that conceptual art was another step in the continued reduction of human expression (the n-1 dimensional signifier). This reduction reached the point of the concept or idea itself. There can now be no work of art without a concept at its root. In conceptual art, the concept is considered more important than its realization but algorithmic art takes this yet a step further: ideas and their descriptions in algorithmic art must be codes. This code is incorporated into their own execution. Whereas in conceptual art there is an inherent delay between concept and the production of the artwork, algorithmic art immediately delivers the conceptualized piece and could go on realizing the same concept for centuries. The algorithm is perhaps artistic concept in its strictest form of description — the final form of art in times of industrial and post-industrial production.

Does it matter then that a particular algorithm was never intended for artistic purposes? Probably not. If we take art as a form of perceptual magic we can see that it changes through time. When forms of perceptual magic change, so do the material conditions of living generally, and technologies and modes of representation, more specifically, all must change too. In time these changes teach us to think in particular ways appropriate to them. That is, they condition us, their makers. This holds true for drawings, written words, technical images and algorithms. Put differently, the incorporation of mathematical procedures into artistic creations was, from its outset, bound to change the definition of art. For if, predetermined probabilities are what determines the visible aspects of the work of art, then what difference
does it make if these probabilities are calculated by humans or machines? After all, we humans, the pinnacle of natural creation (as we once believed ourselves to be) also rose through repetitive calculation and transmission of pre-programmed information. And what difference does it make if these probabilities are observed by machines and not by humans?

It ought to now become clear that information processing before transmission can unleash a plethora of intriguing artistic possibilities. This is why genetic engineering and artificial life can be taken as art forms, and artificial organisms should be considered works of art. Down the road such processes, and others like Webdriver Torso, may lead to unexpected results. The unexpected of course poses a threat but also constitutes a promise for an evolution of art by means of mathematical abstraction—the expansion of its operational possibilities to more senses, channels and manifestations. The proposition we wish to present today is not that these 500,000 videos are necessarily art, but that they offer us opportunities to marvel at the new avenues provided to art by the apparatus, the algorithm and the program. “The idea becomes a machine that makes the art” wrote Sol LeWitt almost 50 years ago. This is especially true today, given that some machines can, quite literally, make what some of us take as art.

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Virtual Reality (VR) offers new ways to perceive and interact with virtual content. Apart from photo-realism, VR can be used to explore new ways of visualization and interaction. In this contribution, we describe two student projects, which focused on creating innovative concepts for an artistic VR experience. We provide a review of sources of inspiration ranging from standard NPR-techniques through movies, interactive artworks and games to phenomena of human perception. Based on this wide collection of material we describe the prototypes, and discuss observations during implementation and from user feedback. Finally, possible future directions to use the potential of VR as a tool for novel, artful and unconventional experiences are discussed.
1 INTRODUCTION

From the beginning, the ultimate goal of computer graphics has always been to achieve photographic quality when rendering. The virtual camera model, which forms the foundation for virtual image generation, represents a simulation of a real camera—even parameterizations such as aperture, focal length and artefacts like lens flare or motion blur have been established as standard techniques in the field of computer graphics. Over time, artists and scientists questioned this dogmatic approach and developed the field of non-photorealistic rendering (NPR, cf. Fig. 5) as counterpoint. Gooch and Gooch argue that NPR offers several advantages for visualizing information by emphasizing specific aspects. They use the example of a picture of a sailboat: “From such a photograph a viewer can infer a vast amount of information such as the time of day, the weather, wind direction and speed [...]. However, such an image would be of little use to someone attempting to build a sailboat.” (Gooch and Gooch 2001). They argue that NPR brings together art and science by using abstraction methods to emphasize the message communicated by an image. This makes NPR a valuable tool for both scientific visualization and artistic expressiveness. Especially when trying to achieve an artistic look and feel of computer generated imagery, NPR techniques, mimicking traditional painting effects such as brush, ink or pencil strokes, are applied as “post-process” to the rendered image.

With the current excitement about Virtual Reality (VR), especially in terms of its applicability on the mass market, the underlying rendering techniques again focus on achieving photorealism. But virtuality is capable of more than just the plain reproduction of reality. Using VR, we can create illusions, manipulate the user’s perception, play with expectations. Virtual environments do not necessarily need to simulate real world physics, instead they can go beyond the boundaries of these rules, simply following the imagination. Regarding alternative rendering techniques, the question arises: What happens if we apply the ideas of NPR to VR? Usually, NPR techniques resemble the methods, look and feel of classical painting and sketching disciplines and are applied to 2D imagery - the imitation and the original are structurally comparable. With computer graphics you can apply these painterly effects not only to stills but also to animated or even interactive imagery. This reveals specific characteristics that are unique to NPR, e.g. the dynamics of brush texture in an animation (Meier 1996, Gooch and Gooch 2001, Hertzmann and Perlin 2000). If we enter the interactive three-dimensional space, what additional
effects occur when using these inherently two-dimensional stylistic elements? What happens if techniques like NPR or multi-perspective rendering are used in VR? How do users perceive an interactive abstraction of the real world? How does it feel when specific elements of the environment are hidden from the users (visual) perception? Can we use sensory illusions to build surrealist experiences?

In the following, we describe two student projects which aimed to explore the potential of NPR techniques, abstraction and sensory illusions in the context of VR, especially when using an Oculus Rift (OculusVR 2015). The first project focused on the applicability of stylistic elements derived from visual patterns utilised in comics, such as Cel Shading, text and speech visualisation or motion lines. The second prototype explored the effect of a reduced visual perception of a realistic environment by presenting a completely white scene, in which the user solely relies on shadows (including his own dynamic shadow) to identify objects. Based on the experiences and observations during the project we want to show some of the opportunities and pitfalls of using NPR-techniques in the context of VR.

2 RELATED WORK

The prototypes developed are basically inspired by three areas of research: human perception, especially spatial illusions and use of light and shadow, stylistic elements utilised in comics and finally concepts derived from Non-Photorealistic Rendering techniques. In the following section we want to give a short overview of several visual techniques and their applicability in the context of VR, which can also serve as a source of inspiration for future work.

HUMAN PERCEPTION AND OPTICAL ILLUSIONS

One source of inspiration were the spatial illusions created by M. C. Escher (Escher 2001). These 2D drawings use the laws of perspective and the ambiguity of 2D projections of 3D objects to create impossible objects. Therefore, these constructions only work from a specific point of view. If used in a dynamic environment where the user can change its point of view, the illusion collapses (Fig. 1, Nolan 2010). However, depending on the type of projection and interaction, the concept of spatial illusions can be employed to create spatial puzzles with unconventional effects (Ustwo 2014, Fig. 1).
Besides spatial illusions, the role of light and shadow for human perception and their use in movies and interactive media were investigated. In the genre Film Noir the shadow is used in many ways. On one hand great dark areas provide the illusion of a safe area where the actor can hide his appearance. On the other hand, the same areas can represent danger because of the unknown that could hide in this area. Shadows are also used to predict the character’s destiny, e.g. shadows of a grid on the actor’s face. Shadows can also represent an actor who is off-stage (Place and Peterson 1974). Providing small lit areas during a pursuit in which shadows run through the image provide a very dynamic illusion. The shadow as third man can represent death, e.g. Nosferatu’s shadow creeping upstairs into Ellen’s Chamber (Murnau 1922), destiny (the silhouettes of both characters disappear in the fog—so their destiny remains unknown, (Lewis 1955)) or the ambiguity of characters (demonic shadows appear behind the suspect on a wall after he collapses (Siodmak 1944)).

Inspired by the Film Noir genre, modern movies like Sin City added highlighting and NPR to create a comic-like environment (Miller 2005). The computer game White Night (Osome Studios 2015) adapted those ideas and reduced the grayscale into black and white, resulting in an even more threatening environment. Regarding light and shadow, another environmental effect served as inspiration: the so-called whiteout. This describes a
weather phenomenon which occurs mostly in arctic or desert regions. Particles in the air (fog, snow, smoke, sand) are absorbing and reflecting light leading to an extremely low contrast between objects and background (Schlichting et al. 1980). Additionally, in arctic regions snow and low cloud cover reflect light as well. Consequently, the distribution of light seems to have no difference in a full 360° view around the spectator. The main effect is that orientation is lost and size estimations of objects are extremely difficult, which also affects depth perception. As a result, small objects near the spectator can be misinterpreted as big ones far away (Goldstein 2009).

This effect can be employed to create new concepts to explore an unknown environment. The computer game *The Unfinished Swan* (Giant Sparrow 2012) puts the player in a completely white environment. The only way to discover surrounding objects is to shoot black ink bubbles into the void. When these bubbles collide with objects they burst and a blur of colour remains. In this way, the player can reveal the environment and is able to recognize objects, their size and find a way through the level.

**STYLISTIC ELEMENTS OF COMICS**

As mentioned before, the simulation of artistic patterns is a key component of NPR to render images. However, the cartoon style supports a more suggestive and stylized way of rendering and is characterized by a typically non-realistic representation, heavy outlines and Cel Shading (Decaudin 1996). In addition to the well-known cartoon shading, McCloud described the Comic as spatially arranged sequences, pictorial or other characters that convey information or generate an aesthetic effect on the viewer (McCloud 2001). The sequences are usually arranged to form a 2D layout, a panel or gutter, and within these spatial arranged sequences typical comic elements are placed to communicate certain activities within the frames. These comic elements commonly imply speech balloons, captions, onomatopoeia (words that mimic sound).
The computer game *XIII* (Southend 2003) employed the stylistic elements found in comics to create a unique experience for the user and combines the narrative 2D panel structure with 3D interaction. While the level of detail in this particular game is quite detailed, other examples may differ in line thickness, degree of abstraction, shading intensity, symbolism and proximity to real faces. Additionally, *XIII* uses onomatopoeia as gameplay element, e.g. by visualizing the movement sounds of enemies behind walls with differently scaled texts (Fig. 4). Furthermore, *McCloud* also introduced a concept of time in comics which is characterized by a single movement in a single panel. The identified categories range from moment-to-moment transitions that picture the blink of an eye over scene-to-scene transitions to illustrate significant distances of time like time skips to non-sequitur that offer no logical relationships between panels. For the perception of time and movement the layout and arrangement of panels is of great importance. The gap between the panels as well as the gap in time is filled by the viewer’s mind, creating an illusion of motion and time. (McCloud 2001) Basically, time in comics is perceived spatially. The gap in time between panels varies, some transitions may be shorter while others depict a bigger time leap. Besides this, different graphics, figures and panel forms thereby affect the impression of narrated time.

**NON-PHOTOREALISTIC RENDERING**

Contrary to the strong trend towards photorealism in computer-generated images, Gooch and Gooch stated that images generated by artists can provide the user with information that may not have been apparent at first glance (Gooch and Gooch, 2001), which serves as motivation for the exploration of NPR techniques. A large number of publications investigates technical ways to simulate artistic styles such as pen-and-ink, water-colouring and pencil sketches as well as cartoon styles (Lake et al. 2000, Hays and Essa 2004, Tateosian 2006, Spindler et al. 2006). Especially when rich brush texturing is applied to an image, several issues with animated or interactive content arise, specifically regarding the frame-per-frame blending of brush strokes and textures.
Techniques resembling NPR are also adapted to movies, especially for intro sequences or credits, e.g. Sherlock Holmes (Ritchie 2009). One popular effect visualizes the transition from a realistic object or person to painted representation or vice versa. In interactive media, NPR has not been used extensively so far. However, there are some examples that use artistic rendering to achieve specific effects. One example is the app Starry Night (Vrellis 2014), where the unique style of brush strokes can be controlled by touch gestures leading to a quite psychedelic effect. Another example is a quest from the role-playing game The Elder Scrolls IV: Oblivion (Bethesda 2006) in which the user enters a physical painting. In this parallel dimension everything has a painterly look (cf. Fig. 6).

On the contrary, NPR techniques are employed in the context of scientific visualization. NPR can be used to emphasize specific aspects to interpret data, support orientation or find patterns or correlations in large multi-dimensional data sets. Additionally, it also has an aesthetic aspect which aims at increasing engagement and communication of complex subjects (Tateosian 2006). Biedermann and Ju found that the absence of full details and...
textures is not of importance for the determination of a visual representation of an object (Biedermann and Ju 1988). The human visual adaptability to recognize objects based on simple line drawing can help to focus on important properties in a virtual scenery. To offer additional value, disturbing details may be omitted and the user can concentrate on the essentials. For instance, this approach is used in astronomic visualizations, the so-called false-colour images, where different shades of grey are coloured to make them more distinguishable and more appealing to the audience (Czolpinski and Babul 2005). Another example are volumetric models which use transparency and depth-based colouring to emphasize the spatial structure of the model (Xia, Zeng and Wang 2013).

Apart from colour and line, perspective plays an important role in virtual environments. Multi-perspective renderings, inspired by arts, offer new ways to perceive a virtual scene (Agarawala, Zorin and Munzner 2000). Furthermore, concepts employed in cubist art, use the fusion of multiple perspectives as narrative (Glassner 2004). Most of these concepts are applied to static images - the adaptation to interactive virtual environments remains an open research question.

3 PROTOTYPICAL IMPLEMENTATION

The intention of NPR settings in a virtual environment is to communicate effectively instead of focusing on the imaging process. Driven by human perception it rather creates illusions of reality than mimicking reality. The aforementioned works showcase the different opportunities to create innovative, unconventional (mainly visual) experiences. As part of a student project, we created two prototypes using the Oculus Rift DK2 (OculusVR 2015) to explore these effects in the context of VR.

COMIC

The comic prototype focuses on the research results regarding the stylistic elements of comic and its effect on the user (cf. section 2). The basic idea was to use isolated sketches and arrange them in form of a storyboard to create a coherent scenario. We investigated how comic elements could be implemented in a three-dimensional virtual environment to create an immersive comic experience. However, the basic concept of a comic is the two-dimensional spatial combination of panels to create a storyline. Panels are the backbone of a comic and as such they should act in the implemented showcase. Being able to shift among the individual comic panels was a main objective for the interaction concept.
Simple compounds were used for the panel transitions such as motion lines and cross-fading. Inside the panels itself simple objects are shown as a still life in 3D with simple geometric objects that offer variations and individual comic elements inspired by McCloud (McCloud 2001). Each panel is resembles a three-dimensional room filled with different comic specific elements and stylistic environments wherein the user can move around to explore the scenery. The different comic effects adopted in the prototype are explained in Table 1.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sky</td>
<td>The main ambition was to create a non-photorealistic surrounding. Hence, most texture assets are hand-drawn in order to obtain cartoon styles. As the user steps forward, a hole in the ground becomes visible represented by a black panel frame to indicate being located in a comic frame.</td>
</tr>
<tr>
<td>Winter</td>
<td>A black border is created around the viewport to illustrate the user’s fall inside the panel (cf. Fig. 7). When the user moves forward through the panels, motion lines appear. Once the user navigates backwards a fade to black effect will appear. This was incorporated to create a narrative structure to illustrate the sequential flow.</td>
</tr>
</tbody>
</table>
| Friends| In this scenery three dimensional objects are placed and rendered with Cel Shading to emphasize their comic look (cf. Fig. 7). The user has the possibility to switch between different visualization techniques of the conversation:  
  - 2D speech balloons connected with lines  
  - looping speech balloons  
  - 2D speech balloons turning to the user  
  - 2D speech balloons with a view control  
  - 3D speech balloons connected with lines |
| Desert| The user can trigger a looping 2D and control it by his view direction, highlighting the concept of spatial reading established by McCloud (McCloud 2001). When moving the head from left to right, the animation plays according to the view direction. |
| Forest| Initially, the objects are displayed as cardboard stand-ups with two-dimensional surfaces placed in a three-dimensional room. To visualize different visual effects one can switch between two-dimensional and three-dimensional objects inside this panel room displayed by a cross-fading from 2D to 3D. |

Table 1. Concepts of the different rooms in the comic prototype.
White shadow is an explorative game in which the user discovers his environment and solves puzzles in a perceptionally reduced scenario. The name was chosen to illustrate its two main concepts. Initially, the user is put into a complete white world resembling the whiteout phenomenon mentioned in section 2. All objects (walls and obstacles) are white and don’t cast shadows, resulting in an overexposed visual experience. The second aspect includes the shadow cast by the user or specific objects that represent the only available source of information about the environment. Therefore, the only possibility to navigate and explore the environment is the interaction of the shadow with the surrounding objects. Using the shadow, obstacles can be discovered, identified and avoided. Applying this method of interaction, the user navigates through his surroundings, gradually building a mental map of his environment, and tries to reach a predefined target area.

We investigated several variations of the concept by modifying the shadow and its characteristics. One concept is using the Oculus Rift as input to control the shadow (Oculus Controlled Shadow). The shadow moves according to the head movement and rotation, similar to a light source positioned near the user’s head. When leaning forwards, the shadow becomes shorter,
when leaning in the opposite direction, it becomes longer. Another concept is to control the shadow with an external input device (User Controlled Shadow), comparable to a light source behind the user which can be moved and rotated in any direction and changes the direction and length of the shadow the user is casting. In this concept, the user is able to create the shadow and modify its characteristics at any time to facilitate the perception of the environment. The third concept was to manipulate the shadow due to the user movement through the world (Environment Controlled Shadow). Shadow casting light sources are placed at different positions in the level. Length and rotation of the shadow depends on the position of the user relative to the light source. This interaction provides an intuitive interaction with the environment because the shadow cast acts in the familiar natural manner. Using environment-controlled shadow offers additional benefits. Using multiple light sources allows for play with penumbras, shadow intersections, different intensities of light sources and shadows as well as movement of light sources and shadows, e.g. a shadow cast by a swinging (and maybe rotating) lantern. This leads to several unusual effects to be discovered by the user.

White Shadow is divided into several levels, in which the user can explore different aspects of interaction. All levels have fixed boundaries to avoid the user getting lost. At the start of each level the environment is lit normally. Via a dolly shot from the finish to the starting point the user can see the route to the target area. When the camera arrives at the starting point the visual representation changes into the whiteout and the user has to find the way to the finish. Additionally, hints are hidden in-game, e.g. when the user has to find a passage through a wall on the right side of the room, a small text message is placed on the left wall saying »try right«. The user can reveal these hidden messages by interacting with his shadow (cf. Fig. 8).

The initial level contains a mace the user can explore. The main idea is, that the user has the opportunity to adapt to this unknown situation. Therefore, walking and looking around are the only possible interactions. Small hints appear when the shadow is cast onto specific objects, like small instructions or arrows to facilitate the task of finding the exit of the maze. The subsequent levels have a more sophisticated design and feature different variations of the core concept:

- obstacles to avoid (static or moving)
- small passages within a wall to find
- platforms to jump on (static, moving, need to be activated)
- objects to move in order to cross a pit
TECHNICAL CONSIDERATIONS

Both prototypes are using the Oculus Rift DK2 (OculusVR 2015) to create an immersive experience in a virtual environment. Therefore, typical interaction concepts were implemented such as view control to trigger certain actions to obtain an even more immersive effect. As of the lack of movement possibilities at the time being, a simple gamepad control was used.

Fig. 9. Implementation of white shadow. White lit environment, with contours still visible (left). Same scene from player’s view (center). Same scene with after post-process (mapping different shades of grey to black and white) (right).

The prototypes were built using the Unreal Engine 4 (UE4), a Game Engine developed by Epic Games (Epic Games 2016). UE4 can be used as rapid prototyping platform to quickly visualize concepts and for easy definition of interactive elements and events. It therefore is well suited to experiment with different ideas, especially due to visual debugging, excellent tracing capabilities and by proving a convenient interdisciplinary workflow between designers and programmers. The seamless integration of the Oculus SDK, numerous learning resources and extensibility with C++ plugins offers a wide range of tools for developing an immersive interactive environment. On the contrary, Blue- print graphs and material networks can become very complex and confusing, especially when scripting complex sequences or working with unconventional materials.

As most commercial graphics engines, the UE4 is focused on photorealistic real-time rendering. Material definitions, illumination, camera models and simulation of physics are optimized for this goal. Although modifications are possible, some of the concepts were difficult to implement. Whereas techniques like Cel Shading are quite straightforward to realize, effects such as a complete whiteout and hard shadows required some rather unconventional approaches (cf. Fig. 9). In order to realize effects like distorted, curvilinear or even multi-perspective rendering it would have been necessary to manipulate parts of the core rendering process which is simply not feasible for a student project.
In conclusion, post-processing effects are quite comfortable to develop, especially if the basic underlying concepts of computer graphics are considered. More sophisticated modifications which affect parts deeply integrated in the rendering pipeline, such as custom perspective or projection rules, are difficult to achieve.

4 DISCUSSION

The main ambition creating white shadow was to explore the opportunities for game design and interaction when manipulating specific aspects of human perception. In reaction some negative aspects were suspected: disorientation and resulting sickness, anxiety or panic. Also difficulties in adapting to the new situation: problems using the shadow as orientation or detecting and recognising the objects were expected. However, most users easily adapted to the new environment and started to explore their unknown surroundings. Also motion sickness represented only a minor problem. Providing minimal optical stimuli prevented the users from recognizing movements conflicting between the real and the virtual environment. An interesting effect can be observed, when the user misses a platform or passage and falls to the ground. Due to the complete white surrounding, the effect of falling down is simply not perceived. Motion lines could be used to solve this issue as in the first prototype. However, in White Shadow the whiteout effect is simply switched off so the user can see the world. Using a safe route, he can go back to the starting point, where the whiteout effect is activated. Using this system, the user can always return from failure and start over; the game does not contain a classical “game over”. This decision was made to underline the experimental character of the game. In terms of enhancing the core principles, persistent shadows are a viable option. When a shadow is cast on an object it could stay for a specific amount of time and fade out slowly. Using this method, the recognition of the environment can be facilitated. Also a persistent shadow represents a viable option. When the shadow hits an object, it is printed on it and will remain there. As a variation, light sources and the resulting shadows can be switched off at some points, therefore enabling different views on the environment, which have to be mentally combined by the user to navigate through the environment.

As for the comic prototype it was important to emphasize the comic-looking experience. The use of motion lines between the panels in some cases caused motion sickness since the camera was detached from the user and moved independently. Especially the observations of the interaction by head movements were promising. Controlling the flow of conversations, or in general
of sequences of actions, contains a lot of potential. It can be utilized to circumvent the traditional trigger approach in interactive media. Usually events are triggered when the user enters a specific area (e.g. stepping through the door). One drawback of this approach is that the user can miss important information if he is focusing on another aspect of the environment. Especially in VR, where the surroundings can be explored in all directions, it is sometimes difficult to guide the user’s attention in the right direction at a specific time. With this kind of time travel, the user can replay actions and events on demand. Panels and the navigation between them can be used to convey a specific perception of spatial arrangements that differ from traditional structures known from real 3D space (e.g. nesting panels, opposite or parallel frames) or to combine different layers of time or space in one visualization.

We discovered that using virtual phenomena and NPR-techniques to create scenarios in VR is a feasible way to discover alternative ways of interaction. Using disorientation, reduction of perception and 2D look-a-like rendering in a 3D environment result in unconventional interactive experiences. Providing a first person view facilitates the adaptation to the new scenario and offers the opportunity to discover new aspects of perception. Using 3rd person view, fixed cameras or dolly shots sometimes result in motion sickness, and should be used sparingly. However, in specific scenarios these techniques can offer several advantages. As NPR has been mostly applied to flat images, a number of questions arise regarding their applicability to stereoscopic imagery, especially in respect to human perception and interpretation of imagery.

5 CONCLUSION

VR offers a wide range of opportunities to create appealing, unconventional and innovative experiences. Apart from the concrete implementation, VR opens a playground for visualization and interactive arts. Traditional phenomena, like the frame of an image, relations between objects and basic image characteristics (like the horizon or verticality) disappear or can be hidden from the user. Effects on the perception and new ways to engage the user or arouse curiosity should be investigated. On the other hand, there is always a connection to the real world, no matter how deep the user is immersed in the virtual world. At least with current technology, gravitational and acceleration forces cannot adequately be simulated using VR. The interesting question is, whether an immersive presentation using as many
modalities as possible can override the perception of these conflicting stimuli. From our observations, a more or less authentic simulation of a rollercoaster induces at least some kind of imagined acceleration and gravity, showing how intensively an immersive visual representation affects other elements of perception. To further explore the deviation from existing principles, virtual phenomena and the absence of common laws of physics can be used to create unconventional experiences and realize more or less unconventional ideas: different projection parameters, abstract geometry or non-euclidian spaces can lead to new ideas using Virtual Reality. VR can combine interaction with parameters we cannot change in reality, e.g. mapping colours of the environment to the current movement speed (Kortemeyer 2013), distorting the space around the user based on his viewing direction, movement or other interaction paths, moving through the environment ignoring gravitational forces. By experimenting with the wide range of available options without relying on constraints of the real world we have the chance to explore VR from a different, naïve and maybe a little reckless point of view. A deeper investigation of unusual and unapparent aspects of Virtual Reality offers the opportunity to reveal more of the potential of this technology. VR can be used as a tool to explore the borders of our imagination—or even to go beyond.

REFERENCES


This paper is summary of our Ph.D. thesis, a work that proposes an analysis on the player-game system relationship through the perspective of an action-oriented framework. This framework is centred on the existence of actors, which are the entities through which action is enacted in the game, and in which the player and the game system are a part of. The grounding principles of this framework are seeded on a transition of action into experience, based on communicational systems that structure the dynamic formation of networks of actors from which distinct behaviours emerge, which, in their turn, promote the enactment of diverse sequences of events establishing narrative, which is a source of experience of the player.

Chronology, responsiveness, thinking and actuation, transcoding, focus, depth, and traversal are the 7 dimensions we unveiled by focusing on the relationship of the player-game system pair through the lens of this action-oriented framework, a framework that, despite seeing both as actors, is able to consider their distinct natures and roles.

We do not consider this work to be an ultimate theory of action. Above all, it is a proposal that video games can be regarded as action-based artefacts, a call to awareness for game designers that when designing for action they are working with the fundamentals on which video games are built upon.
The graphical capabilities of early video games primarily consisted of rarefied figures acutely constrained by the technical limitations of the computers of that era. Since those machines were unable to process complex graphics along with the interactive features expected from a video game, the priority was directed to gameplay (Rollings and Adams 2003, 292). Even in contemporary video games it doesn’t matter how good a given video game looks if it is not playable. Therefore, and since a game’s primary prerogative is to be playable, without action it would become passive entertainment. As Brenda Laurel states: “action is indeed the primary component of human-computer activity” (1991, 135). And that is why, according to her, *Spacewar!* (1962) — to some the first video game in history — was the natural thing to build with computers (2014).

With this in mind, the player has the ability to take part in the “central conflict of the game's narrative” (Wolf 2001, 114), acting within the game world and influencing it in the most varied ways. Therefore, contrarily to a traditional spectator, we may say that the player is an active participant. Action is then the means by which the player is able to alter game states influencing the game system (Björk and Holopainen 2005), which reacts back at the player, in a cybernetic feedback loop (Wiener 1954, 1948). And, as Jesper Juul (2001) states, “this experience is so strong that most people will involuntarily change bodily position when encountering interactivity, from the lean backward position of narratives to the lean forward position of games.” Considering the indispensability of action, Alexander Galloway states that: “Without action, games remain only in the pages of an abstract rule book” (2006, 2), meaning that games only occur when they are actually enacted.

Departing from this and taking into consideration an analysis of 1) Mark Wolf’s theory of interactivity-based genres (2001); 2) Richard Bartle’s (1996, 2004) player taxonomy in which he tackles with a distinguishable difference between *action* and *interaction*; 3) Staffan Björk and Jussi Holopainen’s (2003, 2005) implicit distinction between *action* and *actuation* in their activity-based framework for video games; 4) Galloway’s (2006) definition of *gamic action* through an action-based model in which he evidences the distinction between the actions of the *player* and of the *game system*, as well as those actions within the *diegetic* and *non-diegetic* realms, attesting that *action* and *inaction* are both important phenomena in the player-game system relationship; 5) the capabilities of *modularity* and *recursion* found in the
gameplay-based classification model of video games proposed by Julien Alvarez (2004, 2006) and Damien Djaouti et al. (2008a, b, 2007a, b); 6) the properties of emergence present in Jesse Schell’s definition of operative and resultant actions (2008, 140); 7) Ernest Adams’s view that a “player experiences a video game through its input and output devices” (2014, 255), an experience that is regulated by the user interface, which, contrarily to that in utilitarian software, is not supposed to promote the efficiency of the player’s actions but the challenges in which the game is based on (38); 8) Chris Crawford’s perspective on interactivity as a conversation, “a cyclic process in which two actors alternately listen, think, and speak” (2003, 5), evidencing a communicational structure composed by input, processing, and output, along with Eric Zimmerman and Katie Salen’s (2004) similar view on Brian Sutton-Smith’s model focused on the psychological processes by which digital games are experienced (1986), and the also concurrent perspective of Djaouti et al. (2008) on the structural parts of a video game; 9) Crawford’s position about conflict in video games (2011), along with the idea that for Marc LeBlanc “[a]ll drama originates from conflict” (2005, 444); and 10) Wolf’s perspective that the player is sometimes forced “to momentarily take on the author’s way of thinking” (2001, 4) in order to succeed in the game, which is explicitly depicted in the MDA framework (Hunicke, LeBlanc, and Zubek 2004), allowed us to find that to act in the context of video games is an activity that can be summarily characterised as follows:

To act is to engage on a cybernetic relationship with the game system; a relationship that is both dialogical (in the sense that it is focused on establishing a communicational feedback loop between the player and the system) and dialectical (because the player and the system act as opposing forces).

- To act is to actuate in order to alter or maintain game states or player states, in the sense that, in order to be realised, the actions of both the player and the game system require some kind of operation, regardless of whether they are successful or not in accomplishing their goals.
- Since, when perceived, the player’s and the game system’s actuations are interpreted as signals, to act is to emit signals, and thus to communicate.
- Because the player-game system relationship is not always based on continuous feedback, to act is also not to act.
- And because behaviours are complex actions that emerge from simpler actions, to act also means to influence behaviour.
- Overall, to act is to shape the experience of play, in the sense that it is the player’s and system’s actions that determine the course of the game.

1. “[A]s well as (possibly) through interactions with other players in the same room.” (Adams 2014, 255)
2 AN ACTION-ORIENTED FRAMEWORK

2.1 FROM ACTION TO EXPERIENCE

Based on diverse systems of ideas, the framework we propose is attentive to both the player’s and the system’s actions, following a very particular line of thought that can be summarily described as a multistage transition that goes from action to experience: from action stems communication, communication originates networking, networking creates emergence, emergence gives rise to narrative, and narrative constitutes experience.

*From action stems communication* in the sense that the relationship between the player and the game-system is based on a communicational feedback loop rooted on a cybernetic relationship “involving both organic and nonorganic actors.” (Galloway 2006, 5) These communicate through actions, that are interpreted as signals, in a similar fashion as what we find in Shannon’s (1948) and Weaver’s (1949) model for communicational systems. Hence, in this framework the player and game system emit signals directed at each other, signals that need to traverse through the environment to reach their ultimate destination.

*Communication originates networking* since actors constantly establish links with each other that are frequently interrupted as well, severed by their own will or by decision of others, constituting dynamic networks, a perspective influenced by Bruno Latour’s actor-network theory (1987, 1988, 1993, 1999, 2005, 2013), Graham Harman’s object-oriented philosophy — mainly his perspective on Latour’s work as a contribution to metaphysics (2009) —, and Ian Bogost’s *unit operations* and *tiny ontology* (2006, 2012). For example, both the player and the game system are composed of networks of other actors. Even the environment is composed of other actors.

*Networking creates emergence* because it is from the fluidity of these networks, from their ever-changing nature that behaviour emerges. And it is this behaviour that the player mainly witnesses as the rules of the game in motion. Even unanticipated behaviours on behalf of human players — such as cheating, hacking, modding, etc. —, caused by other software — viruses included —, or even by means of the hardware itself give rise to alternative behaviours.

*Emergence gives rise to narrative* in the sense that the sequence of events generated by these behaviours is what constitutes narrative. Bear in mind that we are not necessarily talking about the storyline of the game but about all the events that result from internal procedures of the game system and from the player’s interactions with it that are expressed in runtime during a game.
That is what LeBlanc calls the emergent narrative (Salen and Zimmerman 2004, 383) and what Tom Bissel names as the ludonarrative (2011).

And finally, narrative constitutes experience because it is these sequences of events that emerge from these behaviours promoted by these networks of actors—that unfold while playing the game—that constitute the action-based experience of the player. An experience that is dependent on processes, on procedures, on action, and that is not related with iconography or theme.

This perspective—grounded on action—is then able to look at the specificities of video games as ergodic media as defined by Espen Aarseth (1997). And this chain of procedures seems to be in tune with the MDA framework (Hunicke, LeBlanc, and Zubek 2004), depicting how the dynamics level links the mechanics and the aesthetics levels.

2.2 ACTORS AND METHODS OF OPERATION

Since this is an action-oriented framework, we propose it to be grounded on the existence of elements we defined as actors, and through which actions in the game are enacted. In sum, everything that is able to act in the game is considered to be an actor, whether that is the player, the game system, a playable or non-playable character, a power-up, the arrow cursor, an item, the camera, etc..

Actors act by emitting signals that may be sensed by other actors and/or by its originator. In order for a given signal to travel between the emitter and the receiver it must traverse the environment. The environment is what allows the creation of links of communication between them, but at the cost of altering the signal, a phenomena that can be classified as noise. However, since the environment is nothing more than a network of other actors that stand between the original emitter and the receiver, we may say that noise is nothing more than the effect of translation or mediation that a given signal suffers when going from one actor to another.

By further inspecting actors, we found the following traits: topology, mereology, access, milieu, I/O structure, and behaviour.

Their topology is based on a recursive structure, in which actors are constituted by networks of other actors, which in their turn are also constituted by networks of other actors, and so on. Considering this, the nature of the actions within a given actor’s micro levels may be different from the ones it enacts, but they utterly affect its behaviour, in the same way that its actions will affect the behaviour of an actor from which it is a part of.
With this in consideration and regarding their *mereology*, actors present themselves as having either an open topology — in which their components are accessible to others — or a closed topology — in which their components are inaccessible to others, appearing to them as black boxes.

We may define an actor’s connections with other actors as its social grounds, its *milieu*. This is what plays an essential role in determining its influence and function in the network.

As we have seen, actors are entities with the ability to generate, alter, convey, and exchange signals. And with that in mind, we were able to discern three separate activities that actors engage on: inspection, a moment of sensing the environment; signal processing, a moment in which the signals are processed and decisions made; and actuation, a moment focused on disturbing the environment in order to emit specific signals. Reckoning these activities, we consider actors to possess a basic *I/O structure* constituted by sensors, processing core, and actuators.

Through the course of the game, actors may assume diverse *behaviours* that can be divided into four distinct classes — drawn from Stephen Wolfram’s (2002) classes of computational procedures, although adapted to take into account the ontological diversity of actors by taking into consideration thoughts and deliberations articulated by Rudy Rucker (2005) and Miguel Carvalhais (2010) on the subject. Considering this, the actions of actors that exhibit *class 1* behaviours express a uniform, deterministic and predictable behaviour. Actors within *class 2* act according to nested patterns of behaviour, which can be perceivable depending on the time that their cycle takes to restart. The output of actors with *class 3* behaviour may present random or pseudo-random results. And actors exhibiting *class 4* behaviour are those that have a complex, sometimes unpredictable, structured but not necessarily deterministic behaviour, being able to plan various strategies to accomplish their goals. A human player is a good example.

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**Fig. 1.** A schematic representation of the I/O structure of an actor.

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4. Usually the player has to understand these patterns – sometimes by trial and error – in order to interact with them.

5. Despite that, they are usually accepted as being part of the challenge of the game.
By further inspecting the methods of operation of this framework, we encountered three distinct types: mediated, direct, and delegated operations. **Mediated operations** are those in which the signals that emanate from the player and/or the system are processed by another actor that stands between them, such as in the practice of tool-assisted speedruns. Despite the fact that every operation in this framework is considered to be mediated, **direct operations** are those where the effects of mediation (noise) are considered to be irrelevant. And lastly, a **delegated operation** occurs when an actor acts in representation of another, such as when the player delegates her role as operator of the game system to a bot, to an artificial intelligence agent, or even to another organism.

### 3 PLAYING IN 7D

From this perspective and focusing on the relationship between the player and the game system, we were able to find 7 distinct dimensions of action.

In the following sections we will focus on brief descriptions of each dimension. Hence, for a more in-depth insight we recommend reading our articles mentioned in each section, or preferably the updated versions in our thesis (Cardoso 2015).

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6. A speedrun is a play-through in which the player tries to achieve the game’s closure or particular objectives in the speediest way possible, in which some are performed with the use of tools beyond the original setup of the game. At the time of writing [http://tas-videos.org](http://tas-videos.org) is a good resource.

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**Fig. 2.** Overview of the seven dimensions, featuring all the variables.
3.1 CHRONOLOGY

By establishing a reasoning that video games are fundamentally chronological, we may classify chronology (Cardoso and Carvalhais 2012c) as a dimension that is focused on understanding variations in the sequences of events, attentive to the manipulation of objective time—the time the player takes to play—and event time—the time related with the diegesis of the game world (Juul 2004).

Preterite actions are those that are focused on past events, accessing the memory of the computational system in order to invoke stored data. Here, we have found two subtypes:

- **Replay actions** allow the player to return to a certain moment in the chronology in order to change its outcome. We find this a lot in trial-and-error based videogames, such as Lunar Lander (1973), Pac-Man (1980), Manic Miner (1983), Ghost 'n' Goblins (1985), Super Mario Bros. (1985), Contra III: The Alien Wars (1992), The Unfair Platformer (2008), Braid (2008), Super Meat Boy (2010), VVVVVV (2010), Blades of Time (2012), Donkey Kong Country: Tropical Freeze (2014), Plants vs. Zombies (2009), Angry Birds (2009), Flappy Bird (2013). We also find them in more cinematic or narrative-based games such as Life is Strange (2015).

- **Review actions** allow the player to access past events without being able to influence their outcome, useful for evaluating one's performance. The ghost ship feature in Wipeout Pulse (2007), the ghost Mii feature in Super Mario 3D World (2013), and the blood stains in Demon’s Souls (2009) are examples.

Despite all actions being enacted in the present time, present actions are those that are solely focused on the really short time span that is the immediate present time. These are usually fast actions and are often not consciously enacted. Therefore, although sometimes they are not executed taking into account one’s best interest, they are essential since conscious thought takes time. Robotron: 2084 (1982), Unreal Tournament (1999), Geometry Wars: Galaxies (2007), Bayonetta (2009), Vanquish (2010), Sonic Lost World (2013) are examples due to their fast-paced nature that promotes quick decision-making.

Preemptive actions are those that work towards the preparation for a determined foreseen situation. This an ability that not only depends on the experience and astuteness of the player but also on the predictability and determinability of the game system. The ‘zapping system’ in Resident Evil 2 (1998) that allows the player to sequentially play two complementary scenarios within
the game, and the case of the sniper ‘The End’ that can be killed at an earlier stage of the game in Metal Gear Solid 3: Snake Eater (2004) in order to bypass it later as a boss are examples.

3.2 RESPONSIVENESS

Responsiveness (Cardoso and Carvalhais 2012b, 2014a) is a dimension that looks at the fundamental input and output structure of the player and of the game system (sensors, processing core, and actuators), discerning their basic input and output states in order to draw the possible permutations between these. With that in mind, we determined four I/O states: non-responsive (N), responsive (R), generative (G) and inactive (I).

We then calculated all possible permutations between these states in systems featuring two actors (player and game system), uncovering functional and dysfunctional methods. *Functional methods* are those where at least one of the actors is receptive to the other’s output. *Dysfunctional methods* are those that are unable to establish a direct pathway of communication between both actors.
Overall, in this dimension we have asserted that variations in responsiveness promote the emergence of different play experiences, also demonstrating that dysfunction in communication plays a major role in the action-oriented nature of video games.

Here we studied the diverse nuances of the communicational system that is the relationship between actors, between the player and the game. We then confirmed that theirs is a relationship not always in constant flux, in which inaction is as valuable and important as action itself, and therefore that dysfunction is not necessarily a synonym of uselessness or error.

### 3.3 THINKING AND ACTUATION

This is a dimension that is observant of the player as an entity of biological origins and is focused on discerning diverse types of player action found between conceptualising and enacting an action (Cardoso and Carvalhais 2013a).

Trained actions are those that the player executes unconsciously, and that are learned and mastered by rote, becoming automated and choreographed. These actions are voluntarily initiated and terminated by the player, but they are not under her conscious control, as they are conditioned and depend on the training the player as undergone. Super Mario Bros. (1985), Sonic the Hedgehog (1991), Super Street Fighter II (1993), Tekken (1994), Wipeout (1995) are some of examples of games that commonly resort to styles of gameplay that require the player to make use of these actions in order to overcome their challenges.

Autonomic actions are those that are dependent on the physiological operations of the player’s body, and that occur without her direct control, will, or even consciousness. PainStation (2001), Tekken Torture Tournament (2001), Nevermind (Early Access 2015), Brainball (2001) are examples of games that resort to these kinds of actions in order to be played.

3.4 TRANSCODING

Transcoding (Cardoso and Carvalhais 2014d) is a dimension focused on the relationship between the performance of the player and of her proxy in the game world, and by considering the corresponding events in player space—the physical space where the player’s body is actually situated—and in game space—the space where the game world resides. With this in mind, we uncovered two major types of transcoding: intangible and tangible.

Intangible transcoding occurs when player space and game space are different. In this case the player needs a proxy in game space in order to act within the game world, and it’s their relationship that is relevant here. We found three distinct types of articulation between them:

• An arbitrary articulation occurs when there is no direct correlation between the actions of the player and those of her proxy. It is an articulation that is subjected to instruction—even for trivial routines—due to its arbitrariness. Jumping and firing in Super Mario Bros. (1985), the ‘fatality’ combos in Mortal Kombat (1992), or even punching and kicking in Tekken 3 (1997) are good examples here.

• A symbolic articulation occurs when there is a partial correlation between the actions of the player and those of her proxy. With this articulation their actions bear some similarity, but they are not the same, they only bear resemblance. Executing the ‘hadouken’ in Super Street Fighter II (1993), shifting between first-person and third-person side view in Metroid: Other M (2010), or executing many of the on-screen prompts in Fahrenheit (2005), Heavy Rain (2010a), Beyond: Two Souls (2013) and Asura’s Wrath (2012) are good examples here.
A *mimetic articulation* happens when the actions of the player and of her proxy are homologous. Here the proxy imitates the player’s actuations to the best of the system’s capabilities, or vice-versa. Attacking or raising the sword in *The Legend of Zelda: Skyward Sword* (2011) is an example, similar to that in *Dragon Quest Swords: The Masked Queen and the Tower of Mirrors* (2007), *Red Steel 2* (2010), *Kinect Star Wars* (2012) or even in *Wii Sports* (2006), as well as particular moments in *Heavy Rain: Move Edition* (2010) where the player has to execute very specific movements indicated by the game which are replicated to a certain degree of fidelity by her avatar.

On the other hand, *tangible transcoding* happens when player space and game space are the same, which implies that the player’s proxy is dismissed. Here we also found three subtypes:

- **Game space is smaller than player space** when the actuations related with the actions of the player only involve part of her body. *Angry Birds* (2009), *Fruit Ninja* (2010), *Fingle* (2012), *Finger Tied* (2012) are some examples since the player mainly uses her fingers directly on the game world, which is featured on a small touch-sensitive screen (the size of a tablet or smartphone, for example).

- **Game space is equivalent to player space** when the totality of the player’s body is involved in game space. *Dance Dance Revolution* (1998) or *Johann Sebastian Joust* (2010) are good examples of games where the player needs to make use of her whole body to be able to play.

- And, **game space is bigger than player space** when the player is forced to travel in order to play, something that is evident in *Coderunner* (2012) and *Ingress* (2013), games that track players’ location through Global Positioning System equipped devices.

### 3.5 Focus

*Focus* (Cardoso and Carvalhais 2014e) is concerned with the player’s attention span and how the game system challenges her by overload or deprival. We emphasize three states—*focused, defocused, and unfocused*—that are transversal to the four uncovered sub-dimensions.

*Time span* is focused on the exploration of the temporal durations that the player is granted to act, enforcing pace and speed.

• A long time span grants the player a limited time to plan her actions. *Worms* (1995) is a good example because each player turn is due in a particular amount time, as well as in *Pikmin 3* (2013). *Max Payne* (2001) even transforms the previous type of actions into these longer time span actions in what became known as ‘bullet time’, as well as *Super Mario Bros.* (1985) when the ‘hurry-up’ theme plays.

• And when a given time span is not enforced on the player she is able to relaxedly act on the game world. Exploring the world in *The Elder Scrolls V: Skyrim* (2011), in the *Grand Theft Auto* series, or in more experimental games such as *The Endless Forest* (2005) is an example. The temporal experience in most dialogues in *Mass Effect* (2007), *Fallout 3* (2008) and *Deus Ex: Human Revolution* (2011) is also an example. *Superhot* (2013) is even more interesting since in game time only advances when the player’s avatar moves.

*Frame* refers to the ‘windows’ through which the player witnesses the game world and its events. Although it is easier to describe it in visual terms, this dimension may also regard non-visual phenomena. 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, consequently hiding another.

• A single frame promotes the player’s undivided attention to it. Some of the many examples are *Pong* (1972), *Asteroids* (1979), and *Super Mario Bros.* (1985).

• Non-simultaneous frames permit the player to witness diverse parts of the game world or the same part from diverse perspectives, sequentially. Examples are found when alternating between Aiden and Jodie (two playable characters) in *Beyond: Two Souls* (2013), when using a ‘Hyoi Pear’ in *The Legend of Zelda: The Wind Waker* (2002) in order to control a seagull, or when exchanging control between teams in *Pikmin 3* (2013) or characters in *Thomas Was Alone* (2012).

• And when simultaneous frames are displayed the player is able to witness diverse events occurring on the game world at the same time, or the same events from alternative perspectives. For example, games like *The Legend of Zelda: Phantom Hourglass* (2007) for the Nintendo DS, and *Assassin’s Creed III* (2012) for the Wii U take advantage of systems that use two screens. *Fahrenheit* (2005) and *Siren: Blood Curse* (2008) frequently divide the screen in various frames, simultaneously presenting different events in the game world. *Screencheat* (2014) is a game based on screencheating, something that happens in competitive games when players peek at the opposing player’s frame, usually to determine their location. Elements
featured in the heads-up display such as maps—as the one in *Metal Gear Solid* (1998)—or the health bar in *Street Fighter* (1987) or *Tekken* (1994) are also examples.

*Sensorial scope* is related to how much of the game world the player is able to simultaneously perceive. In some video games this scope changes along the traversal, and may be controlled by the player or automatically managed by the system.

- A *narrow sensorial scope* forces the player to be attentive to her immediate surroundings, promoting quick reaction since it conditions the amount of time available between the perception of a particular event and the time that that event actually gets concretised. Horror games like *Dead Space* (2008), *Resident Evil* (1996), *Silent Hill* (1999) are excellent examples here since those usually entrap the player in small and/or dark spaces.
- A *wide sensorial scope* permits the player to perceive beyond her immediate surroundings, granting her some leeway between planning and actuating. Games like *The Sims* (2000) and *Starcraft II: Wings of Liberty* (2010) are good examples because they provide a partial overview of the game world.
- And a *total sensorial scope* allows the player to perceive the entirety of the game world. *Pong* (1972), *Asteroids* (1979), *Tetris* (1984) are a few examples.

*Actuation automation* regards the variations that occur between automation and non-automation of certain actuations when the player has to realize two or more operations simultaneously. This is the case of *Brothers: A Tale of Two Sons* (2013), in which the player simultaneously controls two characters, one with each hand with a single game controller.

- When the *actuation is automated*, the player is involved in repetitive actions, whose actuations can be trained, patterned and transformed into automated processes.
- A *mixed actuation* consists of the execution of both automated and non-automated actuations, something that is rendered possible because automated actuations can be kept going without being constantly monitored.
- *Non-automated actuations*, on the other hand, involve the player in constant improvisation and adaptation to the events in progress, requiring their attentive monitoring.

### 3.6 Depth

*Depth* (Cardoso and Carvalhais 2012a) is a dimension that is attentive to the influence of the player on the game system’s behavioural structure. Here we uncovered four player functions that describe how deep that influence is.

While developing *function 1*, the player is only concerned with interpreting the game, which is essential for the player to
understand the system’s behaviour, which, in turn, will be the fundaments for her subsequent actions. Function 1 is in constant development and is grounded on an internal processing of the signals emitted by the system, where the player interprets the network of actors. It is also developed when vicariously learning about the game world.\(^8\)

A player developing function 2 interacts with the game system within the boundaries of fixed and unmodifiable rules, without changing its underlying behavioural structure, exploring it by choosing from a predetermined list of options, exploring the network of actors. *Super Mario Bros.* (1985) or *The Last of Us* (2013) are few examples of the many games that resort to this very contained form of interaction.

A player developing function 3 is granted the possibility to reconfigure the game system’s behaviour but always within the boundaries of predeterminate parameters and values, rearranging the network of actors. It is here that questions of co-authorship start to arise, but novelty is only achievable through the reconfiguration of what already exists within the game world. The player develops this function either by reconfiguring the arrangement of the game world—such as in *Lemmings* (1991) or in *From Dust* (2011)—or by generating actors from a predetermined set of constitutive elements—such as in *Spore* (2008), in *Scribblenauts Remix* (2011) or in *Besiege* (Alpha 2015). *Super Mario Maker* (2015) is a more distinct example since the player is able to create entirely new game levels from a set of particular game elements.

A player developing function 4 is not constrained by the original set of rules, being able to expand or break them by adding new actors to the game and/or permanently removing existing ones. We believe that this is the moment where the player stops acting as a traditional player to start acting as a designer—in Hunicke’s terms (2004)—, defining initially ‘unprogrammed’ behaviours. *Hack ‘n’ Slash* (2014) is an example here, since it is a game in which the player plays by hacking the actual code in which it runs.

### 3.7 TRAVERSAL

And finally, *trastration* (Cardoso and Carvalhais 2013c, b, 2014c) is a dimension related with how the player journeys through the game, by considering diverse intertwinements between the hardcoded narrative—the narrative that is fixed and predeter- mined—and the emergent narrative—the one that is fluid and dynamic, arising from the behaviours of the player and of the game system.


In a **profiling** traversal the game system analyses the player’s behaviour, interprets the emerging patterns, and establishes courses of action. *Silent Hill 2* (2001) system for selecting the ending, the acrobatics skill system in *The Elder Scrolls IV: Oblivion* (2006), the system that dynamically adjusts the location and number of adversaries the player faces in *Left 4 Dead* (2008), or the dynamic game difficulty balancing in e.g. *Super Mario 3D World* (2013) and *Metal Gear Solid V: The Phantom Pain* (2015) are good examples here.

And an **exploiting** traversal occurs when the player resorts to errors and malfunctions present within the system, travelling through an overlooked side of the algorithm. Here examples are found in almost all games, with some errors or glitches being harnessed while in development and implemented in the final product.

### 4 ANALYSIS

After defining these dimensions, we proceeded towards establishing various methods of analysis that at the moment are constrained within a scope that encompasses core actions (the actions that emerge from the core mechanics of the game) and local actions (the actions that derive from local, particular mechanics of the game). With this in mind, we determined three different approaches, which in other words consist of the method of analysis per se, and that can be divided into descriptive, comparative, and relational—which can be focused on an inter-dimensional or on an intra-dimensional analysis.
- A *descriptive analysis* consists in listing the variables for each and all 7 dimensions, giving us a general perspective on the action-based composition of a given game.
- A *comparative analysis* is focused on comparing the different core actions, pinpointing their differences and commonalities, operating on the results of a descriptive analysis. This analysis evidences which variables are constant and transient between core actions, giving us a perspective of the field of possibilities to which the player is constrained to in the game.
- A *relational analysis* is focused on the relationships between the variables on an inter-dimensional or intra-dimensional level, also operating on the results of a descriptive analysis. An *inter-dimensional relational analysis* is focused on the relationships that exist between the variables in each dimension, which can be characterised as conflictual or as non-conflictual. An *intra-dimensional relational analysis* is focused on pinpointing eventual changes in the variables of a given dimension, therefore presenting the transiency of behaviour within the same dimension.

Considering these types of analysis, due to its focus on action, and despite the fact that it still requires further study, this model already showed us that it allows us to peek into a game’s procedural rhetoric9—something that greatly contributes the relationship between the game designer and the player.

5 LIMITATIONS

Considering some of the limitations of this work, we may say that since our primary goal was to uncover each of these dimensions, and although they were thoroughly inspected, each requires further exploration. We believe that that pursuit has the potential to result in various complementary and more in-depth research studies.

There is an interesting asymmetry in the relationships between variables within each dimension, and this also requires further study. For example, the variables in the first level of focus are not mutually exclusive, while all the variables in chronology are. The ones in the former work towards a particular combination to originate a specific state in focus, while in chronology that result is achievable by direct selection. Maybe that happens because in focus we were able to find the underlying characteristics that lead to particular states in that dimension. Perhaps we were aware—even if unconsciously—that there are too many states of focus to enumerate within the scope of this work. However, this leads us to an even more pertinent question: Can we do
the same for chronology and for all the other dimensions? And by doing that will we be able to uncover even more variables/states? And is this a good way to expand our knowledge on them?

There is much to be done regarding a study focused on the articulations between these dimensions, as well. They were scrutinised as independent phenomena, however that also didn’t left enough space and resources for a more detailed inspection on their articulation, something that we only became aware of during the final stages of our research.

Another issue is that although this framework is simple in its essence, the model needs a certain level of synthesis in order to increase the likelihood of being used. However, this fact is compensated by its versatility, as a model that allows one to focus on the whole or on the constitutive parts.

Through this framework, the complexity of the actions being analysed dictate the complexity of their own analysis. Therefore, if an action is too complex, its analysis will follow. The model seems to respond well when analysing simple games and actions by means of descriptive analysis. However, in more complex situations or to have a deeper insight, the assessment also becomes more elaborate, resorting not only to descriptive but also to comparative and relational analyses. This may eventually hamper its use.

And, a real world use of this model within the context of game design and development is yet to be done. We don’t see this as a problem to the theoretical establishment of the model itself, but a rather welcome subsequent study.

6 future work

We do not believe we have uncovered neither all dimensions nor all variables; therefore there is room for further inspection on this subject.

We also suspect that there may be larger groups embracing various dimensions—something that may be uncovered by further inspecting possible articulations between them. For example, we believe that the dimensions of focus and transcoding are more related with matters regarding the interface between the player and the system than any of the others: while the former is concerned with the output of the system and input of the player, the latter does practically the opposite. Also, focus and thinking and actuation seem to be dimensions very attentive to processes much enacted on the side of the player. So, these situations can be indicative of an organisational system yet to uncover, something that may eventually become more evident as more dimensions are unveiled.
A study on the conceptual proximity and farness between variables in disparate dimensions now seems necessary in order to pinpoint eventual redundancies and levels of compatibility between dimensions. Understanding whether diverse dimensions operate in common grounds or not is something that may help us comprehend if a particular action is seeded on an internal conflict or not—something that is particularly important in the relational analysis we proposed.

Furthermore, this is also a study we consider to be moving towards an understanding of aesthetics, since that conflict will be deeply experienced by the player. This is something that was expected and that we see as a natural and progressive development of this work.

In the same way, a study focused on how the articulations between these dimensions may lead the player towards distinct emotional states also seems relevant now. Therefore designing for emotion is also one of the natural courses for future developments, a complex endeavour that we believe should not be undertaken before a reasonable understanding of the matters mentioned in the previous point.

On another subject, a statistical analysis on the player-system relationship through the course of time and across diverse genres may pinpoint how that relationship evolved, as well as what shapes it may assume in the future.

And finally, focusing on a more practice-based research we intend to use this model to study the video game player as musical performer. Here, we not only intend to explore the diverse behaviours promoted by distinct combinations of the dimensions in this framework but also to see what kinds of games and musical expressions emerge, in hopes of contributing to further widen the notions of musical performance and, most of all, to expand the gameplay of musical video games. This is a study that not only directs its focus towards performances, concerts, and installations but also in the direction of applied research on the design and development of innovative video games and musical instruments.¹⁰

₁⁰ We also published an article that is focused on these matters — see (Cardoso and Carvalhais 2014b).

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The first computer games were mainly multiplayer games, and people were coming together to play them. Although the concept of the multiplayer games shifted towards online multiplayer games, which allows people to play from different locations around the globe, recently the collocated multiplayer games are regaining attention. This paper offers an analysis of collocated multiplayer video games, by discussing cases that introduced original interaction modalities. The social relations created within these interaction ecologies have a fundamental role in the history of computer games. To understand how these social relations are conditioned by design choices, five factors have been determined: players’ population, characters’ relationships, control, controllers and screens. These factors constitute a framework that which enables designers and researchers to analyse video games from the perspective of collocated gaming.
1 INTRODUCTION

1.1 EARLY HISTORY

During the early history of video games, games such as *Tennis for Two* (1958), *Spacewar!* (1962), *Pong* (1972), and its follower, *Elimination* (1974) explored different multiplayer modes. These arcade and experimental games served as a base to create and show the great potential for social interactions in the area of computed gaming. For example, Higinbotham created *Tennis for Two* in order to give hands-on experience of one of the technologies available in the Brookhaven National Laboratory in Upton. Students, who were among the most common visitors, appreciated the idea to the point that “You couldn't pull them away from it.” (Anderson 1984). The game was obviously very simple but much more dynamic than the rest of the exhibition, and naturally “Everybody stood in line to play.” (Lovece 1983:40). Creating a two player game, instead of programming an artificial intelligence to play with, was certainly an easier task, but at the same time, this mode was allowing multiple visitors to play simultaneously and interact with each other, leaving space for the rest of the non-players to stand and participate as an audience.

1.2 A SINGULAR EVOLUTION

During the golden era, video games started to grow in complexity, and having the computer as a counterpart became the norm. When game consoles started reaching the houses of players the standard number of players was set to two with some exceptions which were allowing four players either naturally or with the addition of special devices (commonly defined multi-tap). With the advent of Internet, the single players mode was emphasized to the point that “[d]espite the basis of playing, computer games are mostly played alone at the computer or players participate in online multiplayer gaming” (Strömberg et al. 2002:56). The idea of video game players as lone individuals became part of the social imaginary and defined as geeks and nerds. This shift towards online and non-physical communities (Voida and Greenberg 2009) is not exclusive to video games but to a wider area of social relations. Since the start of the social network era, many critiques have developed even from academics and professionals who traditionally promoted the use of innovative technologies, as Sherry Turkle did in her *Alone Together* (2012). Some researchers in game studies share the opinion of Turkle and highlight how the predominant presence of single-player games seems an anomaly:
The emphasis in the last few decades on single-player computer and video games is something of an anomaly in the eons-old history of gaming. While there are notable exceptions, such as solitaire card games, by and large over the centuries games have been valued as social experiences, as a way for people to relate to each other, as a way for people to play together. The fact that digital games are swinging back to favoring multiplayer experiences is not a new trend by any means: it is merely games returning to their roots as social play (Salen and Zimmerman 2004:462).

Of the same opinion Zagal et al. think that “a curious dichotomy exists in the nature of electronic games: the vast majority of electronic games are individual in nature whereas the non-electronic ones are collective by nature.” (2010:448). A comparison with board games is used by Costikyan to explain why “online games suck”:

Long, long ago, in the depths of prehistory—that is, before Pong—games were a social activity. People got together to play Bridge or Poker or Monopoly or Dungeons & Dragons to chat and socialize and have a fun activity to do together. Even head-to-head games that require concentration and discourage table talk—like Chess or board wargames—were social, because you’d invite a friend to play with you, and the game was an excuse to get together. (Costikyan 1998)

1.3 COLLOCATED MULTIPLAYER GAMING

The case of video games seems to be, among all the activities that people share, exemplar because playing is often an obvious reason for people to get together. For this reason, in contrast with the individualistic trend emphasized above, this investigation takes exclusively into account the so called non-network multiplayer games, or better, collocated multiplayer games. These will be observed through the lens of five factors: players’ population, characters’ relationships, control, controllers and the screens. The five factors are gathered from the literature and developed through observation. If we observe Tennis for Two through these factors, we can discover an interaction ecology of devices and humans, where a single shared-screen with multiple input controllers (1) makes two players to compete in rapid (almost simultaneous) turns and (2) defines an audience of non-players which transform gamers into performers themselves. The population involved in the game is composed by two players plus the audience. The characters relationships are competitive since
the players play directly against each other. The players’ actions define a semi-real-time gameplay where both players can technically move simultaneously but their action is effective only in the presence of the ball. The two players have an independent controller. The game is visualized on a single screen where both of the characters are visible in a single frame without any separation other than the virtual net.

2 RELATED WORK

2.1 INTERACTION ECOLOGIES

Taking this initial observation into account, the interest here is to understand the social interactions emerging through five factors of the ecology defined by a video game. Analysing an interaction ecology is an operation of mapping all the relations among the individuals (both human and computational) involved in an environment (Savasta 2015). In general terms, we can say that ecology should not be read exclusively as related to the nature-environment movement but in a wider perspective:

Ecology in my sense questions the whole of subjectivity and capitalistic power formations, whose sweeping progress cannot be guaranteed to continue as it has for the past decade. (Guattari 2000:35)

Or as Bogost puts it from a media perspective:

Following the lead of media ecologists like McLuhan and Postman, media microecology seeks to reveal the impact of a medium’s properties on society. But it does so through a more specialized, focused attention to a single medium, digging deep into one dark, unexplored corner of a media ecosystem, like an ecologist digs deep into the natural one. (Bogost 2011:7)

The five factors observed in the interaction ecology of collocated multiplayer games are what Bogost defines as the medium’s properties. Observing the ecology, in this context, means to map the reciprocal actions of devices and people in the space of the game, and how these actions are allowed or limited structurally. Instead of focusing on the single game or the relation between an individual and a game we will analyse only cases of multiplayer games in which at least two players are involved.

2.2 SOCIAL RELATION MODELS

To understand the limits of this ecology, which is the space of the game, we must introduce the concept of interaction membrane or the magic circle as it has been described by Salen and Zimmerman (2004) and before by Huizinga (1949). The magic circle has already been compared by Montola (2009) to the interaction
membrane described by Goffman (1961). The space of the game is separated from the outside by the rules, acting as a membrane, keeps a degree of permeability. The interactions around the game membrane are divided into two levels by Salen and Zimmerman (2004) as within and outside the game membrane. The interactions within the game membrane are developed internally or rather inside the game which means that they are related to the rules of the game. The interactions outside are developed externally and include the relationships between people independently from the game itself. These characterizations reflect the posture of individuals toward each other in relation to the game. A similar classification is given by the earlier work of Zagal et al. (2000) in which they define two types of interactions: natural and stimulated. The stimulated interaction is what is necessary for the game to happen, the rules of the game define the need for a direct interaction. So, the stimulated interaction can be compared to the interaction within the game of Salen and Zimmerman (2004). The natural interaction is a spontaneous act parallel and independent from the game development, a chatting over the game. A specific analysis of the interactions independent from the game, seen through an activity theory perspective is offered by Ang et al. (2010). Two themes on extrinsic play are defined: “Around the game (discussion on and exchange of game experience)” and “[b]eyond the game (use of the game to play in a different way) and breaking the game (modification of the game)”. Ultimately, Zagal et al. define a case of multiplayer game without interaction and describes it as a case “in which artificial intelligence could replace the human opponent without the human noticing any difference.” (2000). Online games generally limit or deny outside interactions delegating the role of chat and discussion to specific external platforms (as thematic forums) which are used asynchronously, that is before or after the gameplay.

The aesthetic framework built by Hunicke et al. explores games through eight different elements of a taxonomy among which she describes the fellowship (2004). Fellowship as social framework in games is intended as a way of creating constrictions that force a collaborative approach. For example, by increasing the complexity of a task the help of a partner is required to reach a solution. This way of stimulating social interaction can be associated, due to the constrictions, to the within interaction of Salen as well as the stimulated type of Zagal.

In their work of games’ classification, Elverdam and Aarseth present a wide spectrum of factors (2007). Two of these factors are of particular interest here: player composition and player relation. The player composition describes how the players are organized in the game (single player, single team, two player, two
The player relation describes two dimensions: bond (dynamic, static) and evaluation (individual, team, both). Bond defines the relation between the players. This relation though can be static, in the case of a stable relation, or it can be dynamic, when it changes during the game. Evaluation defines how the performance of the players are measured. This dimension specifies the score system of the game: whether each character gains points for himself independently, or the points are gained by the team as one entity, or if the system calculates a combination of the two with points gained individually and by the team.

Stenros et al. (2009), using a similar scale as Elverdam and Aarseth (2007), structure a gradient of sociability in games as single player, two players, multiplayer, and massive multiplayer. This gradient of sociability includes very different elements such as: the possibility of creating gameplays as performances in which an audience is involved; or the possibility of recording a gameplay to create demos for publication or the construction of paratexts (e.g. machinima); the shared scoreboard which defines a competitive level among different players; and the shared gaming capital built by the cheat codes and the online support. All of these elements affect the sociability of the player even in single-mode games.

Stenros et al. divide the two players’ mode into collocated and remote. The collocated game can unfold as simultaneous play, hot-seat game or turn based, and sequential; networked as in the case of LAN parties and parallel in the case of different games played in the same location. In a remote game, the player can join the game on the same server building direct (through characters) and indirect interaction (through the world), back channel (messaging, voice chat) and voice over (in-game or with specific software). Non-simultaneous and remote separated gaming are two more rare cases in video games.

The case of more than two players is treated by Stenros et al. focusing on players/character’s relations. The gameplay can emerge as competitive (multilateral and unilateral), collaborative or cooperative, and can present a communication asymmetry (in the case of multiple collocated players with others remote players, or, as in the case of communication, through separate channels) and teaming up. With regard to massive multiplayer games, Stenros et al. investigate the phenomena of co-presence (the feel of playing and being together) the various degree of playing community (friends, micro, macro) and the neutral relationship (the other players become non-playing characters or audience). The brief review above creates the opportunity and the foundation for further investigation.
3 AN INTERACTION ECOLOGY PROPOSAL

Each of the frameworks and models presented analyses the interaction membrane defining different factors due to the specific focus and perspective of the authors. The framework proposed here tries to synthetize the factors found in the previous studies and, by adding an original contribution, covers the overall interaction membrane. In order to shape a more inclusive overall system we collected different perspectives under a single framework, and in doing so we consciously lost some depth over the single factors. What is left out is a set of parameters for the single player and the remote massive multiplayer since our declared focus is the collocated multiplayer game. Paratexts and increased sociability are also disregarded. What are included as factors are 1) the design of the interface—including the screen structure—and 2) the controllers offered to the player, since both of the elements can influence the social game and are not well investigated in the literature.

The factors proposed in the framework are: players’ population, characters’ relationships, control, controllers and screens. The selection of factors is made in an attempt to combine different frameworks without creating overlapping parameters. The chosen case studies offer an exemplification of various configurations of the framework which combine different factors (e.g. a competitive character relation with two or four players, different type and numbers of controllers independent from the number of players). An example that well explains how these factors can vary independently is given by Bogost:

In some asynchronous games, one player immediately follows another, in others a duration of time elapses between players.

Play might take place on the same computer, console, or device, or it might take place on separate devices. (Bogost 2004:2)

The factors chosen are for these reasons independent and offer a wide variety of elements that are peculiar to the case studies examined, and a non-hierarchical organization of them allows us to combine them without creating confusion.

3.1 PLAYERS’ POPULATION

The players’ population is an ordinal value describing the number of players involved in the game. This element alone ensures neither increased social gaming nor clarifies the relations that are established among them. “Just because a game is played by many people does not mean that social fun will emerge” (Stenros et al. 2009:86). It’s also important to note that especially in the
case of collocation the presence of an audience is very common. This presence of non-players influences the gameplay and the social game. As noted at the beginning, the number of players is generally increasing to the power of two (two, four, eight and sixteen). A greater number than sixteen is verified almost exclusively in online games known as Massive Multiplayers Online Games (MMOGs).

### 3.2 Characters’ Relationships

In literature, the relation between the players in the game are observed from different perspectives. What I believe is preferable is to talk about the relationships among characters or, it could be said, among the roles of the characters. In this respect I define five different modalities: cooperative, collaborative, subordinate, conjugate and competitive. Although these relationships are not always static in the game, in general it is possible to define how the behaviour suggested by the gameplay itself pushes the characters towards one or other posture. As Rogers vehemently highlights, it is possible to define a posture suggested by the game even if the players can blur the differences “[a]fter playing Gauntlet with my stupid friends, I realized even a cooperative game can easily dissolve into a competitive one.” (Rogers 2004:381).

**Cooperative** is the modality in which characters fight with a common aim and are rewarded equally or in interdependence with the others player characters. In the *Bubble Bobble* (1986) series the two dragon characters help each other. As in the similar *Snow Bros* (1990), in order to win the game, the characters have to climb up a series of platforms by killing the enemies in front of them. An interesting example of a cooperative relationship with different roles is *Wakeboarding Unleashed* (2003) where one player drives the boat and the other controls the rider. The cooperation of the characters is essential to win the game. An extreme case of collaboration can be identified in *We Love Kata-mari* (2005) where players control only half of the character imposing strict cooperation.

**Collaborative.** The collaborative modality is structured in such a way that the players temporarily combine their actions, sharing a common goal, but they still individually fight for the final aim in the game. This modality can be considered as a competitive mode with occasional associations. As Stenros *et al.* (2009) suggests, an example is *Counter Strike* (2000) which is a cooperative game where characters cannot harm each other, but in which the attitude of players can transform into competitive.
Similarly, in *LittleBigPlanet* (2008) players can freely play with decorative stickers gluing them on any possible surface, including the other characters. Brought to the extremes, if the players choose a character as a target, they can—by sticking on him large amounts of decorations—prevent him from seeing where he goes.

**Subordinate.** In some games the characters have different roles and an established hierarchy among themselves. One character can have the role of the leader and the other fellows’ characters act as helpers. In *Super Mario Galaxy* (2007), for example, the first player controls Mario while the second controls a star which performs special moves and attacks. Similar cases in which support characters help the protagonists are *DeathSpank* (2010) featuring DeathSpank and Sparkles the Wizard, or *Child of Light* (2014) with Aurora and her little firefly Igniculus.

**Conjugate** is a modality in which the players aim at different goals in the same gameplay. The agenda and motivations here are separate (Rogers 2004). At this stage of the research we could not encounter any examples applying this modality in collocated games, but the conjugate relationship is used commonly in massive multiplayer online games as for example in *World of Warcraft* (2004). It is probably understandable why this modality can be at least unpopular in collocated games considering that if the goals of the players are completely different and the actions totally independent even if the part of the same gameplay it may feel like the characters belong to different gameplays.

**Competitive** is the modality in which the characters face each other. The defeat of one character means the victory of the other, or, in a more general case, in order to win, a character has to defeat all the others. This mode applies to most of fighting games from *Heavyweight Champ* (1978) to *Street Fighter* (1987), to the epic, up to eight simultaneous fighters, *Super Smash Bros* (1999).

**Team competitive** is a modality in which teams try to defeat other teams. It’s a mix of cooperation and competition in which the posture changes regarding the relational roles among characters (cooperate if team members or compete if members of opposing teams). The great classic double match of tennis is an example applied electronically in *Wii Sports Tennis* (2006). A more peculiar example is *Tetris Ultimate* (2014), a recent edition of the classic game featuring different multiplayers’ modalities among which is the team competitive. In this mode the game is divided into two fields, one per team, and each of these fields is divided again in three columns, two columns are accessible exclusively by one of the players and a smaller column in the middle is shared among the partners-players. This mode forces the players to keep a mix of competition and cooperation in pairs.
3.3 Control

How do players act in the gameplay? Are their actions free at any time? Can they act only at specific moments? These are the questions that the gameplay control factor tries to answer. Control is a time related factor different from the *temporal frame* defined in Zagal and Mateas (2007) which regards explicitly the role of time within and outside the game, or from the *time span* studied in relation to the players’ attention by Cardoso and Carvalhais (2014).

**Alternate Turns.** The turn is alternate when a player has no control of his character while the other player is acting on her own. The time defines when a player can act, giving in some case control over marginal aspects of the game which do not lead to the win of the game itself, for example changing the position of the camera. *Worms* (1995) is a typical example of turn based games.

**Semi-Simultaneous.** An action is semi-simultaneous if a player can act on his character but his actions are irrelevant or preparatory. *Pong* can be included in this category because the action taken by a paddle while the ball is in the other half of the field are relevant only during the receiving phase. A game like *Neon Battle* (2015), being a remix of *Pong*, adds a more simultaneous interaction by transforming the field into a circular one, in which the paddles can also touch each other.

**Simultaneous.** The action is simultaneous if the players can always control their characters acting directly in the gameplay. Among the titles already mentioned that fit this mode are: *Super Mario Galaxy*, *Wii Sports Tennis*, *LittleBigPlanet*, *Bubble Bobble* and many others. This is somehow the favourite modality for designers which prefer all the players to act and be part of the game at the same time. It seems when possible an obvious choice for a greater involvement of the players into the game although the other modalities can guide towards valid alternatives.

3.4 Controllers

The device which allows input to the game is crucial to define the relations among players and characters. It is somehow connected to the control factor and it can influence it.

**Independent.** The controller can be independent: namely each of the players has his own controller to interact with his own character. In most of the cases each player holds their own controller as in *Pong*, *Metal Slug* (1996) or *Super Smash Bros."

**Provisional.** In other cases, the controller can be just one. The players need to pass it around while playing. Therefore the device is provisional. In *Worms* the players use, or can use, the same controller for their own turn to apply the strategies for vic-
Another way of applying provisional controllers is established by the players independently from the modes offered in the game. In order to reach the end of long games players can decide to play in alternating turns. Especially in the cases without possibility of saving as for example Flink (1994), Super Mario Bros 3 (1988) and Fatal Labyrinth (1990) this practice becomes a useful resource. Another possibility is that of impersonating every character in the game instead of just the teams in the baseball of the Wii Sports (2006) transforming a two players’ mode into a two teams match. In these cases many modalities (one life per player or one level per player) can be informally established by the players transforming even single player games into multiplayer experiences.

Shared. The controllers can also be organized so that multiple players can act simultaneously on the same device. This modality is again often generated by the players more so than planned by the designers. In the case of Street Fighter (or any other fighting game) a player can move while the other is kicking and punching using the same controller. One example of a designed shared controller is Collabolla (2004) a Pac-man (1980) edition played with fitness balls. The fitness ball is used for hitting the ground in different locations corresponding to forward and backward for one player and left and right for the other. This original controller can be seen as a scaled up version of the dance platforms used with PlayStation or arcade games.

Divided. In games such as Super Mario Galaxy or We Love Katamari the players control the same characters with multiple controllers. In Super Mario Galaxy the second player, the star, can make Mario jump or increase his jumping ability by coordinating the movement with the other player. In the cooperative mode of We Love Katamari the division of the control is more symmetrical allowing each player to control half of the character.

3.5 SCREENS

The spatial organization of the output is the physical property which conditions the players to focus on a certain space of vision.

Single screen means that a single display shows a single frame in which all the characters act together. It can happen that some active characters leave the screen during the game but in this case all the players lose sight of the character, including the player who is controlling it. This happens in games such as Mortal Kombat (1992) where one character can disappear and reappear on the screen or Battletoads (1991) and Micro Machines 2: Turbo Tournament (1994) in which leaving the screen means losing a life or all the game. In many other cases characters are all just forced to stay in the same screen as in roleplaying games such

**Split.** The split screen is a classic solution offered to give freedom of exploration to all the characters using a single physical display. The display is thus framed in multiple divisions generally dedicating one area per player. Size and resolution of the screen are two technical problems that can emerge influencing the gameplay. Dividing the screen to provide multiple cameras is a classic modality of racing games, among them, *Mario Kart 64* (1996) that divides the display into four screens for a four multiplayer mode.

**Multiple** screens is the case in which the game is distributed on different separate displays. This is a modality that can solve the problems of the previous mode, and can also offer an enhanced mobility in the case of displays on mobile devices. Sanneblad and Holmquist (2004) describe *shared displays* referring to contents which are distributed among multiple devices. I believe the term *multiple* better fits the definition in this context, and does not create conflict with the other properties defined here (a single screen among players is in fact shared). In many Gameboy multiplayer games, such as *Gauntlet II* (1991), it is possible to connect multiple devices to play together on separate displays.

### 3.6 FRAMEWORK

In conclusion it is possible to suggest a possible framework for an ecological analysis in collocated multiplayer video games. This diagram (Fig. 1) gives an overview of the five factors and their modalities, and acts as a summary and a guide for further studies.

---

**Fig. 1.** Framework for an ecological analysis of social relation in collocated video games.
defined by the factors. The list presented is non-exhaustive but serves as a guide for the analysis and application of the framework. In the case of single player games I omitted the characters' relationships factor since there are no multiple characters controlled by players.

Table 1. Table of applied ecological analysis of social relation in collocated video games.
4 CONCLUSIONS AND FUTURE STUDIES

This research introduced five dimensions for the ecological analysis of collocated multi-player video games. The five factors defined (players’ population, characters relationships, control, controllers and screens) are gathered from previous literature and observation. The attempt is to clarify the ecological context of game and gameplay in the physical space. In order to experiment and start understanding these potentialities a design application is presented as a conclusion of the study. The aim of this final output is to challenge the described factors and build a base for future discussions and studies.

Following the idea of speculative design as a way “to debate potential ethical, cultural, social, and political implications” (Dunne and Raby 2013:47) an extension of the research conducted is shaped as a design proposal. The output of the research is thus shaped in the form of a video game, an experimental variation of Atari Pong. WiPong is an extended multiplayer version of Pong with a virtually infinite number of players, competing semi-simultaneously through their own controllers on multiple screens. The idea of extended multiplaying applied to local gaming is in clear contrast with the MMOGs trend. The game field, as in the classic game, is divided in two parts one for each paddle-player; in WiPong each player can see only his own half of the field increasing the difficulty of the game (the player is not able to see where the ball comes from before it enters its field). The players compete with each other in a limited physical space.

<table>
<thead>
<tr>
<th>Year</th>
<th>Game</th>
<th>Players</th>
<th>Mode</th>
<th>Simultaneous</th>
<th>Independent</th>
<th>Screen Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>Spacewar!</td>
<td>2</td>
<td>competitive</td>
<td>simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>1987</td>
<td>Street Fighter</td>
<td>2</td>
<td>competitive</td>
<td>simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>1988</td>
<td>Super Mario Bros 3</td>
<td>2</td>
<td>collaborative</td>
<td>simultaneous / alternate turns</td>
<td>independent/ provisional</td>
<td>single</td>
</tr>
<tr>
<td>2007</td>
<td>Super Mario Galaxy</td>
<td>2</td>
<td>subordinate</td>
<td>simultaneous</td>
<td>independent/ shared</td>
<td>single</td>
</tr>
<tr>
<td>1999</td>
<td>Super Smash Bros</td>
<td>8</td>
<td>competitive</td>
<td>simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>1958</td>
<td>Tennis for two</td>
<td>2</td>
<td>competitive</td>
<td>semi-simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>2014</td>
<td>Tetris Ultimate</td>
<td>10</td>
<td>team competitive</td>
<td>simultaneous</td>
<td>independent</td>
<td>split</td>
</tr>
<tr>
<td>2005</td>
<td>Wakeboarding Unleashed</td>
<td>2</td>
<td>cooperative</td>
<td>simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>2005</td>
<td>We Love Katamari</td>
<td>2</td>
<td>collaborative/com-petitive</td>
<td>simultaneous</td>
<td>independent/ shared</td>
<td>split</td>
</tr>
<tr>
<td>2006</td>
<td>Wii Sports/Tennis</td>
<td>4</td>
<td>team competitive</td>
<td>simultaneous</td>
<td>independent</td>
<td>single</td>
</tr>
<tr>
<td>2004</td>
<td>World of Warcraft</td>
<td>N</td>
<td>conjugate</td>
<td>simultaneous</td>
<td>independent</td>
<td>multiple</td>
</tr>
<tr>
<td>1995</td>
<td>Worms</td>
<td>2</td>
<td>competitive</td>
<td>alternate turns</td>
<td>provisional</td>
<td>single</td>
</tr>
</tbody>
</table>
defined by the virtual walls of WiFi a limitation imposed by the system which becomes a feature of the game. The project challenges the maximum population of players and the simultaneity of the game, applying the contemporary technique of the bring-your-own-device.

This study can be followed by tests and observation of the different social patterns emerging from the combination of the different factors. A study using the same games analysed empirically here or with further specifically developed games such as WiPong can reveal more aspects and define effects on social behaviour. “If the social history of video games can teach us anything, it is that humans will use games to connect with each other” (Williams 2005:18). As designers and researchers we need to understand how to better drive the potentiality of contemporary tools to improve this hunt for the old fashioned sociality of physical spaces.

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This paper focuses on human performance and its role in the enactment of algorithmic artworks, considering the human body as a medium for artistic creation. It defines procedurality as a core concept in relation to performative practices, while establishing analogies between human and artificial systems. To this end, it discusses performativity as a concept, addressing different understandings of the term, from human performance to the performativity of code and, finally, the interactive performativity of both human and technological systems. It then addresses artistic practices that simulate human performative strategies through computational means, and considers artworks that reverse this logic, by translating computational processes into the physical realm through the human execution of algorithms, and finally, combining the interplay between human and technological systems. Considering these approaches, this study aims to emphasize how procedurality is tied to both human and computational performativity, while also highlighting the human-computer interactive feedback-loop as the performance of the work.
1 INTRODUCTION

This study considers procedurality as a core concept within artistic performative practices, addressing the role and meaning of the human performer in the enactment of algorithmic artworks. As the ability to execute rules, resulting from the description of processes into formal instructions (such as algorithms), procedurality can conceptually encompass both computers and humans as the entities that perform those rules. In the arts, this notion was imported from music (as one of its inherent qualities), being conceptualized and reconceptualized within a broader scope of performative practices that entail procedures as instructions for action. The notion took shape in computational terms as new media artists started to think in terms of both human and code’s performativity and their combined role in the enactment of the artwork.

In order to contextualize this shift, we present an overview of the notion of performativity, as a concept and practice. We discuss the term under the perspective of artistic practices that imply human performativity (as in performance art) and computational practices involving the performativity of code, as well as performativity applied to the interaction between human and technological systems. Following Salter’s (2010, 21) view on “performance as practice, method, and worldview”, we discuss examples that illustrate the human performer’s role in the enactment of the work, and artworks that simulate human performative strategies through computational means, as well as works that reverse this logic, by translating computational processes into the physical realm through their human execution. Finally, we discuss practices “that operate on, shape, and transform the world in real time” (Salter 2010, 33) by developing a human-computer feedback-loop as a form of interactive performativity.

2 OVERVIEW

2.1 PROCEDURALITY

Janet Murray (1997) defines Procedurality as the computer’s “defining ability to execute a series of rules”, or the ability to perform formalized abstract processes, to which we call algorithms. As formal procedures or methods, algorithms can be considered independently from both the programming languages and the machines that execute them (Goffey 2008, 15-16). Therefore, to consider procedurality as a concept extensible to both human and computational systems entails an abstract understanding
of code, as “real abstraction” or “absolute code”, which allows us “to consider the general properties shared between different code forms”, and thus to think in terms of “both the grammar of code itself” and the programmer's algorithmic/computational thinking (Berry 2011, 33).

In line with this view, Cramer argues that “software code is a conceptual notation”, however, often neglected as an artistic argument due to a “privileging of aisthesis (perception) over poiesis (construction)” that contributes to “a restrained concept of art as only that which is tactile, audible and visible” (Cramer 2002). So, what the term procedurality seeks to emphasize is a focus on “the processes themselves”, rather than simply their outputs (Wardrip-Fruin 2006). In this sense, it refers to the creation of “meaning through the interaction of algorithms” (Bogost 2008). Procedural authorship then means writing the rules that model the way things behave, or defining “the conditions under which things will happen in response to the participant’s actions” (Murray 1997, 152). Hence, to think procedurally is to think in terms of the system’s “expressive processes”, which entails “the structural design or composition of the procedures” that generate variable outcomes (Wardrip-Fruin 2006, 1). In sum, it means to think of software and its creative potential on a generative and interactive level.

2.2 PROCEDURALITY IN THE ARTS

The concept of procedurality is not exclusive to computation, and we can discuss this idea by considering works that make use of notation as a script for action. The concept of notation was brought to the fore in art through music, which gradually became “the model for all performance art” as artists started to explore the gaps between this and other art forms as new fields of practice (Shaw-Miller 2009). For example, Fluxus artists considered “the broader framework in which music signifies” by exploring its procedural and performative nature as guidelines for artistic actions, whose sensory results are seen as the by-products of action. So, we can say that the procedural nature of music was brought to attention by the Fluxus aesthetics as they reinterpreted the concept of the score as a type of notation for action, developed a priori, as “the agent that engages the reader-performer in the theatre of the act” (Shaw-Miller 2009).

As the “silent partner” of music, visual notation is used as “an expedient for catching an inspiration with the purpose of exploiting it later”, being the role of the performer “to resolve the rigidity of the signs into the primitive emotion” (Busoni 1911, 15-16).
Accordingly, Fluxus pieces “almost always provide instructions for setting up a situation”, demonstrating how the “score (...) is not simply a transparent vehicle of description but an acquired and culturally mediated system” for art making (Shaw-Miller 2009).

2.3 NOTATION AND EXECUTION

The score can either give “exact instructions with regard to both its reception and its use” or allow the “realization of a work-idea according to the discretion of each performer” (Schroeder 2010). All scores condition execution depending on how closed or open they are to interpretation, whether developed a priori, intending to “facilitate the performability or (re)production of a work”, or a posteriori, enabling the work’s analytical perception and having its “own aesthetic value as a visual art” (Schroeder 2010). Given that these works make use of notation as a script for action, they can be considered analogous to the use of code for computation, if we conceive of them as algorithms that “meet the requirement of being executable by a human being as well as by a machine” (Cramer 2002). The use of scores for action therefore stresses procedurality as an inherent quality of performance, supporting an analogy between these forms of notation for human execution (as performance) and software code, where notation and execution “fall into one piece of instruction code” (Cramer 2003).

Following the idea of a script for action as the “act of realization, of execution, which is itself the very momentum of the aesthetic experience”, the notion of execution conflates with the notion of performance, which emphasizes the “live dimension” of an execution (Broeckmann 2005). In line with this broader understanding of performativity, and as Frieling (2003) explains, contemporary art practices are returning to, and investigating, the “beginnings of process-based art made with and in the media”, while evoking questions explored by “twentieth-century avant-garde currents on the relationship between happening, action art and performance”.

3 PERFORMATIVITY AS A CONCEPT

According to Chris Salter, “everything has become performative”, and “performance as practice, method and worldview is becoming one of the major paradigms of the twenty-first century”, even if the terms “performativity” and “performance”, lack conceptual clarity due to their different uses and approaches in distinct disciplines (2010, 21-23).
Despite its different connotations, the concept of performance “articulates a common thread: that humans, things, and matter are not fixed but always in a process of change and becoming” (Salter 2010, 30). The author then underlines “certain characteristics of performance that distinguish it from other forms of knowledge making”, of which we can foreground the focus on the “enaction” of “real-time dynamic processes” and “the effect of both human and nonhuman presence” (Salter 2010, 23); the latter “invoking a space that refuses to make a demarcation between inanimate technology and human interpreter” that is characteristic of new media interactive art (Salter 2010, 32).

Following this view, we now discuss different understandings of performativity: as developed in the arts (concerning human performance), as a method or way of doing something according to an orderly, logical, systematic plan (evoking the performativity of code) and, finally, as a performance that articulates both human and technological systems (as an interactive performativity).

### 3.1 HUMAN PERFORMANCE

In the artistic context, the term *performance* is commonly understood as describing “actions, happenings, and time-based events emerging out of the visual arts during the 1950s through the 1980s” (Salter 2010, 23-24). Contemplating the “live event” as a form of expression for “auratic uniqueness” (Frieling 1997), these practices “aimed above all to distance themselves both from the static objects of the visual arts and the dramatic, text-based theatre of the stage” (Salter 2010, 24). Using the body as a medium for artistic creation, they aimed to “explore alternative models and ways of seeing, establishing an emotional and mental framework that integrated the performer and the audience via direct appeal to the senses”, bringing together art and life “in an ‘intermedia’ relationship” (Frieling 1997).

Performance became a way of making art, while embodying the “corporeal presence and materiality” of the human body in the process of art making (Frieling 1997). According to Salt-er (2010, 25), this lead to a reconceptualization, or *performative turn*, considering performance not only as an artistic practice but also as a method. As Frieling (1997) stresses, all performative art forms, despite their particularities, shared the same interest in “process-orientation, conceptualism, irreproducibility, randomness and interactivity” as principles that, rather than an art form, define a way of making art.
3.2 CODE AND PERFORMANCE

The reconceptualization of performance drew attention to fields of study like linguistics and speech act theory (Salter 2010, 25), which relates to a focus on the “tacit, non-verbal, embodied, and immanent act of doing” inherent to practices that are “more concerned with ‘performance’ than with ‘competence’” (Salter 2010, 25), that is, “more interested in parole (speech) than langue (language)” (Arns 2004).

Resorting to this analogy Inke Arns (2004) contextualizes performativity as a quality inherent to software code considering its ability to act and produce variable results. The author’s definition of “code’s performativity” is not necessarily associated to its “ability to (pro)create and generate, in a purely technical sense” (Arns 2004), but rather concerned with its “concrete realizations and consequences” in terms of “its effect on the domains of aesthetics, politics, and society”. This view highlights the effects of code’s “actualization”, evoking its “translational quality” when shifting from a “static atomic form” to an “articulatory form” (Berry 2008) through computation. And it is in this sense that the performative dimension of code is emphasized, whenever “enacted or actively performed anew” (Salter 2010, 26).

3.3 INTERACTION AS PERFORMANCE

According to these different connotations we can consider performativity as a quality of “real-time actions played out in front of a spectator alongside”, be it through human or machinic agency, that is, “the agency of machines trying to equally effect changes in the material conditions of the world” (Salter 2010, 32). Drawing on this idea, and as Salter (2010, 32) states, we can also consider performativity in terms of “artistic processes and events in which the human may no longer be the sole locus of enactment but performs in tandem with other kinds of beings”, namely machines, therefore merging human and technological systems in the performance of the work.

The author adds that “artistic performances that integrate technical systems into their intended strategies of artifice” fuse “multiple concepts of performativity simultaneously”, also highlighting “one of the hallmarks of performance”, that is, “its material embodiment in the world—whether that body is defined by human, machine or other” (Salter 2010, 32).
4 PERFORMATIVITY AS A PRACTICE
4.1 FROM HUMAN PERFORMANCE TO CODE

Often, performance practices “consciously and intentionally entangle technologies”, along with the human body, “so that they are inseparable from the form and operation of the work” (Salter 2010, 35). In this sense, we can evoke works that simulate human performative principles through computational means, for example, when consider walking as an artistic strategy that can be computationally reinterpreted as a form of explorative behavior. According to Bunt (2012), both “conceptual code and lived walking practice” share the same interests: in their procedural-ity, repetitiveness, and dialectic between conceptualism and un-thinking mechanism. Both coding and walking entail continuous events. However there is a “different experience of event”, since, in coding, events relate to a sequence of “precisely timed instructions” and, in walking, to the recognition of (often) “uncertain or unpredictable occurrences” (Bunt 2012, 7), reflecting a duality between the mapping of possibilities and the freedom of choosing how to explore them.

Walking was primarily used in arts by the Situationist International, according to “a technique of rapid passage through varied ambiances involving playful-constructive behavior and awareness of psychogeographical effects” called Dérive (Debord 1956). This kind of explorative walking practice implies a reconceptualization of space and of its experience, developed in time as an activity that demarcates itself from the classic notions of journey and stroll, by emphasizing playfulness and a new way of navigating a space and gathering data about its structure.

One of the artists involved in experimental walking is Richard Long, who approached this method as a “means to explore relationships between time, distance, geography and measurement” (O’Rourke, 2013, 49). This kind of strategy also entails a form of inscription or mapping, as the artist draws the shape of his itinerary on a map and then executes it, leaving a trace of his trajectory. Similarly to the Dérive’s psychogeographic notations, the trace of Long’s walks, works as “both map and path” where the act of drawing presupposes time as an event (O’Rourke 2013, 49).

Projects like the Webstalker (I/O/D, 1997) computationally incorporate and reinterpret these strategies. Being configured as an experimental browser or a kind of mechanism that visualizes the link structure of the web in an abstract manner, the work analyzes webpages and then maps their hyperlink structure in a dynamic graphic map as the result of the user’s navigational activity. And the role of the map is to provide an alternative view.
of a space’s structure. Revealing “the way a browser works rather than actually working as a browser” (Frielings 2003), it can be seen as an alternative kind of dérive deployed in the computational realm, through the mapping of an exploratory navigational activity.

4.2 FROM CODE TO HUMAN PERFORMANCE

While the previous examples emphasized walking and mapping as strategies, ultimately deployed through computational means, other experiments reverse this logic, by transposing the execution of computationally defined procedures to the physical realm. This possibility is explored in the John Henry Von Neumann (McWilliams 2009) performance piece that presents a human (using a pen) and a computer (using a plotter) competing in order to execute the same algorithm. Random numbers are delegated to both entities resulting in two algorithmic drawings, one done by hand and the other by the machine. The instructions contain “the logic of program operation” and, as a conceptual approach to code, the piece reveals how they can be “open to interpretation by different readers, whether human or machine” (Berry 2008).

Another example that reflects on the concept of action scores and on “the modern computer in its earliest incarnation of only an imaginary, theoretical apparatus in the shape of the Turing Machine” (Cramer 2003) is Walk (2004) by Socialfiction.org. This algorithmic psychogeographical piece, entails a “representation of some idealized form of computer code” (Berry 2008) that is meant to be readable and executable by humans.

Similarly, another piece that reverses algorithmic strategies onto the physical realm by means of human performance is Reverse Simulation Music (2007) by Masahiro Miwa. It is a music methodology that comprises “acoustic events born of intentional human actions” defined according to computer simulation-based trials (Berry 2008).

The three examples draw attention to the mentioned “translational quality” of code and to its “dual existence” as human-readable “delegated code” and machine-readable “prescriptive code” (Berry 2008), therefore also revealing the differences between computational automated execution and human interpretation of the prescribed instructions. For instance, when comparing human and machine execution in John Henry Von Neumann, we realize that the first entails a slower process, visible through the length of paper used in the final drawing, in which the nuances of human execution are recognizable. These differences in interpretation can also be observed in Walk or RSM. Although the
activity implied in the first is more explorative, and that of the second, a more automatic process, both examples underline that the human execution of algorithms is not “a passive cloning of conventional circuitry, but rather (…) a creative re-interpretation” (Berry 2008).

These strategies reveal how the “open gaps” inherent to their procedural instructions are “filled in” through the human interpretation of algorithmic procedures; highlight their nature as “performative rather than compositional” events (Berry 2008).

### 4.3 INTERACTIVE PERFORMATIVITY

Returning to Salter, we can stress the idea that new media arts “embrace the dynamic, real-time event that has always differentiated performative practices from the static objecthood of the visual arts” in what he considers to be “a logical step” towards “discovering (or recovering) felt experience, situated context and polysensory affect” (Salter 2010, 21). This shift relates to a growing interest in the use of technology as an “innovative creative expression”, which also reflects how “new technologies” appear to have “suddenly created a horizon of aesthetic experiences with no previous historical precedent” (Salter 2010, 21). In line with this view, Interactive Art emerged as a practice concerned with “processes” and “activity over [sensory] result” (Kwastek 2009). This focus on the interactive process itself is also evoked by Golan Levin's notion of “interactive performativity”, referring to artworks that encourage the audience “to collaborate with the system's author in exploring the possibility-space of an open work, and thereby to discover their own potential as actors” (Levin 2010). Similarly, Boissier's (2004) notion of “exercise” draws attention to the “performatve dimension of experience” of a work that is performed by its spectators.

This idea is reflected in works that exhibit dynamic behavior, by responding or adapting in real-time, when creating an interactive aesthetic experience that involves liveness and incorporates the human presence in the enactment of the work as a performance.

Projects like *Rain Room* (Random International 2012)2 offer visitors the experience of interacting with an artificial system, by presenting a responsive field of falling water that pauses the rain wherever a human body is detected in the installation space. Performativity is implied more on a computational, rather than human level, since the system detects human presence and reacts to it as a live event.

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In turn, the interactive performance *UP: The Umbrella Project* (CSAIL and Pilobus 2013) is defined as a collaborative happening in which the participants control a color-changing umbrella that influences a moving image projected on a screen, which evolves and adapts according to the actions and interactions of the participants. In this case, it is the human performance that is emphasized and mediated through the live responsive behavior of the system, which, in this manner, contributes to the overall performance.

Finally, the *Interstitial Fragment Processor* (Levin 2007) proposes an interactive aesthetic experience in which the negative spaces drawn by the shadow-playing of participants originates positive forms that acquire sounding properties, being that “their accumulations reveal histories of performance and play”. So, this example articulates and underlines both the human and the system’s performance, through the exploration of its creative possibilities on an individual or collaborative level.

With their different strategies, these works then entail multiple notions of performativity, through the interplay between systems and audience, while bringing to the fore the system’s reactive agency to the presence, actions, and performance of the participants. Therefore, these examples also entail “felt experience” and “situated context” (Salter 2010, 21), while involving and articulating both the performance of system and human participants in the actualization of the work. In this manner, they also reveal the expressive use of real-time computation in creating their meaning and experience, as an overall performance and momentum of aesthetic experience.

5 CONCLUSION

By discussing these different understandings and examples of performativity, this paper sought to promote a reflection on the creative and expressive role of the human and computer as enactors of the work, whether working independently or dependent-ly from one another. In their diversity, the approaches discussed range from the use of computation as a means to simulate human performativity, or reversing computational procedures by means of human performance, while also encompassing the interactive performativity of both human and artificial systems.

On one hand, the exploration and combination of rule-bound computation and human interpretation highlights the creative potential of code not only inside, but also outside of the computer. On the other hand, while some works explore and reveal how the nuances of human interpretation and execution can be incorporated and become expressive, other projects stress the combination of the qualities of both technological systems and human performances.
In conclusion, we can say that the works discussed promote an understanding of how procedurality, as the ability to execute rules and produce expressive and, eventually, unexpected results, becomes conceptually relevant as an artistic argument, within different performatives and also different kinds of performativity. Going from human performance to code and approaching the performativity of code through human performance, these projects draw analogies between human and artificial systems, ultimately, invoking the notion of interactivity performativity through the interplay between both agents. With their different strategies, they emphasize procedural as their shared quality and as an inherent quality of performativity.

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This paper contrasts the procedures of science and art by examining the processes of the evolution of thought, and of the context which grounds thought, in both families of disciplines. The decisive difference is the attitude towards reproducibility: in science, reproducibility is sought after, whereas, in contrast, variation (either deliberately produced or arising out of random, uncontrollable processes) is an essential part of the creative process. After reviewing models from logic and programming, which give useful insights into the relation between thought and context, the work of Otto Neurath on the possibly discontinuous evolution of cluster concepts is examined. This body of theory is then applied to music, art and performance, and the relations between them, reflecting upon the current tendency of industrial design and product engineering to construct a smooth, frictionless world inhabited by a fictional being called The User.
1 ART AS A MACHINE

The picture of a machine holds us captive: we imagine that our thoughts and our artistic productions are products of a mechanism whose nature can, in principle, be known, and whose workings (apart from the inputs of the senses) depend only on itself. Such a machine could be investigated quite separately from the rest of the universe. Call such a machine a monadic machine (monadic in the Leibnizian, not in the mathematical, sense). Furthermore (if we are Cartesian enough) the monad would be transparent to itself: introspection could give us insight into the nature of the mechanism. These oversimplifications infect not only our dealings with machines in the wide sense and the way machines are designed (including, for example, musical instruments), but also machines as metaphor: even more so when, under Cartesian influence, imagination suggests that introspection could give us insight into the nature of the mechanisms that we ourselves are.

The concept of machine collides with Simondon’s definition of technical object as “a non-saturated system” (Simondon 1958, p. 41) which “…exists not only by virtue of its functioning…but by virtue of phenomena of which it is, itself, the center…” (Simondon 1958, p. 41), to finally explode in Guattari’s description of abstract machines as an oblique concatenation of multiple components of different types of machines: material and energetic, semiotic and algorithmic, representational, of organs and bodily fluids and of desiring machines (Guattari 1992). Somewhere in this arena we find computer programs, expert systems and Artificial Intelligence: systems which, although it is not proven that they think, nevertheless are closely allied to thought. And so the obliquity of Guattari’s machines subverts the picture of thought as the product of a monadic machine.

Just like the Latin concept of a machina, which could exist materially in the form of an object, or immaterially as an event or happening, or could simply mean a trick or a device, art can be imagined or described as a process that traverses all the ways in which machines can be: it produces a continuous emergence of sense because, throughout their evolution, machines (even though they diverge from the original human gesture) generate life from abstract human vitality as a qualitatively different emergent phenomenon. And in this extraction and abstraction lies the essential dimension of machinic autopoiesis. The enunciative power to define itself goes back directly to the machine as a syntagmatic concatenation. This autopoietic nucleus is what subtracts the machine from its structure, a difference which secures its value (Guattari 1992). This concept of a machine breaks free of a priori specification, either semantic or pragmatic.
Art, similarly to a technical object, in the formation of its own identity is recursively intertwined with the milieu (environment) where it is produced and which produces it. Nevertheless, it is also the center of a different type of vitality: art defines itself in relation to context, as for example that of fine art, new media art, art-science, and the context (or milieu) is defined not only in relation to media or methodology of production but also in terms of economy. If fine art is reflected in the closed world of collectors, art critics, galleries, and the construction of the identity of the artist can nowadays be more important than the work of art itself, following the rules of the age of art’s “financial reproducibility” (Panza 2015), new media art is contaminated by technological investors, multinationals and the game industry. Art-science, instead, eventually seen as a vehicle to foster the digestion of a sort of pop science (almost like a sci-fi novel), risks segregation to a subordinated role, grazing in academia like a teacher’s pet.

In these diversified contexts, what kind of machine, or machina, is an art piece? Could a machine that doesn’t do anything be considered a work of art, in its attempt to signify a gesture which will never happen, or, more generally, non action as the dimension of the impossibility of being? In the dynamics of utilitarian structures, what are the discursive forms of a machine that has lost its function?

Many abandoned technical objects are incomplete inventions which remain as an open-ended virtuality and could be taken up once more and given new life in another field according to the profound intention which informs them, that is their technical essence (Simondon 1958)

Thus, even abandoned technology has a technical essence: consequently, it is possible to ask about machines that have lost their function, and to hope that, in the panorama of abandoned technical objects, art can emerge in the space left open by the disappearance of the picture of a User designed to perform smooth actions in a plastic world: chaos dissipates certainty in the land of disorganised entities.

Fig. 1. Shulea Cheang. Ewaste. Lagos, Nigeria: 2015.
While striving for eternity, the machine is obsessed by a desire for abolition, failure, catastrophe and its own death. This form of alterity, this negation of the very self as inherent to its essence, is developed in diverse forms. Guattari, possibly following Maturana and Zeleny, distinguishes between ‘allopoietic machines’, that produce things other than themselves, and ‘autopoietic machines’, that are capable of generating themselves and which specify continually their organisation and their limits (Guattari 1992). The two processes may be simultaneous. If machines depend on exterior forms — those which generated them, the forms with which they interact, human forms and the form of the environment — then their autopoiesis implies the generation of an opinion on the world of beings, that which is not them, and a reflection upon society.

2 DYNAMICS OF CONTEXT

The monadic concept of a machine undermines itself from within: it is inadequate to the phenomenology of intellectual production (White 2011). Although humans may be aware of their engaging in reasoning, they very rarely are fully aware of the nature of all the concepts they use: rather, some of what they reason with is given to their consciousness, while a great deal of it is hidden from their current awareness. Some of this is internal material of which we are not aware but which is part of our thought. But there is also external material that forms part of our thought (McDowell 1998). Taking these phenomena seriously does not mean ceasing to use machines to model thought, action, and performance: rather, it amounts to moving from the monadic concept of the machine to something more heterogenous, more Deleuzian, and, in particular, moving to a concept of a machine which essentially involves a portion of the external world. Let us call all of this non-salient material, both internal and external, the context. So how do contexts behave?

Examples from logic and computer science can guide us towards an answer, although their accounts will have to be modified, in some ways quite drastically, in order to arrive at a plausible story about reasoning in general. Logic gives a dependent type theory, a formalism that was developed by constructivist mathematicians in order to help with the formalisation of mathematics: here contexts are sequences of mathematical objects, together with their properties, which are under consideration in a particular piece of mathematical reasoning. The rough idea of a context of this sort originates, however, not in logical formalism but in mathematical writing: looking not at the formulae in research articles or in textbooks, but in the prose surrounding
them, it is possible to find that, at a given point, there usually is just such a sequence of salient objects and properties: such objects and properties are generally introduced into the discourse in words such as “let G be a group and H be a normal subgroup”, and, having been introduced, they can then be used in explicitly formulated calculations and proofs.

The semantics of programming languages presents a similar picture. Computer programs are executed in hardware, which provides memory, registers and a processor to manipulate the contents of registers. However, programs are written in programming languages, and such languages talk about more than that (White 2015): they give names to memory location, they provide means for handling the flow of control (that is, what instruction should be executed after the execution of a given instruction). A computer program might appear to be a mere list of instructions, but, when it is executed, each instruction will be executed in a particular context, which will be constructed by the executing computer as the program is loaded and, step by step, executed. The context will then vary during execution, but it will vary in a deterministic way.

Type theory, then, and computer programs have a two-layered semantics: there is the semantics of the overt content (the salient logical instructions and formulae), but this semantics depends on the context which is constructed when the formula is proved or the program is executed.

This two layer semantic model could be used to describe cultural phenomena more generally: however, such models have two significant defects. Firstly, these models — logic and the semantics of programming languages — are intellectual productions, and they take place in environments which are isolated from the outside world. Secondly, the evolution of context in these models is deterministic: they are also discrete systems, so interesting questions such as whether the evolution is continuous or discontinuous do not arise. Even so, these models are a useful reminder, warning against the human tendency to see only what is foregrounded, what is salient. So models like the ones discussed above are needed, but with a less deterministic notion of context. What is needed is a context which, like Guattari’s machines, is part of the natural environment, and which, like that environment, is capable of nondeterministic, discontinuous evolution.

There is a useful body of theory which can illuminate both problems, namely the work done during the twentieth century by both the Frankfurt school of critical theorists and by the Vienna circle. Although these two groups are usually seen as opposing each other, they have significant similarities: both of them viewed human thought as not being isolated from the outside
world but as radically influenced by its social and material environment. They were also quite concrete about the mechanism of this influence: both Adorno (from the Frankfurt School) and Neurath (of the Vienna Circle) think that the concepts implemented in everyday thought are determined by a context made of heterogeneous assemblies of concepts, bodily reflexes, social practices and the like. (Adorno calls these assemblies *Konstellationen* (Adorno 2013, pp. 164ff; cf Müller 2006 pp. 834ff), whereas Neurath calls them *Ballungen* (Cat 2014, § 3), but they play the same role for both authors).

Neurath, as a consequence, opposed the view that all concepts could be fixed by perspicuous definitions: rather, everyday language was full of such heterogeneous assemblies (see (Cat 2014, §3), which could not be analysed in terms of primitive, precisely defined concepts. Even in the practice of science -- for example, in the words which express scientific observations -- we find terms such as ‘microscope’, ‘seeing’, etc., which, on examination, turn out to be quite resistant to definition. The structure of a scientific theory thus represented, furthermore, was not given by axioms.

all content statements of science, and also the protocol statements that are used for verification, are selected on the basis of decisions and can be altered in principle. (Neurath 1934)

Adorno’s *Konstellationen* are very similar: these, as well as being conceptual, also had an essentially affective component (Adorno 2013, pp. 397f, Müller 2006 p. 190). Adorno, too, drew the consequence that many concepts evaded exact definition:

[Language] does not offer a bare systems of signs for the functioning of knowledge. Where language appears essentially as language, becomes representation, it does not define its concepts. (Adorno 2013, p. 164; our translation)

For both authors, these assemblies can, in response to external influence or internal evolution, change discontinuously: most drastically, a world view can lose credibility and simply collapse, but the same process happens on a smaller scale in the normal evolution of our beliefs and worldview. As Neurath says,

A situation may be called unstable if even a small variation in the initial state may bring about a tremendous difference in the state of the whole aggregation [Ballung] in question: ‘tremendous’ here from a sociological viewpoint (Neurath 1944)

So in both cases we have a picture where overt concepts (either the concepts salient to us in the process of thinking, or the concepts referred to by words in text) are constituted of heterogeneous assemblies of other material, some of it conceptual in nature, some of it more affective or pragmatic. It is this analysis of the context of thought which will allow us to describe more precisely the relation between science and art.
2.1 THE MATERIALITY OF INSTRUMENTS

Consider musical performance. Here the context has a further component besides the human agent and their socio-economic environment, namely the musical instrument. It plays an important role in musical performance, a role which is not only material but also semantic: the performer has beliefs about, and actions concerning, this very instrument, and consequently the state of the instrument (namely its physical condition) affects the performance, sometimes quite decisively. Both performer and audience are aware that the performance involves a material object, and the materiality of this object is an essential part of the performance: just as with brushstrokes in painting, the materiality of the musical instrument leaves traces on the performance, and thus the materiality of the instrument is essential to the semantics of the performance in a way in which the materiality of a computer is not essential to the semantics of programs that are executed on it.

The beliefs and intentions which performers and audience have towards the instrument are essentially about that individual instrument, not about the concept of an instrument: they are what are known as de re beliefs (Jacob 2014). Because of this focus on an individual, such beliefs resist formulation in terms of general concepts: to formulate this another way, we should regard the instrument itself (not a concept of it) as a part of the context for the audience's and performer's thoughts about the performance.

The particularity of the instrument is important when the state of a musical instrument changes suddenly and discontinuously. In some cases, the discontinuity of such state changes, rather than being an accident afflicting a performance, a departure from the ideal, can be an essential, intended part of the performance: indeed, the performance can be intended to exhibit just such discontinuous state changes, and thus to convey something important about the way life is exposed to the contingencies and the chaos of the physical world.

3 EXPERIMENT AS VARIATION

This analysis of the contextual nature of thought has provided some room for manoeuvre, and some reflections can be made about the relation between art and science.

If both art and science are based on research, their methodologies differ greatly. The canon of experimental science enforces repeatability on both sides — inductive and deductive — of empirical method: correspondingly, observation, as a qualitative
and quantitative connection in the ever-extending chain of scientific method, is automatically assigned a normative status: it is the main access to what is real. In view of Neurath’s remarks on the unruly nature of even observation sentences, however, we must not assume that such repeatability is automatically given by scientific language or scientific practice: it is, rather, an achievement. Because it is an achievement, it is not inevitable.

And so there is also art. For art, the goal is not known from the beginning: in art observation implies imagination (that is, apprehension of that which is out of the plane of observation), it implies a simultaneous loss of the self and the emergence of subjectivity and individuality (Oreggia 2015, p.18), it implies a friction with the environment which creates the self and, in the process, reflects and instantiates the real (Heisenberg 1958). Art investigates a real into which the self is reflected, in a continuous deformation where each part loses its ontological self-sufficiency, owing its existence to the dependency on the other. For this reason, the main objective of art is always unknown, both in obscure forms such as the trobar clus of Provencal poetics as well as in open forms such as the Provencal trobar leu, because it is this unknown which stimulates the imagination and thus triggers the search. And so the unknown of art is multifaceted, polymorphic, incommensurable.

As an illustration of this can be considered the frequent use of genres which involve some element of indeterminacy: this may fall far short of the deliberate use of aleatoric methods, but, even so, techniques such as monoprinting (Tate Gallery, no date) show the value of the art of non-reproducibility. Conversely, Piero di Cosimo, with his “habit of examining a wall on which a lot of people had spat” (Geronimus 2006, p. 27) sets free his imagination: thus, the smudgy, irregular visual phenomenon, precisely because it is hard to classify, acts as a stimulus for the polymorphic imagination of the artist.

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**Fig. 2.** Ignotus the Mage. Piero di Cosimo. Perseus and Andromeda. (revisited).
Also a series of paintings implementing the same technique will constitute a succession of studies or experiments forming a set or body of work, and these elements will present a certain degree of similarity, or homogeneity, along with a discrete margin of variation between them. Similarly, a study for a landscape or a “natura morta” will show progressive modifications towards a synthesis of a form of durational identity, or succession. The experiment here incorporates and seeks variations, discontinuities, sudden changes of point of view, accidents, synthesis as well as fragmentation. A study for a landscape may repeat the same view at different times and weather conditions, so to say differences in the state of the context, rather than predictable and exact parameters. These are in fact fantastic constructions: there is a sphere where parallel lines never meet, where a perfect sphere can move in the void indefinitely, not far from that place where a comfortable user sits in that optimal immutable position suggested by the chair. Yet nature doesn’t know about such perfect places that are human constructions.

The articulation between general and particular, then, is different for art than for science: Adorno, writing about the role of individuals in his metaphysics, says

Because the individual cannot be deduced from thought, the kernel of an individual might be compared to those extremely individuated works of art which have dismissed all schemata, and whose analysis rediscovers, in the limit of this individualisation, their participation, hidden to themselves, in the typical. (Adorno 2013 p. 164, our translation)

3.1 PHENOMENA HUNTING PHYSICS

In this way, science and art do not necessarily oppose each other, and, as much as art, too, seeks the truth about reality, so too the scientific method is not solely aimed at that truth. In practice things are not so simple: as Nancy Cartwright puts it,

I think of a physics theory as providing an explanatory scheme into which phenomena of interest can be fitted. ...It is part of the nature of this organising activity that it cannot be done if we stick too closely to stating what is true. Some claims of the theory must be literally descriptive... if the theory is to be brought to bear upon the phenomena: but I suspect that there is no general independent way of characterising which these will be. What is important to realise is that, if it is to have considerable explanatory power, most of its fundamental claims will not state truths, and this will in general include the bulk of our most highly prized laws and equations. (Cartwright 1983, pp. 77f)
And certainly parts of scientific theories are literally true, but the theories are not literally true in their entirety. Correspondingly, the process of creating scientific theories is very complex: for every case I investigated where theory was genuinely useful in producing models that accurately described real-world data...every one of these cases was rife with ad hoc additions and subtractions, often substantial. Now the failure of the arguments for them does not show that the laws are false. Rather, I urged, it shows that it is a big leap of faith to move beyond the usefulness of the theory to count it as true. (Cartwright 2015, p. 102)

And so art and science are not to be distinguished by semantic criteria: art attempts forms of verification as much as science is subjective. Objective and non-objective factors play a role in both disciplines, and the creation of art involves a very complex interaction of objective and non-objective, and the quantitative notation of an experiment involves the subjective choice of a number against a floating series.

4 TOWARDS A DYNAMIC OF THOUGHT

The dynamics and the functioning of thought are mysterious because humans tend to forget the complexity and the multilayered strata of the dynamism of context. The question of free will is, in a certain sense, a geometrical problem: free will stays imperscrutable as long as the unextended is confused with the extended, as long as time becomes a simple geometric continuum like space, as long as the context of thought about existence in time, which structures temporal experience and breaks its uniformity, is ignored. Not differently from Spinoza, who “very often said that essence is power” (Deleuze 1980), in Bergson “quality becomes in a certain sense quantity, and is called intensity2, in which a necessary element is space”. (Bergson 1910). Duration, like context, is heterogeneous:

there are two kinds of multiplicity: that of material objects, to which the conception of number is immediately applicable; and the multiplicity of states of consciousness, which cannot be regarded as numerical without the help of some symbolical representation... (Bergson 1910)

The segmentation of the continuous, its fraction, is a multiplicity that becomes number. Symbolical representation is linguistic abstraction. According to Bohm, languages of representation created an immaterial entity called thought that, like a beast, is turning its head to humanity attempting to devour it, an iteration that, instead of augmenting will, increases uncertainty. Why? Because thought is not aware of its own action, it participates in the illusion it creates. Bohm interprets thought as a system: “the
past is active...has left a trace in the present” (Bohm 1992, p. 98).
In Bohm’s vision, thought is the fundamental problem of humanity: this reflection of the past on the present (thought is always past), this incessability of reflection and representation seduces humans with the illusion that representation can be exhaustive, that language can be complete. But, since representation is always incomplete, it must cease to guide us coherently... So we do not expect to find some eternal truth about the nature of matter. The nature of matter as far as we can see could be infinite, unlimited — qualitatively as well as quantitatively... Knowledge cannot be absolute . (Bohm 1992, pp. 102)

Because thought affects what we see, because it participates and is active in perception, representation affects experience. Ultimately, human knowledge is affected by a form of deception; however “thought doesn’t know it is doing it” (Bohm 1992, p. 116), it doesn’t know it is participating in perception, transmogrifying the image of the real, projecting subjectivity onto presumingly solid objects, or conglomerates of possibilities, whatever it is its degree of resolution.

In this sense, the dynamics of thought add another layer of imperscrutability and distance between that which is observed, experienced, perceived, described, and the subject operating this abstraction. Another layer upon the conglomerates of contexts. If these strata of subtle modifications may be seen as threatening imperfections within an eventually exhausting and systematic scientific examination, the poetic value of its enigma, the incommensurable distance between essence and states of beings and objects, this space left open for imagination, becomes salient material that originates the human arts.

5 TECHNOLOGICAL SUBLIME

What if technology was tired of being used?

About a century after the original avant-garde, those art forms which created the idea of the future and predicted our fast pixelated present and the controversial and never ending relationship between humans and machines, seem to have been digested by the engulfing stomach of culture. Yet there is always something in the avant-garde that remains our future. If art has the power to perceive and represent societal change, making visible the reflection of the real onto culture and rendering those forms that foresee and represent a common feel, solidifying ante-litteram (ahead of one’s time) those aesthetics that will eventually become, one day, popular culture, there are always elements of prediction that point to science fiction, impossibility, or a field that will be forever void, unrealised.
The leading edge of art tends to be initially misunderstood, considered provocative, until it becomes mannerism, and it is therefore digested and canonized, almost losing its original content. One could argue that, one hundred years ago velocity, speed, moving images, audiovisuals, radically transformed the aesthetics and the forms of perception, and industry encountered the courtly arts; that, starting from the Bauhaus, the flourishing and experimental field of design was established: that sound recording threatened the acoustic music world, encumbering into music the perception of noise. But what is, nowadays, the new unpredictable form that will influence and transform the aesthetics of the years to come? What is the individuality of “contemporary aesthetics”, and how is technology transforming our perception and interpretation of the real? An aesthetic theory of the machinic that can be meaningful nowadays shouldn’t focus on optimal design, superb function, or smart shape. Giving back aesthetics its ethical function, and the capability to inform and communicate with the community using a universal language, an aesthetic theory of the machinic engages with the inherent question of what a machine is, and how humans are confronted with them, what is it that makes technology sublime, when does art occur in a technological artefact and what are the characteristics of its manifestation.

Yet why rescue this romantic idea of the sublime? This idea that sounds so outdated and reminds us of emotional landscapes and the juxtaposition of nature and humankind, where nature simultaneously reflects the subjective human apprehension of the real and shows the incommensurability of that apprehension. And when nature goes out of control, is stronger, complex and unpredictable in its manifestations, making humans feel fragile, dispersed, affected.

Yet technology, not interpreted as a different realm, but as a fruitful part of the intercourse of nature, shares, and inherits, some of the properties and predicates of the interface to which it belongs. So, in this technological landscape, can the expression of the sublime become a key concept to decrypt aesthetical manifestation (as perceived by the subject) from mere machinic presence, in an environment dominated by functional tools?

In the contemporary debate on fine art, art history and the phenomenology of style, a recurring and fundamental question is that of the identification of a paradigm that can recognise (if not actually define) “Art” (an unknown dependent on time and space), while allowing for variation of culture and historical periods.

If during the XX century’s avant garde it was still the artist with his actions and the procedures aimed at the construction of the art object, or event, to be the subject, and manifestos were
written copiously so as to provoke, reinvent and disregard the established modes of art production, nowadays, in the age of the artificial, and in its cultural, biological and philosophical reappropriation of the real, now that the artificial has been accepted and re integrated into the domain of nature, and the artist has become an orchestrator, or a programmer of the unforeseeable, the machine is finally claiming enunciative power.

Art becomes, then, a manifestation of the machine, while the artist sits and observes, in ecstasis or dismay, with her organs dismembered, like the characters in Francis Bacon's tryptichs (Deleuze 1981).

Technology itself, as a subject rather than a medium, transforming sensing apparatuses into sensata, sensation into affection, thought into expression, as a living soft experiment, describes and comment around its processes, ethics and aesthetics, triggering the foundation of that brave new art which is still our future.

6 CONCLUSION

Nowadays designers and engineers apply their approaches, centered on the question of the user and the use cases paradigm, to the process of art creation, with the risk of flattening an art form to a technical tool. Although art can be defined as a special type of machine, and every technical object implies that inventive intuition which generates its technical essence (Simondon 1958), the canons of interpreting and deciphering interactive art and its avant-garde should be distinguished by those of industrial design and cutting edge technology.

This paper suggests the development of a critique of use in relation to interactivity towards the creation of the discipline of Machinic Aesthetics, which, not differently from Software Studies (Fuller 2008) in relation to software and digital culture, or The Critical Engineering Manifesto (Olitver, Savičić & Vasiliev 2011) as a response to engineering, proposes a reflection and a systematic study, along with a series of interventions, to illuminate and comprehend the field of interactive art, where the machine is assigned the unconventional space to act out of prediction, subjectively and at times ferociously, expressing itself in non deterministic, poetic, or simply symbolic and allusive ways.

In fact, when transformed in well designed commodity, despite its power to interact, art, in the form of technology, dies, becomes an inert object which doesn't provoke any meaning. The artist, as well, seduced by the industry and its idea of good art as well functioning item, lays around the piece, his body is inert,

3. As Simondon's reflection on the dynamical interrelation of contexts (milieu) has shown, there is no relevant difference nor opposition between the two domains.


5. The field of machinic aesthetics aims at tracing and investigating a form of art that allows affective communication and intellectual interchange between the intermingled world of humans and machines.
she has lost her soul. Because the function of art expresses itself mysteriously, in speechless and enigmatic words. Because there was no user in ART.

Acknowledgements. We thank EPSRC and Queen Mary, University of London. This paper wouldn’t have been possible without the inspirational support of Alice, Bob and the White Rabbit. We thank Shu Lea Cheang for the photo Ewaste and Ignnotus the Mage for the image Perseus and Andromeda, published under the Creative Commons Share-Alike license https://creativecommons.org/licenses/by-nc-sa/2.0/ at https://www.flickr.com/photos/ignotus/6928857204

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In this paper I present two different implementations of analogue oscillators that synchronize when they are mutually coupled. I consider these as examples for machine—machine communication without hierarchies and protocols. Synchronization is the most fundamental indicator for the exchange of information. In these analogue oscillators this exchange is realized through a direct coupling, no encoding and no decoding has to be effectuated. Not one oscillator is dominating the communication, they mutually negotiate their timing. This capacity for non-hierarchical communication is a signature of analogue systems. They allow for information exchange without having to recur to symbols or to detect the presence of a signal, already the softest input may modify and modulate the behaviour of an analogue system. Presenting a digital implementation and approximation of an analogue system, this paper is clearly not meant to dismiss digital systems but to open up a perspective on the analogue as conceptual approach towards openness.
1 INTRODUCTION

Obviously, nowadays the machines surrounding us are in communication and this communication is largely built upon a digital subface. All the infrastructure for the communication between machines follows digital paradigms and protocols, from serial interfaces, over MIDI, to Open Sound Control or the Internet-Protocol to name some of the most obvious ones. Inherent to this type of digital communication is its closeness, it is only possible to understand the communication or to intervene in the communication between machines if the protocol is known. Intrinsic to every protocol is also a hierarchy, between those who define the protocols, those who implement them and those who follow the protocols. Inherent to the digital communication is furthermore the need for synchronization or as Trogemann and Scherffig write

...From this general perspective the problem of synchronization is inherent to algorithmic computation, without being explicitly wanted the necessity for synchronization is a consequence of the nature of computation and thus deeply inscribed in the notion of the algorithm. (Trogemann and Scherffig 2013)

With this paper I want to propose mechanisms of machine-machine communication that do not require a protocol and that show synchronization not as a necessity for communication but as a consequence of communication, as an emergent signature of communication.

The mechanisms of machine-machine communication, considered in this paper, share that they are built upon an analogue subface, being characterized by a subtle and graded exchange of information between the machines. The oldest known example of machine-machine communication is that of synchronizing pendulums. It was first discovered in the 17th century by Christian Huygens (Bennet et al. 2002) who was developing maritime pendulum clocks. While at home due to illness he observed that the pendulum clocks, he had developed, were swinging in a perfect counter-phase relationship. Even when he disrupted this fixed phase relation, after some time the clocks would swing again in fixed counter-phase.

This effect of synchronizing pendulums can be reproduced using standard metronomes. Two metronomes or even more synchronize in phase when they are put on a common support platform that mediates the swing between the metronomes. The simplest setup for the experiment uses two empty cans as wheels and a small wood plank as a support base to place two metro-
nomes. After a short time the metronomes will synchronize. There is no hierarchy involved, the metronomes sway and are mutually influencing each other through the common support platform. The Ikeguchi Lab (Ikeguchi 2016a) has an impressive number of demonstrations from synchronizing metronomes to dripping water bottles and candles (Ikeguchi 2016b).

While the scope of this paper is on machine-machine communication examples of synchronization are also observable in organisms. Examples are the synchronisation of fireflies (Buck 1938) or the synchronization of a public when giving applause (Neda et. al. 2000). Such phenomena have inspired the development of a proto-musical system based on synchronisation of oscillators called crickets (Lambert 2012). The present paper points in a similar direction as the cricket system but the focus here is on the fact that the basic principle of synchronisation is based on the exchange of analogue or graded quantities.

I will present two oscillatory systems with synchronization that take their inspiration from synchrony as it is observed in the nervous system (Dayan and Abbott 2001). The first is an electronic realization of a very minimalistic artificial neural network based on the work by Hasslacher and Tilden (Hasslacher and Tilden 1995). The second system is digital approximation of a model of oscillatory neural circuits as they have been proposed and analysed by Shun-Ichi Amari (Amari 1977). In a third example I will show how these two systems can also synchronize with each other, bridging between the analogue and the digital subface.

2 SYNCHRONISATION OF ELECTRONIC ANALOGUE OSCILLATORS

The electronic analogue oscillator I propose is composed of two basic units (see Fig. 1). A basic unit approximates a biological neuron with two functional aspects: first similar to a neuron it only produces an output when stimulated to a sufficient level (Dayan and Abbott 2001). Second, it adapts to its input: on constant input it stops producing output. These two functional aspects are realized by coupling a differentiator circuit to an inverter. The differentiator is built by connecting a capacitor to a resistor, the inverter is then connected in between the capacitor and the resistor. The differentiating part is used to approximate the adaptation to an input, the inverter is used as non-linear, thresholding element.
While a single unit does not do much, oscillatory patterns emerge when the units are connected into a loop (see Fig. 1). Such oscillatory behaviour emerges also in neural networks with very simple threshold models of integrate and fire neurons (Amari 1977; Wiener and Rosenblueth 1946).

The simplest recurrent network of basic units that produces oscillatory behaviour is a network of two units mutually coupled to each other, also referred to as bi-core (Hrynkiw and Tilden 2002). The bi-core can be used to directly drive dc-motors with a gearbox. When a motor is connected, the internal timing of the bi-core is influenced by the motor. I use this setup to create self-organized beats in a machine called the rhythm apparatus (Faubel 2013).

Two bi-cores with motors will oscillate independently, but when they are linked with a cable so that one output connects to the other’s output, their outputs will go in synchrony (see Fig. 2 for the experimental setup). This works also if the oscillating frequencies of the two bi-cores do not match. They will synchronize on an intermediate frequency. However using a variable resistor as link in between also allows for complex phase relationships, where they are in sync but they only meet every n-th beat of the faster going bi-core. This is visible in the data recording pictured in Fig. 3. The two bi-cores start off phase locked on the same frequency over time the coupling is lowered by increasing the resistance of the connecting cable. As a consequence, the faster bi-core can recover its Eigenfrequency, but it stays in sync with the slower bi-core, only matching every third beat.

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What is important to remark is that in order to synchronize these bi-cores only a single connection is needed, there is no difference between reading and writing. Current is flowing in both directions of the connecting cable, not one oscillator entrains the other but their coupling is mutual, they entrain each other. Varying the resistance of the cable controls the degrees of freedom of this coupling. The lower the resistance of the cable the stronger is the coupling.

3 SYNCHRONIZATION OF ANALOGUE OSCILLATORS REALIZED ON A DIGITAL SUBFACE

For the digital implementation of an analogue oscillator I use a model proposed by Shun-Ich Amari, the Amari oscillator. The Amari oscillator is based on the coupling of two neurons, an excitatory neuron is mutually coupled to an inhibitory neuron (Amari 1977). The excitatory neuron has self-excitation, once it becomes active it has a tendency to stay active. It also activates an inhibitory neuron, that when it is active will de-active the excitatory neuron. Once the excitatory neuron becomes deactivated, it will not activate the inhibitory neuron anymore, which is in turn becoming inactive. Without the negative input from the now inactive inhibitory neuron, the excitatory neuron will become active again and the cycle restarts. Both neurons are non-linear, which means that they have to reach a threshold level of input before they go into their active state 3.

The theoretical framework to describe such systems that change their behaviour in time is the dynamical systems theory. The oscillator’s behaviour in time can be described by two equations, the first describing the rate of change of activation of the excitatory neuron \( u(t) \), the second describing the rate of change of the inhibitory neuron \( v(t) \):

\[
\begin{align*}
\tau_u \dot{u}(t) &= -u(t) + c_{uu}\sigma(u(t)) + c_{uv}\sigma(v(t)) - h_u \\
\tau_v \dot{v}(t) &= -v(t) + c_{vu}\sigma(v(t)) + c_{uu}\sigma(u(t)) - h_v
\end{align*}
\]
The two equations are the same, only the parameter values \( \tau_u, c_{uu}, h_u, t_u, c_{vu}, c_{uv}, h_v \) differ. The rate of change of activation of the excitatory neuron is a function of the current activation \( u(t) \), it relaxes with relaxation rate \( \tau_u \) to the resting level \( h_u \) in the absence of other input. The function \( \sigma(u(t)) \) is a non-linear threshold function, the sigmoidal function

\[
\sigma(u) = \frac{1}{1 + \exp(-\beta u)}
\]

where \( \beta \) controls the slope of the sigmoid. When the activation \( u(t) \) becomes supra-threshold it is multiplied with coupling term \( c_{uu} \) and contributes to the rate of change \( u(t) \). The same holds for the sigmoid of the inhibitory neuron \( \sigma(v(t)) \), it contributes with the negative coupling term \( c_{uv} \), when the inhibitory neuron becomes supra-threshold.

While these equations can’t be fully solved analytically they can be approximated or played-out on digital hardware. The standard method to numerically solve dynamical systems is the Euler method, which is in a way similar to sampling data, with the difference that the data is not captured as with a sound-card but computed based on previous computation. The faster the computer the more precise is the approximation of the system to simulate. To play around with these oscillators I programmed sketches for Processing, Pure-data, P5js and the Arduino platform. These sketches/patches are made publicly available.

Two oscillators are coupled by mutually connecting the output of the excitatory neuron of the first oscillator to the inhibitory input of the second oscillator and vice versa. In this coupling the connection strength becomes a parameter. It can be used to switch the synchrony from in-phase relationship to a counter-phase relationship between the two oscillators (see Fig. 3 for

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Fig. 4. Photo of the experimental setup, an Arduino controls two motors, each is driven by one oscillator computed on the Arduino, a video of the experiments is available online.
the phase transition). Both in-phase and counter-phase are stable attractors in the phase space relationship of the two oscillators, the in-phase attractor being more stable. One can gradually vary the connection strength and observe how the system goes from one state of synchrony to the other. This behaviour of phase shift can also be explored in an online version\(^5\).

The fact that the systems are showing two discrete stable states is also an example where at the surface a phenomenon may look digital, the system is either in in-phase or in counter-phase, as if there were only these two options, while at the subface the system is analogue and the parameter to control the phase shift is a graded one.

When both oscillators are set to run at different oscillation-speeds through different values of their relaxation rate, the mutual coupling can lead to interesting rhythmic coordination as is demonstrated by another online script\(^6\).

### 3.1 ASSESSMENT OF INFORMATION TRANSFER

To assess the degree of information transfer the transfer entropy between the time-series produced by two coupled oscillators is calculated. The transfer entropy is a measure to evaluate the statistical coherence between systems evolving in time (Schreiber 2000). The transfer entropy is computed based on the Java Information Dynamics Toolkit (Lizier 2014). In the decoupled condition the transfer entropy is significantly lower than in the coupled condition (0.002 vs. 0.03). In the coupled condition the transfer entropy from the first to the second oscillator is not significantly different from the transfer entropy from the second to the first oscillator (0.032 vs. 0.030). This shows that the coupling is really mutual, it is not that one oscillator is entraining the other but they are mutually coupled each is influencing the other to the same degree.
3.2 COUPLING OF MULTIPLE OSCILLATORS

The synchronisation of Amari oscillators is not restricted to only two oscillators, larger numbers of oscillators will also synchronize. The connectivity between the oscillators may be random or all to all connections, both produce synchronized behaviour. This coupling of multiple oscillators is demonstrated in p5js script that can be viewed online as well. The activity of the oscillators is rendered into an ever changing display and is made audible by using each oscillator to modulate the amplitude of a sound generator. Ten tiles on top represent the activity of each oscillator, the lighter colour corresponds to higher activity. The big tile below is a slowly varying oscillator modulating the overall coupling strength. The row below shows the phase plot of the excitatory versus the inhibitory neuron of each of the oscillators. The last row shows the evolution of each oscillator in time (see Fig. 6).

4. SYNCHRONISATION ACROSS ANALOGUE AND DIGITAL SUBFACES

As the digital implementation of the Amari oscillator is conceptually analogue, it can be synchronised with analogue hardware. To connect the bi-core oscillator with the Amari oscillator, the bridging takes place on two levels, bridging from analogue to the digital subface and vice-versa and bridging the two analogue subfaces. The former is done with the classical components of the Arduino platform, the analogue Pulse-Width-Modulated (PWM) output and the Analogue-Digital transducer of the analogue ports (see Fig. 7 for the setup). The latter is done by using the analogue input value associated with the bi-core as input to the excitatory neuron of the Amari oscillator and by transforming

the PWM output from the Arduino to a continuous activation by low-pass filtering it with resistor-capacitor pair. The strength of the mutual coupling is controlled with an additional potentiometer.

5  CONCLUSION AND OUTLOOK

I have shown three examples of machine-machine communication that show synchrony as an emergent effect of mutual information exchange. All examples are analog oscillators, the first is implemented with analog electronics, the second is conceptually analog but implemented on digital hardware. The third is a mix of both types showing how to bridge analog and digital subfaces.

I specifically chose this second example to show that an ana-
log approach can be realized on digital hardware and pertain the special quality of analog systems, which is an openness to sub-threshold input. This openness manifests itself in the fact that the oscillators synchronize based on a very soft mutual exchange of activation. On the other hand the second system also shows how a dichotomy of two separate states, namely in-phase and counter-phase oscillation, can emerge as distinct stable states out of a continuum of possible states. I see this as an example where the surface is digital either in-phase our counter-phase, while the subface is analog (the continuous activation of the neural variables).

The effect of synchrony is in all examples a result of mutual coupling where cause and effect are in a circular relationship. The degree to which the systems synchronize depends on the Eigen frequencies of the oscillators and on the coupling strength. This type of soft-coupling presents an alternative to established hierarchical methods of synchronization, such as the master-clock principle. With the bridging from the analog to the digital subface it becomes possible to link these oscillators to the digital protocols such as the MIDI protocol, effectively linking between analog and digital hardware.

With the examples of oscillator synchronization presented in this paper I hope to establish an appreciation of the analog as a conceptual paradigm that allows for an openness and flexibility in process communication.

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Wiener, N., and Rosenblueth, A. The mathematical formulation of the problem of conduction of impulses in a network of connected excitable elements, specifically in cardiac muscle. Archivos del instituto de Cardiología de Mexico 16, 3 (1946), 205.
This paper explores the creative potential of the transmutability of digital data, from a theoretical discussion of the concept to its contemporary manifestations in creative practices. It begins by addressing the creative possibilities associated to the topic and then provides an overview of artifacts that imply or express transmutability as an artistic concept and method, while focusing on data sources of a textual nature.

To this end, we resort to a framework for the description and analysis of these artifacts, focusing on their conceptual dimension, on their mechanics and on the elements of their experience. In particular, we address the concepts they approach through the use of data in textual formats as source information or content, we consider the processes for its manipulation, and describe the resulting sensory manifestations while emphasizing their dynamics and variability.

In this manner, this study seeks to highlight how transmutability becomes relevant as an artistic argument, by proposing aesthetic experiences that explore the ubiquity of data in our contemporary world.
1 INTRODUCTION

In order to understand the creative potential of the mutability of digital data, we can begin by considering that, within the computer, “all media objects are composed of digital code; they are numerical representations” (Manovich 2001, 27). Thus, digital data, when regarded as raw material, can be translated into any tangible form through algorithmic manipulation. This creative potential is explored through practices that rely on software as their medium and involve articulations between sounds, images, or other physical or sensory realms.

According to Golan Levin (2010), the underlying principle motivating the development of such artworks is the transmutability of digital data. This notion becomes the conceptual and technical starting point of this study, which seeks to provide an understanding of the concept and examine creative practices that not only explore an analytical view of data, but also develop expressive audiovisual languages that provide new perceptions or aesthetic experiences of data.

Following this idea, the focus of this work is on the exploration of textual material, given that “a lot of the richest information we have” is available in text formats (Viégas qtd. in Heer 2010, 7) and “grows on a daily basis” (Nualart-Vilaplana et al. 2014, 224), while considering the “advances being made in text analysis research” and computational manipulation (Nualart-Vilaplana et al. 2014, 221). This represents a transformative potential worthy of development and exploration, which implies a reflection on data that entails the creative potential of the “text processing algorithms” (Kucher and Kerren 2015, 117) applied to its manipulation and transformation.

2 TRANSMUTABILITY AS A CONCEPT

The principle of transmutability relies on the mapping of any input data stream into sounds and images; as Golan Levin emphasizes, the “premise that any information can be algorithmically sonified or visualized” can be the “starting point for a conceptual transformation and/or aesthetic experience” or a means of “enabling some data stream of interest to be understood, experienced, or made perceptible in a new way” (2010, 273-4).

In this sense, the notion appears associated to other concepts that similarly express the inherent mutability of digital data or the potential of mapping any (digitized) physical or sensory phenomenon into new tangible forms. It is related to the transcoding of digital data, as a direct consequence of describing information
numerically (Reas et al. 2010, 79) and evokes transmediality as a “translatability across media” (Hayles 2006, 194). This notion can also be associated to transmateriality as a term that sees “digital media and computation as material flows (...) transducing anything to anything else” by “sourcing new inputs and/or manifesting new outputs” (Whitelaw 2009).

Therefore, we can say that artifacts that explore this inherent mutability of digital data creatively question the “nature of our now ubiquitous data systems” by making data “explicit” and tangible, while probing its “potential, and significance” (Whitelaw 2008). In this process, different approaches and methods for re-configuring data may be involved, following mainly analytical or aesthetic purposes. This means that the aim of the project, “from poetic to functionalist” (Whitelaw 2009), can be to provide a “new reading or understanding of information” or, in turn, to explore data in order to “create expressive languages or sensory experiences” (Lee et al. 2014, 420).

3 APPROACHES TO TEXTUAL DATA

In accordance with these analytical or expressive approaches, when considering data in textual format, we can identify different conceptual purposes and aesthetic intents.

Some projects assume textual data per se as the subject matter of the work, that is, they consider text as raw material (“the text as it is”) or extract and consider “a representative part of that text” (Nualart-Vilaplana et al. 2014, 224) as the result of “text mining algorithms” (Kucher and Kerren 2015, 117). The focus of these works is on the exploration of the formal specificities of text as source material, considering that a text can have “multiple internal structures”, a specific morphology (paragraphs, sentences, words), diverse data types or formats (txt, html, etc.) and different patterns, as well as “a subjective component and an abstract structure that is not readily analysed by a computer” (Nualart-Vilaplana et al. 2014, 223-224).

Other projects consider textual data as content that conveys some kind of meaning, or represents a given subject matter. In these cases, the focus is on semantics rather than form, and the aim is to propose a new “understanding, perception or experience” of that content (Levin 2010, 274) or to “portray not merely data, but the personal, emotional reality that the dataset refers to” (Whitelaw 2008).

Finally, text can be considered as an abstraction, in the sense that what is conceptually emphasized is the translation process itself (Levin 2010), or the possibility of mapping any kind of data
into a new tangible representation. In such cases, and “depending on how the text is treated and processed”, it can be detached from its semantics, being that the textual source or origin “is not always relevant” (Nualart-Vilaplana et al. 2014, 228). The dataset is treated as “an abstract set of potentials”, since “the process doesn’t care what the dataset is, or was”, and treats it as “just input” (Whitelaw 2008).

These different strategies thus expose the potential of translating and revealing inherent, and eventually latent or hidden, dimensions of text into a new expressive manifestation, relating to its formal specificities, semantic aspects, or abstraction through a translation or mapping process.

4 Transmutability as a Creative Practice

In order to provide an overview of the range and scope of creative approaches that are tied to the principle of transmutability, in their potential diversity, we selected a group of artworks corresponding to the following criteria: (1) use software as medium; (2) explicitly work on or explore information in textual format; (3) entail visualization and/or sonification methods; (4) whose result emphasize the significance of data and/or the transformational process involved as subject matter of the work.

4. Harris, Jonathan and Sepandar Kamvar. We Feel Fine. 2006
7. Luining, Peter. ZNC Browser 2.0. 2003
8. Maigret, Nicolas. Pure Data Read as Pure Data. 2010

In order to analyze these works we resorted to the frameworks proposed by Wardrip-Fruin (2006) and Hunicke, LeBlanc and Zubek (2004) for understanding aesthetic artifacts that are digital computational systems, or works that are driven by processes, as dynamic systems. These frameworks highlight that, when examining these artifacts, we must consider not only their sensory results or modes of expression but also their procedural modes of expression and dynamics (Ribas 2014, 53).

In this sense, the model proposed by Wardrip-Fruin addresses the interplay between data, processes, surface, interaction, author and audience (2006, 9-11). It also considers the “forms and
roles” of computation that distinguish the ways in which the work operates, according to its computational variability, interaction and source of interaction (2006, 398). In addition, the MDA framework provides different but interrelated perspectives focused on their mechanics, dynamics and aesthetics (Hunicke et al. 2004).

Drawing on these frameworks, our analysis highlights the alignment between the works’ themes and concepts, as implemented through specific data and processes, while considering the elements of their experience, namely the surface elements and dynamic behavior that define the works’ experience (Lee et al. 2014, 423), according to the following dimensions:

Conceptual dimension (theme and content) – considering the subject matter of the work (relating to its content, such as its approaches to text), while addressing the significance and relevance of transmutability as an artistic argument;

Mechanics dimension (data and processes) – regarding the implementation of concepts with specific data and processes as constituent elements of the system (data collection, values and input method, as well as mapping processes and their possible articulations);

Experience dimension (surface and dynamics) – contemplating the sensory outcomes (output format, modes of expression) and the observable behavior of the work (output nature, system behavior), as aspects pertaining to the nature of the work as a technological and aesthetic artifact, and relating to the variability and determinability of its behavior.

By considering such views we seek to describe the salient traits of these projects, while tackling into the questions that their conceptualization, enactment and experience may raise.

5 ANALYSIS
5.1 CONCEPTS: THEMES AND APPROACHES

According to the previously mentioned approaches to textual data, we can identify diverse creative and aesthetic intents, as well as relationships to text as the main referent or subject matter.

We distinguish projects that tend to explore the formal and material qualities of text (its format or internal logic), for example, manifesting a particular interest in literary works as “a field that, apart from being characterized by complex combinations
of words, can present high levels of human abstraction and freedom of structure and experimentation” (Nualart-Vilaplana et al. 2014, 234). Works such as Ben Fry’s *On the Origin of Species* (2009) give us a perception of the evolution of scientific ideas and the gradual refinement of Darwin’s discourse over several editions of the book. Another example is *History Flow* (Viégas and Wattenberg 2003) that visualizes and reveals patterns emerging from the editing history of Wikipedia articles.

![Fig. 1. On the Origin of Species (Fry 2009) (left) and History Flow (Viégas and Wattenberg 2003) (right).](image1)

Other projects, in turn, focus on content, using text as a means to explore a given subject matter. Rather than focusing on the text format, these projects focus on the meaning that the text conveys, seeking to express or portray the reality that the textual data refers to, as an “index of reality” (Whitelaw 2008). For example, *We Feel Fine* (Harris and Kamvar 2006) is defined as an “exploration of human emotion”, by gathering “emotional data” on a global scale, through the search of blog entries with occurrences of the phrases “I feel” and “I am feeling”. Another example is *Listening Post* (Rubin and Hansen 2001) that provides an audiovisual reading of online conversations in real-time, by collecting data from unrestricted blogs and forums, as a reflection on the “immediacy of virtual communication”.

![Fig. 2. We Feel Fine (Harris and Kamvar 2006) and Listening Post (Rubin and Hansen 2001).](image2)
Additionally, other projects use textual data as an abstraction, that is, as raw material, or as some kind of textual codification that can be used as input, regardless of its source or meaning. What these projects put to the fore is the malleability of text as digital data, and thus the computational processes applied to its manipulation, or the possibility of translating “anything” into “anything else” (Whitelaw 2008). An example of that is Spam Architecture (Dragulescu 2005) where patterns, keywords and rhythms found in junk mail are processed and translated into three-dimensional models allusive to architectural forms. Another example is ZNC Browser 2.0 (Luining 2003) that seeks to reveal the “arbitrariness of code” as a “conceptual piece” that automatically translates the html code of webpages into a sequence of sounds and colors, thus proposing an abstract “sonic browser”.

5.2 MECHANICS: DATA AND MAPPING PROCESSES

When we look at these systems from the point of view of their mechanics, we can distinguish different forms of data collection, kinds of input and their values, as well as different visualization and sonification methods or mapping processes.

Many of the projects analyzed rely on a fixed dataset as input that is inserted into the system by its author. This dataset is then explored as a whole, allowing the development of visual and/or auditory expressions that seek to reveal the complexity and inherent structure of the data, namely when spatially or temporally displayed. An example of that is Shakespeare Machine (Rubin and Hansen 2012) that pulls out “interesting speech patterns” that emerge from every Shakespearean play.
However, some projects, use a continuous data stream, whose values are changing in real time, or even chunks of information that gradually update the values. These streams or chunks are usually captured through computational processes and inserted into the system automatically, as in 1:1 (Jevbratt 1999-2002) that uses web crawlers to search for IP addresses, which are then stored in databases that are visualized through different interfaces.

5.3 SURFACE: SENSORY RESULTS AND EXPRESSION

The diversity of sensory modes of expression and formal aspects of representation that we see in these projects are tied to their different aesthetic intents and approaches to textual data as subject matter. We observed that many of these works use visualization methods, proposing a purely visual expression of data, while only a few examples use sound or sonification in addition to, or as a complement, to the visualization procedures. That is the case with Hard Data (DuBois 2009), in which the author seeks to re-contextualize “formal stochastic music in the context of real-world statistics”, while creating abstract audiovisual experiences based on data from the American military actions in Iraq. Among the projects analyzed, we also included one example of a physical rendering of data, that is, Weather Bracelet (Whitelaw 2009) in which the author creates a “wearable data-object” generated from daily weather data sourced from the Bureau of Meteorology.

In terms of formal aspects of representation and expression, it is not always evident what aspects or parts of the text are actually represented in the output, through the visualization or sonification process, being that many projects don’t even present textual information as output, and only a few present parts of the
source text. In *Shakespeare Machine* (Rubin and Hansen 2012), fragments of speech “appear, dissolve, and move like a choreographic dance”, according to an algorithm that sets rules for the combinations of words. In turn, *On the Origin of Species* (Fry 2009) presents the whole source text in the output.

Nevertheless, most of the projects analyzed approach structural aspects of the text, such as grammatical or morphological attributes as parameters that are mapped into graphic or audio features. Many of these projects resort to abstract elementary figures and sounds that, when combined, can reveal unexpected patterns or rhythms, or even complex configurations emerging from the data. For example, *Pure Data Read as Pure Data* (Maigret 2010) translates the source code of the application Pure Data into sounds and colored pixels, in order to promote a “physical experience of the digital data”.

### 5.4 BEHAVIOUR: DYNAMICS AND VARIABILITY

Adding to the mentioned formal aspects of expression, the source of data also influences the nature of the output and the dynamic behavior of the work, depending on whether the work is open or not to interaction with external input.

The use of a fixed dataset usually corresponds to a system that is closed to external input. As such, the output is an instance that the system generates each time it runs, resulting in either a static or a transient (non-variable) output that promotes a contemplative experience based on the formal or semantic qualities of the source data.

In this case, the output can be a static image resulting from a process of ‘filtering’, such as a selective “snapshot” of the final state of the work or of “accretions” of processes over time (Dorin et al. 2012, 247). For example, the project *Bible Cross-References* (Harrison 2008) presents a global view of the “textual cross references found in the Bible” through diagrams that “honor and reveal the complexity of the data”.

When the output is transient, as a time-based or animated sequence (usually in response to a time dependent dataset), the work privileges a perception of patterns emerging from the text or a way to “understand or follow its evolution over time” (Nualart-Vilaplana et al. 2014, 230). An example of that is *On the Origin of Species* (Fry 2009), whose animated visualization demonstrates the changes and additions of text over the successive editions of the book.

Conversely, a continuous data stream can be used to gradually determine output variations, providing an immediate perception of input fluctuations coming from external data sources or
processes. That is the case in *Listening Post* (Rubin and Hansen 2001) that culls information from online sources in real time. Also, in *We Feel Fine* (Harris and Kamvar 2006) we can see that the interface grows and changes as new updates in the blog entries are found.

In addition, when the user can explore or navigate different views, the experience of the output becomes varied, even if the system is not necessarily producing variable results while acting on the same input. For example, in *1:1* (Jevbratt 1999-2002) the user is allowed to navigate through the interface, being able to “query the (visualization) system and obtain a unique representation for each search” (Nualart-Vilaplana et al. 2014, 230).

### 6 DISCUSSION

According to these observations we can highlight what these projects share, as a creative exploration of textual data, and how they diverge, regarding their conceptual approaches to the source data, as well as the different aesthetic intents and kinds of experience they propose.

Based on our selection, we observed that projects that use literary works put an emphasis on form since these texts present a “high level of abstraction and little formal structure” (Nualart-Vilaplana et al. 2014, 228). The potential lack of regularity in terms of vocabulary or length of the texts and their subjective discourse structure, result in more creative freedom and expressive possibilities, since there are no given conventions or rules for representation.

The fixed nature of these texts is usually associated with a sequential analysis of the whole, that is, the visualization often follows the texts’ sequence or order. One exception is *Shakespeare Machine* (Rubin and Hansen 2012) in which parts of the text are selected according to different rules, and the reference to the original text sequence is then discarded.

The examples analyzed, however, seldom explore aspects inherent to the literary text by means of sonification processes. And this is something we consider worthy of further examination and exploration, given the mentioned high level of abstraction and formal structure of the text and their openness to subjective interpretation.

When the focus is on meaning, a wider scope of themes emerges, ranging from human social dynamics (e.g. virtual online communication, identity, or different kinds of statistics), to natural phenomena (e.g. meteorological data), or even to the density and complexity of the web structure. These projects tend to either
work with a fixed dataset or sequential updates of that data, presenting an indexical narrative of a reality, thus putting to the fore its latent, or even hidden, patterns.

Finally, the exploration of text as an abstraction is mostly related to an analysis of data as raw material, pertaining, for example, to web content or digital data that can be readily analyzed by computational means; it can be considered as it is and subjected to any kind of arbitrary mapping, hence emphasizing its “malleability” and “susceptibility to transformation” (Whitelaw 2008).

The dataset is thus detached from any given meaning and treated according to a subjective process or conceptual approach, being that the output does not necessarily point to a direct relationship with the source data. Since the nature of the source data does not determine or condition the mapping process, this kind of approach is more prone to involve sonification and audiovisual results.

7 CONCLUSION AND FUTURE WORK

The previous discussion also suggests that the aesthetic experience of these works is not merely focused on their sensory results, but on the understanding of the processes leading to the observable results. Accordingly, we can consider that “what we experience, even as static displays”, are the results of “software performances”, which give us not objects but instances or occasions for experience (Manovich 2013, 33). So we interpret these outputs as the products of processes. In this sense, these projects entail a process of “procedural interpretation” or an understanding of the work that often involves “mental simulations of the processes behind the surface” (Carvalhais and Cardoso 2015, 143-144).

According to this idea, we acknowledge the potential for a deeper examination of these forms of procedural interpretation, namely, through a refinement of the framework concerning the distinctive features of the experience of these artworks. This implies considering their dynamics and variability, and therefore, further discussion of what we consider to be the aesthetic artifact in question; the system and the outcomes it presents to the audience as instances or events. Consequently, when examining the dynamics of the work, it is important to consider both the variability of the system and the variability of the outputs, given that the aesthetic artifact can be considered both the software and its outcomes, as in 1:1 (Jevbratt 1999-2002).

Furthermore, an examination of a broader scope of systems that are open to interaction with external data or processes can
be of interest, in particular, considering human input, or audience interactive work as well as the possibilities that are given to the audience for accessing, influencing or determining variable outcomes.

Acknowledging the multiplicity of transmutability as a creative concept and practice, this study sought a deeper understanding of artistic approaches to textual data, highlighting their focus on form, content or abstraction. To this end, it described a set of aesthetic artifacts according to a framework focused on their themes and subject matter (concepts), their data and processes (mechanics) and their surface and dynamics (as the elements of their experience).

With this approach, this study sought to reveal the creative and expressive potential of transmutability and to emphasize its relevance as an artistic argument that comments on the growing amount of digital data that permeates our contemporary world.

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This paper outlines the design considerations for the creation of three interactive experiences about the AIDS Memorial Quilt — an extremely fragile work of U.S. cultural heritage. The AIDS Quilt Touch project is a complex media system that includes not only interactive experiences, but also nuanced socio-technical practices to engage audiences in viewing, searching, and annotating the AIDS Quilt.

Keywords
Interactive memorials
Large artwork display
Poetics of interactivity
AIDS Quilt

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1 VISUAL PROCESSING IN SERVICE OF CULTURAL HERITAGE

We began this project with a technocultural question: how might digital technologies augment the cultural significance of the AIDS Memorial Quilt? In 2013, Richard Kurin, a director at the Smithsonian Institutions, identified an AIDS Memorial Quilt panel as one of most significant 101 objects that defined the United States in the 20th century (Kurin 2013). Yet in 2006, U.S. newspaper headlines told a different story. On the occasion of the 25th anniversary of the AIDS epidemic, The Los Angeles Times announced: “The Quilt Fades into Obscurity.” Even though sections of the Quilt continue to circulate on a regular basis, public awareness, of the historical significance of this work of material cultural, is limited. The Quilt belongs to several intertwined histories (internationally as well as in the U.S.), including the history of art-based activism, the history of struggles for gay and lesbian rights, and the history of public health protests. Given that some of the first generation of panel makers are now entering their 80s and 90s, there is rising concern about the future of the development of the archive of Quilt stories. Our project was designed to address important questions as to how to archive and disseminate information about the Quilt. To do so, we created three interactive applications, each of which required the development of new approaches to visual processing, data display, and user experience design.

Fig. 1. “Arduino”, accessed December 28, 2015, https://www.arduino.cc/
Under the stewardship of the non-profit organization The NAMES Project Foundation (Atlanta, Georgia, USA), the Quilt now comprises 48,000 individual panels that commemorate more than 98,000 names (Fig. 1). This represents roughly 15% of the number of people who have died of HIV/AIDS in the U.S. The size of the Quilt is staggering. Each panel of the Quilt measures 3 feet by 6 feet; every panel is stitched into a 12-foot by 12-foot block (Fig. 2). If the Quilt were laid out for display it would cover more than 1.3 million square feet. If a person spent only 1 minute visiting each panel, it would take 33 days to view the Quilt in its entirety. The impact of the Quilt plays out at different scales; certainly its cultural significance is tied to its massive size, the quantity of names represented, and the spatial dimensions of its array. But its impact also plays out at the scale of individual panels, where the stories of tens of thousands of people—those who died and those who lovingly created the panels—are literally stitched into a historical material archive.

We created three digital applications, collectively called AIDS Quilt Touch (AQT), that enable viewers to interact with different kinds of information about the Quilt. Visitors can browse a Virtual Quilt, enter comments and reflections in a digital guest book, search for names, and read episodes about the development of the AIDS epidemic over time. These AQT experiences enact a “poetics of interactivity” designed to evoke an appreciation of the different scales of significance of the Quilt (Morse, 2003). Because the Quilt is a richly textured material artifact, our designs rely on the use of tactile modes of interactivity. Applications have been optimized for display on touch-enabled devices (interactive tabletops, large touch screens and mobile, hand-held devices) to provide an intimate, and body-based experience of viewing Quilt information.

Encountering the Quilt is always a moving experience. While Quilt blocks continue to serve as the focal point of community HIV/AIDS awareness events, the entire Quilt has been displayed only five times in its 35-year history. The first display took place in 1987 when the first 1,920 panels of the Quilt were laid out on the Mall of Washington—the expansive national public park that spans the grounds of the Lincoln Memorial to the United States Capital. This display was part of an historic event in the U.S.: the National March on Washington for Lesbian and Gay Rights. Subsequent displays of the Quilt unfolded on the Mall in 1988, 1992, and 1996; each time the Quilt tragically grew in size.

The most recent attempt to display the Quilt took place during the summer of 2012 when the Names Project Foundation sponsored a month-long event called Quilt in the Capital; during that
time the Quilt was also featured at the Smithsonian Institute’s annual Folk life Festival. Although sections of the Quilt were displayed indoors during that month, inclement weather prohibited the entire Quilt from being laid out on the Mall. What we now realize is that the textile Quilt will never be laid out in its entirety again.

Working in collaboration with the NAMES Project Foundation, Balsamo, MacDonald and a distributed team of research-designers from the University of Iowa and Brown University, created *AIDS Quilt Touch* a media-based suite of digital experiences to augment the circulation of information about the Quilt at the *Quilt in the Capital* events. The following objectives guided the design of these experiences:

1. Use appropriate technologies that enhance and augment the personal and embodied experience of viewing the Quilt;
2. Raise awareness about the stories of the Quilt panels;
3. Assist people in viewing a specific panel using location aware technologies on mobile devices;
4. Assist in the annotation of the Quilt through the creation of tags and the collection of additional descriptive materials;
5. Raise awareness about the archiving needs for the Quilt;
6. Communicate the cultural importance of this work of international cultural heritage;
7. Raise awareness about the contemporary status of AIDS in an international context;
8. Promote the Quilt as a living memorial.

The *AIDS Quilt Touch* project provides viewers with access to a digital archive of Quilt images as well as to stories about the creation of the Quilt and the rise of HIV/AIDS in the U.S. Like all memorials, the *AIDS Quilt Touch* interactives serve as the stage for the manifestation of a broad range of relationships among viewers and technologies. As a media system it includes elements that are simultaneously cultural and technological: material works as well as digital representations of Quilt panels, discursive descriptors (metadata tags) as well as textual accounts (stories, memories, recollections), and unique contributions from individual human agents (Quilt makers, activists, health care providers) as well as from social collectives (audiences, families). The media system also includes new practices and protocols, and emergent modes of interactivity.

Our challenge was this: how do we respect and maintain the cultures of the Quilt while developing a digital expression of its essential qualities. We began by asking how the intimacy of seeing the textile Quilt could be matched by digital applications. In designing these applications, we devised methods for visually representing Quilt data sets to enable new insights and the production of new knowledge. The design process drew insights

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1. Funding for this project was provided by grants from the Office of the Digital Humanities of the U.S. National Endowment of the Humanities: “Design of an Interactive Tabletop Device for Humanities Exhibitions.” Project Director: Anne Balsamo. The list of objectives and descriptions of interactive applications quoted from the project final report.
from the history of public art as well as the histories of public discourse about HIV/AIDS. As works of public art, these applications were created to evoke new perceptions through experiments with scale, mobility, and modes of human engagement in public spaces. As a mode of public communication, these public interactive experiences were designed to engage people in conversation about the intimate impact of the AIDS epidemic, the richness of lives lost, and the contemporary status of AIDS/HIV infection in the United States. Balsamo uses the term “public interactives” to name the mode of interactivity in public spaces that incorporates computationally enabled responsive surfaces to serve as the stage for spontaneous social encounters (Balsamo 2011). In creating these dynamic media experiences, we were especially interested in staging experiences to communicate with younger people who, having been born in the 1990s and 2000s, are growing up in a very different culture than that of the 1980s when the AIDS epidemic began. In this sense, the AIDS Quilt Touch experiences serve the broader cultural purpose to create a digital memorial and a contemporary context that can bridge generational interests.

2.1 INTERACTIVE EXPERIENCE #1: AIDS QUILT TOUCH
VIRTUAL QUILT BROWSER

The first experience focuses on one of the most compelling aspects of the Quilt: its spatial expansiveness. The AQT: Virtual Quilt Browser is an interactive browser that enables visitors to view, zoom, and pan across a collection of digital images of 48,000 Quilt panels displayed on a multi-touch table display. Collaboration with the Computer Visualization Research Team (led by Andy Van Dam) at Brown University resulted in the creation of a customized gesture-based interactive mode optimized for a large-surface multi-touch table display.²

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2. The Brown Team had already developed an application called LADS (Large Artwork Display on the Surface) that enables gesture-based interaction with large-scale art works. The AIDS Quilt project offered the Brown team an opportunity to work with a different kind and much larger work of art. Information about the LADS project can be found at: http://cs.brown.edu/research/lads/

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Fig. 2. Eight panels that became the first block of the AIDS Quilt. Photo in public domain available from http://www.aidsquilt.org/view-the-quilt/search-the-quilt
The digital representation of the Quilt—what we refer to as the Virtual Quilt—is comprised of 5,900 individual digital images; each image depicts one Quilt block that measures 12 x 12 feet. The size of the image file of the Virtual Quilt is 28 billion pixels. Viewers are able to browse the Virtual Quilt from different viewing perspectives, ranging from a bird’s eye view of the entire quilt (as if seen from the height of the top of the Washington Monument) to a close-up view of a single panel (Fig. 3). In research on mobile viewing experiences of visual data, one of the qualities that has been determined to contribute to a rewarding experience is the ability to zoom between levels of detail: to toggle between a focal area and a view of the context of an image (Allessandro, Dunser and Schmalstieg 2010). By allowing for multiple viewing “distances,” the AQT: Virtual Quilt Browser encourages users to engage with the scale of the Quilt, and to move from a consideration of its immensity and spatialized expanse, to a meditation on the affective details stitched into individual panels.

The physical size of the table (three feet by four feet), and its horizontal orientation enables multiple people to collaboratively browse the Virtual Quilt and interact with the image in a physical way through the use of touch. This mode of interactivity re-embodies the experience of exploring a digital archive to make it social and communal. Studies suggest that the use of horizontal displays is particularly effective in supporting the collaborative viewing of visual data (Back et al. 2001; Harrison, Minneman, and Balsamo 2001; Chiu et al. 2008; Tuddenham, Davies, Robinson 2009). Horizontal tabletop displays have been also effective in enhancing collaborative storytelling in public spaces.3

3. In the early 2000s, Balsamo and MacDonald, with colleagues at Xerox PARC, were involved in research efforts to develop the Tilty Table, an interactive museum exhibit created as part of “XFR: eXperiments in the Future of Reading.” This work represented a significant step towards the development of the AQT: Virtual Browser. For a description of the creation of the XFR exhibit, see: Balsamo, Designing Culture: The Technological Imagination at Work. Duke University Press, 2011. Other research that supports the observation that horizontal displays enables collaboration include: Rogers and Rodden, 2004; Mazalek, et. al., 2009.
In presenting a close-up view of individual panels, the use of the touch table showcases the media rich texture of panels. Many panels include photographs and other memorabilia. By enabling people to browse and read individual panels, the application promotes social engagement among multiple users who often collaborate on reading individual panels.

HCI researchers make the important point that tabletop computational surfaces actually involve both “interactive” user experiences and “non-interactive” experiences—where people gathered around a surface watch and view other people’s actions (O’Hara 2010). During the time that the AQT interactives were installed as part of the Quilt in the Capital events, we noted the emergence of an emergent “non-interacting” user behavior. These visitors sought to annotate their experience of viewing the Virtual Quilt by taking photographs of the digital images displayed on the tabletop (Fig. 4). Like creating a rubbing of an etching on a memorial wall or gravestone, photographing the digital image of a Quilt panel functioned as an emblem of witnessing. The desire, on the part of members of the public, to capture the act of “digital witnessing” is one of the unexpected outcomes we watched happen time and again.

2.2 INTERACTIVE #2: AIDS QUILT TOUCH TIMELINE

A second digital experience, the AIDS Quilt Touch: Timeline, takes the form of an interactive timeline of the histories of AIDS and of the AIDS Quilt. To create this public interactive, the team collaborated with researchers who had created a beta version of a crowd-sourcing timeline creation application called Chrono-Zoom. Displayed on a large touch display, the timeline enables visitors to browse a visual record of key events marking the 35-year history of the AIDS pandemic and the 30-year history of the creation of the AIDS Quilt (Fig. 5).
The AQT: Timeline was designed to inspire people to engage in conversations about the broader social, political, and bio-medical events that are part of the multi-faceted history of AIDS and the Quilt in the U.S. In creating interactive content, we took account of the cultural critiques of the way in which AIDS and the understanding of HIV have been narrativized in the “official histories” of the epidemic. Many scholars and activists contest these histories for the pejorative bias that sneaks into descriptions and accounts. For example, the persistent reference to people who are infected with HIV as “AIDS victims” propagates identities that are not consonant with those promoted by activists and people living with HIV. The term “victim” implies a state of powerlessness. Drawing on the history of AIDS activism, this application presents key episodes that highlighted critical acts of social intervention—when, for example, activists confronted government officials and protested official policies. The interactive makes it possible to present multiple histories—both those that serve as official accounts and those that serve as counter-narratives.

2.3 INTERACTIVE #3: AIDS QUILT TOUCH RESPONSIVE WEB APP

The third interactive experience was developed by a team from the University of Iowa’s Digital Studio for Public Arts & Humanities under the direction of Jon Winet. The team created a mobile web application called AIDS Quilt Touch: Responsive Web App that enables viewers (1) to search for a specific Quilt panel and view it in high resolution; (2) contribute commemorations and reflections to a digital guest book; and (3) locate the display of a specific panel when it was to be displayed on the National Mall (Fig. 6). Built using open-source tools, the app makes use of the most advanced protocols of responsive web design (RWD) to provide a platform-neutral viewing experience that enables users to navigate information with minimal efforts of resizing or scrolling of web pages. The AIDS Quilt Touch app resulted in the creation of an open-source platform that enables the dissemination, co-creation, and preservation of an extensive digital archive of Quilt materials.
Beyond the evident concern for preservation, the primary benefit of the creation of these digital experiences is that they offer opportunities for increased accessibility and visibility of the AIDS Quilt as a living memorial. Given the sheer size of the Quilt and the logistical difficulties associated with displaying it, the AIDS Quilt is difficult to keep in the public eye. Online, global, multi-platform access can help keep the Quilt visible. The applications produce a kinesthetic intimacy with images of the Quilt. As the most broadly accessible experience, the *AQT app* introduces a new mode of annotating the Quilt, by allowing, via the online text-based submission system, for user-generated personal contributions. Enabling users to participate in the process of annotation addresses the public/private dynamic that is at the heart of the Quilt's commemorative and affective powers; these contributions add new layers of cultural significance to the Quilt archive.

Designing the *AQT* digital experiences raises methodological questions about working with large visual data sets. Our original aim was to computationally process the visual dataset of block images in order to identify cultural patterns that would extend our understanding of the significance of the Quilt. Through various experiments we determined that size and quality of the visual material is not amenable to algorithmic computer visual processing: images of individual panels are too indistinct and irregular to detect via computational processes. We determined that it would be more efficient to engage people to do this visual processing. To this end, MacDonald created a “community

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**Fig. 6.** AIDS Quilt Touch mobile web app launches. Photograph by author.
sourcing” application that enables viewers to assist in the identification of each block layout. In this application, users were asked to determine the location of a panel within a block image by clicking on the box closest to the center of each panel, which recorded the position of that panel within a block. In very little time, through the participation of a small community of coders, the original visual dataset has been annotated with the location of every panel on each of 5,900 blocks.5

The next phase of development will involve the creation of new “community sourcing” techniques to obtain information about materials, colors, symbols and text that appear on individual Quilt panels. We are designing strategies of public engagement through the creation of incentives and opportunities for “civic archiving.” To engage panel makers, we have designed an application called AQT: Story Making Studio that easily enables them to record and upload media-rich contributions and stories about individual panels. The aim is to motivate members of an important “community of interest” to engage as a “community of participants” in archiving the Quilt. We seek to connect our current cultural moment with a cultural formation created in a different era. We remain humbled by the challenges of honoring the cultures of the Quilt, in light of the intransigence of code and programming environments, and the unique quality of these digital datasets. The intended outcome of this project is the creation of a digital memorial where the panels in their physical and virtual expression—and the heartfelt emotions embedded in each stitch—remain legible to all.

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Internet criminals create fake websites that mimic real websites and use them for advance fee fraud or other criminal activities. Over the last ten years members of the vigilante scambaiting community “Artists against 419” maintain the biggest open-access database of fake websites. They use “passive reconnaissance” and “open source intelligence” (osit) tools to gather information to file reports with the hosting provider to get the websites taken off the web. This chapter takes a closer look at the group’s strategies and explains the artistic research installation called “Megacorp.” that visualises a sample probe of 1000 websites from the database collection.
1 INTRODUCTION

In recent years the web has been increasingly used for end-user e-commerce to buy goods and services: flights and holiday recreation, music and film streaming (entertainment), ordering food and daily groceries for home delivery. The number of fake websites is increasing and scammers use them to present a trustworthy and professional appearance to trick people. It is easy for non-tech savvy people to design a website by using open-source Content Management Systems (CMSs) or freely available web design templates. They register Top Level Domains that use wording similar to that of the original companies. Often, clones of real websites are created by scraping real companies’ websites, and then the fake login pages are used in phishing attacks. There are programs that report phishing incidents automatically, but they still rely on reports of phishing incidents from users. (Husak and Cegan, 2014) Vigilante online communities of scambaiters try to identify, block and report Internet crime activities. For this they have developed various strategies, ranging from creating warning platforms to collecting fake checks or blocking bank accounts, and organise themselves in different forums. One of these subgroups call themselves “Artists against 419” and host the biggest open-access database of fake websites. (Zingerle and Kronman, 2013b) As of May 2016, there are over 4800 registered users and an average of thirty-five websites are added to the database each day. They use “passive reconnaissance” and “open source intelligence” (osint) tools to gather information to file reports with the hosting provider to get the websites taken off the web. Since 2007, the group members discontinued using web programs such as “Lad Vampire” or “Muguito” to run “Denial of Service” attacks against the websites and instead now use their own tools and written reports to maintain a good relationship with hosting providers and law enforcement. (Cain 2004, Brenner 2007)

2 OPEN SOURCE INTELLIGENCE TOOLS

Scambaiters use various vernacular tools and social engineering techniques in order to run background checks on suspicious business websites. Open source intelligence (osint) refers to intelligence that has been derived from publicly available sources both on- and offline. In this paper, I want to cover the most popular tools for finding fake websites. These tools are used in ethical passive reconnaissance to gather as much information about the target as possible. (Bansal and Arora 2012) In this version of passive reconnaissance, activists and hacktivists
seek to gain information that will support their political causes or other such ethical motivations. Law enforcement officials may also use passive reconnaissance as part of a criminal investigation. Ethical or not, passive reconnaissance is always done without the authorisation of the person or organisation that is being targeted. (Glassman and Kang 2012) This leads to an effective combination of classical social engineering attacks on the target, which in turn can be used to harvest more information. The chapter concludes with the collection of the information and filing a report that is then sent to the registrar, hosting provider and other warning institutions. The following chapter was the hands-on part of a workshop called “Credible Fictions-Deceptive Realities”. In the workshop the “Megacorp.” installation served as a point of departure to further investigate Internet activism, fake websites and osint-tools. The online tools were presented to the group of participants, and information was gathered and discussed amongst the participants using the collaborative writing tool “piratepad”. As an example website I want to focus on start-office.biz. According to their website, start-office.biz is an international company specialising in organising virtual offices. They are located at the Wienerberg Twin Towers in Vienna, Austria, and currently offer jobs to local agents who should “provide relevant information online for direct clients and other relevant stakeholders through popular social networking sites”. In the following chapters, we will use the osint tools to analyse the website and raise the suspicion that the website is not legitimate. One browser-addon that merges a lot of the tools discussed here is called “Passive recon”. The Firefox extension adds a right-click menu option called “Passive Recon”, which opens a menu with a lot of possibilities. Around fifteen different options are available with the possibility of querying all databases at once. The queries are divided into groups, for example “DNS lookups”, “whois and domain lookups”, Netcraft Site reports, “Google queries” and “Email server mx record lookups”.

2.1 LOOK AND FEEL

Every website is designed differently. Over the years certain trends in usability set standards for web designers. You can always ask yourself how coherent the web design is. Does a photo with the company logo have a pixelated poor quality, whereas all other photos are crisp and sharp? Does the logo look badly manipulated into an image? On the front page of our example website we see the dark black logo of start-office.biz. Font type and size of the logo look misplaced and don’t fit the overall dominant grey and dark blue colour combination. In one of the header
images the logo is clearly squeezed into the image. The company's headquarters are supposedly located in Vienna, Austria. The website claims to operate on a global scale and runs hundreds of offices in the USA and Canada. The page language is English, and no German translation is available. On the “testimonials” page we find a review from a person called “Michel” from France, who refers positively to a different company:

“Sunex's virtual office allows me to service these clients from anywhere in the world, while maintaining a presence in Texas.”

So it seems that this review was copied from another website and the company's name was not changed. The “career” page offers an application form to apply for a “local agent” position. The salary is stated in USD and is paid on a weekly basis, which is also a very uncommon practice in Austria.

### 2.2 DOMAIN NAME

Check the Domain name where you enter the site. If you click a link, the clicked text and the hyper-link that opens in a browser can be two different websites. That way, closely similar characters (e.g. i, l and number 1) can lead customers to fraudulent websites. “Wrong key typos” or “QWERTY typos” can occur when the user hits the wrong key that is near the intended key on the keyboard, e.g. “voding” instead of “coding”. One can easily miss, transpose or double a character when typing on the keyboard. In our example the domain name is written correctly. A random sampling of over 105 million web pages revealed that 70% of .biz-domain pages analysed were fake. (Bansal and Arora 2012)

<table>
<thead>
<tr>
<th>Original website</th>
<th>Bankaustria.at</th>
<th>Amazon.com</th>
<th>Facebook.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look-alike chars</td>
<td>Bankaustrla.at</td>
<td>Amason.com</td>
<td>Facebo0k.com</td>
</tr>
<tr>
<td>Wrong key</td>
<td>Bankausgria.at</td>
<td>Amaz0n.com</td>
<td>Fadebook.com</td>
</tr>
<tr>
<td>Missed key</td>
<td>Bankastria.at</td>
<td>Amazon.com</td>
<td>Facbook.com</td>
</tr>
<tr>
<td>Transpose key</td>
<td>Bankasutria.at</td>
<td>Amzaon.com</td>
<td>Faceboook.com</td>
</tr>
<tr>
<td>Double a character</td>
<td>Bankaaustria.at</td>
<td>Amazoon.com</td>
<td>Faceboook.com</td>
</tr>
</tbody>
</table>

### 2.3 SECURE SOCKET LAYER (SSL)

Websites where you have to create a profile, login to your account or pay with a credit card offer additional security with an SSL encryption of your provided information. Internet scammers will not pay extra for this service in order to defraud you. In our
example the website does not offer a profile page or a login, so
the use of https to secure the customer's data is not necessarily
needed. Often, scammers include the logos of SSL Certification
companies like Verisign, TRUSTe or Thawte.

2.4 CROSSLINKS

You can check how many other websites link to your targeted
website. In search engines like Duck Duck Go or Waybackma-
chine, type “link: www.start-office.biz” or use online search tools
like backlinkwatch to figure out how many websites link to your
website in question. Neither of these tools report any backlinks.
It is not a criminal act to not have any websites linking to your
website, still it looks suspicious when a page claims to be a global
player, but no customers link.

2.5 CONTACT INFORMATION

Every page needs a possibility for contacting the website owner.
Is the contact email the same as the domain name or is it a free-
to-use webmail service? Is the postal address a valid address?
This can easily be checked through online streetmap services.
Phone numbers can also be checked to see whether the area code
belongs to a local number or if it is part of a call forwarding pro-
gram. What happens when you call the number? Is the line in
use during office hours? In our example the companies address
is the Twin Towers in Vienna, although it does not provide a floor
number. The phone number has the correct country code “+43”
for Austria and “1” as a city code for Vienna. A quick search in
the local online telephone database ensures that the telephone
number is registered at the state telecommunication company
A1, but there is no name entry to be found. There are two email
addresses on the website: support(at)start-office.biz and hr(at)
start-office.biz. An alter ego personality contacted both address-
es and claimed to be looking for a job in Vienna. A person called
Thomas Anderson replied as a representative of the company,
sent me his Skype account details and three pdfs that I should
read through, fill out and return in time. The three documents
included an application for employment, a confidentiality agree-
ment and a job offer signed by a Michael Adams, Director of
Start-Office.biz. By using an IP tracker it is possible to analyse the
email header and determine the IP address from where the email
was sent. In the case of the email from Michael Adams, the email
provider is Telmex Colombia S.a. in Barranquilla, Colombia. A
NSA report identifies eleven main types of hidden data, metada-
ta, and embedded content that may be found in PDF files. (Kaul-
Most of the meta-data was swiped when the pdf was created with the online tool “go4convert.com”, just the creation date was left and from that we can see that the internal clock was set to “Central European Summer Time” (CEST). So the files have been sanitised and no metadata was found.

2.6 IMPRINT

Depending on in which country the company operates in, a trade registry number, VAT number, company address and other legal metadata and terms of use have to be published as a “Site notice”, “Legal notice” or “Legal disclosure”. This information can be double checked on pages like VIES/VAT number validation from the EU Commission\(^1\) or the BBB-Better Business Bureau.\(^2\) According to E-Commerce law, Austrian companies operating commercially must have a legal notice on their webpage. In the contact section there is no legal notice or VAT number published.

2.7 DOMAIN WHOIS

WHOIS\(^3\) stands for “Who is?” and is a web-utility used to look up information on domain names, contact information as well as some technical information such as the domains name servers (DNS). Every domain owner has to provide valid contact information. This is part of the registration agreement and providing false information can result in your domain name being deleted, although some types of domains do allow you to have placeholder information for another company as the domain owner. By doing a whois look-up on a targeted domain, you can see when a domain was registered, updated and how long this registration is valid. Scammers often use the minimum timeframe of one year to register their domain, since they are sure to operate for only a few months and then open another domain. Further important information one can gather is the hosting provider’s name and contact information. It is also possible to track down inconsistencies, e.g. different addresses or website owner other than what is stated on the website. In our example the registrant contact is a Mr. Fred Bohnsack, living in 2775 Holdom Avenue in Surrey, B.C., Canada. The website is hosted with hostgator.com and is registered for one year.

2.8 REVERSE IP LOOKUP

Using a reverse IP Address lookup tool\(^4\) it is possible to gain more insight about all the different websites and domains hosted on that IP-address. Often scammers run several websites at once

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and it is just easier, cheaper and more convenient to host them under the same provider. This way, it is often possible to observe the working methods of a group of scammers who operate several websites at once.

2.9 HTML CODE AND TEXT ANALYSER

Scammers often reuse their website templates. Once their websites are taken off the Internet, they make small changes e.g. the business name, address, the logo or in the written text, and then they register a different domain and upload the site again. To be able to more quickly track the website once it re-surfaces, anti-scam activists use online services like “Talkwater alerts” and “Google alerts”. With these services one can search for certain keywords or phrases and get instant alert messages when the website is indexed. Activists specialise in certain businesses and build up alert clusters. When we look into the HTML code we find a reference that the website was “mirrored from sunexsolutions.com/ by HTTrack Website Copier/3.x [XR&CO'2013], Sat, 11 Oct 2014 06:46:46 GMT”. That way we know that the website “start-office.biz” is a clone from “sunexsolutions.com”. Another toolset that can be used to track copied content on the web are online plagiarism detection services like “citeliner” or “copy-scape”. Once you copy/paste phrases of the websites text into the searchbox, the services use the Google API to return websites that use the same or similar text. The matching text areas are highlighted.

3 FILE A REPORT TO THE HOSTING PROVIDER

In the previous chapter we discussed various different online tools for gathering background information about a website. Now it is time to bring the information together and file a “Terms of Service (TOS) and Acceptable Use Policy (AUP) Violation” report. This report is sent to “Hostgator”, the hosting provider of the website. First, the website was reported on the AA419 forum with a copy of the whois registry and the links to the copied websites. A moderator of the forum checked it and added it to the database. Then it was possible to file a report email and sent it to the hosting provider, asking the abuse team to double check our suspicion and delete the website. Another possibility for sending a warning to an Austrian institution is the “Watchlist Internet”, where it is possible to file a report online.
Subject line: TOS/AUP Violation start-office.biz

Dear HOSTGATOR abuse team:

The following domain is hosted on your servers or is within your IP block. Please investigate and suspend this fraudulent domain: Website: start-office.biz, IP: 192.254.186.125.

THIS SITE IS FRAUDULENT FOR THE FOLLOWING REASONS:

+ Site is listed in Artists Against 419's database of fraudulent websites: http://db.aa419.org/fakebanksview.php?key=106062

+ The listed telephone number does not exist.

+ The address listed for the site is false. The address listed belongs to another business or does not house any business named “start-office”. Twin Tower, Wienerbergstrasse 11, 1100 Wien, Austria t

+ The WHOIS registration does not appear to be affiliated with the site, or with a domain registration company. The contact details are likely fake: (copy whois link)

+ Site is being used in a job scam, also known as a “check” or “money mule” scam.

Check the “job description” listed on the suspected site. I am sending a copy of this message to fakebanks@aa419.org, which retains copies of all such abuse letters. If you feel more information is needed before you can proceed with closing this domain, please feel free to contact me under the email address xyz@gmail.com.

4 THE MEGACORP BUSINESS CONGLOMERATE

The research into the scam baiting community “Artists against 419” led to a deeper investigation of how this community tracks fake business websites and reports them. We wanted to visualise the database, so our idea was to look at all these fake companies as though they were one big evil corporate conglomerate that wants to take over the world. This so-called “Megacorp.” is inspired by
its equally powerful counterparts in science fiction. The term was coined by William Gibson and inspired many other authors of the dystopian cyberpunk science fiction genre to create megacorps in their fiction, amongst others the Tyrell corp. (Do Androids dream of Electric sheep), Encom corp. (Tron), Weyland-Yutani (Alien series), Cyberdyne skynet systems (Terminator).

The artwork is based on a collection of 1000 fake websites scraped from the Internet. “Megacorp.” serves as an umbrella company that tries to visualise the overall business segments and countries where these fake businesses are present. An interim report was published for the exhibition, where visitors had an opportunity to browse locally through the network of fake websites. Additionally a corporate presentation video and a location reconnaissance video reflect both the imaginary and the real world outreach of the “Megacorp.” In the following I describe the processes of gathering and analysing data and finding a language to visualise the dataset thus created.

3.1 DATA GATHERING

The data gathering process took several months, from September 2014 to April 2015. We visited the “AA419” database on a daily basis and automatically downloaded websites using a site scraping tool. The scraped websites were analysed and categorised according to business segment, street address, colours used, registered city and country. Once 1000 companies were gathered, we grouped them initially in twenty business segments, which we later reduced to ten, since we figured out that e.g. companies in transportation, courier and logistics are are similar enough to be grouped together. When analysing the different cities and countries, we focused on the top eight countries and correlated them with the top five cities (Fig. 1).

![Fig. 1. All business segments and visualisation by continent.](image)
3.2 DATA VISUALISATION

To visualise the gathered data and to tell a compelling narrative about the fake business conglomerate, we decided to reenact a business corporate presentation in the form of a fair booth (Fig. 2). To achieve this we highlighted the main parts of the data visualisations on roll-up posters and created a corporate image show-reel (Fig. 4) that gives a fast overview of the main business segments and the global outreach. Since we created the Megacorp. within a year we decided to present all the gathered material in the form of an interim report (Fig. 3), a financial report that is usually used to cover a period of less than a year that is not typically audited. In the installation we also presented a local website where visitors can browse through the acquired companies alphabetically, sorted by country and by business segment. Another video (Fig. 4) showed some of the companies’ websites and our attempt at physical reconnaissance, when we visited the addresses where the companies claimed to have their headquarters and see what kind of company is actually registered there. During the “Credible Fictions - Deceptive Realities” workshop we extended this video through a virtual reconnaissance of companies addresses through the workshop participants, who mainly used Open Street Map, Google maps and local company registrars to figure out which companies are registered at a certain address. The collected screen-shots were added to the existing video, and so one outcome of the workshop became part of the exhibited installation.

Fig. 2. The ‘Megacorp.’ installation setup represents a business fair booth.
5 RELATED WORK

The culture jamming artist duo “The Yes-Men” initiate campaigns and actions to raise awareness about what they consider problematic social and political issues. One of their mottoes is that “lies can expose the truth”. Since 1999 they have created fake websites that mimic global corporations like Monsanto, General Electric or Apple or organisations like the World Economic Forum or U.S. Chamber of Commerce. On the websites “The Yes-Lab” they published fake news reports, bogus press-releases and invitations to fake press conferences.

For over ten years, from 2005 to 2015 Nicholas Feltron published a yearly report of himself trying to quantify his daily actions and behaviour. Each year he tried different approaches to
give very intimate perspectives into his daily life: which places he travelled to, how many steps he took, what he ate, who he talked to, how many photos he took, to what he drank. He tried several different devices that helped him track his activities, and he even designed his own iPhone app called Reporter. Nowadays Felton works at Facebook and was lead designer in the development of the Facebook timeline. (Wilson 2015)

The artist duo Jodi exhibited L.V.Y. at linkcabinet.eu in Oct 2015. The work features three mistyped top domains “LinhedIn.com”, “Vodacone.com” and “YouTuhb.com” and “reveal the double intent to mimic one of the most common glithc (sic!) that occur while using a keyboard, while at the same time trying to exploit it to reach a chance audience”.

The hacker “Amped Attacks” specializes in distributed denial-of-service (DDoS) attacks targeting Islamic State websites and white power supporters. “Amped Attacks” uses #tangodown in his tweets’, a hashtag commonly used by the Anonymous hacktivist group to report websites they have taken down. The name “tangodown” refers to a term used by the US Special Forces to describe an eliminated enemy during a firefight. (Protalinski 2015)

6 CONCLUSIONS

In this paper I analysed the scambaiting community “Artists against 419” and their use of open source intelligence tools to report and shut down fake business websites. In a workshop setting we used an example website to test these out and file a report with the hosting provider to get the website taken off their servers. The artistic research lead to the creation of the artwork “Megacorp.”, that serves as a business conglomerate and visualises a sample probe of 1000 fake business websites. The visualisation shows that most of the websites we found are located in the UK (220), USA (163) and UAE (35), whereas 220 companies do not indicate a direct address. A lot of websites resurface again once they are deleted, so they can be found by using “plagiarism checkers” and “text alert services”. To track down and report several fake businesses the activists use reverse IP-lookup, so completely new and unknown websites can be added to the database. In future workshops we plan to use the Megacorp. repository to further explore strategies to uncover and report clones and copies of fake business websites.

Acknowledgements. The “Megacorp.” installation was developed for the Steirischer Herbst 2015 and was exhibited at the “esc—medien kunst gallerie” in Graz (Austria) as part of the exhibition “What remains—Strategies of saving and deleting” curated by Reni Hofmüller.
REFERENCES


This paper seeks to explore how FM radio technology can combine with social and phenomenological interactions to mediate, hybridise and perform a given physical site. Methodologically we propose a novel experimental methodology of creative writing workshops incorporating FM transmitters to stage those interactions. We argue that this workshop may be understood as an act of collective making, exploration and reflection offering a rewarding way to explore and enrich socio-technical ontologies and experiences. Our findings highlight spatial interactions of radio signals with physical and social elements of site as well as participants’ self-identification with technological objects.
INTRODUCTION

We have come to understand technology beyond its manifestation as technical artefacts but rather as complex socio-technical entities that are embedded and co-evolve with social practices and activities. Generally speaking, technology is embedded in organised social activities, such as work, entertainment, communication and so on. Each of these social contexts provides a ‘stage’ for the technology to be used while the technology also shapes these contexts (Williams and Edge 1996) and performs our understanding of them.

In regards to technologies which express location, and more specifically, the social context of technology, use is deeply intertwined with the physical and material aspects that determine location. Mobile technologies, for example, in their capacity as locative technologies, are most commonly understood as connectors of distant places. However, we are also familiar with how they intervene in our social relationships and help shape the places we inhabit, through navigation, location-tailored advertising and geotagging on social media.

Location, then, which we conceptualise in this paper as ‘sites’, is not limited to our physical surroundings, but also exists through our social relationships and interactions as they are mediated by locative technologies and also as experienced in person.

In our effort to define and understand locative technologies, we argue in this paper that the focus should not be on studying technology simply as a mediator of physical location (connector) but rather on exploring the sheer breadth of possible and complex ways in which locative technology can interact with and create sites. We understand this complexity as existing across both the semantic content associated with site, and the particular material and infrastructural affordances of the operation of a given technology within a site.

Within this dual semantic and infrastructural framework, radio has the potential to operate as a locative technology. For example, we may understand the cultural soundscape of a given city through the content we can hear on a car radio as we drive. In London different local radio signals can be heard in different parts of the city, giving each area its own particular sonic identity. Radio has the potential to provide more localised understandings of spaces when placed within a deliberately short transmitter range. Here a radio transmitter can act as a beacon tied to a particular point within a set physical topography. At this point radio moves away from being a form of mass media with blanket coverage and begins to echo the specificity of more recent locative technologies.
Within this paper we approach radio through the creation of such a system of short-range transmitter nodes. The system is explored through a walking exercise where participants move through the radio field while holding FM radio receivers. The participants of the walk were also involved in authoring the transmitted content and choosing the position of the transmitters. The data which forms the outcome of this project comes from the participants’ reflective group discussion.

The paper begins with a brief overview of the links which have been drawn between locative media and theories of performativity. This is followed by a justification of the use of the term ‘site’ over ‘space’ or ‘place’. We then explain the workshop structure, placing it in a methodological context with similar practice-driven approaches. Finally, we present an account of the focus group discussion and our analysis.

**LOCATIVE PERFORMATIVITY AND SITE**

Considerable work has been done on the relationship between geographic points and their wider meanings in smartphone-driven locative media. Here, location has been understood as the bare bones of a place, with meaning being hung dynamically on a set of co-ordinates by location aware interfaces (de Souza e Silva and Frith 2014, Timeto 2015). In this way the media relevant to a particular location does not represent it, but rather constructs or performs it. It does this both through its deployment at the place in question and through its connections across a network. In practical terms, we often understand a given place through the semantic content attached to it, be that the user’s position on a map, nearby yelp reviews, geo-located instagram posts, or the availability of uber drivers. Through establishing transmitter nodes with a limited range, radio can offer similar performative affordances. The media transmitted from a particular location could be understood to be creating meanings and identities connected to that point in space.

It has been argued that performances can take place as linguistic acts, where saying something makes it so. This mode of performativity was famously suggested by J. L. Austin (1962). A key example used by Austin was the point in a marriage ceremony where the priest pronounces the couple to be married. Performance can also be understood to take place at a deeper level, born out of and activated across social, cultural and political conditions (Bourdieu 1991). This more structural notion of performativity realises complex interactions with the sited contexts in which an action takes place. For example, in a park on a summer’s day a group of people are sitting together having a
picnic. They may or may not be drinking alcohol depending on whether the laws which govern the park allow outdoor drinking (and their own readiness to contravene those laws). The park’s existence may be the result of a combination of the decline of a previous use of the site (such as a docks or a canal) and the institutional decisions which allowed for the park to be constructed. When understood this way, the act of having a picnic with friends becomes a performance of a series of social, legal, physical and political contexts. When added to the mix, technology has the ability to emphasise, contravene, hybridise and re-assemble these contexts, altering the performances which make up the site.

How we conceive of site also requires considerable unpacking. The fields of geography, sociology, architecture and cultural studies all have extensive, complementary and contradictory literatures devoted to the relationship between space and place. We have chosen to use the term site here, primarily because of its connections to site-specific art. Although practices within this field vary wildly, a site-specific piece of work will often refer to particular histories, contexts and affordances relevant to a set of locations. There is also some overlap here with the discipline of archaeology. As Galloway and Ward point out, “In archaeology as with locative media nothing is considered more important than context” (2006). What is shared is how one situates and understands the site. However, contexts need not be understood as given and contained entities lying out there waiting to be discovered. Research continually creates and defines contexts according to the interests of researchers and what values they want to extract from the work (Dilley1999, Goodwin and Duranti 1993). Science, Technology and Society scholars may understand concepts as technology, sociality, context and site as fundamentally unstable and constantly emerging across a network of interactions (Law 2004, Law and Urry 2005).

In this project our object of inquiry was the interplay between physical, social and transmission contexts. These foregrounded contexts (which could also be understood as sites in themselves) are in turn constructed from a rich and fluid layer of institutional, economic cultural and historical contexts, which are constantly altering each other.

The richness and fluidity of this understanding of site is reflected in the nature of radio space. At any one time we are surrounded by multiple electromagnetic signals both naturally occurring and emerging from communications infrastructure. Late 19th century radio pioneers such as Sir William Crookes understood radio as an etheric realm of communication between hidden voices without bodies. In this realm even speaking to the
dead might be possible (Peters 1999, 104–105). More recently Anthony Dunne has spoke of using design to rediscover some of the rich metaphoric possibilities around the electromagnetic realm, calling for objects that explore “the links between the material and immaterial that lead to new aesthetic possibilities for life in an electromagnetic environment” (2008, 80). This etheric richness can be easily produced by the listener through the simple act of tuning through a radio dial looking for a given signal and coming across unstable static, snatches of voices and fragments of music. The affective power offered by radio in this way gives it particular affordances which may be lost on other forms of locative media.

**MOTIVATION AND STRUCTURE OF THE WORKSHOP**

Dial Stories was a one day workshop hosted at X Marks the Bokship / Matt’s Gallery in London in June 2015. The gallery approached us to do this project because of an ongoing collaborative relationship with the curators. The use of an open call was decided in collaboration and stemmed to some extent from their desire to produce work which could help build a community of interest in their programme. While this aspect of the process meant giving up some control over the research process, we understood Dial Stories as being at once a form of research and an artistic exploration of site. The positioning of the project in collaboration with the gallery was therefore important. Eight participants answered an open call via the gallery mailing list. The majority of them were artists from various disciplines (sound, sculpture, performance) alongside two researchers and one writer. Around half of the participants were familiar with the area surrounding the gallery, with two walking through it on a daily basis. Despite the lack of control in selection, this sample group proved useful because of their academic and professional training in thinking reflexively about site and performance. The site in question was Mile End park which lies next to the gallery. The park was chosen because it allowed a particularly rich social environment in which to stage the project. The presence of people not initiated into the workshop allowed potential for complex and surprising interactions as well as a sense of implicit performance.

The day began with a walk around the park to allow participants to explore the site. The group were split into pairs with one person tasked with showing the other a location they had found interesting. Each participant then wrote a piece of freeform creative writing in response to the location they had been shown.
This step allowed the writing to be a social as well as a phenomenological interaction with the site. The writing was then spoken, recorded and uploaded to a collection of short range FM transmitters built from modified Raspberry Pis. The Pis were modified before rather than as part of the workshop because of time constraints. The participants then each took their transmitter (all transmitters were set to the same frequency) containing their speech and placed it at a location within the park. Once the transmitters were in place, the group conducted a walking exercise with handheld FM radio receivers, moving around the park in a loose formation from transmitter to transmitter. The radio sound was amplified from the radio receivers via the built in speakers and was audible to the other people sat out in the park. The day ended with a half hour long group discussion about the workshop and performance. The data and analysis in this paper is primarily taken from that group discussion.

We gave the participants some constraints over where in the park to put the transmitters because of transmitter strength (60-80 metres broadcast range). By giving control over the placement of transmitters to participants within this area, we aimed to involve them in the structural composition of the radio space as well as the production of spoken content. Likewise, by using a group discussion to reflect on the process and collect data, we hoped that the group interactions that had driven the day's activities would continue, allowing group reflection and production of meaning.

**THE WORKSHOP AS A METHODOLOGICAL TOOL**

In this workshop, we intended to produce something approaching a reflexive hybrid ecology (Licoppe and Inada 2012) where participants live in and through locative media which contains an element of themselves. This is understood as a kind of augmented (sonic) reality, but, crucially, a reality which is self-authored. This reflexivity draws attention to participants’ socio-technical and phenomenological relationships, taking place between themselves, the site and the combination of the two. In order to achieve this reflexivity and hybridity, the design of the workshop was extremely important. This was done initially through the writing process, by translating interactions between sociality and presence within the site into text. These texts were spoken and recorded in the gallery’s small recording studio. Through speech, the texts were re-performed as they were translated from the page into audio. These vocal performances were then translated into radio signals by the transmitters. These signals are re-translated back into speech by the radio receiver. At
this point another implicit performance takes place as the workshop participant moves through the site, looking for the radio signals and receiving a combination of signal and static. Each of these steps is intended as a layering and complexification, with the participant’s initial reflections on the site being altered as they pass through each point of translation: from participant to written page to studio to audio to transmitter to radio receiver.

We imposed some limitations on transmitter positioning to make the overlays, seams and edges of transmitter range audible. By having a transmitter with a limited strength, the edges of the signal and the interactions it has with the physical environment and changes in the position of the radio become noticeable. At certain points two signals may overlap, or there may be gaps between participants’ signals. This potential layering and unpredictability is useful because it raises questions around the ways FM transmitters interact with each other within a given physical site. This in turn can provoke reflection on how technology can create, hybridise and layer sites and spaces. At some points it was not possible to hear any of the participants’ signals. This was not understood as a problem because the aim of the project was not to provide effective blanket radio coverage of the park, but to create a rich and sometimes glitchy radio space to provoke critical reflection.

By using an experimental workshop framework we were keen to explore the meanings produced when the design of a system takes place as part of research. Matt Ratto has referred to this process as Critical Making. He argues that, when a system or object is designed, the real work is being done through the act of making rather than lying in the nature of the finished product (Ratto 2011). The process of making can act as a reflective and pedagogical tool to create a deeper understanding of the workings of a given technology. In Dial Stories, time constraints prevented us from offering participants the opportunity to build their own FM transmitter, we instead concentrated on the ‘making’ of a network of radio signals. Here our concern is with exploring the materiality of radio as a medium and ontological questions surrounding its relationship with ideas of site and socio-technical practices.

Alongside an ontological concern with technology and experience, Dial Stories is also interested in how technology can interact with the contexts which compose a site. Context in this case can refer to the built environment, the social environment or the historical, political or economic aspects of the site. All these aspects frequently overlap and co-create each other. They may also shift dramatically in relation to whom is experiencing them. Above all it is difficult to see these contexts as something distinct
from the activity of performing research. Dilley draws attention to the influence of the particular research questions at stake: “contexts are sets of connections constructed as relevant to someone, to something or to a particular problem, and this process yields an explanation, a sense, an interpretation for the object so connected.” (1999, 2). Law and Urry make a stronger claim that methods “can help to bring into being what they also discover” (2005, 395). The interaction between certain contexts can be seen as the centrepoint of the production of meaning. Goodwin and Duranti (1993) argue for the significance of the social person and their context as an interactively generated form of praxis. In Dial Stories there was an ongoing tension between the roles of the participants. They were at once discovering and making the site. This took place in both individual and social frameworks as they moved together and alone with radio receivers. They did this both in the focussed state of looking for a particular transmission and the more open state of panning through the FM spectrum to see what signals were present around them. Their actions, both as creators and performers of content, were at once bounding the site of enquiry and opening it up multiple layers and interpretations.

Fig. 1. Workshop participants with FM receivers.
OUTCOMES OF THE GROUP DISCUSSION

The three overarching themes foregrounded during the discussion were: the implicit performance of the walk (especially in relation to people in the park not involved in the workshop); the spatiality of both the park and the radio spectrum as sites; the content being broadcast (through the aesthetics of speech on an otherwise chaotic radio spectrum and through textual overlaps with the physical space and the bodies within it). Issues relating to participants movement and embodiment during the walk were also mentioned several times.

The interactions between the participants and other people within the park was addressed early in the discussion. One participant said that he felt uncomfortable with the act of moving through the park with radios which were frequently untuned. He described the process as “invasive”, saying “it’s a bit problematic bringing noise into other peoples’ space”. This provoked discussion between participants, with several arguing that the response they had felt from the public was more curiosity or amusement than annoyance. For one participant, the act of the group moving together was more important than the content being broadcast. She argued: “I don’t think they would have seen noise and chaos—they would have seen the spectacle of people collabroatively listening to the radio”. What was clear across responses to this issue was that the participants were undoubtedly thrown into a position of implicit performance and this was explicitly addressed by one person who said: “It’s what kind of receiver you’re being—like in the park—do we look like a load of people who are trying to tune into art stuff—you know what I mean, the role and the receiver and our identities.”

The same participant described a moment when she was trying to pick up a radio signal while avoiding a group of people sitting near the transmitter:

“When people were sitting on the tree stumps—I didn’t want to interrupt them so I was ducking and weaving around the paths so I wouldn’t interrupt them—that was a real performance for me—that’s when I felt like it really happened.”

For her the social negotiations of the walk were where the meaning was being created, where “it” was happening.

The spatiality of the transmissions were also a rich point of discussion. The particular properties and materiality of FM provided a number of interesting interactions with the space. One participant described the way a signal bounces off the trees and buildings in and around the park:

“I was more trying to picture these fields of sound in my mind. It’s interesting with [one particular] piece because I really found
there's a lot of interference from trees and stuff and found there'd be a pocket up here where I could get a signal, but no point around it and there was a point where on three sides I had this kind of wall of other radio stations or static and there was just this bit in front of me where I could hear it. I mean yeah, you just kind of relate to the space differently.”

As well as the particular interferences between the signals and the physical environment, there is a topological element to the act of placing transmitters. In the words of one participant: “It's putting another space onto another space onto another space.” While the topography enacted by the interface was significant, one participant also commented on the influence of the wider FM dial and, by implication, the city beyond the park:

“It's nice there were so many transmissions going on—it connected us with the outside world and the real world I think. If it had just been our broadcasts it would have been very insular and closed. I really liked having these interruptions of random stations. It reminded you there's life outside the park.”

By using the open FM spectrum to broadcast our transmissions we utilised a radio receiver's ability to tap into a broad range of signals, many of them stations clearly local to London. This connected the performance to a wider spatiality. The FM spectrum within London is blanketed with numerous community stations and others acting with various degrees of legality. They frequently provide language and community-specific programming to audiences in London's multicultural population. In this way, radio can be seen as enacting and perhaps spatialising some of the many cultures within the city.

The portability and small size of the radio also gave the technology a particular set of affordances in relation to embodiment and performance. It was carried by the participants in their hands and so it was acknowledged that holding a radio made one officially part of the workshop, different from members of the public who may also be hearing the transmissions, but not implicated in performing them. This was born out by one participant's description of a man who walked with the group for some time, but without a radio and therefore clearly a member of the audience.

The fact that the radio was held also offers a set of possibilities connected to embodiment. One participant described the overlap between spoken transmissions and the possibility of using body position to switch between them:

“The thing that brought me the most pleasure—there were two that were very close and if I moved my body one way I could pick up one and if I moved my body the other way I could pick up the other and there was something really pleasurable about that.
Similarly, I was playing with putting the radio down and picking it up - and you were saying ‘inhale / exhale’ so there was a really nice synchronicity of text and movement.”

The feeling that the technology was responding to the site through the movement of the body was very significant to this participant. She also touches on the possibility of overlaps in meaning between the content of the spoken word and the body and site. Several other participants also commented on spoken word that explicitly referenced roads, trees and water in and around the park. One participant reflected that if she did the project again she would think about using a more direct form of address with the listener, telling them to look in a certain direction or move in a certain way. Also significant was the rhythm and meter of the spoken word. One participant argued that repetition was particularly effective in the writing because, as a technology that utilises the temporality of sound, radio loses a lot of content. Other participants reflected on how different their spoken content sounded from everything else on the dial, one said:

“It made me think of how radio is produced from certain state of mind. and if the mind is a whole palette of sounds or voices, then this [participants’] kind of voice is under-represented.”

Three participants reflected that they might have preferred moments where the spoken content overlapped, so that they could move from one voice to the next with minimal radio noise in between. This fed back into the discussion about performance and invasiveness, with one participant saying that the noisy nature of much of the content on the dial probably contributed to that anxiety. She reflected that if we were only amplifying spoken word that anxiety might not have been so strong.

The way in which participants’ bodies moved through the park was also commented on, with one person feeling that they had the richest experience when they broke off from the group and explored on their own. This idea was supported by participant observation. The group would frequently splinter into smaller sub groups as participants took to listening on their own or in tandem with another person. A core group of around four alternating participants remained moving around me, having been cast as the workshop ‘leader’.

**IMPLICATIONS FOR UNDERSTANDING RADIO AS A PERFORMATIVE LOCATIVE TECHNOLOGY**

One participant described the listening process as deciding what kind of “receiver” one was being. This linguistic shift was particularly interesting as it meant the participant was becoming self-identified with the technology. This is perhaps unsurprising when, as another participant noted, small bodily shifts had
the potential to alter the position of the aerial and, in turn, what sounds were being produced. Radio is a good way of realising this embodied aspect of user experience. The technology responds in a very fine grained way to the position of the user and their position relative to other physical aspects of the site which may produce interference in the transmission and reception of the signal. Several participants noted this potential of the technology in relation to other physical objects in the site. This point contributed to a wider theme of spatiality, as understood through the site of the radio transmissions, the physical site and overlaps between the two. The fact that the hybridisation of site was done iteratively through a series of tasks made this process clear, with one participant describing the process as “putting another space onto another space onto another space”.

Radio contains an inherent mobility also related to spatiality. One participant picked up on this, noting that it brought in signals from “the outside world and the real world”. The slip here, where the outside world is mentioned with the real world is noteworthy. Both are constructed as distinct from the transmissions taking place as part of the workshop. The transmissions which are being broadcast from outside the park appear to provide a measure of objectivity through their exteriority. They act to bound the radio site. Usually one might understand a radio site as being bounded by an act of re-tuning, the point where the radio station changes as we move through the dial. In this case the bounding is being done through the transmissions’ spatiality. Likewise, the tuning process is re-understood as something which takes place through a spatial act of movement and presence in and through the park.

The theme of the type of content being produced by the workshop was also important. One participant said: “It made me aware of how different our texts were from other stuff that were on those frequencies and it made me think how radio is produced from certain state of mind and how the mind is a whole palette of sounds or voices, then this kind of voice is under-represented.” This reflection also goes some way towards collapsing the distinction between person and technology. The participant began to equate radio content with a state of mind and then go on to characterise the mind as a “palette of sounds and voices”, themselves the raw materials of radio content. This would again suggest that the workshop process produced a situation where the boundaries between person and transmission begin to blur. Through transmission, the radio begins to perform the participant’s relationship to site, both in an Austinian sense of literally using spoken word content, and through the wider affordances of FM technology and the way it emerges alongside physical and
social contexts. This melding of technology and participant was also picked up on at the other end of the signal chain where existing socially with the radio in the space was described as “process of becoming a receiver”. Again, the functionality of the technology begins to blur with more sensory and embodied aspects of being in a given place.

It should be noted that the responses given here are from a small sample group. Eight people cannot give conclusive or widely applicable information about a set of interactions. But what they can do is create deeper insights into potential actions between people and technology within a given situation. The reflection exercise provides another layer of experience to the workshop, creating more value for them as participants. Their reflections can in turn provide technical and reflective prompts and inspirations for interventions in the future, both for the participants’ projects and for the wider research community.

**CONCLUSION**

The aim of the project was to explore how a given technology (FM radio) can perform and enact a given site. Through the workshop, a site was created which combined technical, reflective and phenomenological versions of the park with the physicality of the objects and bodies within it. Themes of aesthetics, spatiality and performance emerged, through the discussion, as did an underlying sense that the technology was combining with the spatiality of the park and the movement of bodies. Through the mode of interaction, retuning the radio became a fully embodied process; participants walked from one transmission to the next, raising questions about where the boundaries of each voice began and ended. One participant began to slip between technology and phenomenology in the discussion, questioning what kind of “receiver” she was being. In this way, the workshop re-casted radio as a spatial medium and opened up reflection on the way it can operate socially and topographically.

The concerns of this project are also distinctly methodological. John Law has problematised the idea of method as “a set of short circuits that link us in the best possible way with reality”, instead proposing a case-specific methodological approach that “will take time and effort to make realities and hold them steady for a moment against a background of flux and indeterminacy.” (2004, 10). I would combine this understanding of method with Matt Ratto’s focus on the value of the production process to “to use material forms of engagement with technologies to supplement and extend critical reflection and, in doing so, to reconnect our lived experiences with technologies to social and conceptual
critique.” (2011, 253). A project like this one has the potential to bring strangers together and form points of convergence around a given place, exploring the relationship between personal, social and technological realms. The communal writing and construction of the transmitter network allowed a collectively authored layering of the site. This layering interacted with and (at least for the duration of the workshop) redefined the contexts which compose the site. The reflection carried out in the group discussion may not produce hard and fast truths about all sites or every technology’s ability to mediate and construct it, but it serves to inspire further thoughts and thereby “enrich and not only reduce” (Asdal and Moser 2012) the object of study.

Acknowledgements. Warm thanks go to Eleanor Vonne Brown and everyone at X Marks the Bokship and Matt’s Gallery. We would also like to thank all the participants who made the workshop what it was. This research was completed as part of the Media and Arts Technology Programme at Queen Mary, University of London, funded by the ESPRC.

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Printed media have a highly consolidated visual infrastructure. But printed (preponderant) visual part has been wrongly considered as coinciding with its whole. That is why they have been recently massively translated into another universal medium (the digital) through a direct process. What is missed, much more than nostalgia, is a small perceptual universe that is instinctually unfolded every time the physical medium is used, while it is misdirected if not negated in its new screen-based embodiment.
SCREEN TOUCH VS. PRINT TACTILITY

“A theory of cultural change is impossible without knowledge of the changing sense ratios affected by various externalizations of our senses” (McLuhan 1962, 49)

There is a recurring comparison in the media between the convenience of using printed content in digital form versus its traditional paper format. A published work in a computer file format has a series of promoted qualities: lightness and hence portability, speed in accessing it, its (near) instant ability to be searched, quantified, linked, cross-referenced and more in general “calculated,” which makes it a terrifically tool-enforced version of the original work. But there is a constantly underestimated aspect: its “user experience” considered from a perceptual perspective, which, paradoxically, turns out to be quite “deprived” compared to the classic printed publication. It is worth then to analyse it sense by sense. We can assume that digital content uses primarily one sense: sight. Excluding taste, then, we can start considering smell, which is almost completely absent in digital media, if we exclude the eventual smell of the hardware, initially present when the device is very new, due to the first heating of plastic and electronics, but then so light that it’s quite irrelevant. Hearing may or may not be involved, depending on the used system, as we don’t have standards yet, but a plethora of different open and proprietary software systems. Hearing usually is involved in two different ways. One is to better simulate the print sensorial experience, typically through a sound sample played when the user is virtually turning the pages. The other is the use of alert sounds, which are functional to the digital interface, so to the superstructure that the software system is implementing in the system, resulting then quite unspecific, or anyway not contextualised to the reading experience. In fact they are generally meant to attract attention about some impeding fault or to warn about something about to happen, so their mission is to distract from the reading to focus on an external event.

Sight, instead, is very involved, although the text appears always in the very same way. That’s true if we have a classic retro-illuminated screen (a backlit one), like in tablets, smartphones, laptops and the last generation of e-readers, which is meant to ensure readability with any external light condition, so anytime, anywhere (at least until the battery is charged). But it’s also true for e-ink based readers, as the screen binary technological nature of half-white-half-black tiny balls guarantees contrast but also a uniformity of the page, only slightly changed by the natural or artificial surrounded lighting. To quote McLuhan, again,
“Unlike previous environmental changes, the electric media constitutes a total and near-instantaneous transformation of culture, values and attitudes.” (McLuhan 1969)

In comparison, classic printed publications are using a much richer sensorial environment, providing inputs for multiple sensory modalities.

Again excluding taste, and following the same order, smell is quite directly involved in the composition and age of both paper and ink, indirectly giving specific information about the text, also because it varies a lot, even within the same olfaction domain (old books smell in an ample different degrees of dust and mould, depending on their exposure to light, specific preserving environments, etc.), being often associated by readers with certain content or specific environments like particular libraries, which sums up different smells as any closed environment. Technically there are several hundred so-called VOC, or volatile organic compounds, which books give off, strictly related to the chemical elements used in type of paper, the binding adhesives and the printing inks. In this respect there are a few artworks which since the seventies have tried to synthesise perfumes with the smell of specific printed matter, from old books to a fresh copy of the New York Times, but the most ironic attempt to remark the absence of smell is a fictitious company, establishing an e-commerce website selling their ‘Smell of BooksTM’ spray cans, to help e-book customers feel more comfortable with their new devices. The product is ironically guaranteed to be “compatible with a wide range of e-reading devices and e-book formats and is 100% DRM-compatible.” And addressing a more general concern, “If you’ve been hesitant to jump on the e-book bandwagon, you’re not alone...”

Hearing is mainly about the physical manipulation of the book, including the sound of bending and closing the, usually thicker, cover, which is quite different from the sounds heard while flipping or turning the inside pages. Very importantly, each time we turn a page, the resulting sound is slightly different, and not really quite the same as it is implemented in simulated digital environments. The use of sound in print has been explored by a few experimental artists using samples of manipulated paper to generate compositions. But a more conceptual approach has been taken in Cyclisations by Olaf Hochherz\(^2\), a sound artist whose work mainly consists in associating cultural fields using sounds as bridges between them, with their own “language”. In Cyclisations he’s exploring further his previous experiments with book’s acoustic feedback, using it as a filter and integrating it with another conceptually stratified level. The concept of

1. Smell of Books
   http://smellofbooks.com

2. Hochherz, Olaf Cyclisations
   http://hochherz.klingt.org/?p=1500
“feedback” is extensively used through the manipulation and use of books but then integrated in the live enunciation by the cybernetic theoretician Stafford Beer and embedded in the sound pieces. Hochherz refers to cybernetic theories, questioning the dreamed “feedback” system they were investigating through his own practice, which, on the opposite, takes feedback under control. The book’s physicality becomes then a starting point, with the sound integration of its content in various coherent forms, and coalesces a virtual representation closely describing it without showing even a single page.

Sight in print is also extensively tested, since print is front-illuminated and therefore depending on very different (natural or artificial) lighting conditions, combined with the extremely varied light-reflecting or light-absorbing characteristics of paper with all their degrees, technologies and filters involved.

And finally touch, and thus tactility, is just reinforcing this comparison. Already in the 60s, Frank K., Lawrence wrote that “Tactual sensitivity appears early in fetal life as probably the first sensory process to become functional.” (Frank 1960, 6)

In the digital realm we have a merely functional and decontextualised touch: if we still use mouse or trackpad “prosthetics”, our fingers are functionally used for clicking, swiping, or tapping in the very same way for all the different types of content, but in a standardised universal modality, which, again, cannot be conceptually unplugged from the inescapable design of digital interfaces. In the digital realm our fingertips are simply annihilated, even if they possess the highest concentration of touch receptors and thermoreceptors of all the areas of the human skin, aside from our genital parts. From being extremely sensitive and “broadband” input sources for our body they become neutral machine-oriented prosthetics. This is something we deal with every day, and already in 1983 Baudrillard affirmed that the transition from the tactile to the digital is a primary factor of the contemporary world. (Baudrillard 1983, 115)

In traditional print tactility gives information on different levels, and the process of paper selection is, in fact, still an important part of quality publishers’ work. It gives information about colour (sight), texture (touch) and odour (smell) that is, possibly consistent with the whole of the work. If we are already familiar with a book, the texture of its cover unawares gives us information about its content (confirming what we are about to read) even before we open it, and eventually we would be able to recognise certain books while being blindfolded. Every added element (lamination of any type, hollow punches, special inks, other materials integrated in the cover) is not just an additional
piece of information, but a further experience for both sight and touch, and so further information. Our senses are constructed to have a “very large bandwidth”, and “sense” is derived from the Latin word “sensus” that, in this respect, means ‘faculty of feeling’, which is all but mechanical or standardised. Tactility, as any other sense, is about perceiving differences, and the more differences we are trained to perceive, the more we learn and the more we are able to perceive, in a virtuous endless circle. Quoting McLuhan again “(print)... has acquired new interest as a tool in the training of perception.” (1969, 99)

The physicality can be considered through a few other possible perspectives. It’d be even possible to adventure in theorising about bacteria transmitting information through print. In fact they are travelling through different bodies being touched over time by different readers in libraries, or from the author to the enthusiastic fan after an author signing events, or even from one traveller to the other through free newspapers left or passed in commuters’ trains or through free flight companies branded magazines in airplanes touched and read by different travellers respectively during one day or one month period. Would they transmit some kind of information, which can unconsciously affect the reading, or just dirt and flu? Although this might sound like pure speculation, it remarks that the physical circulation of information is meant to be not only physical, but remarkably social, while the digital circulation of information is meant to be customised but strictly personal. It’d be defined as “the tension between virtual and visceral” as described by Beth Williamson in her essay “What Does it Mean Not To Touch A Book?.” (2015, 155)

We can consider even state of the art digital publications as still a “simulation” of the printed ones (like the classic pdf standard), in a quite ambiguous trajectory. They mimic the structure and conventions of print, adapting them to the needed digital parameters, but they probably fail in re-creating a similar experience, and trying to appeal to sight as much as possible, including, for example, the visually compelling fast zooming (in and out) abilities. The screen has uniquely flexible qualities of display, but it can’t effectively render three-dimensional space yet if not through a simulation which our senses recognise as flattened, in any case. It is how French researcher Émeline Brulé defines the digital simulation of print: “mimetism.”
THE MATERIAL SPACE OF INFORMATION

We'd wonder then: how many things do we physically and consciously “touch”, establishing an enriched relationship with them? Not too many—but screens and printed materials are surely among them. More generally, materiality has its own space of information, which is very different from the immaterial one. The three-dimensional space of materiality is essential for locating, estimating and recognising cultural objects. But there is more. Since the senses are more deeply involved with the content, we often make an emotional investment in these objects and we don’t want to lose this investment as it often happens in the inappreciable, enormous size of the digital space, experienced through a small bi-dimensional screen, incapable of rendering in details the huge content of our hard-disk repositories. Digital publications, being prone to the screen, would have to cope with this aspect of their own nature. But, in turn, they would also take the opportunity to exploit their unique ability of hosting infinitely reprogrammable and infinitely transmittable content. Instead of simulating the (unsurpassed) print “interface”, which has been gloriously established and refined since more than five centuries, they would build on the ability to instantly create, combine and calculate content, trying to accomplish the level of intimacy between writer/publisher and reader close to the one that McLuhan attributes to printed materials. And, if properly handled, tactility could play a fundamental role in this process, even if there is no simple equation to fill the gap between the machine and our fingertips. In robotics, for example, the still primitive “tactile sensors” are devices measuring information derived from physical interaction with their environment, but they are generally modelled after the biological sense of cutaneous touch (still heavily simplified), and they are definitely uncertain, for example, when it comes to sensing “pain.” How would they “feel”, for example, the cover of the book “Unpleasant Design” (Savicic and Savic 2013) that was equipped with a large band of sandpaper? The designer used it to perfectly reflect the principle of exclusion put into practice in urban design like benches that are impossible to lie on, but would a general algorithm be educated enough to interpret it?

In digital publications tactility would be enhanced in a proper way, avoiding clumsy simulations, and appealing instead to our nerve endings in a direct way, maybe through interconnected new artificial materials. They would provide new information to the screen reader, being eventually able to materially assume a decent number of “states” that would be perceived as
new textures, appropriately reflecting their possibly direct and instinctual relationship with the content. Then, the two different worlds would begin to form new sensorial combinations, and even an hypothetical hybrid between them could be conceivable. It would be in direct relationship with our senses, but simultaneously be able to reflect both the unchangeability of the printed page and the perennial dance of information in our digital world.

**SUBVERSIVE PRINTING AS A PERFORMATIVE GESTURE**

Mixing the different spaces of communication of print and digital is becoming a popular strategy among contemporary media artists, especially through the materialisation of content which is meant to be on the screen in a sizeable and touchable classic format. This is often accomplished using the book as an explicit repository, conceptually collapsing a minimal library in a single item. Referring to the seminal Jorge Luis Borges’ “Library of Babel,” Philipp Adrian, for example, has compiled his “An Index(5)” printing two volumes with all the possible permutations of five letters, claiming then to have printed the Library of Babel index, as the first five letters of any printed book should be there, somewhere. And if print content is frozen in time, then its qualities can be remarkably useful when we deal with the same content in a digital format. Jesse England’s “E-book backup” is applying it literally, reversing the usual backup strategy. It’s an artists’ book containing the whole text of George Orwell’s “1984,” whose every page hosts a photocopied picture of the same page displayed on an Amazon Kindle, explicitly referring to the controversial 2009 incident when (England points out) “Kindle users found their copy of George Orwell’s 1984 and Animal Farm had been removed from their Kindles without their prior knowledge or consent.” And some of the most controversial contemporary artist’ books are trying to fill pages with content which is not supposed to be printed, for various reasons. Then some subversive gestures, especially breaking discretion, can be attempted. The anonymously authored “Contacts” is an excellent example: it collects a selection of key decision makers’ business cards in art, media, politics and culture, after ten years of “excessive networks” accomplishing a strategic privacy leak. And print as subversive archive has been used paradigmatically at the highest emotionally extent by artist (and UbuWeb founder) Kenneth Goldsmith. In at least a couple of artworks he has committed to bring Aaron Schwartz’s vision to the art world through print. Schwartz downloaded and shared 2.7 million copyrighted and

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very expensive academic publications from academic online service JSTOR, as a radical and symbolic act, but was arrested and threatened with a possible fine of one million dollars plus several years in prison. He committed suicide in 2013 at the age of 26. (Nelson 2013) One of Goldsmith's most renowned performances (inspired by Schwartz) is “Printing out the Internet” where he asked people to print what they want from the Internet before sharing it in a gallery space (LABOR in Mexico City). A few tons of paper were delivered and a reading marathon started (“reading the entire internet”). There were, of course, negative reactions, for example the spontaneous online petition asking him to stop the work for environmental reasons. Goldsmith went even further reprinting 250,000 pages from Schwartz's liberated files in a public installation at Kunsthalle Dusseldorf, part of the exhibition ‘Smart New World’, deliberately performing a gesture he felt did justice to Schwartz's vision. His subversive use of print as archival of unauthorised digital information uses the medium in one intricately illegal way, rendering it into a tactile dimension, where it’s difficult to consider it illegal; still one of the most controversial ways print can be used nowadays.

AGENTS VS. MEDIA

Finally from a more general perspective the role of the digital and especially of the internet should start to be questioned, especially in relation to print and retrospectively, looking at the past interactions between print and other media to understand the present.

Jeffrey Schnapp, ex director of the Stanford Humanities Lab affirmed: “the book is a construct in constant evolution: a construct that routinely and dynamically interacts with a shifting array of other media types. In other words, the book is a technology.” (Schnapp 2014)

So historically, looking back at how other media has been reflected into print, we can notice that traditional print reacted in various way to newer media.

American Researcher Katie Day Good found that in the 1920s the Chicago Daily News published several ‘Radio Photologues’ (Good 2013), or travel diaries that could be listened to through the radio and which were visually amplified through the pictures published on the same day on the newspaper. So what radio was doing was to change, not to suppress print, exactly as an agent would do.

Talking about TV we have another outstanding example: the experimental paperbacks by Marshall McLuhan, Jerome Agel and Quentin Fiore. They embodied in the universal paperback format the TV synthetical information aesthetics and lan-

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6. “Printing out the Internet - Wikipedia, the free encyclopedia”

guage, accumulating concepts and becoming in the definition of Schnapp “inventory paperbacks” (Schnapp and Michaels 2012).

In order to survive the online competition even newspapers for a decade have included more ‘data’ in their own visual structure than they ever did, in various graphic forms, from big figures to sophisticated infographics.

So print has been deeply influenced by other media and evolved accordingly.

And if we look at audio and video, they have been slightly influenced in the narratives and in technical specifications by other media, too, including the internet, but they still are mostly sequential in their own nature with the same original characteristics.

They have been ‘conditioned’, not reinvented.

Then the big question is: is the internet a real medium, since it didn’t invent completely new formats which were used by the majority of people, or an agent, inducing radical changes in other historical media, but leaving their inner core intact?

**CONCLUSIONS**

To exploit all these trajectories what we would need to do is to peek into the empty spaces still left in the juxtaposition between print and digital. There are plenty of these liminal spaces, and it’s there that ideas and interventions are yet to be performed. Realising that the infrastructure we have is intrinsically distributed, and re-appropriating it in a specific and creative way is the key to mutate our messy information daily spectacle into a heterogeneous and constantly experimental scenario, which can possibly be the flourishing and liberating landscape of contemporary and future publishing.

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The Drawbox Project is a children-oriented, interactive audio-visual installation. Visitors are invited to draw colourful sketches on paper and then use the Drawbox—a special workstation installed at the exhibition space—to deliver their drawings into a dynamic physically-simulated world. Participants witness their drawings come to life, as shapes receive real-world physical properties, propel in motion and collide with drawn shapes of other participants in an imaginary drawn world. When two DrawBoxes are installed in remote locations, the drawn shapes from both locations are presented in a shared world, creating an ambient, creative connection. We describe the development and deployment of the DrawBox in two locations simultaneously.
1 INTRODUCTION

The DrawBox Project was born out of an invitation received from two museums to create an interactive experience that would connect children in two remote locations for a shared, playful manner. Seeking an activity that would be easily achieved, inclusive and enjoyable, we chose drawing. Drawing is a simple yet rich form of self expression. We start drawing as early as we can hold a crayon, we sketch and doodle through life. Drawing is both an intra-personal endeavor, used within an internal dialog, and an inter-personal endeavor, used to convey ideas and present oneself to others. In the Drawbox project, a pen-on-paper drawing is the starting point for a playful transition between the physical and digital worlds, and for a new type of connection between children.

2 THE EXPERIENCE

Participants in each location are invited to draw with colored pens on paper. They then place their paper drawings into a box with an opening, and press a large button on the box. The drawn shapes instantly fall into a projected, graphical world inhabited with shapes drawn by other visitors. The shapes collide, break up, bump and jump, retaining enough of their form to be identifiable, but changing enough to surprise and delight. The projected world is in constant motion: shapes that exit to one side of the world enter at surprising times and orientations on the other side. Sounds of collisions between shapes extend the materiality of the drawn world, creating a dense, heterogeneous landscape-soundscape.
The installation can be either run in only one location ("mono mode") or in two locations concurrently ("stereo mode"). In stereo mode, visitors in remote locations all contribute to a single, shared world. Shapes delivered from each local station are color-coded in order to identify their origin within the shared world (e.g. yellow shapes from one location, green from the other). In this mode, participants witness each others’ creations; they can relate to the drawings of others with their own, and correspond with each other through drawing, creating a form of artistic dialog. In contrary to stereo mode, in mono mode the shapes partially retain their original color characteristics (see “Implementation”).

2.1 DESIGN VALUES

In a world of wide-band communication and digital “everything”, we sought to create an interaction based on the beauty and simplicity of the physical drawing, and an opportunity for a calm, gentle channel of communication with others. The themes that the Drawbox Project explores: self-expression, storytelling, and the connection with the other, are universally fascinating to children in a wide range of ages and regardless of national identity.

The Drawbox project enables children to experience spontaneous interaction with other children through the act of drawing—both co-present children and children in a remote location. Contrary to screen-based interactions, where it becomes increasingly harder to distinguish between real and virtual agents interacting with a user, Drawbox affords a kind of personal, embodied play and interaction scheme analogous to a playground setting. Simplicity is a main design value in the project, and one single button constitutes the entire interface, making it inclusive to children of young age and of varied abilities.

Fig. 2. One button press sends the drawing into the projected world.
3 IMPLEMENTATION

The Drawbox is built from off-the-shelf materials and custom software built with Processing. The implementation is hereby described in detail.

3.1 PHYSICAL BOX

The physical Drawbox is a rectangular standing structure built of wood. At its center is an opening, a cavity in which the drawing is placed. The cavity is well lit from above using fluorescent lamps. A high-resolution web camera is installed at the top of the opening, concealed from children’s reach. The 35mm concave momentary push button is connected to a MacMini computer via a simple hardware interface (an iPac controller); pressing the button causes the capture of the image by the camera and the initiation of the algorithmic analysis.

3.2 IMAGE PROCESSING

Contour, dominant color, and morphological analysis are performed. Each contour is converted to a vectorized polygon and added to a physics engine simulating rigid body dynamics in 2D. The new virtual shape is initiated with physical parameters corresponding to the morphological features of the drawn shape. Shapes are analyzed to retrieve their relative size, total area, density, calculated as the ratio of drawn area relative to the bounding box area (Bourke 1998), and shape symmetry, as judged by the center-of-mass position relative to center point of the shape’s bounding box (Loncaric 1998).

3.3 PHYSICAL SIMULATION

The shape features are mapped to physical world parameters—body mass, body friction and restitution (the strength with which the body bounces back from a collision). Then, the newly created virtual shape is tinted by the dominant color of the drawn shape (in the mono version), computed from the hue histogram of the original drawing (Androutsos et al. 1998). A shape entering the world gradually breaks apart, separating into the loose contours comprising the original drawing. Drawings from all locations are joined through a shared cloud-based data folder, which allows an easy installation and enforces no limit on the number of Drawboxes which can be connected in a network.
3.4 SOUND DESIGN

We designed sounds that enhanced the materiality of the drawn objects, giving them a quality of realness while also adding a slightly comic aspect, in line with the quality of the colorful drawn shapes and their bouncy motions. We utilize the detection of object collisions within the virtual world for constructing a sound generation engine which sonifies the world dynamics through collision triggering and velocity to amplitude mapping. This reflects the language of physical motion dynamics, such as acceleration, velocity, mass, collision, elasticity, etc. Equipped with a library of custom-made sound samples, the engine scales the force of objects collisions to a relative amplitude of sample playback. Furthermore, dynamic features of the virtual world, such as the peak velocities of object's motion are mapped to relative amplitudes of continuously playing samples, creating an additional layer of sonification.

4 INSTALLATION

The project was installed for four months in the Design Museum Holon, and concurrently for a weekend at the Victoria and Albert museum in London. The installation proved to have an enormous attraction for children and adults alike - over 55,000 shapes were drawn during the period it was installed.

4.1 LOCAL INTERACTIONS

Children enjoy drawing on their own on one of the installation tables, and then having their creations gain the center stage as they place their drawing in the DrawBox. They often press the button many times to fill the drawn world with multiples of their creations. Beyond the deep engagement of children with the installation, we observed strong motives of iterative exploration.
throughout the interaction. As children view the effect the Drawbox has on their drawing, they are often compelled to refine their drawing and make new ones, seeking to enhance the effects, or to “outwit” the system and draw their shapes such that they will break and scatter in a certain way. Throughout, a spontaneous dialogue emerges between participants as they look at each other’s drawings and try to experiment with the principles that govern the transformation from paper to the digital shape.

4.2 REMOTE INTERACTIONS

While we had only a few days of “stereo mode” to observe the interaction between remote participants, the initial observations are promising. Once told that shapes with the unfamiliar color are arriving from a different place in the world, children expressed deep curiosity towards the children there, and actively sought ways to communicate. Two recurring examples were: writing a greeting (e.g. “Hello”), and responding to a drawing with another drawing (e.g. drawing a spider in response to a spider that arrived from the other location).
5 DISCUSSION

We observed a great interest by visitors of all ages in the Drawbox. It seems that the ease of participating (making a simple line drawing), coupled with the temptation of seeing what happens to the drawn shapes when they fall into the world, collide and break, was a good combination. While some participants created refined drawings, most created quick, playful sketches. It may also be that the partial scattering and disbanding of the shapes as they fell into the drawn world reduced people’s shyness in presenting their creations to others, and allowed them a playful sketching experience.

In the current design, locations were identified by color, and the remote presence of children in the other location was verbally explained to the participants (e.g. “the Yellow shapes are being drawn in London!”). Achieving the optimal level of awareness to the remote others—enough to enhance curiosity and communication, not too much to take away the pleasure of the simple, local drawing experience—is an interaction design question of great interest. One option we believe holds promise is to show—in each location—a real-time video stream showing hands and papers, but not faces, of children in the other location.

Witnessing the unfolding interaction between children over distance has highlighted the potential of exploring a genre of interaction design we name “connected playgrounds”—shared playful interactive experiences which transcend physical distance. The framework of connected playgrounds aims at the design of intuitive interactions which connect children through self-expression, storytelling, collaboration and synchronization.

Designers have been exploring, in recent years, the possibilities of interactive playgrounds: environments with sensor-enriched objects that react to the interaction with the children and actively encourage children to play (Soler-Adillon and Narcis 2009, Tieben et al. 2014). The research in this area identifies key issues regarding the design of these playgrounds: social interaction, simplicity, challenge, goals and feedback (Sturm et al. 2008). However, the connected playgrounds research agenda invites a novel perspective on both interaction design principles and the afforded communication over distance. Insights should pertain to the mechanisms of joint action over distance, and to the conditions necessary to permit an unbiased, positive and curious sense of the other. On a societal level, connected playgrounds can be seen as a unique tool to promote and foster a playful channel of interaction between people from different cultures, driven by spontaneous exchange and discovery of a common language,
regardless of national identity. In this regard, the Drawbox project provides a platform for exploring how children discover a common language through imagination, experimentation and communication.

6 FUTURE WORK

Motivated by the acknowledged appeal of the Drawbox project, we plan to continue its development, and envision future developments which could expand and refine it further. We see exciting perspectives for future work in both the research and the applied domains.

6.1 THERAPEUTIC ENVIRONMENTS

Foremost, we envision an application of the Drawbox project within hospitals for children, as means to employ the therapeutic power of drawing. Studies which examined children’s hospital-related fears and coping strategies highlight that children express these experiences and fears through drawings (Salmela 2010). In assessing children’s coping strategies, studies employed children’s drawings (Brewer et al. 2006) as well as draw-and-tell conversations (Driessnack 2006). Although tele-presence systems have been proposed in a hospital context (e.g. Fels et al. 2001), they have been largely pedagogical in nature, rather than open-ended and playful.

The Drawbox project installed in a network of children’s hospitals will offer a connected playground where children can be given a joyful experience, both as a form of distraction as well as a means for expressing their feelings and coping through drawing. Furthermore, interacting with children in other locations may
provide an opportunity for a normative dialogue and exchange, reconnecting with everyday ordinary child concerns, and drawing away from the context of hospital stay. We are now at work to pursue these developments.

### 6.2 EXPRESSIVITY ANALYSIS

A research agenda can aim at characterizing and quantifying the creative process of participant's drawings, namely through a morphological analysis of drawn shapes, uncovering features of expressivity, versatility and individuality throughout iterations of drawings (Noy et al. 2012). Expressivity analysis may consist of computing the Kolmogorov complexity of drawn shapes—measures of randomness and entropy, in order to derive the shape's complexity measure. Structural shape complexity may be estimated using entropy of the global distance distribution (GDD), entropy of the local angle distribution (LAD) and a randomness measure (Page et al. 2003). The effect of the interaction setup on these parameters—namely, the effect that co-present and remote participants have on the drawing style, can be highly revealing.

**Acknowledgements.** We wish to thank Naama Agassi, Irad Lee, Liat Segal and Yael Avni for their contribution in the development of the project.

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This paper introduces Prefalll135, an interactive installation that uses the kinetic energy of falling water to generate real time visuals and sound. It consists of a tangible user interface of watermills and taps, which enables users to control the water’s flow. The angular velocity of each watermill is mapped to parameters of the audiovisual system, permitting the users to create dynamically their own collaborative or solo audiovisual composition.

Prefalll135 integrates both Do-It-Yourself practices, regarding the construction of the physical interface through means of personal fabrication, as well as Do-It-With-Others practices, respecting the collaborative development processes employed and the extension of the use-value produced by open-source communities. Being a project inspired by nature, Prefalll135 fosters the concept of reuse and free access to resources, both in digital and physical spheres.
1 INTRODUCTION

Technological advances in the Human Computer Interaction and the social web domains enable the involvement of an increasing number of creators and audiences both at end-user level as well as during the development process, leading towards a more democratized approach of the creative act.

Embedded interaction, tangible interfaces and ubiquitous computing narrow the gap between users unfamiliar with new technologies and interactive installations. Everyday objects are augmented with a layer of digital information, without changing their original function, look and feel (Kranz, Holleis, and Schmidt 2010). The users are invited to interact with them by using the skills they already have for sensing and manipulating their physical environments (Ishii 2008). Thus Windows-Icons-Menus-Pointer (WIMP)—based interfaces disappear from the foreground, while computation technologies weave themselves into the fabric of everyday life until they become indistinguishable from it, as it has been anticipated by Mark Weiser (2010). Moreover, tangible interfaces permit simultaneous manipulation of interactive artifacts by multiple users, supporting multi-user collaborative interaction. TUIs can be used as sharable interfaces, where collocated groups are able to work together on shared representations (Marshall, Rogers, and Hornecker 2007). Contrary to single user technologies of sequential interaction, tangible interfaces can support control sharing over collaborative activities. (Jordà 2008)

Advances in the social web domain facilitate the involvement of an increasing number of creators to collaborative DIWO and Peer-to-Peer (P2P) projects. In DIWO practices the process is as important as the outcome, involving participants in continuous peer enactments, through digital and physical networks (Garrett 2012). A wide range of users employ social web tools to collaborate in peer-production projects and participate in FLOSS and OSHW communities. They meet the communities’ members both in digital and physical spaces, while they share, reuse and freely redistribute the produced use-value under commons-oriented licenses (Bauwens 2015). DIY makers use their own digital communities (Kuznetsov and Paulos 2010), where they similarly share designs, ideas, instructions and interact with each other.

The rise of desktop manufacturing technologies, together with commons based peer production, privilege a more sustainable productive model of “designing globally-manufacturing locally.” (Kostakis et al. 2015)
Prefalll135 consists of a DIY construction that counts with a semi-transparent acrylic box of approximately 2m x 1.5 m x 0,20m (height x width x depth). Inside the box, a waterfall is formed by an amount of water flowing from the highest level of the structure to the lowest. A water pump elevates the water back to the top of the construction, making the water circulation autonomous and potentially endless.

The water flows through three different levels, each one counting with a water container. Three taps are fixed on each container, and below each tap a watermill is mounted. The watermill rotates by the falling water when the corresponding tap is open. By manipulating the taps, the users of the installation are able to determine the flow of the water and to control the rotation of the watermills.

Sensors connected to an open source hardware electronic microcontroller detect the angular velocity of each watermill. The input data are used by a custom open source software to generate audio and graphics dynamically. The visuals are rear-projected and mapped on the vertical surfaces of the construction, while the sound is directed to the speakers surrounding the installation. Thus the physical construction is augmented by a digital audiovisual layer that evolves in real time according the users' interaction.
3 DIY TANGIBLE USER INTERFACE

3.1 THE PROTOTYPE

Re-appropriation of obsolete objects or materials, broad access to digital fabrication technologies and shared knowledge databases are some of the practices gradually leading to a democratization of manufacturing, which influences all sectors of design, production and distribution of material objects (Mota 2011). A new class of creators and producers emerge as “the dominant paradigm of user-as-consumer gives way to alternative framings of the user as creative appropriator, hacker, tinkerer, artist, and even co-designer or co-engineer” (Tanenbaum et al. 2013). DIY is currently a wide spread phenomenon covering a variety of domains including art, electronics, crafts, music and more, while its practices have been of increasing interest to HCI researchers who argue on the benefits of the application of these practices to the HCI domain (Kuznetsov and Paulos 2010; Tanenbaum et al. 2013).

Following the DIY concepts, the first version of Prefalll135 used exclusively recycled found objects. The wooden base of a bed, plastic pipes, camping water buckets, or components of children’s toys such as plastic windmills, were some of the re-appropriated materials re-purposed under a new context. These objects were customized and mounted on a single construction...
to serve the prototype’s needs. The idea of a DIY construction of recycled objects underlined the notion of sustainability that was present throughout the development of the project. In general, the DIY stance during its various and different manifestations in the middle of the 20th century turned into a creative act of rebellion against mass production, consumerism, planned obsolescence and waste (Mota 2011). Current DIY initiatives keep reflecting these notions and support “the ideology that people can create rather than buy the things they want.” (Kuznetsov and Paulos 2010)

3.2 THE STABLE VERSION

The need for a more robust and precise construction led to the redesigning of the physical part of the installation. Found materials also bared certain limitations. For example, it was difficult to find a semi-transparent surface of a sufficient size for supporting rear projection. Furthermore, the lack of a water pump required manual elevation of water, from the lowest to the higher container of the installation.

During the re-designing process of the physical interface a series of experiments on 3D printing practices took place. Digital fabrication technologies, such as the 3D printing technology, can be considered as another indispensable practice towards the democratization of manufacturing. Personal 3D printers are in a process of becoming economically affordable and accessible to a wider range of users. Their ability to provide physical substance to digitally designed objects provides the possibility to produce and circulate goods outside the centralized manufacturing model (Mota 2011). As a result of the realized experiments, certain parts of the watermills were 3D printed in the new version of the construction. The new version counted with an acrylic box, nine watermills, nine taps, four water containers and a one water pump.
3.3 DESIGN GOALS

The tangible interface was designed with a primary goal to target user groups unfamiliar with new technologies and WIMP—based interfaces. Interactive functionality was embedded into water taps and watermills, which are objects with familiar functioning. Users were expected to interact through opening and closing the taps, directing the water to the watermills and making them rotate. Namely, interaction design was based on well-understood actions related to common physical objects. This design approach made the interface intuitive and self-explanatory, without any need for instructions or a user manual.

A second design goal of Prefalll135 was to support multi-user collaborative interaction. Prefalll135’s tangible interface permitted simultaneous manipulation of interactive artifacts by multiple users. The users can open and close different taps at the same time and share control on the flow of water and the audiovisual output. Thus they experience their audiovisual creation while they apply collaborative scenarios.

4 HARDWARE

Electronic prototyping platforms wrap the details of microcontrollers functionality in user-friendly environments allowing users to build sophisticated applications with a relatively low learning curve. Among the variety of available platforms the Arduino\(^1\) microcontroller was selected. One reason for this choice was the fact that Arduino hardware is open source and distributed under a Creative Commons license. It has also a wide community of users contributing to the creation of a common knowledge base, which includes detailed documentation and software/hardware extensions and applications. Moreover, its widespread use has led to the development of libraries that wrap the communication of Arduino boards directly within other programming languages or environments, which facilitates the development of applications that integrate Arduino-based input/output modules. Arduino consists of a series of open source hardware boards and an IDE (Integrated Development Environment). For this project an Arduino Mega Board was used.

Several options were available for capturing the velocity of the watermills’ rotation. The first version of the project did not use an electronic circuit and followed quite a different approach. It captured the rotation of the watermills through a computer vision module. For this reason a unique fiducial marker was attached to the rear part of each mill. A camera placed behind the watermills recognized the ID of each watermill and the angle of rotation.

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Later this option was abandoned and an electronic circuit replaced the computer vision module. The electronic circuit proved to be stable and accurate, while it avoided lighting or other setup issues related to the use of a camera. By opting for this approach, a rotary encoder was necessary. Instead of using a commercial one, a lower cost DIY rotary encoder was built using the CNY70 sensor, a reflective optical sensor with a transistor output. The sensor consists of an infrared emitter and a phototransistor in a leaded package, which blocks visible light. The sensor is able to sense whether the emitted infra-red light is reflected back or not. Thus if it is mounted near a spinning wheel with a striped black and white pattern, an appropriate circuit will produce a logic-level pulse stream whose frequency is directly proportional to the angular velocity of the wheel.

Nine striped wheels were printed and attached to the rear face of each watermill. Each CNY70 was mounted as close to the spinning wheel as possible, and connected to the Arduino Mega Board. Thus, the software of the installation could easily calculate the angular velocity of each mill by reading the input of the corresponding Arduino's analog pins.

5 SOFTWARE

The software of Prefall135 consists of a custom program developed for the needs of the installation. The software contains three modules. The first module handles the interaction and communication between hardware and software, and between the different software modules. The second one handles the visual generation, while the third one is responsible for the audio generation. The first two modules were developed in C++ using the openFrameworks toolkit, while the third module was developed with Pure Data.
5.1 INTERACTION MODULE

The openFrameworks platform was selected primarily due to the fact that it is an open source toolkit for C++, a high performance, efficient and flexible programming language. Additionally openFrameworks provides a user-friendly framework, easily extended, while it wraps together several commonly used libraries, which enable communication between the different modules of Prefall135. Furthermore, it has a broad community of users contributing to the extension and documentation of the project.

In order to achieve communication with the hardware, the interaction module of the installation establishes a connection between Arduino and openFrameworks through an instance of the ofArduino class using the firmata protocol. Through this instance, the software is able to read values directly from any Arduino’s pin and calculate the angular velocity of the watermills. In this way all the input data is made available for the visuals and audio generation modules. In order to send the required info to the audio generation module an instance of the ofxOsc class is initiated which uses the Open Sound Control (OSC) protocol to send data through a network connection.

5.2 VISUALS GENERATION MODULE

The visuals generation module uses the angular velocity of each watermill to dynamically generate graphics. The generated graphics draw inspiration from the natural element of water and consist of a fluid simulation function and a simulation of a flocking behaviour function.
The fluid simulation uses the *MSAFluid* open source library by Mehmet Akten\(^5\). The library solves and displays real-time 2D fluid simulations based on Navier-Stokes equations and wraps in an API the fluid solving algorithms by Jos Stam (2003). The API provides methods for adding and getting forces and controlling fluids' color at any position.

The flocking behavior simulation is based on the code *Pond* (Reas and Fry 2014) written by William Ngan\(^6\). The code was re-written in the C++ programming language and adapted to the installation. This code is an implementation of Craig Reynolds' model of separation, cohesion, and alignment (Reynolds 2001). The model coordinates animal motion such as bird flocks and fish schools and consists of three simple steering behaviors, which describe how an individual member of the flock moves, given the positions and velocities of its neighbors. The behaviors include a) *Separation*, steering to avoid crowding local neighbors, b) *Alignment*, steering towards the average direction of local neighbors and c) *Cohesion*, steering to move toward the average position of local neighbors (Reynolds 2001).

The rotating watermills act as points of attraction for the flock, while the attraction force is proportional to the angular velocity of the watermill. The rotation of the watermill also increases the velocity and energy of the flock members and changes their color. Each watermill affects only the flock members that are inside a circular area of certain radius around the watermill. Simultaneously a simulation of an agitated fluid is generated and projected around the rotating watermills. In order to achieve perceptual coupling of the physical watermill and the digital image, the nine points calculated by the software have to coincide with the watermills when projected on them. For this reason a calibration mode has been designed that enables refinement of the projection mapping.

### 5.3 Audio Generation Module

The audio generation module was programmed in PureData, an open source visual programing language suitable for real-time sound processing and generation. The data concerning the rotation of the watermills is send to the audio module from the interaction module through the Open Sound Control (OSC) protocol. Similar to the visuals, the inspiration for the generated sound was found in the sounds of natural elements such as water and wind. Three different methods of audio composition were employed in order to achieve this result: additive, subtractive, and wavetable synthesis.
The additive synthesis module has been used to simulate the sound of wind, the subtractive synthesis module simulates the sound of rain, while the wavetable synthesis module simulates the sound of falling water drops. Each watermill has a specific function in the audio module. Some of them generate original sounds while others affect parameters of the previously generated sounds such as the volume, frequency or wave forms, thus creating dynamic evolutions in the overall audio output. The use of algorithmically generated sounds has been privileged over the employment of pre-composed material, avoiding ROM-based solutions.

6 COMMUNITY AND USER FEEDBACK

6.1 COLLECTIVE PRODUCTION AND COMMUNITY FEEDBACK

The paradigm of collaborative production in the artistic context is gradually gaining ground and the reasons range from non-for-profit personal and social-driven incentives to economic motivation. Participation in DIWO, P2P projects, FLOSS and OSWH communities promote the feelings of shared creativity and knowledge, communication and the development of social relationships (Benkler 2006). Moreover, working in DIWO projects and producing collectively result affordable for a wider public, especially in times of economic crisis (Koutsomichalis and Rodousakis 2015).

The Prefall135 project emerged through the collaboration of interdisciplinary artists of the Once Upon A Byte art and technology collective based in Barcelona. Later more people got involved in the project through the workshops, presentations and residencies that took place during the development process. The Prefall135 development team participated actively in FLOSS and OSWH communities by sharing, reusing, and extending the freely accessible use-value. Prefall135 distributes its source code under a Creative Commons Attribution-ShareAlike 4.0 International License, that prevents private appropriation and places it in the public domain. The Prefall135 team often collaborated remotely and asynchronously, following the paradigm of internet aided CSCW (Computer Supported Cooperative Work). They extensively used social web tools (wikis, blogs, media sharing platforms, mail lists and VoIP) to share resources, communicate, co-edit and document the development process.

Apart from sharing the project results online and virtually meeting the developer communities in digital spaces (forums, wikis), the creators considered it appropriate to meet the communities’ members in physical spaces as well. In this context,
they participated in presentations addressed to the openFrameworks and Arduino developer communities at ZZZINC — Cultural Research & Innovation in Barcelona and at FrownTails in Athens, respectively. During these presentations the authors further propagated the knowledge acquired during the development of the project and also received the communities’ feedback. Further interaction with the communities of developers and artists was achieved through a number of workshops and residencies, that the creators of Prefall135 attended.

6.2 EXHIBITIONS. USER FEEDBACK

In parallel with the presentations to the developer’s communities, a series of exhibitions addressed to the broad public took place. The project was exhibited at various venues, festivals and institutions, such as Sonar, the 19th Festival of Advanced Music & New Media Art in Barcelona; Fabra i Coats Creative Factory in Barcelona; and the Creative Algorithms exhibitions at Espaço o Tempo in Montemor-o-Novo, and Pavilhão do Conhecimento in Lisbon. During these exhibitions, the development team had the chance to discuss issues related to the project with the audience, study users’ interaction and receive feedback from a broad public. The exhibitions attracted numerous and diverse audiences, with regard to age, motivation for visiting the exhibition, and level of familiarity with interactive technologies. Especially valuable in terms of observations on user interaction and feedback was the participation of Prefall135 at the Creative Algorithms exhibition, where more than five hundred students of schools of the area visited the exhibition and interacted with the installation.

6.3 REMARKS AND OBSERVATIONS

Below is presented a selection of interesting remarks and observations in relation to users’ interaction.

The interface seemed to be easily comprehensible by the majority of the users, independently from age and technological skills. The absence of WIMP-based interfaces encouraged novice
users to interact, explore and get engaged with the installation. Regarding the motivations for interaction, greater diversity was observed. For example, children focused on the ludic aspects of the installation considering it a game. Users familiar with digitally synthesized sound regarded Prefall135 as an instrument for sound composition. Other users explored the possibilities of creating a visually engaging augmented sculpture. Similarly, part of the users focused either on the visual channel of the installation or on the audio channel, while most of them perceived the audiovisual output as a whole. In relation to the collaborative possibilities offered by the installation, children seemed to explore them more extensively, often applying scenarios of simultaneous interactions. Finally in terms of learnability and predictability (Levin 2000) of the audiovisual system, the visual response to users actions seemed more easily apprehensible but also more predictable than the audio response. Concerning the audio response, while most of the users easily associated the generation of a sound with the rotation of a watermill, novice users encountered difficulties in understanding the function of watermills that affected the overall audio output of the installation as opposed to watermills that function as sound generators.

7 CONCLUSIONS

This paper introduced Prefall135, an interactive tangible installation for audiovisual composition. The custom software and hardware built for the installation were presented, as well as the challenges of incorporating the natural element of water with new technologies and everyday objects. Certain technologies and practices from the HCI and social web domains were discussed, which facilitate the participation, interaction and collaboration of an increasing number of users either at end user level or production level, contributing to a more democratized access to the creative process.

Prefall135 is a project that draws inspiration from nature and underlines the concepts of sustainable design, preservation of resources (either natural or digital), and free access to such resources. DIY and DIWO communities support sustainable approaches through practices including the re-appropriation and re-purposing of obsolete materials, the development and free distribution of open tools and open data, free access to resources through commons-based licensing and knowledge sharing. Prefall135 integrates both DIY and DIWO practices, it is produced collectively and develops close interconnections with the open source communities. Considering the development process equally as important as the result, multiple iterations of design/
development-discussion/feedback have taken place both in digital spaces (forums, blogs) as well as in physical spaces (community member meetings, workshops, residencies). The result of this process has been the development of multiple constructive collaborations and a rapid evolution of the project.

Regarding the interaction design, the main goals of Prefalll135 were to engage a wide range of users through an intuitive interface and to promote collaborative synergies. The first goal has been pursued by embedding interactive functionalities in everyday objects and avoiding WIMP-based interfaces. The second goal has been pursued by enabling simultaneous manipulation of interactive tangible artifacts by multiple users. According to users’ interaction, observations and feedback during the multiple exhibitions of Prefalll135, it is estimated that these goals have been achieved at a certain point, as both novice and experienced users got engaged with the installation and easily managed to control the interface, while many of them applied scenarios of collaborative interaction. However a more systematic user study and effective evaluation of the users interaction would be valuable for the future improvement of the interface and the user experience.

Acknowledgements. The development of Prefalll135 was supported by Phonos Foundation and Ciência Viva. The prototype was developed during the Master in Digital Arts of the Pompeu Fabra University, under the supervision of prof. Sergi Jordà. The authors would like to thank the Once Upon A Byte collective and the venues, festivals and institutions that hosted exhibitions of Prefalll135.

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This paper describes a sound installation designed to increase our aural awareness of animal sounds, aiming to reinstate our natural connection to our own habitat. Based on casual, semantic and reduced listening modes, we developed a sound installation that presents creative aural experiences to enhance our connection to the natural soundscapes by recreating lost or forgotten environments, thus contributing to the preservation of sound memory in the contemporary world. This paper explains the concept and implementation of the installation and offers a discussion of the role of listening in our society and strategies to make it a more conscious act.


1 INTRODUCTION

A sound space is bound to the individual as a listener and to the state of their auditory surroundings: we are always in a complex sonic exchange with our environment. Because our society is increasingly creating a distance from the natural world and its sounds, it is important to raise awareness in the individual of the listening process. This in turn can encourage aural learning and expand our auditory consciousness.

This paper describes in detail the technical and conceptual process of an installation entitled *Acousmatic Park* that enhances our aural awareness through artistic practice. Usually, people are disconnected from the listening act. Most of the time, they are only hearing.

As Murray Schafer pointed out, there is a notable dominance of the visual modality in society. Consequently, children’s ability to listen was, in his experience, deteriorating. Because of this problematic, he argued passionately for listening skills to become an integral part of the national curriculum (Schafer, 1977; Wrightson, 2000). Schafer also proposed a program, Ear Cleaning, designed to train the ear to listen with more discernment to sounds, particularly those of the environment (1969).

According to Pauline Oliveros, hearing is an involuntary process while listening is voluntary (2000). Also, Kai Tuuri et al. argue that listening is an active process that provides a means to select the information that meets our needs from the auditory environment; it is usually associated with voluntary attention and intentional focus (2007).

In a society increasingly connected to digital technologies and inundated with constant sound stimuli, aural awareness should be valued. Considering that we live in an urban context, used to a certain daily soundscape of electronic, machinery, industry, transportation, business, and many other technological sounds, the population has less access to sounds from nature. Natural environments are starting to be “forgotten.” Regarding this condition, Wrightson argues:

In the developed world, sound has less significance and the opportunity to experience “natural” sounds decreases with each generation due to the destruction of natural habitats. Sound becomes something that the individual tries to block, rather than to hear. (2000, 12)

Cities are more and more urbanized, and it is starting to become difficult to find quiet or natural areas. Even the parks or gardens we have access to within the cities are “contaminated” by the sounds of highways, airplanes, and construction, among others, leading to the masking of the real sounds that should characterize these areas.
In a context in which the awareness is being raised of the impact of urban sound on our society, we are beginning to face the problem of increasing noise in cities. One of the resulting dangers to ecosystems include some species of animals leaving noisy areas (Francis and Barber, 2013). According to studies in emerging fields such as soundscape ecology, we can observe, for example, how animal sound communication (bioacoustics) has been changing due to a soundscape transformation caused by increasing anthropogenic noise (Francis and Barber, 2013; Pijanowski et al., 2011). By developing these fields, we can increase our knowledge and understand how humans affect ecosystems (Pijanowski et al., 2011). Bernie Krause describes the dilemma in his latest work:

More than 50% of the material recorded over nearly five decades comes from sites so badly compromised by various forms of human intervention that the habitats are either altogether silent or the soundscapes can no longer be heard in any of their original forms. (2015, 29)

Based on the links between science, sound, and technology and supported by both sonic architecture and urban planning, we are challenged to seek new approaches in sound perception and consciousness. In this paper, we present a sound installation through which we propose tools to increase awareness of sound in order to maximize the relationship with the listening process.

According to Michel Chion there are three identified kinds of listening states: causal, semantic and reduced listening. **Causal listening**, the most common mode of listening, consists of listening to a sound in order to gather information about its cause (or source); **semantic listening**, a mode that refers to a code or a language meant to interpret a message: spoken language, for example, as well as Morse and other such codes; and **reduced listening**, a mode that focuses on the traits of the sound itself, independent of its cause and of its meaning. This term, reduced listening, was first coined by Pierre Schaeffer in the context of concrète musique and is closely related to acousmatic listening, another concept introduced by Schaeffer. Acousmatic listening refers to a situation where the sources of the audible sounds are not visible for the listener (1994). Supported by the work done by the previous authors and by Chion’s modes of listening we develop experiences that not only increase our aural awareness and raise consciousness of our listening act but also reinforce our connection with natural soundscapes.
2 RELATED WORK

This work, entitled Acousmatic Park, is framed in artistic, scientific and social science fields, and it features original contributions based on sound recording. The main contribution of this work is offering the community a more conscious sound approach, strengthening its relationship with the natural environment and promoting environmental education. We want to promote more “attentive” citizens in a world with constant sound evolution, thereby providing work that can increase people’s awareness. As the composer and creator Oliveros states:

Deep Listening involves going below the surface of what is heard, expanding awareness to the whole field of sound, while finding focus. This is the way to connect with the acoustic environment, to all that inhabits it, to all that there is. (2000, 39)

For Pauline Oliveros deep listening is “a practice that is intended to heighten and expand consciousness of sound in as many dimensions of awareness and attentional dynamics as humanly possible” (2005). The deep listening act can be considered a kind of meditation in which people can achieve relaxed mental states. The goals set for Acousmatic Park intend a creative exploration of the listening modes in a controlled environment in order to provide an incentive for a conscious approach to the listening act. In fact, sound strategies implemented in Acousmatic Park have been shaped to convey quick and easy experimentation with sound compositions with different degrees of interaction and immersion and allow engagement with several natural environments. This installation draws upon our search for aural awareness and for the relationship between nature and its sounds. The project is supported by research on artistic work that shares the same ideas and concepts that we will present shortly.

Chris Watson, in his work Whispering in the Leaves (2008-2010), uses sound recordings from tropical forests of South America to create immersive soundscapes. He created two compositions of vocalizations, voices and songs from different species corresponding to dawn and dusk, the times of transition in the rainforest. In his piece visitors are meant to concentrate on the listening process.

Another relevant work is Chairs (1995-2007), by Peter Ablinger, that foregrounds listening as the main purpose of the piece. For Ablinger, the most important element is not the piece or the composition, but the listening process itself. It is not the sounds themselves but instead the act of listening that becomes the piece. This work is interesting because it directs the listener’s attention through the action of “sitting.” In this way, the public will be more aware of the act of listening.

1. http://www.chriswatson.net/

2. http://ablinger.mur.at/docu01.html
Another artist that relates to our goals is Leah Barclay with the *Listen(n)Project* (2014), a piece that explores remote embodied experiences of natural environments through sound. It focuses on community awareness and sustainability by studying how rich digital media environments and acoustic ecology practices can be used to broaden discussion about the value of precious, yet fragile, environments. It explores how virtual ecological engagement through sound can nurture environmental awareness and community agency.

The work led by artists and activists from the documentary *Racing Extinction* (2015), that transformed the St. Peter’s Basilica in the Vatican in a public art project to raise awareness on climate change and endangered species is also a reference project for the themes of community and global awareness. The artists want to inspire more people to care for the planet and be more conscious about saving it. This is a very important issue because we are starting to see the impact that these kinds of art practices may have on communities by encouraging a shift in behavior and a change in people’s habits in order to protect the natural environments.

In Bearnie Krouse’s latest book *Voices of the Wild* (2015), he gathers a set of recordings in the same place in different years and shows how the habitat’s sounds have changed through times. This book can be read in conjunction with a website in which the audio clips are stored, featuring recordings from all over the world.

Finally, we also consider the work of Francisco Lopez, an influence because of his approach to sound and the listening process. In his live performances, Lopez calls our attention to the sounds themselves rather than to their sources and suggests that the audience should wear blindfolds to enhance the experience.

3  DESIGNING THE SOUND INSTALLATION: A CASE STUDY

3.1 PROPOSAL: *ACOUSMATIC PARK*

Research study of the subject — aural awareness and listening modes

Initial proposal — development of a site-specific sound installation for Casa da Música, Porto, Portugal.

In Acousmatic Park, we aimed to expose members of the public to a new sound approach so that they could use the sound in a creative way, thereby improving their aural experience. With the
development of these capabilities, we enable people to listen to
their environments with greater awareness. We offer an explo-
ration of the listening modes of Michel Chion, believing that this
process helps exercise our auditory perception on a deeper level.
Given these elements, we believe that through the development
of sound installations, we can raise public awareness of not only
a different approach to sound but also a reinforced relationship
between society and the natural environment, thus preserving
memories of these almost “lost” sounds.

We developed *Acousmatic Park* in order to achieve these goals.
*Acousmatic Park* is a route through four rooms that work as lis-
tening spaces. In each room, we present a different sonic experi-
ence with a specific soundscape and a suggested listening mode.
These listening experiences are based on a simplified model of
Michel Chion’s three listening modes. Bearing this in mind, ev-
ery room provides a sound approach on cognitive and emotional
levels inviting the public to actively engage in the listening act.
Currently there is a more complex listening model brought by
Tuuri et al. that defends, for example, multimodal listening, but
for this installation we decided to explore the basic model. (Tuuri
et al., 2007)

### 3.2 EXECUTION / IMPLEMENTATION

After a careful survey of Casa da Música’s facilities, we selected
the spaces based on the possibility of a narrative between the
rooms, proximity between rooms, acoustic properties and physi-
cal characteristics, dimensions, localization, acoustic potentiality,
general ambience, illumination, and the presence of windows.
We also had in mind the logistics of the rooms, the normal op-
eration of Casa da Música, and a logical evolution through the
listening modes.

To enhance the immersive experience, we selected four rooms
that we will describe in the next section. These four rooms are
contiguous, which allowed us the possibility of a path. Also they
have quite different characteristics, which permitted us to have
a creative approach in the use of spaces.

With the support of Macaulay Library of Ornithology that
kindly provided part of the sounds, and by original recordings
made by our team in Zoo da Maia (Fig. 1), Parque Ornitológico
de Lourosa, Centro Veterinário de Exóticos do Porto, and Sealife,
we built an original sound library mainly composed of animal
sounds. For the recording process we used Sound devices 702T
Portable digital recorder; custom made hydrophones; CS-1 Shot-
gun Microphone; Rycote windshield kit 4; Zoom H4 Handy Re-
corder; and Zoom H2 Handy Recorder. This experience *in loco*
was important to understand the expressiveness and the artistic potential of the sounds. We could define which animals would be most appropriate to use within the installation. This original library provided a more consistent basis for the project and actively contributed to the preservation of sound memory of the chosen species.

The recordings made today will eventually become “acoustic fossils,” possibly preserving the only evidence we have of ecosystems that may disappear for lack of ability to protect them. (Pijanowski et al., 2011, 213)

A digital platform with a website (Fig. 2) was developed as a complement to the installation so that the visitors could obtain more information regarding the work and the sounds. We also used QR (Quick Response) codes in rooms, which allowed us to increase the user’s relationship with the project, directing the user quickly to the website.
3.3 DESCRIPTION OF THE ROOMS

In all the four rooms, we propose a soundscape essentially composed of animal vocalizations that stimulates and challenges our listening awareness from different perspectives. For each room, we provide a brief description of the concept and context, the type of composition, and the suggested listening mode.

Table 1. Room characteristics.

<table>
<thead>
<tr>
<th>ROOMS</th>
<th>CHARACTERISTICS</th>
<th>SUGGESTED LISTENING MODE</th>
</tr>
</thead>
</table>
| 1. Cibermúsica (Cybermusic) | Natural light with a glass wall  
                               Acoustic treatment promoting sound amplification Connected to Foyer Renascença | Open, creative listening                       |
| 2. Foyer renascença (Renaissance Foyer) | Natural light with a glass wall  
                               No acoustic treatment  
                                Connected to the Sala Laranja | Causal listening                             |
| 3. Sala Laranja (Orange Room) | Artificial light, no windows  
                               Interactive room  
                               Kinect  
                                Connected to Sala Roxa | Semantic listening                           |
| 4. Sala Roxa (Purple Room) | Artificial light, only presence lightning  
                               Dark room  
                               Immersive room | Reduced listening                           |

*Acousmatic Park* explores the listening modes covered above. The modes can be engaged in any room; however, some rooms are more suited for a particular type. The listener can have a free approach to the experience by moving through the rooms and deciding how long he will spend in each room. The listening modes are designed not only to help the listener increase their aural awareness, providing different conditions for the listening act, but also to draw his attention to environmental education. Connor writes:

Perhaps it is the sound of animal sounds that most impresses us with the sense of a specifically sonic field of action and awareness, precisely because the sound of unowned animals is usually separated from visual confirmation. Whether it be the whirr of cicadas, the twittering of birds, or the hum of bees, the animal sounds that we hear are normally separated from their sources. (2014, 19)
The room Cibermúsica (Cybermusic) is characterized by a nocturnal or crepuscular soundscape in which listeners are mainly presented with nocturnal species. The narrative for this room is based on a night walk in a lake area, and we can listen to a full range of animal sounds that alternate with a quieter ambience. The sound composition is based on calls from several amphibians, such as frogs and toads, but also from birds, insects, bats, and some natural sounds such as water or wind. In order to encourage the visitors to engage the first listening challenge, the strategy for the composition was based on two essential aspects: the expressiveness of the sounds and the relationship between them.

Our strategy for this first room was to present a preliminary listening experience to the visitors. As this room is the first connection with the installation, the idea is to encourage the listener to become more aware of the sound environment by engaging with the listening act in an open and free way. We intend for the visitor to have no specific concern with the listening mode but instead to focus on the conscious listening act. In order to keep visitors engaged with the soundscape, we offered sounds to arouse curiosity and alternated between known sounds and less familiar sounds to promote interest. For a more immersive experience, people are invited to lie down and are encouraged to close their eyes (Fig. 3). In order to facilitate concentration on the listening act, we had blindfolds for the eyes (Fig. 3).
In Foyer Renascença (Renaissance Room), we present a soundscape easily recognized by the listener in order to explore causal listening. When we find a direct relationship between the sound and its source, we further develop the capacity for sound interpretation. The narrative for this room is based on the transition from a sunny day to a thunderstorm in a tropical forest, and the sound composition is mainly comprised of diurnal birds, monkeys, insects, and some natural sounds such as rain, water, and thunder. There are animals that can predict these events and even emit specific vocalizations before the rain starts, so the strategy for the composition was based on the relationship between environmental events and specific responses in terms of animal behavior.

We took advantage of the large glass windows in the first two rooms (Cibermúsica and Foyer Renascença) and searched for new approaches of sound transmission. Thus, in both rooms we questioned the use of a traditional stereo system that interferes visually and gives the listener an indication of the sound source. After exploring different types of sound transmission through unconventional surfaces, we came to the solution of using speakers from the brand Feonic. These are quite small speakers, almost imperceptible with a 4 ohm impedance and 100 watts power, and they transmit the sound to other materials through vibration. We used two exciters in each room to transmit the sound through the entire glass window (Fig. 4), making the most out of the building materials.

Fig. 4. People listening in Foyer Renascença room, Casa da Música, Porto, 2015; detail of the Feonic speaker in the window.
ROOM 3: SALA LARANJA

The sound environment in the Sala Laranja (Orange Room) is composed of alarm or distress calls from different species that are usually presented when a danger or threat appears (defending the nest, warning a predator, or crossing the security perimeter). The listener has the opportunity to interact with the space, and the sounds proposed are related to semantic listening. We used Sonorium, an application developed by Digitória that creates a sound map of a physical space, which triggers specific sounds according to the presence and position in space of the visitors. Sonorium is an electronic virtual instrument that detects and interprets even the slightest movement, captured through a motion detector. It applies a tridimensional virtual grid to a physical space allowing the creation of a set of hotspots that are activated by the user’s position, thereby triggering a predetermined sound or MIDI note.

This room is characterized by empty space exploration (Fig. 5) and requires the presence of the public, which introduces the concept of participatory installation. There are specific areas in the room that act as sound triggers. Most species presented in this room vocalize or react when they feel the approach of a predator, so we thought it would be appropriate to play with the distances in order to create danger zones in which sounds are triggered. To help the listener to detect sounds, a path was designed on the floor (Fig. 5).
ROOM 4: SALA ROXA

The characteristics of Sala Roxa (Purple Room) led us to design a narrative of an underwater environment. The sound composition is based not only on species of marine mammals such as dolphins, whales, seals, elephant seals, but also on fish and water sounds. Because the strategy for the composition was promoting a confrontation with very rich and deep sounds, we used vocalizations with a very different range of frequencies that combined together to give rise to a very unusual soundscape. This challenges the listener to approach the auditory process in an unusual manner. Here, we intended to develop reduced listening without any attempt at sound interpretation. We explore not the connection with the source but the evaluation of the sound itself. The characteristics of the sound, such as pitch and timbre, are the focus of attention.

Because it is the last room, we engage the listening mode that requires the most training. To help the listener, this room remains in almost total darkness (Fig. 6). The soundscape is composed of abstract sounds to encourage the listener to focus on the characteristics of the sound and not on the source.

4 RESULTS

In order to understand and evaluate the reactions of the visitors, we collected feedback using direct observations, photography and video records, and interviews with the guides that followed some of the visitors within the installation. This way, we could obtain information without interfering in the experience. This
feedback allowed us to better assess the preferences and behaviors of the visitors within the frame of our artistic objectives. We had a total of 720 visitors: 352 individual visitors that explored the installation by themselves and 368 that had a guided tour. In these tours, the visitors got to know all the Casa da Música facilities, including the rooms with the installation. The guides followed these groups through the installation, explained the concept of each room, and observed the overall reactions of the visitors. They also were available for any simple questions regarding the work.

From our conversations with the guides we assessed that Sala Laranja and Cibermúsica captured the most attention from the public. The visitors spent much of their time interacting with the sounds in Sala Laranja, and it was interesting to observe that the use of a Kinect promoted the dislocation and use of the body in the physical space. The conditions provided in Cibermúsica helped the listener concentrate and primed him for the listening act, and this room kept visitors for the most time. At Foyer Renascença, visitors spent less time and very few sat down for a longer experience, probably because they came from Cibermúsica, where they had spent time sitting or lying down. We observed in Sala Roxa that visitors engaged with the sounds but left the room quickly, perhaps because the presented soundscape was more abstract. We experienced some problems when dealing with large groups that interfered with the behavior of solo visitors, leading to distraction and consequent loss of attention. This also happened when occasional external sounds overlapped the soundscapes.

Based on our observations, feedback gathered among participants, and information from the guides, we inferred that the causal listening seemed to be the most immediately used mode among the visitors (and people in general) in all the rooms. Even in Sala Roxa, where the suggested mode was reduced listening and the visitors were meant to disconnect the sounds from sources, people tried to guess the original sound. Michel Chion also explains this when he refers that an acousmatic situation may create favourable conditions for the reduced listening, however it may also increase the listener’s effort to identify the source (1994). On the other hand, we also observed some visitors repeating rooms to try the different modes. We conclude that these challenges and practices should be more regular so that people may learn these methodologies, and develop their skills, in order to use them in daily life.

Regarding the enhancement of aural awareness, we conclude that if we provide the necessary conditions, people can become conscious of the listening act itself. We also learned that people are easily distracted from their focus and that listening is a
process that needs practice and training, especially the listening modes less used on a regular basis, such as reduced listening. We are confident about the transmission of our objectives because, through the exploration of these procedures and from the information collected, we perceived that visitors left with an understanding of the purpose of the installation. In all the rooms people engaged with the soundscapes and with the listening act. We attained an enhancement in their aural awareness in certain moments of their time within the installation. We could also conclude that if people are reminded of the act of listening, they become aware of it. At this point we also assume that these reminders need to be on a regular basis to promote a more comprehensive awareness of sounds.

What we could not conclude was if people after the installation where challenged to maintain this consciousness of the sounds from their environment and if the installation helped them with this behavior. In the future we would like to track whether this behavior disappears immediately after the visit to the installation or if people left more attentive to their surroundings.

5 CONCLUSIONS AND FUTURE WORK

Because of the lack of aural awareness in society, we searched for solutions to raise our consciousness of sound and the listening act in our daily life. We developed an interactive sound installation as an answer to our problems. Currently we are witnessing excessive environmental noise, which usually leads to the need to “clean” our ears. There is a lack of connection between people and nature and its sounds. This work offers a way to outline this issue from an aural point of view, allowing an engagement with nature through the compositions used in the project. By creating spaces that simulate natural environments, we proposed innovative acoustic experiences to the listener. The documentation available in the rooms regarding the explanation of the listening modes and the concepts of each room, together with the information and sounds provided on the website, were central for achieving the intended listening experiences. Otherwise, it would be difficult for the visitors to attain the level of attention and awareness required for the overall experience. The strategies described in this paper provided us a better understanding of how people approach sound and the listening act. We can conclude that this kind of art practice can be a starting point for a more conscious approach to the listening act and a heightened awareness of sounds.
Acousmatic Park is going to be presented at the Zoo da Maia facilities, and we plan to continue the sound recordings. We aim to catalog their animal collection, integrate more sounds, and expand our original library by updating the website with new information. We also want to add sound walks and sound maps to the installation in order to improve the exercises for practicing the listening act. Through our artistic practice, we want to enhance environmental education, promote a better understanding of wildlife, and encourage people to respect the animals in their environments.

Finally, although the main objective of the project is increasing aural awareness, its scope can be expanded to other areas such as live performance, visual arts, and educational practices, among others. Future work will include improving the conditions of the listening act to allow a more complex and permanent response in the individual. At the same time, we are also planning a more medical approach (sound frequency therapies) for the use of these natural soundscapes in order find treatment options for tinnitus problems. Searching for the relation between aural practices and treatment approaches for these conditions can be a challenge and a way of connecting medicine and sound art. We seek the possibility of developing new auditory practices by proposing innovative approaches to sound in a critical and creative perspective. We question how the listening act will evolve in our society.

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‘iAm’ is an online short-film editing engine that generates pseudo-infinite instances of the same story. This artistic artefact can be considered a working prototype that serves as a proof of concept. Its artistic aim is to point out the relationship between humans and machines by letting the software make decisions during the editing process. The technical implementation becomes an experiment to test the importance of narrative patterns and structures of specific ways to formalise a story, while at the same time it questions the idea of final cut, authorship and finished work. It is a multidisciplinary project that involves UX design, software development and film shooting. The artefact becomes a formalization of several ideas.
1 A CRITICAL APPROACH TO VIDEO EDITING INTERFACES

Standards are important to set up bridges of communication. Standardised protocols such as language or other means of codes, common ways of interaction and a global infrastructure, are needed for the creation of a global society. In the 1930s, Otto Neurath pioneered with the isotype the progressive development and use of icons in our culture. The aim was to create a standard visual language that would be international and easy to understand for anyone. In the field of technology, the popularization of icons was done by Xerox and Apple in the early 1980s. Since then, Graphical User Interface (GUI) and the field of User Experience (UX), have been growing constantly. It is well known that metaphors used in the first personal computers helped to reduce the gap between analog and computational environments. This historical moment was important for the adoption of technologies by a large audience that was mostly familiar with analog processes instead of using computation.

GUI allows visual exploration of possibilities and characteristics of the applications. Most of those interfaces are visually appealing and use metaphors that relate to the cultural, economic and political systems from where they belong (Lakoff 2003) and are conceived to address a specific audience.

Since the turn of the 21\textsuperscript{st} century, online video has been popularized due to an increasingly higher bandwidth, better compression codecs and the popularization of technologies like Macromedia Flash and, more recently, HTML5. Platforms like Vimeo (2004) and YouTube (2005) have fostered the presence of audiovisual documents in the net. Today’s media content is mostly produced, distributed and viewed in a digital environment and uses standardized metaphors and icons that we all recognize. Analogous standards had an influence on the terminology used in software and were translated into the new environment (Echeverria 1999). The logics used in analog cinema and video editing worked perfectly in this new environment, but they are not exhaustive. Mainstream software such as AVID, Adobe Premiere or Apple FinalCut allow to easily understand the principles of editing in real life analog mechanics. However, expert computer users lack the possibilities of using coding in those interfaces, and native computer users find that most of the icons they use have no references to real life elements. A new logic to the computational context is needed to fully take advantage of this environment.
1.1 REINVENTING THE MEDIA.

Nowadays, in this context, audiovisuals are realized, produced and distributed mainly using this new digital environment (Vialas 2013). According to Murray, instead of just translating the analog content to a digital container, “digital design is about shaping interaction within new combinations of the format and genre conventions that make up a new medium” (Murray 2011). Along the same lines, Manovich stated: “We do expect computer narratives to showcase new aesthetic possibilities that did not exist before digital computers” (Manovich 2002).

We can think of all the material accumulated during shooting as forming a database, especially since the shooting schedule usually does not follow the narrative of the film but is determined by productions logistics. During editing, the editor constructs a film narrative out of this database, creating a unique trajectory through the conceptual space of all possible films that could have been constructed. From this perspective, every filmmaker engages with the database-narrative problem in every film, although only have done so self-consciously. (…) Given the dominance of the database in computer software and the key role it plays in the computer-based design process, perhaps we can arrive at new kinds of narrative by focusing our attention on how narrative and database can work together. How can a narrative take into account the fact that its elements are organized in a database? How can our new abilities to store vast amounts of data, to automatically classify, index, link, search and instantly retrieve it, lead to new kinds of narrative? (Manovich, 2002).

Manovich points to some essential characteristics of digital cinema, especially considering how the database of media can be manipulated and accessed. Briefly reviewing how editing software addresses this idea, we find several approaches. If we observe mainstream editing software such as AVID, Final Cut or Premiere, we can see a multitrack timeline that follows the analogy of a celluloid. For the media selection dialog window we commonly use an easy to navigate folder structure and a preview window. That software is meant to output a linear closed audiovisual cut. Observing software with a more contemporary approach to the editing capabilities we find those producing web-docs such as Korsakow [http://korsakow.org/], Klynt [http://www.klynt.net/] or Interlude [https://interlude.fm/]. In those cases, the navigation through the database of a media is designed using a diagram instead of a linear timeline. Underlying metaphors in that software are ‘nodes’, ‘neurons’, or ‘narrative units’ that can be connected together with the interaction of the viewer.
On the other hand, tools for VJing or live cinema such as Resolume, Modul8 or GrandVJ, substitute the idea of a timeline for a preview and a real-time output and allow many different ways to access the media database. The interface is meant for real time performance and it includes random access to files, live sources and multiple layers. There is a relevant amount of artists and creators that use graphical programming environments such as Max/MSP/Jitter, vvvv, Isadora, Pure Data and Touch Designer, or that use scripting frameworks such as OpenFrameworks or Processing. In those cases, the use of algorithms to edit audiovisuals is possible and allows interesting ways to navigate the media database.

For those different tools, examples and tools made by artists, filmmakers and developers such as Aaron Koblin, Chris Milk (Koblin and Milk 2010) with their online contextualized generative proposal The Wilderness Downtown, the artist Carlo Zanni (Zanni 2006) (Zanni 2007), the projects and thoughts of Michael Lew (Lew 2002) (Lew 2015) or the famous Bear 71 documentry (Mendes and Allison 2012), among others have been reviewed.

Taking into consideration these ideas, and focusing mainly on ways to access a database, an artifact that is based on generative editing principles has been developed.

2 ‘iAm’ THE PROJECT

For the project, a multidisciplinary 28-member team was created, including filmmakers, producers, artists, actors, UX experts, and coders. The main difference between a common filming team was the presence of two software developers and an interface designer, as well as a director with experience in filmmaking and software development.

The project consists of a website that allows users to view a new cut of the short-film any time they want. The director’s cut becomes the software’s cut created, by the viewer’s demand, as a unique random instance of the potential combinations of the short.

The artefact involves different disciplines, and has 3 main parts: the shooting of an audiovisual repository according to a specific script, a web-based software interface based on a visualization of the amount of footage and its possible instances/combinations, and a server-side software that edits the selected shots in real time and encodes the result into a web-friendly format for online viewing.

The content of the shots reflects on how technology is changing our daily lives and often shifting us from natural contexts to stressful landscapes of information overload. It questions who
is really in control: humans or machines. The very design of the project reinforces this dilemma by generating an automated cut, never edited before and only conditioned by the pattern set up by the director, but out of his control.

**2.1 INSPIRATION AND IMPLEMENTATION PROCESS.**

A poem, reflecting on the relationship between humans and machines, on the co-dependence, the addiction and the increasing presence of technology in our daily life, was the start of the project. This poem, written mostly using aphorisms, is able to be read randomly and still make sense. Some of the inspirational sources of the ideation and practical implementation of the project, together with the original poem, can be found here: [http://iam.caotic.net/influences.html](http://iam.caotic.net/influences.html)

When trying to convert those sources of inspiration into an audiovisual project, a hybrid between website and film was considered to be the most interesting solution. A draft of the structure was developed by mixing the possibilities of code driven decisions together with the ideas of cinema as a navigable database, considering the possibility of producing a generative short film. One of the core aims was to merge the possibilities of both traditions while exploring the possibilities in film editing that open up when merging both.

**2.2 IMPLEMENTATION: FOLLOWING A DESIGN AND CREATION METHODOLOGY.**

In a very early stage of the project Terenci Corominas, Albert Blanc, both filmmakers, together with the programmer Julià Minguillón, were invited to join the project. One of the first issues that had to be addressed was to overcome established metaphors in editing and film production. The team had to discuss methodologies that allow new ways of thinking and writing the script. Dialogs, sketches and group research about common references were established during the first two weeks of the project. Concepts of live performance, randomness or platonic ideals were discussed. Some guidelines for the project were agreed: the project had to be narrative; a clear synopsis had to be explained; it had to create new formal results each time viewed and the illusion of choice or interaction had to be avoided if the viewer would not really be able to choose or interact.
After several sketches (Fig. 1.) and discussions, the resulting proposal was a folder-based database with all the media available, sorted in a way that a pattern could be executed to randomly select clips from each folder and create a coherent story. Design and creation methodology allowed to test some of the ideas and to adjust and address problems found in the early ideation.

Once the mechanics of the software were decided, the team plotted six stories that all shared the same structure and synopsis:

Someone is doing a common thing and gets distracted by a phone call; when trying to talk on the phone he/she get exposed to a big amount of images/information; when they hang up the phone what they were doing has changed dramatically.

The filmmaker team followed the common filmmaking notation to develop a synopsis, storyline, storyboard and film planning, but considering as many shoots from different angles as possible, so for each scene at least two different possible shoots were available. Each take was edited individually and kept as a clip in order to combine them freely later. With this way of working the synopsis engendered a very strong guideline, and it allowed a richer diversity of shootings while respecting the structure to be added.

Fig. 1. Sketches of possible concepts and data visualizations used in the design and creation process.
With that common structure, the original poem has been
adapted and divided into 37 sentences, nine soundtracks have
been prepared by two different musicians, and about two hours
of archive audiovisuals, including scenes of films, documentaries
and found footage, have been compiled. Each of those clips are
saved in a tree folder structure allowing storage of many clips in
each set-scene folder (Fig. 2.). All available information for each
clip (cast, folder location of the file, duration in frames, and to
which narrative group it belonged) is kept in a XML file (Fig. 3.).
As a result, each short film follows one of the six plots, choosing between all the shots available in each scene, choosing one sentence from the original poem, a soundtrack from the nine available and selecting several frames from two hours of archive film. All elements are randomly selected following the main structure and the resulting short film has a duration of 25 seconds.

This solution allows the control of the flow and rhythm of the film, ensuring it makes sense and stays coherent, and at the same time maintaining a possibility of the greatest number of combinations.

2.3 DESCRIPTION OF THE TECHNICAL EDITING PROCESS.

A PHP website plots a data visualization (Fig. 4.) using Processing.js that represents all clips and media in the database as a graphical pie. When the user presses the central “play” button, the Processing sketch generates a random combination and starts an animation to show the resulting structure of the created short-film. Meanwhile, this combination is sent as a chain to a script written in Python that checks the availability of the footage and generates a command to FFmpeg software to concatenate the chosen combination. The resulting file is stored to a folder that keeps all the generated short-films named by date of creation (Fig. 5.).
The visual representation intends to visually convey the amount of combinations. The timeline as graphical pie represents the fact that, although there is only one starting point, the centre, the possible endpoints (on the perimeter) and the paths to reach them are virtually infinite.

3 CONCLUSIONS

So far, about 740 films have been generated and stored in the server of the project and can be viewed by any visitor. All of them follow similar structures and have the same pattern, but none of them can be considered a final cut. Each of them is a valid variation of an idea that cannot be defined more than in its structure.

The artefact serves to illustrate some of the possibilities of using computation to edit audiovisuals and explore means to visually represent that process. While understanding the broad software possibilities that exist today to conceive the editing process (non-linear editing software, web-docs or interactive cinema platforms, VJing and live cinema and even tailor-made experiments), this project explores the intersection between computational generative art (Galanter 2003) and the field of film editing. As a result, new ways of editing, storytelling and real-time contextualization of film are detected as possible.
Showing the process and visualizing the database of footage is an important part of the project. As Janet Murray states, new manners to design and represent have to come with new digital tools and systems [5]. In this case, the big challenge is to question a preconceived notion of fixed narration and to show and explain how a specific generative editing short film works.

As Olav W. Bertelsen and Søren Pold state in their paper “Criticism as an Approach to Interface Aesthetics” (Bertelsen and Pold 2004) it is not about rejecting the actual interfaces, but to understand in a critical way, that many more possibilities exists beyond the proposed metaphors and setups.

We conclude that metaphors such as Premiere or Final Cut, along with many of the ideas underlying the logics of the mainstream production system, such as authorship or masterpiece, can today evolve into more complex and rich concepts and for this, a critical approach to the interface is needed.

4 FURTHER RESEARCH

The project is designed to be able to make modifications to the structure or increment the footage archive by just updating the XML file and folders. It follows several standards and it is developed with open source tools. These characteristics make it an interesting tool for further explorations and it has become a playground to test various experiments and essays. Evolving the project, by using more sophisticated ways to select the footage instead of randomness, seems to be appropriate to explore a more interesting dialogue between the viewer and the potential combinations of the narration.

Further research interviews and focus group methodology are planned in order to review the data visualization and the UX. On the other hand, new development is being done to speed up the process of rendering, testing different codecs and HTML5 live streaming, to ensure a smooth experience for the viewer and eliminate waiting time.

Besides the interest of the mechanism, the interface and data visualization of this experimental audio-visual, other theses arise; it is known that viewing the same video many times gives us different information and our perception of it evolves. Would viewing many instances of a pattern be more efficient in communicating an abstract concept than the repetition of a specific instance several times? Who is the protagonist of this artefact - the viewer, the author or the code? Is the message as relevant as the interface we look through? Are there better ways to visualize
the repository? Is it possible to create a self-explanatory interface? How do people perceive this type of generative film? Do they prefer to see a unique cut? Does it trigger a sense of distinction or value, or the opposite? If a tool for filmmakers were to be developed following the iAm principles, would they use it? How would they adopt it and in which cases? Should this interface be a graphical user interface or a command line interface? These are questions that remain to be explored.

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Exhibition
This paper presents the motivation, background, and implementation of Living Mandala: The Cosmic of Being, an interactive graphics installation that combines real-time data, multi-cultural mandalas, scientific imagery, cosmological symbols, and sound. Built with an open source programming language and environment, this living contemporary symbol is an exploration into uncharted territories of the human soul sculpted by our present time. Its interactive revolving graphical system visualizes our perceptions of life (microcosm) and the universe (macrocosm), our connections to ancient mythology, cosmology, and cultural heritage, and the relationships among humankind, science, technology, and nature in a globalized society. Merging cultural traces—art, history, science, and technology—this living organism alters every moment, responding to the movement, color, light, sound, and temperature of its surroundings. Following ancient quests, it unites indigenous mandalas from diverse cultural contexts to create one that is contemporary and universal.
1 INTRODUCTION
1.1 WHAT IS MANDALA?

The vegetative universe opens like a flower from the earth’s centre, 
In which is eternity. 

William Blake (Gilchrist 1880)

In Sanskrit, mandala means secret circle and center—the symbol of the cosmos in its entirety, while the square is the symbol of the Earth and human-made world. Its traditional design hence often consists of a series of concentric forms, suggestive of a passage between different dimensions. In this essence, it pertains not only to the Earth but also to the macrocosm and microcosm, the largest structural processes as well as the smallest. It is the gatepost between the two. Thereby the mandala is a living structural matrix subjected to the infinite processes of growth and transformation by the virtue of the ever-changing relationships both internal and external to its basic structure. (Arguelles 1974)
The center is the beginning of the mandala, the origin of all forms and processes, and ultimately the eternal potential. The center of the mandala is not only the external space but also of time. The center of time is now. (Arguelles 1974) When living in the present, one’s physical existence and position in consciousness unfold like a mandala at the center of one’s own compass, awareness, and experiences. Expanding from its center, mandala is a manifestation reflecting human consciousness and perception of the universe in their present time, which continually appeared in rituals and art forms throughout history.

1.2 DIGITAL ARTWORKS INSPIRED BY MANDALA

Although the roots of digital art are ancient and varied, digital art came into existence shortly after the development of the computer, which emerged in its modern form in the 1940s. (Wands 2006)

During the six decades of human-computer interaction and computer graphics development, mandala and its abstract symbolic form have continuously influenced artists to explore and create new artworks digitally. James Whitney’s astounding analog film, “Yantra,” (1957) anticipates the digital visual effects of brother John Whitney’s “Catalog” (1961) and mandala-like symmetry of James’ “Lapis” (1966). In the tradition of cymatics, pioneered by physicist Ernst Chladni in the late-eighteenth century, “Protrude/Flow” (2001) by Sachiko Kodama and Minako Takeno interactively transforms three-dimensional patterns in black magnetic
fluid to stimulate viewers’ most primitive emotions, which appears to be choreographed to its sonic environment. (Shanken 2009) “Nanomandala” (2003) is an installation by media artist Victoria Vesna, in collaboration with nanoscience pioneer James Gimzewski. It projects images in evolving scale from the molecular structure of a single grain of sand to the recognizable image of the complete mandala, and then back again. Inspired by Buddhist and Islamic art, Anne Spalter manipulates city footages around the world to develop patterned compositions that explore the concept of “modern landscape” in her works such as “Meditations” (2014).

1.3 RATIONALE AND OBJECTIVE

Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

T.S. Eliot (Eliot, 1934)

As a Chinese artist living in the Western world who continuously explores visual art and cultures, it is astonishing for her to realize that certain universal symbols appear in different cultures and represent eternity, divinity, and harmony. One of those is mandala, the symbol of the round of life and death, of the cosmic procession of beings, planets and stars, of earthly seasons and galactic cycles. (Arguelles 1974) Whether it is the Chinese I-Ching, Navajo ceremonial sandpainting, Tibetan meditation sandpainting, or Aztec calendar, mandalas present views of humankind as the microcosm through their own compasses. Since our world has dramatically transformed in the past two hundred years and the stages of human development remain the same as they were in the ancient times, the artist’s intuition led her to wonder what a contemporary mandala would be, for which this project was created.

_Living Mandala: The Cosmic of Being_ not only reflects our present awareness and perceptions of the universe, but also investigates the changing relationship between humankind and its environment since the Industrial Revolution. The objective of this work is to expand aesthetic experience and enhance human perceptions of the rapidly changing global environment, the universe, and the center of being. Enriched by profound cultural heritage, this dynamic and symbolic graphical system bridges ancient mandalas, cosmological icons, scientific and technological studies, nature elements, and real-time interactive graphics, through which new meanings and imaginations emerge.
Digital media provides a means for artwork to consist of motion, time, light, data, sound, and interactivity, which serve artists to envision and represent the complex message of their work. *Living Mandala: The Cosmic of Being* is a new approach to visualize mandala, an ancient art form, in a contemporary context using digital technology. It was built with Processing (an open source programming language) and Arduino (an open source hardware).

Edward Tufte, a pioneer in information design and data visualization, stated that among the most powerful devices for reducing noise and enriching the content of displays is the technique of layering and separation, visually stratifying various aspects of the data. (Tufte 1990) With complex graphics throughout human history and intricate interactivity, the system consists of three overlapping layers each representing a different timeframe (Fig. 1):

- The thirty-six colorful mandalas from sixteen cultures on the bottom layer represent the past five millennia;
- The fifteen white semi-transparent graphics of human studies on the middle layer represent the past five hundred years;
- The real-time computer generated interactive graphic system and nine nature icons on the top layer represent now, the center of time.

When the three images from each group overlap representing different times and human consciousness simultaneously, *Living Mandala* is born, which connects art, culture, science, information, and technology from the past to the present in a harmonious and meditative unity (Fig. 2).
2.1 THE BOTTOM LAYER

On this layer is a looping animation of thirty-six mandalas and cosmological circular imagery (Fig. 3) collected from sixteen cultures in five millennia. The image changes calmly every five seconds.

In order to make a diverse and balanced mandala collection from world cultures as many as the artist could find, the searching and selection process is both time-consuming and rewarding, because some ethnic groups created many more mandalas than others.
2.2 THE MIDDLE LAYER

Slowly moving in a counterclockwise rotation the middle layer consists of fifteen white semitransparent circular graphics (Fig. 3), carefully selected by the artist, in a random sequence indicating the dynamic of change in the past five centuries. Every graphic image was either designed by the artist or recreated digitally based on a public domain image. Those images represent human studies and perceptions of the world and the universe, among which are the Vitruvian Man, the path of Venus relative to the Earth over eight Earth years, the constellations, the golden ratio.
pentagram, the planetary orbital paths, phyllotaxis patterns, the Seed of Life, Galactic Geometry, the Platonic solid — dodecahedron, GPS satellite constellation, atom diagram, and the illustrations representing Industrial Revolution, information technology, sound waves, and the electric field.

2.3 THE TOP LAYER

In a clockwise rotation the top layer representing now contains two sections: a circular pattern of nine nature icons appearing randomly one after another and an animated interactive vector graphic system programmed in Processing.

Albert Einstein wrote, “A human being is part of a whole, called by us ‘Universe,’ a part limited in time and space”. (Einstein 1972) Although this art project bridges many aspects of humankind in art, history, culture, mythology, cosmology, science, technology, anthropology, etc., it is equally important to combine classical elements and basic components from the natural world, which are part of the universe. For instance, in classical thought the four elements earth, water, air, and fire frequently occur in ancient Greece, China, and India. Thus the following nature icons (Fig. 3) were created by the artist: water, fire, mountains (earth), stars, leaves (wood), wind (air), feathers, shells, and animal tracks.

This interactive vector graphic system was designed to be able to see, hear, feel, and think, shown in Fig. 1. The live video feed and motion detection allow it to see; the audio detection makes it sensitive to sound; the changing colors synchronizing with online weather data of the local temperature indicates how it feels; the color alternation and movement determined by algorithm enable it to think.

CONCLUSION

The interactive graphics installation presented in this paper connects the potential of digital technologies with traditional art, culture, mythology, and scientific studies, in order to create aesthetic and meaningful experiences for diverse viewers. Living Mandala: The Cosmic of Being is much more than an animated interactive infographic. It transcends the concept of mandala and touches the core components that matter today: mixing multiple data streams in a single platform; building an environment for consideration of data in cultural and temporal realms; presenting a framework in the context of human history; and packing striking and universal visual components and conceptual
thinking into a limited presentation space. Furthermore, it translates the dynamic contemporary cultural landscape—a modern approach to an ancient quest—to enhance human cognitions and perceptions of the universe and humanity in our time.

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“Nero ipogeo” is the third of my acousmatic cycle of compositions dedicated to the colour “nero” (the first one “Nero metropolitano” [2014] and the second “Nero siderale” [2015] are published on a CD edited by “Taukay Edizioni Musicali”). The sources of “Nero ipogeo” are audio gestures of high frequencies (not dissimilar to the whistle) and underground sounds on the verge of audibility or inaudibility. The principle of the compositional fragmentation and of the compositional reduction is taken to the absolute extreme. I sculpted a kind of sub-atomic composition that picks up the sounds from the crevices between one quantum event and the next one. The intention is to lead the listener to the most attentive and perceptive kind of listening.

It is mainly designed with the open source software supercollider. The techniques used are different, the sound material is partially the result of elaborations of samples and partially the result of synthesis techniques as well. In “Nero siderale”, the problem of perception bounces immediately back to itself: if it represents the attempt to attest our primordial and original openness to the world, this attestation is however never complete, it is never completely expressed or expressible. Something indeed remains. This constitutive openness of the perception, which helps it establish its paradoxical character, is well expressed by Merleau-Ponty in In Praise of Philosophy where, in the pages dedicated to the philosopher Henri Bergson, is stated that reaching the core of perception would be the same as seizing the meaning of the world, but which, however, remains and cannot but remain a scrap in the expression of this seizing.
Internet criminals create fraudulent websites that mimic real websites and use them for advance fee fraud or other criminal activities. Over the last ten years members of the vigilante scam-baiting community “Artists against 419” maintain the biggest open-access database of fake websites. They use “passive reconnaissance” and “open source intelligence” (osit) tools to gather information to file reports with the hosting provider to get the websites taken off the web. This chapter takes a closer look at the group’s strategies and explains the artistic research installation called “Megacorp.” that visualises a sample probe of 1000 websites from the database collection.
1 INTRODUCTION

The number of fake websites is increasing and scammers use them to present a trustworthy and professional appearance to trick people. It is easy for non-tech savvy people to design a website by using open-source Content Management Systems (CMSs) or freely available web design templates. They register Top Level Domains that use wording similar to that of the original companies. Often, clones of real websites are created by scraping real companies’ websites, and then the fake login pages are used in phishing attacks. There are programs that report phishing incidents automatically, but they still rely on reports of phishing incidents from users. (Husak and Cegan, 2014) Vigilante online communities of scambaiters try to identify, block and report Internet crime activities. For this they have developed various strategies, ranging from creating warning platforms to collecting fake checks or blocking bank accounts, and organise themselves in different forums. One of these subgroups call themselves “Artists against 419” and host the biggest open-access database of fake websites. (Zingerle and Kronman, 2013b) As of May 2016, there are over 4800 registered users and an average of thirty-five websites are added to the database each day. They use “passive reconnaissance” and “open source intelligence” (osint) tools to gather information to file reports with the hosting provider to get the websites taken off the web. (Glassman, and Min Ju, 2012) Since 2007, the group members discontinued using web programs such as “Lad Vampire” or “Muguito” to run “Denial of Service” attacks against the websites and instead now use their own tools and written reports to maintain a good relationship with hosting providers and law enforcement. (Cain, 2004, Brenner, 2007)

2 THE MEGACORP. BUSINESS CONGLOMERATE

The research into the scambaiting community “Artists against 419” led to a deeper investigation of how this community tracks fake business websites and reports them. We wanted to visualise the database, so our idea was to look at all these fake companies as though they were be one big evil corporate conglomerate that wants to take over the world. This so called “Megacorp.” is inspired by its equally powerful counterparts in science fiction. The term was coined by William Gibson and inspired many other authors of the dystopian cyberpunk science fiction genre to create megacorps in their fiction, amongst others the Tyrell corp. (Do Androids dream of Electric sheep), Encom corp. (Tron), Weyland-Yutani (Alien series), Cyberdyne skynet systems (Terminator).
The artwork is based on a collection of 1000 fraudulent websites scraped from the Internet. “Megacorp.” serves as an umbrella company that tries to visualise the overall business segments and countries where these fake and fraudulent businesses are present. To visualise the gathered data and to tell a compelling narrative about the fake business conglomerate, we decided to reenact a corporate business presentation in the form of a fair booth. To achieve this we highlighted the main parts of the data visualisations on roll-up posters and created a corporate image show-reel that gives a fast overview of the main business segments and the global outreach. Since we created the Megacorp. within a year we decided to present all the material gathered in form of an interim report, a financial report that is usually used to cover a period of less than a year that is not typically audited. In the installation we also presented a local website where visitors can browse through the acquired companies alphabetically, sorted by country and by business segment. Another video showed some of the companies’ websites and our attempt at physical reconnaissance, when we visited the addresses where the companies claimed to have their headquarters and see what kind of company is actually registered there.

Acknowledgements. The “Megacorp.” installation was developed for the Steirischer Herbst 2015 and was exhibited at the “esc—medien kunst gallerie” in Graz (Austria) as part of the exhibition “What remains—Strategies of saving and deleting” curated by Reni Hofmüller.
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Theorem 8.1 is a 3-channel video projection installation exploring the intersection of art and mathematics. It investigates the artistic possibilities of the mathematical concept of orthogonal projection.

Given a set of digital images (the “dictionary”), orthogonal projection decomposes any source image into a weighted sum of those dictionary images. The elements of the dictionary are brightened or darkened by definite amounts so that their mixture approximates as closely as possible the source image.

Orthogonal projection is used in many practical digital signal processing applications, for instance to extract information from incomplete data or to reduce the complexity of high-dimensional data. The aim of this project is to open up this technological black box, to foreground the computational process involved, and to experiment with its artistic possibilities. The mathematical concept is investigated not as a practical tool but as an end in itself.

A fixed dictionary of still images from the film Alphaville (Jean-Luc Godard, 1965) is first selected. Then four disjoint sets of 30 images are extracted from this dictionary. Every image in the movie is then orthogonally projected onto each of the four sets of frames.

The installation consists of three video projection channels. In the center channel, the full original movie is shown in chronological order together with the four reconstructions.

The left and right panels show the four sets of frames used in each the four decompositions.

The three channels are to be projected onto one single wall.
PHILOSOPHICAL AND SOCIAL CONTEXT OF THE WORK

Theorem 8.1 has been developed with social and cultural concerns in mind. The French philosopher Bernard Stiegler has noted that one of the most prevalent processes in contemporary culture is a widespread destruction of knowing-how. [1] According to Stiegler’s analysis, every technical innovation makes possible an externalization of knowledge. For instance, the techniques of writing make possible an externalization of memory onto (e.g.) physical paper. Memory is materialized in some physical medium. In the process of externalizing ourselves, we also change ourselves. [2] There is a harmful aspect to these changes. As we come to rely more and more on technological exteriorizations, such as for instance computational media, artists lose more and more knowledge. [3] In particular, we no longer know how to do things. For instance, a graphic designer can emboss a digital image using a software package like Photoshop with a click of the mouse. It is only slightly more difficult to assemble (“stitch”) a set of photographs into large panoramas. New technologies appear to augment our capacities for doing things, but the supposedly competent user does not need to understand the algorithms that work behind the scenes to make these outcomes possible. As a result, the artist who uses the software is under the illusion that s/he knows how to emboss images or how to create panoramic images, but in fact has no conception of what these procedures actually involve. The artist dissociates her/himself from the mathematical foundation of her/his own tools, which become black boxes. This ignorance masquerading as knowledge prevails in the modern world. Stiegler describes this destruction of knowledge as a process of de-skilling whose outcome is “systematic stupidity” [4] We believe that Stiegler’s diagnosis accurately and persuasively captures a crucially important aspect of our contemporary predicament as citizens and artists.

What can artists do to address this situation? One possible direction involves a practice of experimental exploration at the intersection of art and computational mathematics. This practice must satisfy two constraints. First of all, the artist must open at least one technological black box. The artist, often in collaboration with a scientist, chooses one or more computational technologies
and acquires at least a basic theoretical knowledge and practical knowledge (knowing-how) of those technologies. The artist thus refuses to use technologies without actually understanding them. Instead of rejecting technology, the artist engages critically and reflectively with it. By proceeding in this way, the artist works to overcome the stupidity that Stiegler diagnoses. In Theorem 8, for instance, the artist chose to explore the concept of orthogonal projection, an idea that has been applied, for instance, in computer vision algorithms.

Secondly, the artist must not use this technology for some instrumental purpose, such as surveillance, face recognition, or image compression. Rather, the artist must investigate possible ways of connecting the abstract mathematical concepts that undergird this technology to concrete visual (or otherwise perceptible) experiences and diverse subject positionings. This critical investigation becomes an end in itself. The artist does not aim to achieve a practical end but rather to explore the intrinsic possibilities and limitations of the technology and its relation to the field of the visible. Possibly in collaboration with a scientist, the artist develops a research direction based on definite and systematic questions that arise in part from a mathematical or scientific framework. The questions take the following general form: What are the possible ways of relating the mathematical concepts that undergird this technology with perceptual experiences, and what are the tensions or limitations of these relations? These questions must orient her/his experimental art practice.
SIMPLE SETUP

*Theorem 8.1* can also be exhibited using display monitors in place of projectors, which can be shown using three frameless 16:9 monitors (of the same model) aligning side by side. The monitors should have a minimum of 42in (107cm) diagonal.

MATHEMATICAL FRAMEWORK

This section contains a comprehensive description of the algorithm employed in *Theorem 8.1*. It is intended for the mathematically literate reader who wishes to acquire a more precise and in-depth understanding of *Theorem 8.1*. A certain background in elementary linear algebra is presupposed.
1 THE ALGORITHM

A grayscale image of $n$ pixels can be considered as a vector in $\mathbb{R}^n$. Any set of $k$ linearly independent images (“the dictionary”) determines a $k$-dimensional subspace of $\mathbb{R}^n$. Any vector $v$ in $\mathbb{R}^n$ can be approximated as a linear combination of images in the dictionary by the following method:

Let $A_{n \times k}$ be a matrix consisting of the $k$ images in the dictionary. The $(i, j)^{th}$ entry of $A$ contains the $i$-th pixel of the $j$-th image. To project a given vector $v$ in $\mathbb{R}^n$ onto the subspace spanned by $A$, we need to obtain the vector $c$ of coefficients

$$c = A^+ v$$

where $A^+$ denotes the Moore-Penrose pseudo-inverse of $A$, or

$$A^+ = (A^T A)^{-1} A^T$$

We wish to reconstruct the input vector $v$ as a weighted sum of images in $A$. The coefficients in $c$ express the contributions of the individual dictionary images to the reconstruction. The first coefficient represents the weight of the first image in the dictionary, and so on. The sign (positive or negative) of each coefficient specifies whether that image is to be added to or subtracted from the other images in the dictionary.

Given the coefficients, the orthogonal projection $p$ of $v$ onto the subspace spanned by the vectors is

$$p = A c$$

The entire algorithm can be concisely expressed in one line as:

$$p = A (A^T A)^{-1} A^T v$$

The source for the class that computes the orthogonal projection of a vector can be downloaded in this link:

2 VISUALIZATION CHALLENGES

The principal aim of Theorem 8.1 is to make visible the computational process that underpins the concept of orthogonal projection. To paraphrase Gregory Bateson’s well-known definition of information, we may say that the visualization method has been designed to render visible every “difference that makes a difference” to the underlying computation. With this goal in mind, the exhibition display shows the changing coefficients of each image in a subset of the dictionary and the resulting approximate reconstruction of each source frame in the running movie.

The algorithm used to compute the orthogonal projection of an image does not assume that the columns of the dictionary matrix $A$ are orthonormal or even orthogonal. This approach is
one of the distinguishing marks of Theorem 8.1 relative to the earlier version of this project, Theorem 8. In the previous version, the images in the dictionary were first pre-processed using the Gram-Schmidt procedure, to ensure that they were orthonormal. This approach facilitated certain computations, but it resulted in a dictionary with vectors containing both positive and negative brightness values. Negative pixel values could not be translated directly into physical light intensities and were set to zero for the purposes of visualization. A consequence of this decision was a considerable loss of data in the final visual display. In contrast, the current version does not pre-process any of the frames in the dictionary. Pixel values are always represented as numbers in the range $[0, 1]$, with 0 denoting a black pixel and 1 denoting a white one. There are no dictionary elements with negative pixel values.

The goal of aesthetic visualization poses another challenge. The orthogonal projection of a given $v$ onto the subspace spanned by $A$ sometimes outputs a linear combination with negative coefficients. Let $c_j$ be a negative coefficient corresponding to dictionary image $A_j$. How is product of this negative coefficient with the values in $A_j$ to be visualized? The solution adopted here (suggested by Felipe Cucker) is the following: If $c_j < 0$, every brightness value $A_{ij}$ is replaced with $(1 - A_{ij})$ and then multiplied by the absolute value of $c_j$. This transformation replaces the dictionary element with its “negative” image (where the word “negative” has its usual photographic meaning).

This solution contrasts with the approach adopted in Theorem 8. In that case, the use of the Gram-Schmidt procedure as a pre-processing step meant that every frame in the dictionary had some positive and negative pixels. Multiplying any frame by a negative coefficient transformed negative pixel values into positive ones and vice versa. For visualization purposes, negative pixel values were set to zero (black), which resulted in a considerable loss of information. In this new version, the images in the dictionary are not preprocessed; since all pixel values are positive, the multiplication of any dictionary image by a negative coefficient would turn all of its pixels into negative values. Adopting the same solution as in Theorem 8 would in such a case produce a completely black image. The alternative solution adopted here preserves more information and so gives a more comprehensive picture of the underlying computation (although the approach employed in Theorem 8 has its own distinctive visual character).

The connection between the mathematical and artistic aspects of the work lies here: every aesthetic decision has been made with an eye to rendering perceptible every difference that makes a difference to the computation of the orthogonal projection of an image.
3 SELECTION OF FRAMES IN THE DICTIONARY

In Theorem 8.1, the dictionary consists of frames extracted from Godard's *Alphaville*. Every image in the film is then projected onto a subset of this dictionary.

How were the frames in the dictionary selected? Frames from Godard's *Alphaville* were chosen by a sequential method. The magnitudes of every frame $f$ in the frequency domain (after a Discrete Fourier Transform) were compared with those of $r$ immediately preceding frames. Image $f$ was selected for inclusion in the dictionary if the difference was higher than a fixed threshold.

Acknowledgements.
Mathematical Advisor: Felipe Cucker
This work has been partially funded by City University of Hong Kong Research Projects #9610322 and #7004725.

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We present Wikisonnet, a procedural poem generator using text drawn from Wikipedia (Wikipedia 2016). Occasionally, without the author’s intent, a string of words in a Wikipedia article will follow iambic pentameter. Wikisonnet extracts these, storing them along with rhyme and grammar information. Then it stitches them together, composing poems on the fly. To focus the poem on a particular subject, the algorithm can favor lines from a starting page, from pages linked to that page, or from pages similar to the starting page. Sometimes nonsensical, sometimes full of surprising juxtaposition, Wikisonnet poems each have several authors—like Wikipedia itself. But unlike Wikipedia, the poem as a whole is a product of the algorithm. A Wikisonnet poem is therefore a collaboration between human and machine sources, where the reader ascribes meaning to the end result through interpretation.
INTRODUCTION

The move from print to web transformed the written word from static text to dynamic hypertext. In the words of Kenneth Goldsmith, a contemporary American poet, “language, once ‘locked onto a page,’ has become ‘completely fluid.’” (Perloff 2010) Generative poetry grows naturally out of this language pool. Through it, we investigate possibilities for recombining text, examining the impact of medium on meaning. Through the resulting juxtaposition we re-encounter familiar language in an unfamiliar context.

Wikisonnet attempts to create such an encounter with Wikipedia. While reading an article on Wikipedia, it’s easy to forget that millions of individual authors have contributed to Wikipedia as a whole. Occasionally, one of those authors writes a revision in accidental prose—a few words in iambic pentameter. Wikisonnet seizes this text, extracts it from the original source, and grafts many such samples together into an Elizabethan sonnet. The result, whether nonsensical, satirical, or eerily poignant, excavates the language itself from the information it conveys, offering the reader an unexpected opportunity to revisit the latent poetry of Wikipedia.

Fig. 1. Wikisonnet as an installation
https://s3.amazonaws.com/wikisonnet/Wikisonnet-2.mov
RELATED WORK

The line between author and curator started to blur in the twentieth century, as authors experimented with reducing personal contribution to their work. Marjorie Perloff traces this development in *Unoriginal Genius: Poetry by Other Means in the New Century* (Perloff 2010). With its extensive interpolation of source material, T.S. Eliot’s “The Waste Land” shows the earliest rumblings of this transition (Eliot and Vendler 1998). Though rightly celebrated, Eliot’s masterpiece did meet with some critical rebuke, or at least confusion, for its long passages of apparently undigested citation. But as Perloff describes, this poetic collage represented a deliberate attempt to effect “coordination rather than subordination, likeness and difference rather than logic or sequence.”

Later in the twentieth century, Raymond Queneau (a founding member of the experimental writing collective *Oulipo*, the *Ouvroir de littérature potentielle*) would write *Cent Mille Milliards de Poèmes* (Queneau 1982). Completed in 1961, the work contains ten sonnets, each printed on fourteen separate, moveable cards. Since each line has the same rhyme sound, they are interchangeable, allowing for 1014 possible poems. In *The Wasteland*, Eliot lets the reader interpret each citation; Queneau continues the trajectory: in allowing the reader to pick and choose particular lines, he invites her into the role of author.

In *Moveable Type*, Ben Rubin and Mark Hansen offer a digital update to *Cent Mille Milliards de Poèmes*, extracting and re-assembling digital text into poetic form (Rubin and Hansen 2007). The piece extracts text from *The New York Times*, either citing content directly or pulling from live web searches related to *The Times*. Then, one line at a time, it displays the results in the lobby of the newspaper’s headquarters. Pulling together data from distant sources, *Moveable Type*’s audience gets a holistic feel for a complex system that otherwise escapes human sensitivity. Rubin: “We want it to feel almost like an organism that is living and breathing and consuming the news.” (Kennedy 2007)

Today, authors and readers are moving to the Internet, where dynamic content enables new poetic encounters. The massive databases that power Google are making their way into the hands of computational poets, who use algorithms to scan vast stores of speech and text. Queneau asked the reader to arrange pre-written text, but algorithmic authors can work so fast that the reader can create poems on demand according to his or her specifications. “The US political poetry generator” (Unknown 2016) lets the reader choose a US politician along with a well-known poet, then generates poems combining text from the two sources. As is the case with Wikisonnet, the original text is unaltered, only
excised from its source and spliced together with other fragments. Interestingly, the early 20th-century desire to remove the author’s voice from the final poem may here be realized. The reader chooses a politician and a poet, their words appear on the page, but the author who enables the entire experience has been reduced to the role of an engineer, a technician.

METHOD

Wikisonnet arranges Wikipedia into an Elizabethan sonnet, a fourteen-line poetic form with its own particular rhyme scheme. Each line conforms to iambic pentameter, consisting of ten alternating stressed and unstressed syllables. To compose a poem, Wikisonnet proceeds in two phases: a scraping phase and an authoring phase.

Fig. 2. An example of words in iambic pentameter. The half circle above the syllable denotes a weak accent, and the slash a strong one.

Fig. 3. The same example text block, with part of speech labels added to the words that will be stored by the scraping algorithm. Note that only the bold text is in iambic pentameter. The two words preceding and following the iambic pentameter text are analyzed and their parts of speech stored, but the words themselves are ignored.
SCRAPING PHASE

In the scraping phase, Wikisonnet downloads Wikipedia’s monthly XML dump, the most current revision the Wikimedia Foundation provides (Wikimedia 2016). Next, using the TextBlob package (Loria 2015), it parses each article, scanning for consecutive words in iambic pentameter. The sentence, “He finished his rookie season with a .255 batting average, despite confronting trouble hitting certain types of pitches,” from professional baseball player Robert Clemente’s Wikipedia article, returns “confronting trouble hitting certain types.”

When the algorithm finds a block of interest, it analyzes its grammatical structure. The Pattern package (De Smedt and Daelemans 2012) for Python constructs a parse tree for the sentence, labeling each word with a part of speech tag. The algorithm, however, only stores the part of speech tag for the first two words of the iambic pentameter text block, the last two words, and the two words immediately preceding and following the text block.

Finally, the algorithm stores the last word in the text block, along with its rhyme class. It then uses the NLTK (Natural Language Tool Kit)’s pronunciation dictionary to determine rhyme (Loper and Bird 2002).

AUTHORING PHASE

In the authoring phase, the algorithm pieces lines together to write a poem, which must: 1) be a sonnet, and 2) satisfy the constraints of English grammar. To focus the poem’s content, the algorithm starts with a given Wikipedia article. Once finished scanning this page, it moves to related ones, determined using Latent Dirichlet Allocation (Řehůřek and Sojka 2010).

To generate grammar constraints, the algorithm uses a part of speech “seam matching” technique, aligning the overhanging parts of speech from one fragment with those from the next. This helps Wikisonnet write poems with speed, a high degree of variety, and little sacrifice in grammatical accuracy.
We watch the bud of promise; and the flower looks out

(a) Line of text, with parts of speech labeled

The river glideth at his own sweet will: Dear God!

(b) A candidate poem continuation

...the flower looks out

(c) The seam between two lines

We watch the bud of promise; and the flower glideth at his own sweet will: Dear God!

(d) The completed continuation
EXAMPLES

HAMBURGER

In other places in the country there in the United States, the Middle East or pewter with the help of spoons or bare unwanted side reactions are decreased.

The motor is supplied directly from the side including mustard, mayonnaise, explorer, author and inventor, some supplies are meant to last for several days.

Around this time, Sukarno had begun to aid in eating sauce in French cuisine or just the patties served without a bun, that is related to the kidney bean.

Donations and affiliation fees in the United States and overseas.

JOHN CLEESE

Among the most important is the fact A. Crockett, Jr. “Henry Louis Gates his overall objection toward abstract expatriates in the United States

It is considered scripture, classified in British advertisements for Compaq enthusiasts; it could be used to guide the publication of his almanac.

That there is a substantial likelihood of Doctor in the House (and later Cleese did not object to starting the statehood for making war to forge a lasting peace.

“The Universal Language” skit from All about postponing love until the fall).
Design by Tweet enables Twitter users to collaboratively code visual compositions by writing tweets that use a simple Processing-inspired API. Twitter users can participate by sending a specially formulated tweet to @designbytweet. In response, this account will automatically post an image of the composition after executing the user's commands. The Design by Tweet name mirrors that of Design by Numbers, one of John Maeda's projects at the MIT Media Lab in the 1990s.
1 OVERVIEW

This paper introduces *Design by Tweet* (DBT), a tool enabling collaborative, Processing-inspired creative coding via Twitter (video demo). DBT is, at its essence, a Twitter bot that continuously listens for @reply tweets to itself (tweets that begin with “@designbytweet”) via the Twitter API. Hosted on a Node.js server, DBT parses each of these @reply tweets and first makes a determination as to whether or not it is in the required format. If the tweet is able to be parsed according to the DBT format, its commands are then executed and the resulting visual output is applied to a persistent server-side canvas / drawing surface. DBT then responds by posting a tweet with an image of the canvas following the execution of the user’s commands, mentioning the user in the tweet text.

While many projects (like Processing) have made creative coding significantly more accessible, the need for standalone integrated development environments still presents a barrier to entry. DBT aims to address this issue by appropriating an existing platform that is conventionally used for social communication and interaction. Twitter’s prominence means that using it as a platform for creative coding makes logical sense in terms of increasing the potential number of creative coders.

2 TECHNICAL DOCUMENTATION

The collaborative nature of DBT means that multiple users simultaneously contribute to a single canvas. The DBT canvas is a fixed size, with a width of 1024 pixels and a height of 512 pixels (for optimal visibility on Twitter). The origin, where the x- and y-coordinates are both equal to 0, is located at the top-left corner. From the origin, the x (horizontal) axis increases toward the
right and the y (vertical) axis increases toward the bottom. DBT users can view the current DBT canvas, as well as a historical record of all previous canvas iterations, on the @designbytweet Twitter profile.

Users can participate by sending a specially formulated tweet to @designbytweet. The format of this tweet should follow “@designbytweet command1; command2; command3; ...” where “@designbytweet ” is the DBT Twitter handle, followed by a space, and “command1; command2; command3; ...” is a sequence of one or more DBT API commands, each followed by a semicolon. Spaces are not needed between both commands and the comma-separated parameters of commands. Users may include as many commands in a tweet that can fit within Twitter’s 140-character limit.

The DBT API is “Processing-inspired” in the sense that it reflects the programming syntax that the Processing project has developed and promoted (Processing). However, the functionality of the DBT API is limited to a subset of the Processing API. Many functions, as well as code elements like variables and loops, are not currently implemented. Also, all parameters must be literal values. The initial DBT API incorporates some of the most useful commands for quickly generating visual output (full documentation and API reference available at http://www.experimentalinterfacelab.org/dbt).

3 CONTEXT

While legitimate, interactive Twitter bots respond to some sort of structure within a human Twitter user’s tweet — for example, @KLMfares (Twitter 2015) — one would hesitate to refer to this as programming the bot due to the fact that the interaction does not occur over a series of back-and-forth-tweets (a “conversation” in Twitter terminology). This is even true for the only other (to the author’s knowledge as of this writing) example of programming via Twitter, Wolfram Research’s Tweet-a-Program (Wolfram 2014). This Twitter bot allows users to tweet Wolfram Language programs to @wolframtap and receive the output in reply. However, these programs must exist within a single standalone tweet, and there is no collaborative element integrated into the system.

As an example of a broader programming-related use of Twitter, users of the SuperCollider language for real-time audio synthesis and algorithmic composition share short, self-contained programs via the #sctweet and #supercollider hash tags (although these programs are not executed on Twitter itself).
4 FURTHER WORK

DBT currently exists as a provocation — a number of Twitter users have demonstrated its technical viability, but its conceptual viability remains to be seen and can only be tested with the broader audience that would accompany increased visibility of the project. The author hypothesizes that this visibility may come along, in part, with increased utility of DBT, and so expanding the DBT API is a priority for further work on the project. Several early DBT users expressed particular interest in the ability to repeat code easily, such as with a “for” loop. Moving forward, it will be necessary to identify those elements of the Processing API that can successfully be translated to and used within the context of Twitter. For example, certain aspects of the Processing API that use commands to encapsulate other related statements — like beginShape() and endShape(), or pushMatrix() and popMatrix() — may not be appropriate for use by DBT given its collaborative focus. A user using these commands in a way similar to Processing might find his or her efforts interrupted by another user attempting to contribute to DBT at the same time. Accordingly, all future improvements and additions to DBT must be approached with the objective of facilitating user collaboration in mind.

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LASACT is a temporary, interactive Light and Sound-Installation. Visitors are able to modify the visual appearance and sound patterns by using a web application for mobile devices. Chaotic and harmonious lines alternate while visitors are taking control of the installation—since everybody is able to take influence, chaos may erupt till people start to coordinate their interactions. The visitor can interact in his own scope but is presented with the result of a collaboration. Inside this enclosed system self-perpetuating ideas will be established: questions arise regarding the visitor’s own influence and significance leading to a situation where concepts and ideas are amplified reciprocative.

Nowadays brief moments of absence—induced and facilitated by the smart phone technology—are accepted even during face to face meetups. Members of today’s society escape the real world and dive into their own virtual bubbles. The LASACT installation conveys these aspects of communication, social relation and group dynamics.
The installation NarcissUs is a critical and artistic approach towards the development of intelligent machines. The main goal is to unfold the emergent results that the learning process from artificial beings in mixed reality environments can encounter. It consists of a feedback loop between a computer generated portrait (NarcissUs), a camera, a moving mirror, a face recognition algorithm and an evolving learning machine seeking for self awareness. NarcissUs searches for its reflection, learns from it and evolves through expressive exchanges. The installation is a metaphor from the mirror-stage and the moment of self recognition, which is recognised by Lacan as an essential act of intelligence. Whether this act is also a symptom of consciousness or not, is open to discussion. NarcissUs intends to argue, to which extend artificial beings can be perceived as self-aware.
“Destiny without necessity, freedom without memory, existence without choice, causality without destiny” (Deleuze)

1 CONCEPTUAL DESCRIPTION OF THE ARTWORK

The research body of Narcissus consists of the two major phenomena. The first is the mirror stage described by Jacques Lacan (Lacan 2004), who analysed the period in which young person is captivated by it’s own reflection, and remarked the learning process that emerges through the interactions in which the person is engaged with itself. The second one is about the presence of self-referential systems in nature, as observed by Kurt Gödel (Goertzel and Pennachin 2007). Gödel made use of self-referential systems to prove the existence of complete systems that can be described or understood through mathematical means or any other forms of logical argumentations, concluding that any system would require in some point to refer to itself by intending any completeness, which would result into an incomplete description. In less formal terms the principle of self-referential systems has been named by the computer scientist Douglas Hofstadter (Hofstadter 1999) as “strange loops”. He suggests that the awareness of the self is a recurrent idea which is self-referring over and over again until intelligence and consciousness emerges out of erratic repetition.

“NarcissUs” is an obvious word-game between the name “Narcissus” from the greek mythology and the word “Us”, which refers to the human kind. The Narcissus in the Metamorphoses from Ovid (Ovid 1986) is imprisoned in a state where the only thing he is able to see is his own reflection. While not being aware of this situation, he falls in love with its mirrored image. His incapability to cut beyond that situation, has doomed him into an erratic behaviour. Eventually, he realises that the object of desire is literally unreachable and his self-love turns into frustration and despair, which ultimately leads him into self-destruction.

As Narcissus, we (human beings) are able to see our own “images” through mirrors, reflections, pictures, videos and in more abstract ways, through the descriptions that other humans make of us. Thus, we are unable to get more than projected images of ourselves. These images, which are only fragments of a complex reality, are used by others to depict us and to communicate with us. The concept of enaction introduced the idea of existence beyond a set of passive perceptual abilities. Rather than that we are actively being in the world and we are able to perceive ourselves and our environment not only through one exclusive sense, but with all of them at once. Each of these senses allows
us to perceive one or more sensorial stimuli (sound, touch and motion among others) and the multi sensorial experiences help us to build an image of reality. Therefore the processes of self-perception through each sense are uneven and biased by focus and relevance.

Senses provide us with partial and fragmented “images-sounds-smells-tastes-textures” of our selves while “being in this world”. By gathering all those fragments and gluing them together in reference to the environment, ourselves, our experiences, our needs and our capability to remember, is how we tend to construct and reconstruct a “whole image” of the world and ourselves.

Deleuze’s studies on perception and the senses, enlighten the paradoxes of the temporal states of being, the causes, the consequences and the dualisms from the corporeal and the incorporeal existences. He concludes that at the surface from things, the ideal and the incorporeal can only be “effect” (Deleuze 1993).

We suggest, as many others have done and also have inspired us (Noë 2004), that from the process of building the image of the world and-or from the process of constructing the image of the world and from being in this world, awareness and consciousness arise and manifest as an effect at the very surface of existence.

Taking the reflexions from Deleuze, Lacan and Gödel into account, we pursue the unfolding of the process of learning from the world, inside the world and from the self, by reproducing it through a simulation using technology and mixed media. In order to achieve this we propose a feedback-loop setup which integrates machine-learning processes, machine-perception and physical randomness or noise (motion and reflection), which continuously influences the learning process, the senses and the body from the machine.

NarcissUs intends a critical and artistic approach towards the development of intelligent machines. The issues and outcomes, which the learning process from artificial beings may encounter, are unfolded through this installation. The proposed setup displays the aesthetics of erratic machine behaviour through a technological mix of machine learning algorithms, virtual environment, physical computing and non-trivial behaviours. It materialises in a self-referential system the concept of computer self-awareness and the perceived emergence of artificial consciousness.
2 TECHNICAL DESCRIPTION OF THE ART WORK

NarcissUs is a machine-learning setup in a mixed media environment. It integrates elements within the virtual reality, such as a human-face model, with elements from the material reality such as a motorised mirror. This combination of elements opens a door to a third space composed by abstract elements and processes, which allow the emergence of perception-feedback loops.

On the virtual side an expression-able 3D Model of a human face is being displayed on a screen and is provided with agency by connecting it to the reality through a camera and a facial-expression recognition algorithm. On the side of the material reality a mirror is placed in front of the camera and the display, where NarcissUs exists as an image. This reflective device is attached to a motor with the purpose of providing NarcissUs with the possibility of searching for faces in its surroundings. The rotation of the motor is regulated by the same algorithm in charge of facial expression recognition, meaning that the search will stop at the moment NarcissUs finds a face.

NarcissUs looks at itself and constantly intends to copy its own expressions, falling continuously in erratic or random states. NarcissUs’s learning process is driven by the necessity of reducing stress to the motor and to stand by itself. The learning engine is written in Java and it is based on the deep learning and reinforcement algorithms (Kesha Patel, Patel, Hexmoor and Carver 2012).

The human face model, the expression control and the basic decision algorithms are driven by Unity 3D Engine and are written in C# and JavaScript. FaceOSC (McDonald 2012) is an open source algorithm based on Jason Saragih’s Face Tracker Algorithm, which is in charge of the face tracking and expression recognition. An Arduino Micro-controller is used to drive the motor taking care of the mirror rotation through serial communication.
3 IMAGES AND DIAGRAMS OF THE ART WORK

Fig. 1. NarcissUs Demo Setup — Snapshots.

Fig. 2. NarcissUs Setup for Art Installation. Scale and dimensions from the installation may vary according to the allocated space and availability of materials.


McDonald, Kyle. FaceOSC. Open source for face tracking and recognition. Github repository: https://github.com/kylemcdonald/ofxFaceTracker

Nightfields explores how motion derived from natural forces can be used to propagate relationships between audio and visual elements in an artwork.

The piece is based on motion tracking data, derived from unseen video footage of a group of leaves blowing in the wind. These natural data profiles are then used to both animate visual elements and trigger audio events, resulting in an audiovisual texture that is continually transforming in a subtle way.

Although non-representational, the work aims at bringing an evocative quality to abstract imagery, as suggested by the title.
**VISUAL ASPECT:**

The visual element of the work (the light-spots) was originally inspired by found photographs of fireflies captured at night. These images became fused with various memories and moments experienced by the authors that are intentionally left unstated. Removed from any personal frame of reference or context (with the exception of the title of the work), the memories are reduced to convey only their basic visual essence realised as abstract forms (i.e. circular forms of varying hues and sizes). The forms are then animated using motion data recorded from unseen video footage tracking the movements of leaves in the wind; this is then used to trigger audio events in the overall composition.

**AUDIO ASPECT:**

The audio for *Nightfields* is a result of generative pointillistic synchronisation. Sounds are triggered when the light spots hit an imaginary ‘floor’, which is the lowest vertical point of their individual motion trajectory. The sound source for the work was a Berimbau (a Brazilian, single-string percussion instrument, used in the Afro-Brazilian martial art Capoeira).

The sound is formed on the principle that no two recorded articulations of the same sound source are identical - there are always minute variations in the balance of overtones - largely due to tiny variations in microphone proximity, force of articulation and strike position on the string. In the case of *Nightfields*, every light spot is associated with an individual articulation of the Berimbau. There is a sharp attack followed by a long sustain. As the light spots fall, the individual Berimbau samples are released. When this happens en masse, the result is an evolving drone whose various harmonic components emerge and disappear, defined by the combinations of recorded articulations and their relative phases, which is ultimately triggered according to the rhythm of the wind.

**CONCLUSION:**

*Nightfields* attempts to bring an evocative quality to abstract artwork by fusing audio and visual forms with motion derived from natural sources. On perceiving the artwork, the viewer is able to focus on and identify the motions of individual forms and also those as a collective group, rather like the experience of watching a mobile controlled by the erratic motions of the wind. By employing natural motion, the work aims at bringing a trace of the familiar to what is essentially an unfamiliar experience.
DRIPPIMENT

IVO TEIXEIRA

RODRIGO CARVALHO

TIAGO GAMA ROCHA

FRANCISCA ROCHA GONÇALVES

Computation
Communication
Aesthetics
& X
Bergamo, Italy
Beyond liveness is an audiovideo exhibition based on live audio visual performance *Shipwreck score* by INIRE. Its concept concerns mutual interdependencies between genres as live performance and audio and video installation, in the context of the discourse about performance and its documentation. The exhibition is composed of three parts, hardware DVD player with video documentation of the performance *Shipwreck score*; audio video installation with multi channel audio stream based on the performance; laptop with a google questionnaire about liveness issue.
INTRODUCTION

The term liveness in the context of digital performance mediatization has been used in the installation’s title with reference to Philip Auslander’s definition; he used the word ‘mediatized’ in relation to mutual permeating and mediation/mediatisation of theater and television in order to indicate that television is the main model for theatrical borrowings. Auslander emphasizes that the category of liveness is of historical, not ontological nature. For him, television is the model and standard for 20th century culture and it sets out norms of narration and perception. As mediatization is a historical category, the television visual pattern is only a genealogical aspect of the problem. The role of television is currently being taken by the Internet and, in concord with this, present indication dominating communication is constituted by IT technologies; they are also a point of departure for research on digital performance.

Steve Dixon in Digital performance explains that the liveness concept had been subjected under consideration before digital performance was born. Dixon begins from onthology of the medium of photography, settles meanders of liveness discourse from Heidegger’s theory of phenomenology, Benjamin’s notion of aura dissolution, McLuhan’s idea that “the medium is the message” and simulacra and simulacrum by Baudrillard, to the contemporary performance research such theorists as Susan Sontag, Peggy Phelan or Philip Auslander.

In deliberation on liveness the notion of a display assumes a broader context. Auslander (2008: 5) quotes after Baudrillard: “What is mediatized is not what comes off the daily press, out of the tube, or on the radio: it is what is reinterpreted by the signform, articulated into models, and administrated by the code” (Baudrillard 1981: 175-176)

1 WORK ON PERFORMANCE SHIPWRECK SCORE — DOCUMENTATION OF EXPERIENCE

Audio video installation beyond liveness consists of three elements. The first of it is the hardware DVD player, connected to an LCD screen with headphone. With this device it is possible to display several audio video documentations from live performance Shipwreck score acted in different venues.

Performance Shipwreck score was connected to the audio sphere of the space, Djúpalónssandur bay on the eastern coast of Iceland, at North Atlantic Ocean, where an English fishing ship
sank in 1948. The parts of the wrecked vessel, as also its surrounding space, was a groundwork for recording of sounds and images of the project. Elements of the ship were set into vibrations by wind, stones, human voice, cello bow and unexpected people passing by. The visual part was based on photographic documentation made on site. Its multi-layered structure also consisted of a verbal narration, prepared as a sort of radio broadcast depicting the plot and performance circumstances. Narrative vocal compositions were live processed and transformed.

For the creation of performance field recordings of sounds of the space and photographs of the vessel parts were used. 3D spatial structures were extracted from still frames of the vessel. Performance score was based on field recordings used for granular synthesis on voltage-controlled modular systems. The archive files, as a basement for construction of onstage improvisation were deconstructed by the analogue modular system in both the audio and visual. The project touched the question of documentation and archive in the context of performance and the issue of its transistory nature. The mapping of the real space, converted into a map of the embodiment, both collective and individual, created space between corporal and digital memory, along and across the bay.

The main idea of *Shipwreck score* was to treat performance as a form of recording and reflection of the affect as well as documentation of the experience of memory of the place. Memory is used in a twofold way: as collective memory remaining in the space of a crashed ship and former crew; and as performer’s individual memory, who through preparation and performance of action on stage reconstructs an affect experienced on the spot and presents it to an audience.
Paraphrasing Derrida’s (1987: 9) metaphor:

look closely at this shot from the performance. It’s a reproduction.

I confide to

You this solemn and sententious aphorism: did not

everything between us begin with reproduction? Yes,

and at the same time nothing is more simply false, the

tragedy is there.

The second part of the exhibition is an audio video installation based on live performance. It’s composed of video projection and multi channel audio stream. The files used for making the work are taken from live performance documentation files. The idea is to make a creative, archival form of the live work and to explore the convergence of art genres when the performance becomes the installation.
3 WORK ON DOCS QUESTIONNAIRE — DOCUMENTATION OF THE REACTION OF AUDIENCE

The third part of the exhibition is a laptop with access to the Internet. It displays a survey about liveness issue, which allows to get the feedback from the receiver. A survey and visualization of its results are another form of documentation of the experience. In this case, it is all about the recipient's affect. Answers given by respondents shall be shared and visualized on the project's website after the display.1

One of the basic questions we have to ask is whether mediatised participation in digital art has any impact to the reality in which we live? Does art take patterns of mediatization from reality or perhaps by means of a precedent influences, digital art creations inflow actual attitudes in a communicational situation? If we follow Wolfgang Welsch (1995) on a statement that art may successfully act as a model to describe reality and human nature manifests itself in all expressions of life and social behaviors, especially in creative activities, to analyze the condition of the society we may as well use research on the latest digital art.

The idea behind a survey is to gain insight which stadium of memory documenting is more efficient:

• Documentation of artists experience in direct/inmediated digital performance, based on the performer-participant scheme. In this case, the performance Shipwreck score is disappeared here, the only rendering is its record.
• Documentation of performance created with the use of one of the two schemes:
  1. Objective video camera recording
  2. Done-over of the gathered material and creation of a new work based on audio and video recording made during the performance

We shall use questions from the preface of “Liveness. Performance in a mediatized culture” by Philip Auslander as an introduction to the survey:

Why would you make live work in an age of mass communications?

Why work in more or less the only field which still insists on presence?

For artists interested in ‘the contemporary’ this area of live performance seems like a bit of backwater. Do you have something against mass-reproduction?

Do you work from some quaint notion about immediacy and real presence?

I don't know.

Answer the question (Forced Entertainment 1996)

1. See http://www.inire.net/
Acknowledgements
The exhibition was realized as a result of the research project No. 2014/15/N/HS2/03858 “Post medial performance. The contemporary technological context of performative actions.”, funded by the National Science Centre, Poland.

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BULLSHUT APP: A SOCIAL INTERFACE TO AVOID SMALL-TALK

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What if we were able to find a real conversation by only knowing a specific interest from our conversation partner?

BullShut App aims to avoid awkward moments at any sort of social events. Its main purpose is to create a conversational space among two individuals during a brief period of time. By typing a chosen topic, one is allowed to find other users and to be found by them in a radius of around 30 metres. The App’s final purpose is finding and establishing a real conversation between two strangers with a shared interest. After typing the topic one is interested in, one gets the possibility of starting a chat limited to 140 characters per user. Therefore, if they want to talk to each other, they will have to find each other in person.
1 INTRODUCTION

Our smartphone is a distraction tool. It entertains us in our daily lives. It makes us believe, that we are not alone, but connected to each other the whole time. A smartphone is an essential device for most of us. But, where do we find a limit between necessity and dependency? Are our phones able to rule our social exchanges and interactions?

These questions arose due to the proliferation of mobile phone Apps in the last years: almost each one of our problems is arrangeable using an App. We have Apps for almost every task and moment, helping us to quantify ourselves and to control all our actions and movements. This interest in getting to know ourselves better, might also be putting us apart from having a look at the people around us. This device helps us to keep in touch with people we no longer see and feel, but what if its use was reverted to allow us to interact and get to know people directly around us?

I would like to bring to the front our problems to find and establish a real conversation, in a society where everything is mediated by our phones. On one hand, BullShut App’s main purpose is to ease our social interactions and bring us back the pleasure of having a conversation about something relevant to us. On the other hand, it questions our ability to speak about something serious, with consequences and truly interesting for us, without the mediation of a device.

2 DESCRIPTION OF THE PROJECT

2.1 CONCEPTUAL PREMISES

BullShut App makes use of a technology, which in our mobile phone might be considered almost obsolete by many users: Bluetooth. A technology, which when it first appeared on a mobile phone, was presented as a fast way to share files among users. This exchanging mechanism has been now replaced by a more sophisticated way to share files and data: the Internet. We no longer want to share files or photos with people nearby, we do not always have our friends close to us, so we like to share our files with people far away from our current location.

In spite of this, Bluetooth technology might help us in the task of reaching people out of our social network-based domains. In order to be more specific, Bluetooth limits our research to people who are spatially in our surroundings. But, are we ready to interact with them? Do we want to do it? Do we want to see a stranger and hear her/his voice? For some people it might be scary, for some others a nice experience in which the phone gets back its human dimension: bringing people together.
2.2 TECHNICAL SPECIFICATIONS

In order to realise this project I worked together with Tassilo Posegga, a master student with experience programming smartphone applications. During the whole process, we used the Android Studio IDE [1] due to one of the attached samples: we did not have to start to program it completely from scratch. On the contrary, we could start modifying a preexisting App named Bluetooth Chat, making it easier, to establish the connection protocols and implementing the two-way chat over Bluetooth between two Android devices. Thus, afterwards we could concentrate on the workflow's design and the rest of details and characteristics, as the possibility of changing the Bluetooth name of the device when the App is started and also limiting the chat duration to 140 characters per person. This limit introduces a new handicap for the users who prefer typing rather than talking, because once the user finds a topic and starts chatting: either she uses the chat to find the other person, or she will take the risk of running out of characters and never knowing who this person was.

3 ON CONVERSATION AND HUMAN INTERACTION

3.1 IMPROVING OUR INTERACTIONS

About human-human and human-machine interaction there are currently some finished and ongoing projects, which make me start to reflect on our communication troubles and its relation with technology. One of the most remarkable projects would be the work by Lauren McCarthy at the MIT in Massachusetts [2]. She developed in the recent years several pieces of Device Art. An example of it would be the ‘Conversacube’ a box which helps and gives some advices on a date, or ‘pplkpr’, an App that tracks and auto-manages our friendships. The interest in these topics has increased in the last years, because nowadays we might be in front of a generation of human beings not very capable of interacting without a smartphone.

It is hard to deny, that we are in a world, where people isolate themselves everywhere: at a bar, waiting for the bus, in the pause of a conference, or in the corridors of a festival, either looking at the news feed of their own virtual social life, or talking about random topics they do not really care much. Therefore, it might be necessary to open a gate to allow real exchanges and subvert the use of a mobile phone. A device, which for some years lost its main purpose: shortening distances between people by using the voice.
1. Tap on the pencil icon to write the conversation topic you would like to talk about.
2. Save it by clicking on the floppy disk icon.
3. Once you saved your topic, tap on the magnifying glass icon & find another users.
4. Select one of the available topics and start a chat.
5. Remember: there is a 140 characters/person limit!
6. Find a conversation partner and enjoy a pleasant face-to-face exchange of ideas.


Links to BullShut App:
Download: https://play.google.com/store/apps/details?id=ic.bullshut
Video: https://vimeo.com/135243073
**WiPong: A Massive Multiplayer Collocated Game**

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**Keywords**  
Massive multiplayer collocated games  
Pong  
Collocated interaction  
Game design

WiPong is an extended multiplayer version of the iconic video game by Atari. WiPong is a game played with smartphones/tablets by an $n$ number of players simultaneously in a defined physical space. A server provides the access to the game which can be played only within the limits of the Wi-Fi signal and the server capacity of the connected devices. All the players have to discover the limits of this virtual landscape and keep themselves in the game by following this special rule. The aim is to push the boundaries of collocated multiplayer games by taking the most classic of the arcade as an example. The players connect their own device to the central system and in the presence of at least one partner they can start the game. The gameplay reproduces the classic *Pong* game with the difference of having infinite extensions of the game field on the opponents’ devices. Each player controls a paddle visible on the half of the *Pong* field within his/her screen. The ball, after being hit by the paddle, disappears from the top of the screen to reach the opponents’ fields. The system redirects the ball to one of the other fields of opponents available. The number of fields is determined by the number of the players ranging from two to $n$. Where the ball will go to and which direction it will come from is the challenge of the game for the players.
1 INTRODUCTION

*Tennis for Two* (1958) by William Higinbotham is the first video game in history that reproduced the mechanics of tennis. *Pong* (1972) by Atari inherited this tradition by becoming the first widely distributed commercial video game: a two players’ game that features two paddles and a ball. In the original edition of the Atari cabinet the gameplay was conceived as strictly for two players and there was not an option for a single player mode. Many alternative editions, clones, and evolutions have been developed after the series created by the first *Pong*. Among them, *Elimination* (1974) from Kee Games, later distributed by Atari as *Quadrapong*, was offering a four simultaneous player match in a cocktail table cabinet with a horizontal screen. As well as *Pong*, *Elimination* is a strictly multiplayer game with a minimum number of participants of two and a maximum of four. In the history of both cabinet and home console video games, the maximum number of simultaneous players has for some time been four. *WiPong* is yet another experimental variation of the Atari *Pong* as was the work of Till Ballendaat with *Proxemic Pong* (Greenberg et al. 2011) and the forty variations proposed by Cardoso and Carvalhais (2013). The peculiarity of the *WiPong* is the potential to offer an infinite number of simultaneous players within a collocated environment.

2 COLLOCATED GAMING

The limit of collocated players has been challenged by Nintendo many times with Joy Pair, Nintendo 64, Nintendo Wii and Gameboy (through Game Link Cable) consoles. While most of the game developers focused on Massive Multiplayer Online Games (MMOGs), Nintendo extended the number of players with wireless connections, adapters and cords up to the limit of 8 simultaneous players and up to 16 players in the case of turn-based games. The innovative aspect of online gaming conquered, next to the developers and gamers, the attention of academics in a way that a vast number of literature on MMOGs and Massive Multiplayer Online Role Playing Games (MMORPGs) have been produced. The social relation patterns emerging in collocated gaming are inherently different than the relations established in MOOGs and MMORPGs. *WiPong* aims to position itself between massive multiplayer collocated gaming and massive multiplayer online gaming.
3 WiPong

WiPong aims to reflect upon collocated social interaction patterns with a large number of players. As an alternative to the online communities and the alone togetherness (Ducheneaut et al. 2006) of MMOGs, WiPong is an experiment that can be defined as a Massive Multiplayer Collocated Game (MMCOG).

WiPong is structured as a bring-your-own-device system. The server is a Raspberry Pi; it is a dedicated web server that works as a hotspot. The Wi-Fi channel provides access exclusively to the game. The game is compatible with the majority of mobile devices (such as smartphones and tablets) through their browser. Each player, once connected to the system, is brought directly into the game, where the paddle is controlled by touchscreen.

The difficulty of the game is enhanced by two factors: 1) The players do not see how the ball is hit by the other players’ paddle and so do not know which direction the ball comes from; 2) The players do not know if the system directs the ball to their field or not. The scoring system rewards the player by giving one point for a hit, two points for a hit and a won score (if the ball beats the opponent), and takes away two points for a missed hit. When the player decides to exit the game, he/she has the opportunity to save his/her name in the scoreboard as in the classic arcade games.

Soon gamers will be the anomaly. If we’re very fortunate, they’ll disappear altogether. Instead we’ll just find people, ordinary people of all sorts. And sometimes those people will play videogames. And it won’t be a big deal, at all. (Bogost 2011)

CITED ARTIFACTS

Elimination aka Quadrapong, Kee Games, 1974.
Gameboy, Nintendo, 1989.

Joy pair, HAL Laboratory, 1985.
Nintendo 64, Nintendo, 1996.
Pong, Atari, 1972.

Tennis for two, William Higinbotham, 1958.
Wii, Nintendo, 2006.

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Dark Path #2 is an acousmatic piece of electroacoustic music. Acousmatic music hides the source of sound, creating better opportunities for concentration on the sound itself. Thus, it is possible to appreciate those characteristics and peculiarities of sound that often remain unheard.

The sounds used in the piece were recorded in a soundscape dear to the author located in the Italian region of Marche. They were processed then composed together to create the musical work.

*Dark Path #2* can be defined as a journey through light, shadow, shape, color, drifts and landings.

Acousmatic music, which originates from Pythagoras, who would lecture his students from behind a screen on the grounds that they would be better able to focus on his words if they were not distracted by the sight of the person speaking, is a form of electroacoustic tape music.

It begins in the 1940s and 1950s in Paris, with Pierre Schaeffer and *musique concrete*, before the adoption of the term “acousmatic” by Francois Bayle in the 1970s (Marc Battier, “What the GRM Brought to Music: From Musique Concrete to Acousmatic Music.”, *Organised Sound*, 12(3), 2007). For Schaeffer, the sounds of the world become musical material: any sound that can be recorded, is then edited, treated, and manipulated, until a composition is crafted from these real-world materials.

While the emphasis in *musique concrete* was initially entirely on reduced listening and on sounds of the world freed from their sources and causes, over time it became increasingly clear that, in fact, it is nearly impossible for the human mind not to ascribe, even if only unconsciously, a string of causes and sources to the sounds we hear. Reduced listening is possible, but it requires constant, wilful, active effort on the part of the listener to deliberately ignore the possible sources of the sounds being heard; even then, the extent to which these sources are really being completely ignored is debatable. (James Andean, “Sound and Narrative: Acousmatic composition as artistic research.”, *Journal of Sonic Studies*, vol. 7, 2014).
The soundscape composition is a form of electroacoustic music, developed at Simon Fraser University and elsewhere, characterized by the presence of recognizable environmental sounds and contexts, the purpose being to invoke the listener’s associations, memories, and imagination related to the soundscape.

At first, the simple exercise of ‘framing’ environmental sound by taking it out of context, where often it is ignored, and directing the listener’s attention to it in a publication or public presentation, meant that the compositional technique involved was minimal, involving only selection, transparent editing, and unobtrusive cross-fading.

This ‘neutral’ use of the material established one end of the continuum occupied by soundscape compositions, namely those that are the closest to the original environment, or what might be called ‘found compositions.’

Other works use transformations of environmental sounds and here the full range of analog and digital studio techniques comes into play, with an inevitable increase in the level of abstraction. However, the intent is always to reveal a deeper level of signification inherent within the sound and to invoke the listener’s semantic associations without obliterating the sound’s recognizability (Barry Truax, “Soundscape, Acoustic Communication & Environmental Sound Composition.”, Contemporary Music Review, 15(1), 1996).
1 UBQUITOUS TECHNOLOGY IN THE CITY

Contemporary cities are being shaped by the growing ubiquity of technology, which influences the way we experience and interact with the city (Greenfield 2006; De Lange and De Waal 2012; Townsend 2013). The development of cities is being largely influenced by visions of big tech companies and governments that propose systems of embedded digital and network technologies as an answer to the growing urban complexity (Haque 2012; Townsend 2013; Powell 2014). Those visions are focusing mainly on the positive effects of technology, such as safety and efficiency. On the other hand, the same technology can produce all sorts of side effects, for example, in relation to privacy, anonymity and spontaneity, among others (Townsend 2013; Brynskov et al., 2014; Nissenbaum and Varnelis 2012). Reacting to this context, all around the world, various organizations, collectives, individual artists, designers and researchers are exploring the potential of digital technologies and new media art as tools to visualize digital layers of the city, ignite discussions, and question the future of cities based on these dominant visions (Andersen and Pold 2013; Greenfield and Shepard 2007; Bleecker and Nova 2009).

In accordance with these views, the aim of our research project is to explore the possibilities of digital technologies in order to create urban interventions that can render the city a more playful, unexpected and heterogeneous place1.

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1. Tweeting Antennas was started at Master’s course in Communication Design and New Media at the Faculty of Fine-Arts, University of Lisbon, under the supervision of Luísa Ribas, Sofia Gonçalves and Miguel Cardoso, with the collaboration of Francisco Salgado from the Engineering Institute (Instituto Superior Técnico), University of Lisbon. It then became the starting point for the further research that we are now developing in the Masters.
2 CONCEPT

Under the motto of old and new media in urban space, the project *Tweeting Antennas* seeks to explore the following dualities:

1) visible vs. invisible communication processes
2) contemporary vs. dead media
3) digital vs. physical spaces

Two key factors for the project’s idea and development are:

a) Approaching the current trend of embedding everyday objects with internet connectivity—a concept best known as the Internet of Things. More specifically, investigating how ubiquitous connected devices can influence the functioning and the appearance of future cities;

b) Exploring specific sites and landscapes, in this particular case, the historical part of the city of Lisbon—a city built on many hills. In this characteristic cityscape, the buildings are usually not very high, hence the rooftops are easily accessible and very visible, as well as the obsolete antennas that pervade them.

The project seeks to take advantage of existing objects and structures that are characteristic of the cityscape of Lisbon, namely, its emblematic rooftop antennas. The majority of these are broadcast television receivers, which became obsolete with the emergence of cable and digital television, can now be seen as monuments to broadcast television, that in this age and particular location, become a sort of dead media.

*Tweeting Antennas* thus re-purposes rooftop antennas, as obsolete communication structures in the context of contemporary cities, enabling them to receive and send information again, in a new and unexpected way. The idea is to render visible fragments of social digital media communication in physical space and in real time, through the kinetic motion of the antennas.

The project transforms the tweet messages one sends using social media, (which are usually global and remain in the cloud, delocalized), into local and ephemeral events. It encodes this information, rendering it visible but at the same time encrypted, anticipating the necessity of alternative means of communication in future cities where surveillance is omnipresent.
3 IMPLEMENTATION

3.1 INPUT

As data source, we decided to use Twitter; more specifically, geo-located tweets that are fetched in real time in a physical proximity to the installation site. Twitter was chosen for several reasons: it is one of the most common channels for immediate distribution of information and it is widely used from mobile devices; meaning we could visualize tweets from people that are in public spaces surrounding the installation. Finally, the limitation to 140 characters made their translation into motion feasible and faster.

3.2 TRANSLATION

In order to translate tweets into movements that would make sense (considering different possibilities of encoding the information), we had to find a way to represent each character in a tweet as a unique sign that would be translated into the position of the antennas. The solution was the flag semaphore system — a telegraphy system for visually conveying messages over distance that normally includes a person holding two flags, one in each hand. Therefore, when the flags are in fixed positions they represent a single character in the tweet message.

3.3 OUTPUT

The final output is a system of two modified antennas connected to stepper motors and an Arduino controller that, through a program written in Processing, translates each character of the nearby geo-located tweets into the corresponding position of the flag semaphore code (Fig. 1).

Fig. 1.
The project *Tweeting Antennas* is a work in progress and, so far, two prototypes have been developed and exhibited. The first prototype was exposed at *Fabrica Features* in Lisbon. The second prototype was produced for the New Media and Digital Art Festival *PLUNC* in Lisbon, in September 2015 (Fig. 2).

The second version was adapted for *xCoAx* having the piece reacting to any tweet containing the keyword *xcoax* in addition to nearby geo-located tweets.

**Fig. 2.** Second prototype of Tweeting antennas.
4 RESULTS

The current project was conceived as an urban, and site-specific, intervention that seeks to emphasize the ubiquity of digital technology in an urban context. At the same time, it aims to reveal and incite a reflection on the ways in which invisible layers of digital information are changing both our personal experience and the physical appearance of today's cities.

Tweeting Antennas is influenced by the local and invisible layers of information that surround them. If no one sends tweets in the proximity, the installation remains static. Therefore, it requires participation, even if the participants are usually unaware of their active role, or of the potential impact of the flows of information they help create. In this manner, we believe the installation becomes a metaphor for the invisible data gathering processes that are currently occurring within the city, eventually, without our full awareness. By appropriating dead media, Tweeting Antennas also proposes a play of contrasts from visible to invisible communication processes, from contemporary to dead or forgotten media, and from digital to physical environments.

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Haque, Usman. What Is a City that It Would Be 'Smart'. Volume #34: City in a Box, 2012.


Authors: Design Futures Lab: Directed by Nicole Koltick, Project
Designers: Jay Hardman & Elena Sabinson,

Credits: Engineering by Mike Hogan. Score by Nathan Cochran
Research Assistants: Tashia Tucker, Kristin King, Yiyun Liu. Film
Shoot: Jocelyn Motter-Tarquini, Eric Teti, Sam Cowan
NESL is a 6 minute short film by the Design Futures Lab. The film arose from a broad speculative design research project in the Lab entitled Synthetic Ecologies: Autonomous Botanists. The project explores the poetic potentials of a new robotic species, entitled NESL. NESL (Nurturing Emergent Synthetic Life) are a series of crystal gardening robots situated within a dynamic digitally modelled and fabricated synthetic terrain. These robot gardeners have machine vision capabilities and are programmed with simple algorithms governing their behavior within the landscape. This involves choice in what color crystal “seeds” they plant as well as density of crystals within a given area. These decisions result in a series of aesthetic compositions of synthetic crystals throughout the landscape. The landscape itself is a dynamic synthetic machine which further influences the habitat through the introduction of fluids and movement to facilitate crystal growth. One particular focus of the project involves NESL’s vision and a narrative surrounding their burgeoning aesthetic awareness and participation within the synthetic ecology. This project can be read on another level as a glimpse into our naïve synthetic past. The robots, crystals and terrain evoke the biological through relatively basic computational methods. The world they influence and inhabit is simple, beautiful and yet incredibly hermetic. The robots present as empathetic figures striving to achieve a biological legitimacy. As research into robotics and AI explodes, there remains a vast potential of unexplored territory exploring our relationships to these systems and the narratives we weave surrounding their adoption into our lives. This project proposes a species of robots, an artificial environment and a set of interactions to provoke questions surrounding the role of newly emergent synthetic species, with a particular focus on non-human aesthetics.

In this work, we allow the viewer to assume the robots’ point of view in key scenes. In our development of the storyboard for the film we wanted to particularly highlight the life cycle of crystals in the landscape and the changes they undergo in tandem with the robot’s awareness and interactions within this world. Speculations on non-human aesthetics form the foundation of this research and are particularly foregrounded in the film. Robot vision is explored and the film uses both human and robot point of views in contrast. In the design and development of the robots we considered, how might they make themselves? Their skin is a carefully developed 3d printed flexible textile. Their internal components are fairly simple electronic and robotic systems. Their skin, pinchers and vision systems were carefully developed to perform within their synthetic landscape. The landscape they inhabit embodies its own set of algorithmic behavioral logics which influence crystal growth and landscape development.
The aesthetics of the project evoke the natural through highly synthetic means and are highly calibrated, with an extremely pristine white world and white robots meeting a highly colorful set of crystals. These stark contrasts are utilized to call into question issues of subject and object, and the imprecise location of agency in a series of interrelations. Both the white robots and the white environment are dynamic computational systems. The wild colorful crystals can be understood as the “most” biological element and least controlled aspect of the piece, yet their growth, color and form are carefully calibrated as well. The crystals have been developed to behave within the landscape in very particular ways. The landscape itself is mechanically actuated, machine controlled and has the capability to expand with a series of air bladders as well as seep water. Each of the three components, robot, landscape and crystals embody a range of prescribed behaviors while also harboring potentials for disruption and change through interactions with the other systems. The robots engage with one another, the landscape and the crystals. They have limited intelligence and that intelligence is deliberately geared towards aesthetic recognition, deliberation and action. While creative robots are not a new phenomenon they usually retain their industrial appearance and operate in more direct ways. In this project something else is going on. The robots are creative but in a more subtle mediated way. Rather than performing a specific set of actions, they are situated within a nested series of relationships and their influence is less obvious. The pursuit of the film project was not meant to simply portray the physical components of this piece, but rather to deepen our provocations through a more sustained glimpse of the relational potentials embedded within. This synthetic ecology operates outside of language and is centered on sensation, affect, movement, color and form allowing us to immerse viewers deeply within the habitat and occupy multiple points of view both internal and external to NESL.
While the term “marketing” and the multidisciplinary approach it encompasses has become a deeply ingrained, understood, and almost imperceptibly implied part of (post)modern western society (Hirschman, 1986), rarely has it been directly associated with art in the role of its subject. Instead, being neither art nor science, it is often met with apprehension and derision, seen as a form of the ever threatening wizard behind the curtain of capitalist and consumerist mechanisms. Amidst timid attempts at subverting marketing to make use of genuine artistic values for its purposes (Brown and Patterson, 2000) and cynical attacks at its basic values and effects on society, there exists a lack of endeavors that would try to establish whether art can arise or is contained in marketing principles *talis qualis*.

With that in mind, the idea behind our audiovisual piece “Click Click Sale” is to explore the obscure phenomenology of marketing together with its reliance on people, needs, dynamisms, and communication patterns that have come to symbolize something entirely inhuman, manipulative, and belligerent. To show that a valid system of aesthetics can be extrapolated even from the most unlikely of marketing sources, we took the data collected by an online advertising system and produced a sensory display of otherwise abstract information in two domains — the aural and visual. The data set consisted of clicks on ads and subsequent conversions\(^1\) tracked during the period one day in all campaigns of a selected advertiser. The software system used to collect such data also automatically enriched each click and each conversion with various properties relevant for understanding and optimizing marketing performance. These properties include the users’ geographic location, device information, tracking parameters, and different identifiers. Displayed in the visual and aural domains, users’ clicks and conversions flourish into new manifestations, revealing masked, uncanny connections on a locational and behavioral level. As a side effect, our project once again

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1. Conversion of site visitors into paying customers — the desired outcome of marketing efforts.
shows that similarly intimidating buzzwords such as “big data” and “market metrics” that are today, more than ever, associated with the dehumanization and privacy invasion of users, can be, if willing, interpreted in an innocuous or even artistic manner.

Besides considering the aesthetical aspects, the piece also strives towards precise representation of abstract data in their full substantiality. By representing the information collected from the software directly and without significant interventions, we have avoided tainting the data with our personal interpretations and any contextualization. As the auditory and visual displays have been modelled after consciously formed rules, contextualization is apparent, but only at the lowest possible epistemic level—that of an individual datum. Because of that, our work does not attempt to analyze associations and connections in the data, does not generate or search for meanings, does not come to judgments or conclusions about the data, and it also forgoes the use of any external sources of knowledge. Everything that is projected from our work is sourced from the pristine data itself. It’s the adherence to this principle that enabled us to demonstrate the diversity that is idiomatically attached with big data, with the added significance stemming from the actions and nature of actors in this system: individuals, real people who have interacted, clicked, and converted.

The aesthetic consequences rely on the data’s inherent and authentic diversity without any additional factors of randomness or manipulations. Part of the onus of interpretation, thus, falls on the observer and the observer’s ability to feel and understand the scope of the exposed variety. Consequently, the piece is not the result of coincidence or aleatoric principles; each choice is the cogent and contemplated result of a compositional, creative process. To disclose all the grandiosity and impressiveness of a large data set, the sonification process relied on the mapping of each data record into a grain of sound whose timbral characteristics, i.e. the amplitude envelope, dynamic changes, spatialization, duration, and amplitude level, were directly derived from attributes of the sonified click or conversion. Instead of driving a typical granular synthesizer, the resulting soundscape is synthesized by summing all particular elements in the microsound time scale. In the same manner as users collectively shape market demand, small and individually inaudible grains blend together in a rich and astonishing cloud of sounds. A chronological order of clicks and conversions is maintained showing that collective online activity results with a lifelike constant evolution.

The visual part of the piece was implemented as a dynamic representation of conversions and clicks. The direction and modes of progression of the visualization depend on the data
associated with users’ actions. In other words, conversions and clicks that share similar values such as geographic location or that are completed using the same type of electronic devices tend to group together and push towards similar areas. The program that implements this aspect reads static data extracted from the marketing system and creates ephemeral imagery. As a result of their increased frequency, clicks are represented as more dynamic, frenzied abstract shapes and are, in part, statistically processed. The employed statistical method results with minimal impact and avoids injecting any new meanings, implying any links based on causality, interpreting or justifying the data.

In the end, similarly to the system that we are observing and projecting, the value of “Click Click Sale” will be determined by our own observers and “consumers” and the discussions it spurs. Data collected from a system for online advertising pose meaning, indications, and commercial value, but only once they have been systematically analyzed within a given context. In the same manner, our audiovisual piece, its aesthetics, concept, and form, become complete only when faced with the observer’s expectations, prejudices, and personal aesthetics. Whether or not it will reveal some novel aspects of material which is usually abstract and distant, remains to be seen.

Artwork (Video): http://tiny.cc/ClickClickSale

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When considering the now widespread and familiar interventionist tactics of wireless data capture, either by script-kiddie hobbyists or a government adversary, SSID_exquis intervenes right at the moment of capture itself and alters the access modes of the usually read-only environment in the commonly known WiFi part of the 802.11 radio spectrum. Positioned as a performative and participatory work in public contexts, the project blurb reads as follows:

SSID_Exquis is a gamified exercise in collaborative poetry, manifested in WiFi. Its participants can publicly broadcast wireless network names, or SSIDs, by contributing to a collectively assembled list. From this list a series of wireless LAN beacon frames is generated which are transmitted periodically to announce their presence in the surrounding 802.11 radio spectrum. In a continuous fashion the resulting flood of publicly accessible wireless networks is logged, constituting timestamped cadavres exquis.

Beyond the obvious reference to the Surrealist writing technique (which was later popularised through its adaptation to drawing and collage) cadavres exquis, technically the project functions as a captive portal which presents its users with a webpage containing info about the work and some HTML form fields allowing for the contribution functionality. Whereas a captive portal would normally be used to constrain a user’s movement on the network (or in the case of malicious use; capturing sensitive data from an unsuspecting user), in SSID_Exquis the aim is to make a WiFi radio spectrum writable by allowing each participant to have their say in form of beacon frames.

From an anthropological perspective, SSID_Exquis builds upon the popularisation of niche-tech subculture surrounding topics related to “hacking”, penetration testing and wireless network auditing – a post-Snowden collage of sorts. The project is structured around an “infusion” (using a native scripting language that can tie various available software components together) built on the so-called WiFi Pineapple MarkV device, a hard-
software platform which has a dedicated following via the HAK5 Youtube channel and forums. In essence the platform is a cleverly put together mashup of very hackable WiFi radio chips, and a browser-based interface which allows for in-depth modification of its configs.

Ironically, SSID_Exquis subverts an earlier project built on this platform; dubbed Occupineapple, it was originally intended for protesters trying to get their word out via a sequence of broadcasted SSIDs – a technique dubbed “beacon flooding”.

Performances
Choreographers: Katerina Foti and Natasha Pandermali
Supervisor: Dr Julio d'Escrivan
Co-Supervisor: Prof Monty Adkins

Pen-y-pass is an interactive dance piece using eight Gametrak controllers as a choreographic tool. The paper demonstrates the inspiration from the contemporary choreography methods by William Forsythe and Wayne McGregor to adopt the interface as a choreographic tool.
1 INTRODUCTION

*Pen-y-pass* is an audiovisual interactive dance collaboration with two choreographers using eight hacked tethered controllers from the vintage game console, Gametrak\(^1\). The Gametrak’s tethered controller can be pulled in and out and send data of the tether’s length. Therefore, the tangible controller requires users to move in certain ways; its nature of interaction directly impacts on movement creation process. I chose this device as an interactive interface because the piece is focused on how to devise choreography with physical obstruction in particular. This paper explains my compositional approach related to contemporary dance choreography methods, how I used Gametrak as a choreographic tool and the process of the audiovisual work in *Pen-y-pass*.

2 MENTAL IMAGERY TO PHYSICAL IMAGERY

In a previous experiment several years ago, I asked a dancer to tether six Gametrak controllers to her waist. This condition naturally made her repeat the same movement to check how far she could move or not. It was very interesting for me to observe this behaviour because the motion tracking technology interfered with the size and shape of the dancer’s kinesphere. This idea was discarded at the time, because it simply made it difficult for the dancer to move freely. However, I brought back this idea and set this condition as a task to create interesting movement and audiovisual work.

2.1 RESEARCH IN CONTEMPORARY DANCE CHOREOGRAPHY METHODS

Contemporary choreographers often provide tasks for dancers to form ‘mental images’ which dancers need to decide how to move in response for that imagery. (Clark and Ando 2014) In one of William Forsythe’s lecture videos from *Improvisation Technologies* (William Forsythe 2008) Noah De Gelber dances with an imaginary table and dismantles its parts as choreographic process. After that he creates an imaginary chair and resizes to go underneath. Forsythe calls those imageries as “Choreographic Objects” and as dancers move along with the objects their kinesphere change.

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1. Gametrak is invented in 2000 by Elliott Myers, the founder of In2Games. It is designed for motion games using two hands such as golf or boxing for Xbox and PlayStation.
Wayne McGregor’s instructions also involve the use of one or more forms of imagery as stimuli for dancers. The tasks require either imagining geometric spatial image or visualising a three-dimensional image in mind. (DeLahunta, Clarke, and Barnard 2012) Another method McGregor uses is providing dancers a physical problem, which they have to ‘solve’ through movement. For example, dancers are “asked to imagine a rigid rod connected to their shoulder, which is then pushed or pulled by a partner some distance away.” (Clark and Ando 2014, 187)

Innovative movement creation can start from alternative points in mental, as well as physical, space. (May et al. 2011) The common approaches Forsythe and McGregor have is that they both use 1) ‘mental imagery’ to provide inputs for the beginning of a movement rather than on the end, 2) set ‘limitations’ to seek new choreography, and 3) discover new ways of moving in the ‘process’. Inspired by those methods, I decided to set visible and tangible imagery using Gametrak’s tethered controllers. It works as ‘physical imagery’ which dancers need to work on as either choreographic tasks or physical obstacles to solve through movement creation process.

2.2 TECHNICAL SET UP

Eight hacked Gametrak controller have placed in a square room (Fig 1). At the end of each tethered controller a small carabiner has been attached so that it can be hooked on a dancer’s wrist bands as well as on a neck, waist, and ankles. I have used an Arduino micro controller as an interface to receive data from the tethered controllers and send to my computer.
2.3 CHOREOGRAPHIC TASKS

The tethered controllers constrain a dancer's body and limit kinesthesia. The main focus in this experiment is not to demonstrate how dancers struggle with their constrained bodies but to see how this setting can impact on their improvisational process.

The two choreographers were asked to attach and detach eight Gametrak controllers on each other's different parts of bodies. When any parts of their bodies were attached to the controllers, dancers had to complete at least one or more tasks addressed here: they had to 1) figure out how far they can move with the tethered body parts, 2) improvise freely within the tethered space, or 3) use the tethered controller as imagery to build choreography or think those as their extended body parts.

3 AUDIOVISUAL WORK IN PEN-Y-PASS

Pen-Y-Pass is a mountain pass in Snowdonia and the piece draws an epiphany of complete isolation in Snowdon in a wintertime. I used some footage I have taken in Snowdonia (Fig 2) as resources for the visual work. The visual work is created in the program, VVVV, and the tethered controllers are programmed to generate the visual work as well as the sound composition programmed in MAX.

![Fig. 2. Still shots of the footage taken in Snowdonia](image)

The performance is divided into four different parts: it starts with an encountering moment of the windy mountain. Although all eight wires are connected to the two dancers (four each), the dancers only use one of their hands to start the piece. Gradually they begin to use more wires to move freely and create more horizontal lines for the visual projection. The second part represents the pass as a maze and the
projection shows grid balls structured as a cube. The dancers detach one of the wires and leave three wires with diagonal arrangement. I asked the dancers to attach one part of their bodies as a starting position for this part and think those diagonal wires are as their extended bodies as if they are turned to the diagonals (Fig 3). The third part demonstrates the night I had in a lodge in Snowdon with dreamy and surreal mood. The night fell into complete darkness. Only the sounds of hail hitting windows faintly held my consciousness. The dancers are asked to detach two more wires from their bodies which let them to dance more freely with this dreamy narrative. The last part finally reveals a clear sight of the snow mountain after the pitch-dark night passes. The performance of Pen-Y-Pass is filmed and produced as a screendance video.

Fig. 3. Pen-Y-Pass (2016)

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CONTINUA: A RESONATOR-FEEDBACK-CELLO DUET FOR LIVE CODER AND CELLIST

ALICE ELD RIDGE  CHR IS K IEF ER
Continua is a duet for cellist and live coder, each playing a hybrid instrument based on the Halldorophone, an electroacoustic instrument in which electromagnetically-controlled feedback can be induced independently on each string. The physical interface ostensibly affords a traditional gestural performance practice, but one that is substantially altered by the nonlinear, generative feedback processes; the electronic interface enables remote digital intervention and live-coding, but in a form considerably augmented by the physical interface.

The evolution of new musical instruments—acoustic, electronic, digital, augmented, hybrid or robotic—can be profitably framed in number of ways: the characteristics of their constituting materials; the particular qualities of performance praxes they afford; the varying roles of and relationships evoked between performer and instrument; and the loci of musical agency (Schnell and Battier, 2000; Livingston, 2000; Collins et al, 2003; Magnusson, 2009, Bown et al, 2009). Improvising with an acoustic instrument can be seen as a physical dance with a softened critical mind around a fixed resonant form; Live Coding might be seen as a staging of the performer’s mind as instrument, situated in a principally static body, unleashing generative sound-producing processes on the world. We are interested in the continua between these practices and how emerging hybrid instruments may afford new modes of ensemble performance.

Continua is a collaboration between a live coder who works with physical, gestural controllers (and also plays acoustic instruments), and a cellist who works with generative and adaptive systems (and also codes). We share an interest in the trade-offs between expressivity of bodily gesture afforded by physical interfaces and the musical possibilities of generative and adaptive processes when instantiated in code (Kiefer, 2015), (Eldridge, 2005).

Our instruments are two retro-fitted acoustic cellos following the design of Halldór Úlfarsson’s Halldorophone. At the end of the finger-board, under each string, sit four CycFi electromagnetic coil pick ups, the gains of which can be individually controlled. These signals are processed externally and fed back to a speaker built-in to the back of the instrument. This feedback pathway can be made more complex with the addition of a second transducer fitted on the front surface of the instrument (pictured). The non-linearities of the signal pathway create richer dynamics than a simple feedback circuit and provide opportunities for musically-meaningful intervention. The cello strings are a significant parts of the feedback circuit, and provide a rich interface for interaction.
In this performance we investigate two different set ups. The cellist controls gains with analogue pedals and a mixer, exploring the balance of bowed, plucked and electrically-induced string oscillations. The sustained oscillations created by the feedback also enable new percussive preparations: bolts, sticks or other objects stuck between the strings can be set in continuous motion, and drift along strings toward nodes of vibration. The signal pathway for the live-coder runs from pick-ups through an audio interface into SuperCollider before being sent to the in-built speaker and transducer. In SuperCollider we can monitor incoming signals and explore mechanisms for exciting and damping the strings. In this performance, a watt-governor like process is used to control a frequency-shifter, which acts to damp the strings when the feedback reaches a threshold. In another patch, synthesized sound is injected into the system via a ducking compressor, creating interactions between the digital sound and acoustic feedback. By virtue of the rich nonlinearities in the physical feedback system through the cello, these relatively simple patches produce a range output from serene drones to brutal screams and yelps. The two instruments, played in close proximity during the performance, also influence each other, allowing the two performers to explore the two instruments as one coupled feedback system.

As a duet we are interested in exploring the continua between gestural control of fixed physical interfaces and remote live coding of adaptive software instruments. How do the expressive potentials of gestural control and the alluring uncontrol of generative, adaptive processes play out in hybrid instruments? How does our experience of time differ when we perform using both in-the-now gestures and temporally-extended generative processes? what are the musical and performative implications? Our initial explorations of this new electro-acoustic-digital feedback instrument suggest it is positioned at the intersection of contemporary gestural and generative improvised performance practices, inspiring exploration of the rich unchartered continua.

**Credit:** With thanks to Halldór Úlfarsson for inspiration, instrument design tutorage and inspiring attention to detail.
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This performance work integrates audio-visual performance with dance and theater. The electronic synthesis and the visuals are generated from orbits in 8 dimensional space created with the octonion algebra. This piece includes vocal improvisations, which are an elaboration on the harmonic structures formed by the algorithmic composition. Further I have included text fragments from Plato's Timaeus and dance performance with a 3-faced mask. Audio and visuals are directly related and computed realtime and the performance is set up so that I live interact with the complex structures and thereby influence the path of the iterative processes. The interaction with the generative work stands central in the performance, and it is a practice and development of the state of mind which intuitively can sense the state of the computation which can not be grasped by the rational thought. The theatrical elements, such as the vocalizations, the dance and the Plato fragments form a theatrical whole with the very abstract and mathematical generative work. Further these performance practices function as a technique to deepen the state of mind and enhance the interaction with the electronics.
Anemone Actiniaria is an algorithmic improvisation duo founded by Hanns Holger Rutz and David Pirrò. In it, they couple computer systems and introduce semi-autonomous agents. As artistic research project, the seemingly well-defined concept of algorithm is subject to a new reading based on material agencies. Mutual observation and overwriting is initiated between our systems, Wolkenpumpe and Rattle, rooted in physical modelling and in the generation of parametric models based on machine learning. This is inspired by the notion of an emergent new machine through ‘orientation’ and ‘composition’ as outlined by Heinz von Foerster and Dirk Baecker, whereby the functions of operators and operands of the formerly separated systems begin to vacillate.
1 OVERVIEW

*Anemone Actiniaria* is centred around one apparently simple proposition: that a sound object moves from one player to another, is dismantled and reconstructed and spatially represented. All writing processes are characterised by an immanent spatiality. In our case, they are rooted in two open source software systems, *rattle* and *Wolkenpumpe*. These systems, while used in live improvisation, are characterised by a certain autonomy through which they become actual performative agents rather than remaining an “instrument” to be played by the human musician. We are interested in the differential movement of algorithms, their potential to generate spaces that are not solution spaces to a given problem but topographies of the material traces of a composition and improvisation process.

Rutz’s system *Sound Processes* interlinks with the compositional and performance process by providing a memory model of musical objects that traces their historic trajectories. As a sort of integrated versioning system it operates on a database that stores the evolution of sound objects. A special live performance interface *Wolkenpumpe* is constructed on top of this framework (Fig. 1). In the project *Anemone Actiniaria*, sound input is taken from the other player’s system and fed into different stages of DSP treatment and analysis, from relatively simple coupling to decomposition using genetic programming of sound synthesis structures that are matched with the input sound.

*Fig. 1. Wolkenpumpe.*
Pirrò’s system *rattle* (Fig. 2) is a mass-based dynamic systems modelling server. Models can be built by adding, placing or removing particles, defining their properties (e.g. mass, attrition etc.) and linking them to each other using forces or constraints. These functions can be freely defined, offering the possibility to realise a great variety of dynamical systems ranging from mathematical models describing simple physical systems to non-linear chaotic systems. In *Anemone Actiniaria*, sound input is taken from the other player’s system and fed into the physical model, building new phase spaces from analysis of this input. As a result, the system can adapt to timbres and rhythmic structures from the other player.

2 COMPOSING SYSTEMS

This way, a sound emitted by one player may now modulate or even produce the sound of the other player, with a varying degree of indirection that is capable of producing highly unexpected new sound structures. The “imperfect reconstruction” of sounds across system boundaries leads to an intrinsic form of spatialisation. This is a spatialisation that does not exist independently from objects, an approach that has been criticised (Eckel et al. 2012). We are not concerned with spatialisation as the attachment of positions and trajectories in a virtual space...
to such existing objects, nor are we concerned with the construction of acousmatic spaces in the first place. Instead, we take spatialisation as an algorithmic strategy through which multiplicities are rendered as co-presences in a performance.

The more we acquire experience in this compound feedback system, the less accurate it becomes to speak of a co-modulation of sounds. What we observe is a drift towards something like a Foersterian double closure where the two systems we develop become oriented and aligned with another (Foerster [1993] 2003). The production of one system is not only heard by an audience but translated into parameters of the other. Each player will have to give up something in order to gain something else, in order to let the new machine compute its own reality based on the transformation of its support structure (Baecker 1996). Although the coordinates of the project are still in flux, we have already encountered a configuration where a perplexing refraction and assimilation of sound across the system boundaries occurs, a configuration where we can start to step back and become observers and inter-actors rather than the intenders.

We are currently experimenting with a live video system that captures this kind of assimilation (Fig. 3).
REFERENCES


s.laag is a piece composed for Dutch Bass Clarinettist Marij Van Gorkom, as part of the http://dutch-uk.network project. This interactive media work employs sonic path-finding techniques and game-audio tools to explore the concept of “modular metaphor”. It navigates across the intersections between the Real, the Virtual and the modular augmentation of a musical instrument. The Dutch word ‘laag’ means low but also layer, stratum and thickness, which resonate more with the compositional thinking behind this work. Slaag (pass in Dutch language) evokes the sonic fluxus between the acoustic instrument and the electronic medium.
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-OI-0124-FEDER-D22700) and PEst-OE/EAT/UI0622/2014.