NEW MEDIA AND IMPRESSIONISM

Christian Clark | May 2015

MASTER'S THESIS IN COMPUTER SCIENCE

PEDECIBA INFORMÁTICA

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to Micella

ABSTRACT

This master's thesis is framed in the areas of New Media Art (NMA) and Human Computer Interaction (HCI). In particular, it is focused in the study of New Media Art pieces that share a set of characteristics (the most important one being that they are composed by atomic elements), might be explicitly interactive, and are usually exhibited in public settings or have been designed to be consumed by a large simultaneous audience.

The content of the thesis can be divided in four big items:

1- The review of a certain set of NMA pieces, their characteristics, and some similarities hold between them and the impressionist movement that emerged at the second half of the 19th century, along with some visual perception principles of Gestalt psychology.

2- A selection and an adaptation of pre-existing theoretical frameworks for modelling interaction in public settings. These theoretical frameworks comprise a set of tools for describing, analysing, and designing New Media Art pieces.

3- The presentation of a set of selected artworks authored or co-authored by the author of this thesis. A description of their characteristics and technology will be presented.

4- The introduction of two tools for artistic production, which were instrumental for the construction of some of the artworks here presented: Sendero (an LED lighting system), and N.IMP (a tool for real time visual content generation).

Keywords: art, new media art, interactive art, interaction, HCI, human-computer interaction, interaction in public settings, tools for artistic production.

PREFACE

This is my master's thesis in Human Computer Interaction (HCI) and New Media Art (NMA).

If at the moment when I became an engineer someone would have told me that in a few years I would be working on these subjects I would not have believed it.

At the time, I was working on databases, web frameworks and web technologies, and, anecdotally, I wrote my undergrad thesis on the field of cellular networks simulation.

Anyway, I remember clearly when I started my transition to NMA and HCI, it was at a Cat Power concert in which I fell asleep at least three times and where I met Tomás Laurenzo, someone with whom I would end up collaborating in dozens of projects later on, and who would drag me more and more into these fields of investigation.

Before that time one could say I was not an artist. Although now that I write about this, I am not really sure if I am an artist, or if that is something I pursue. What I do know is that I enjoy making art pieces, I enjoy the process of building them tackling all the problems that arise, and that I will keep on doing these things.

A few months after that first encounter with Tomás I decided to start a master's degree using the projects we worked at as milestones, and this is the result of that decision.

Many things have happened and changed since then: my professional activity has derived more and more into these subjects, I am part of an artistic collective working on NMA and interaction called Bondi, I have exhibited art pieces in local museums and international exhibitions, I became an Assistant Professor at my school where I act as advisor on undergraduate projects and teach a workshop on interaction, and I got married.

This thesis finishes this transition, and will hopefully set the ground to new objectives.

ACKNOWLEDGEMENTS

In first place I would like to thank my advisors: Dr. Franco Robledo Amoza, Dr. Tomás Laurenzo, and Dr. Álvaro Cassinelli. Without their guidance, trust, and help none of this work would have been possible.

This master's degree was developed within institutional spaces for discussion that are the result of the hard work of academics such as Laurenzo and Robledo in our university.

In the same way, I would like to thank my reviewer Dr. Andrew Burrell for his time and effort.

As mentioned in the preface, my friendship and my work with Tomás Laurenzo are the reasons behind this entire journey. His help and motivation are impossible to assess. My most sincere gratitude goes out to him.

The art and interaction design collective Bondi is comprised of amazing people to which I thank deeply: Pablo "Palmer" Gindel, Fabrizio "Twinkerbolton" Devoto, Tatjana Kudinova, Guillermo "Guile" Berta, Germán Hoffman, and Marcela Abal.

Two of the art works presented here, Celebra and Barcelona, were possible thanks to funding by the Uruguayan Government, through the Comisión del Bicentenario, and the Uruguay Encendido program respectively.

Lastly, I would like to express my gratitude to my parents, Estela and Omar, and my brother Germán for their unconditional support, and most especially to mi wife Marcela for her love, help, and patience.

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Altern current
CSCW	Computer supported cooperative work
DIP	Dual in-line package
DIY	Do it yourself
DSL	Digital subscriber line
FFT	Fast Fourier transform
GLSL	OpenGL shading language
GPU	Graphics processing unit
GUI	Graphical user interface
HCI	Human computer interaction
HTTP	Hypertext transfer protocol
IP	Internet protocol
LAN	Local area network
LED	Light-emitting diode
MIDI	Musical instrument digital interface
NMA	New media arts
OSC	Open sound control
PCB	Printed circuit board
PDA	Personal digital assistant
PWM	Pulse width modulation
RFID	Radio frequency identification
RGB	Red, green, blue
RSS	Really simple syndication

SMD	Surface mount device
SMT	Surface mount
TCP	Transfer control protocol
TTL	Transistor-transistor logic
TUIO	Tangible user interface
UDP	User datagram protocol
USB	Universal serial bus
XML	Extensible markup language

1 INTRODUCTION

New media art, media art, multimedia art, or electronic art are some of the names that have been used when referring to art that applies new technologies, or scientific knowledge, to the artistic production.

In his book "The language of New Media" [44], Manovich defines "new media" as all media that involves the use of a computer at some stage of the communication process, including acquisition, manipulation, storage, or distribution.

New media art (as we will refer to it throughout this document) is an artistic discipline where existing technology and new technology are used to create artworks that explore new ways of artistic expression.

One of its main attributes is technologic and scientific appropriation by the artist. When an artist achieves a critical mass of knowledge in these fields, he or she becomes capable of exercising an appropriation of the scientific and technological media (because in order to appropriate it, one must understand it), and thus he or she is empowered to apply it in the artistic production, decontextualizing, and reinterpreting it [40].

This means that the way the artist applies scientific or technological knowledge (or their production) in an art piece is part of the artistic discourse.

This thesis analyses a selection of new media art artworks and their means of expression. These artworks are installations that exhibit some distinctive characteristics, such as being built upon atomic elements (a concept that will be defined later on this document), and share a similar implicit use of some visual perception processes.

We will refer to this selection of artworks as Modular New Media artworks through out the rest of this document.

As we will see later on, they are well suited for creating big, immersive installations where a large number of concurrent spectators can consume the artwork. This thesis also explores what happens when these artworks scale up and the number of spectators rises. It is necessary for the piece to identify the spectators? Is it necessary to have a special spectator that drives the act of interaction? And if so, how is he or she determined from the rest of the crowd? How does he or she transfer this ability to interact with the piece?

All of these questions imply that during the development of the artworks it is necessary to use some sort of interaction design process to drive and polish the art of interaction, thus this brings Human Computer Interaction (HCI) to the table. This thesis will look into the current available theoretical models in HCI, applied to a NMA context.

In addition, a number of art pieces and performances were produced as part of this masters degree, from which a selection of the most significant work has been made and will be presented within this document.

Lastly, two tools for artistic production were developed: an LED lighting system (Sendero), and a tool for the production of visual contents in real time (N.IMP). Both of them are open source and open hardware, and will be presented here also. At the time of writing this thesis both tools are being improved and new versions are being developed.

1.1 Publications, exhibitions, and awards

A number of exhibitions and publications were made during the extent of this master's degree, and a few distinctions were achieved. All of these accomplishments are hereafter presented.

1.1.1 Exhibitions

Celebra

Laurenzo, **Clark**, Gindel, Devoto, Hoffman.

- Museo de las Migraciones, Montevideo, Uruguay, 2013.
- Facultad de Arquitectura, Universidad de la República, Montevideo, Uruguay, 2013.
- International Symposium of Electronic Art, ISEA 2013, Sydney, Australia, 2013.

- Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay, 2012.
- High school number 61, ProCiencia, Montevideo, Uruguay, 2012.
- Espacio de Arte Contemporáneo (EAC), Montevideo, Uruguay, 2011.

Son

Laurenzo, **Clark**, Gindel.

- Studio 99, Microsoft, Redmond, USA, 2012.
- National Museum of Visual Arts, Montevideo, Uruguay, 2011.

Barcelona

Laurenzo, **Clark**, Gindel, Devoto, Kudinova, Abal.

- Uruguay Encendido, Sofitel, Montevideo, Uruguay, 2013.

Bosque Estroboscópico

Clark, Mateo, Hernández

- Nova Awards, Teatro Solís, Montevideo, Uruguay, 2014.
- Architecture School, Universidad de la República, Montevideo, Uruguay, 2014.

1.1.2 Publications

- T. Laurenzo, **C. Clark**. **Celebra**, Proceedings of International Symposium of Electronic Art, ISEA 2013. Sydney, Australia. July 2013 [41].

1.1.3 Awards

- Celebra was shortlisted for Laval Virtual 2013. Laval, France.
- Barcelona was shortlisted for Live Performers Meeting 2015, Rome.

- Sendero was used in the lighting and interaction design on the architectural project of Arq. Casaravilla et al., obtaining a special mention at the Antel Arena project development contest held in August 2013, Montevideo, Uruguay.

1.2 Thesis organization

This thesis is organized the following way:

In the **second chapter**, an enumeration of some examples, influences, and characteristics of Modular New Media artworks will be presented.

The **third chapter** will identify and adapt the existing theoretical framework for interaction design in public settings for the use in artistic production design, description, and analysis.

The **fourth chapter** presents the art pieces developed during this master's degree:

- Celebra. A site specific, massive, new media art installation comprised by two hundred LED lit balloons.
- Barcelona. A pentakis dodecahedron interactive sculpture that reacts to participants and generates light patterns.
- Son and Réunion. Two art pieces that transform the interactor's silhouettes into abstract representations.
- Bosque estroboscópico (stroboscopic forest). An installation and a performance tool comprised by more than forty fluorescent light tubes in a plantation distribution.

This chapter also presents two tools for the artistic production:

- Sendero. A lighting system, including hardware and software solutions to control a large number of RGB LEDs at high speed.
- N.IMP. A real time visual content generator based on nodes and data paths.

In the **fifth and last chapter** the final conclusions will be laid down, an analysis of the original artworks using the proposed theoretical framework will be performed, along with the enumeration of future work plans.

This document contains a great deal of images, it is important to note that all images of third-party's artworks were extracted from their official online documentation (available in the references section). The images of the original artworks developed in during this thesis will be credited on appearance.

Finally, artworks' documentation, tools' source code, and other technical information is available at http://clark.uy

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2 NEW MEDIA AND IMPRESSIONISM

2.1 Introduction

This chapter will present a few characteristics that are present in Modular New Media artworks. These artworks are similar, or share concepts in areas such as construction design, medium, behaviour, and interaction design.

In addition, this chapter will present a few similarities between these artworks and the impressionist movement along with Gestalt psychology. Although there are many theories of perception, the focus on Gestalt psychology is deliberate, since it provides simple rules that describe visual perception that align in a better way with an engineering approach to our problem.

The chapter will start with a summarized revision of the Impressionist movement, the Gestalt theory, and their backgrounds.

Next, it will examine a few representative new media artworks that are of interest, discussing their characteristics.

Finally, the chapter will discuss methods for content generation for new media artworks, and will briefly explore data processing and its role in these artworks.

2.2 Background

By the end of the 19th century, a new artistic movement was developing in France by a handful of painters who were not part of the traditional gallery circuits, and who were trying to find their place in the art scene at the time.

Their distance from the realist painting styles assured them a difficult start, a few skirmishes with the art critique community, and a late-coming consecration.

This new kind of painters differentiated themselves from the precedent art by their treatment of light, their capability of capturing the visual essence and movement of a scene, and by the application of human visual perception knowledge.

Initially called “impressionists” in a pejorative manner due to their paintings being apparently unfinished and lacking of detail, this group of artists would adopt this denomination and would change its connotation to a meaning of revolution of the pictoric medium that would later expand to other forms of art.

The impressionist movement brought the settlement of new contrast and colouring techniques using plain colours without mixing (differing from the traditional approach which used smooth mixing and darkening shadowing), and fast brush strokes.

On the other hand, impressionists also pioneered on selecting the subjects of their paintings. Coming from a tradition stipulating that only the picturesque was worth being painted, the impressionists started to paint mundane scenes such as Monet´s haystacks. Anecdotally, something “pintoresque” means that something resembles a picture scene, so painters would end up painting the same things all over again.

According to Gombrich, “the magical effects of light and air were more important that the subject of the painting itself” [26].

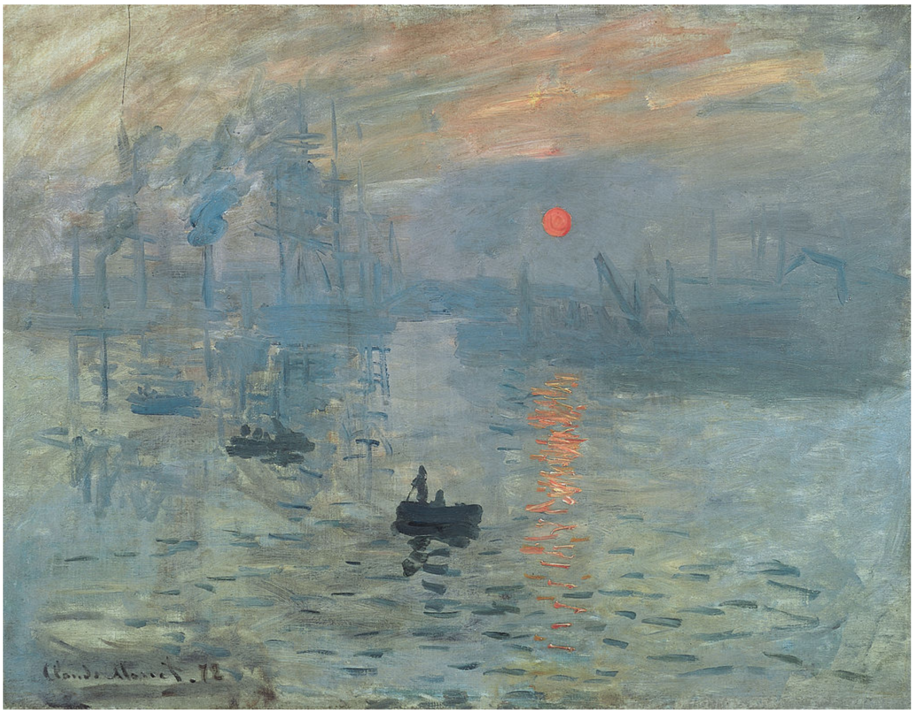

Figure 2.1: Impression, Sunrise (Monet – 1872). Painting from which the movement took its name.

On the other hand, at the end of the 19th century, young painters such as Georges Seurat would start a new movement named post impressionism, extracting numerous concepts from the impressionism of his masters, and adding the use of the chromatic vision studies performed by Hermann Von Helmholtz [80], Eugène Chevreul [17] and Ogden Rood [69; 70], among others.

Seurat, considered a neo impressionist [18], used small brush strokes of uniform colours, knowing that the colours would be mixed later on in the viewer's retina (or in fact in his mind).

This approach to painting that explicitly relied on the viewer to finish the piece was denominated *mélange optique* [3], and was to be used more or less explicitly by other painters as well. While appreciating art, the viewer always finalizes the artwork, interpreting perspective, creating a three dimensional scene, or interpreting a face or a chair. But impressionism made this finalization explicit, and thanks to this explicitation it becomes part of the artist's expressive vocabulary.

Post impressionism was also represented by Cézanne, Gauguin, and Van Gogh; nurturing from the impressionism aesthetic but bringing to the mix a more thoughtful emotional expression to the mundane subjects. On the other hand, postimpressionism had more liberties at the time of presenting more fantastic subjects (scenes that do not exist in nature).

Almost at the same time in Germany, during the 1910s, Max Wertheimer and his assistants Wolfgang Köhler and Kurt Koffka were studying visual perception and would later propose what is known as Gestalt Psychology, a branch of psychology based on the study of mental processes under the assumptions of the Prägnanz law, psychophysic isomorphism, and a top down approach to perception (in contraposition with the structuralism, and conductism of the time). As any other theory of perception, Gestalt maintains that the result of the perceptive processes is an elaboration of the brain.

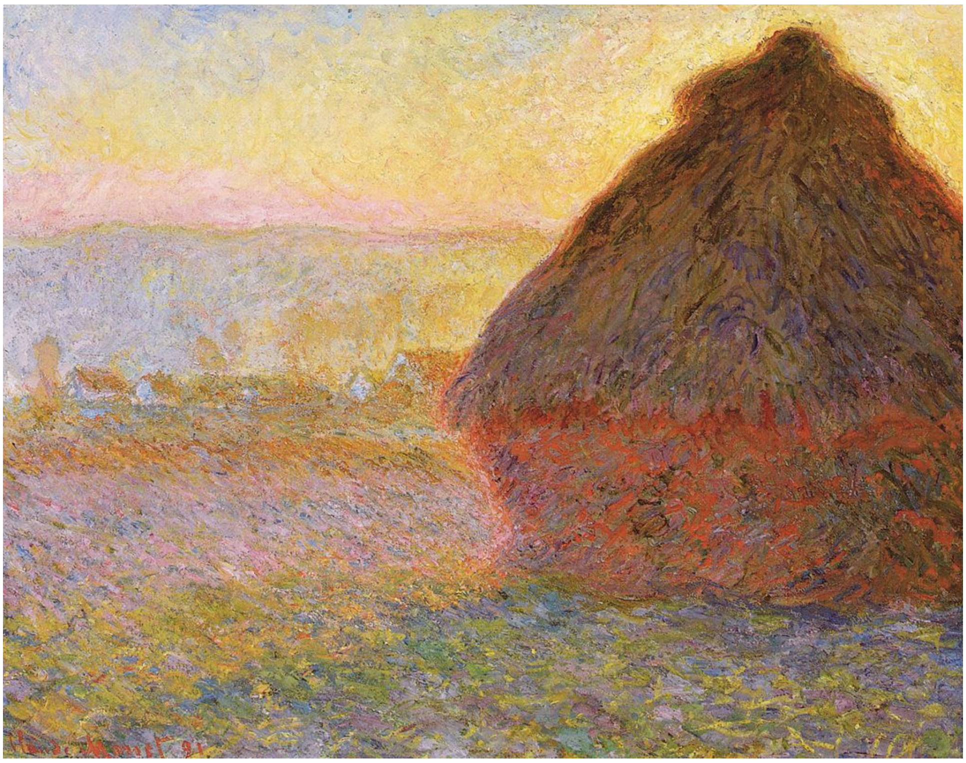

Figure 2.2: Haystacks (sunset) (Monet 1890 – 1891).

Figure 2.3: La Parade (Seurat, 1889). An example of neo impressionist pointillism, and Self-portrait with straw hat (Van Gogh, 1887).

> *"... the nature of the parts is determined by the whole rather than vice versa; therefore analysis should go 'from above down' rather than 'from below up'. One should not begin*

with elements and try to synthesize the whole from them, but study the whole to see what its natural parts are. The parts of a whole are not neutral and inert, but structurally intimately related to one another." [32]

The Prägnanz law establishes that all cognitive experiences will tend to be organized, symmetrical, simple, and as regular as possible given the cerebral activity pattern at the time. It is also known as the simplicity law, where simple and clear things will be recognizable before complex and strange forms [32].

Psychophysical isomorphism establishes that the brain transforms incoming sensorial information, and that transformed information is what is used in the perceptive processes. This means that given a set of stimuli generated by a certain perceptual activity in the brain, that activity will be correlated (by comparison) to the most similar previous activity in order to be interpreted. An example of this is the PHI phenomenon, where the mind is tricked to see a moving light source while in fact there are multiple light sources that blink simulating a moving object [81] [76], the fact that the brain activity generated from the blinking light sources is very similar to the brain activity generated by the moving light source is the key element making the brain perceive the latter in both cases.

Gestalt has applied several of its principles to try to analyse visual perception, and thus has proposed configurations in which visual perception is ordered by the brain, perhaps the most widespread are [32]:

Figure-ground relationship: this principle stipulates that visual perception is divided into two elements, the figure which is clear and unified, and is the centre of the subjects attention, and the ground which is diffuse and that extends to everything that is not the centre of attention.

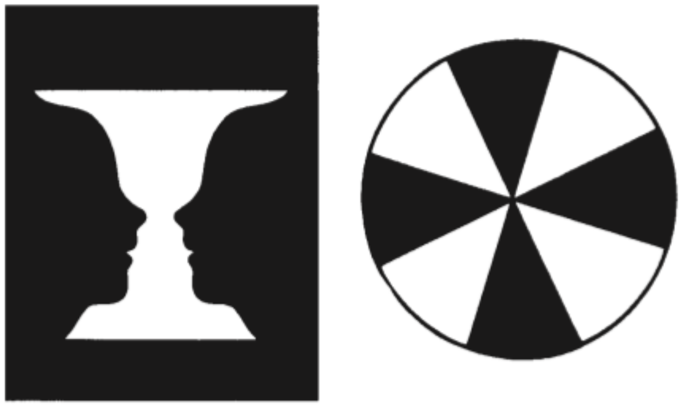

Figure 2.4: Figure-ground relationship.

Principle of good continuation: when two stimuli have spatial continuity, it is a tendency to respond to them as a configuration.

Figure 2.5: Continuity. This distribution of point can be seen as two curved lines.

Principle of proximity: when two stimuli are relatively close together, they tend to be grouped as a single perceptual unit.

Figure 2.6: Proximity. The lines and the crosses tend to be perceived in groups of twos.

Principle of inclusion: according to this principle, when there exists more than one figure to be recognized, there is a tendency to perceive the figure containing the biggest amount of stimuli. If, for instance, there's a small figure contained in a larger figure, one will tend to perceive only the larger figure. The workings of camouflage are a great example of this principle.

Figure 2.7: Inclusion. One will tend to see heart-shaped lines, instead of the word "men".

Principle of similarity: similar objects will most likely stand out as perceptual units.

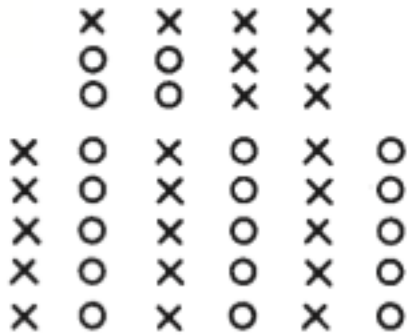

Figure 2.8: Similarity. The columns of o's and crosses are easily distinguishable in the image.

Principle of closure: this principle might be the one that better evidences the presence of isomorphism in perception, and the Prägnanz law. According to Gestalt psychology our brain transforms stimuli in ordered configurations experimented at cognitive level. Thus, we are able to perceive closed rectangles and circumferences in the image below, and we are even capable to identify a horseback mounted man at the far right of the image.

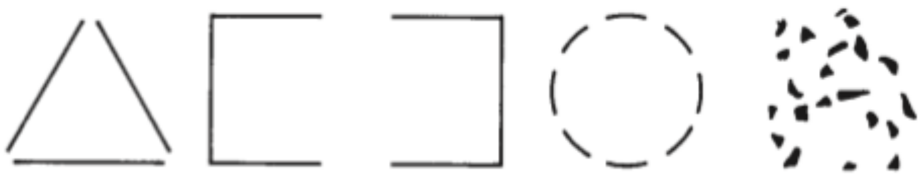

Figure 2.9: Closure. Triangle, rectangle, circumference, horseback mounted man.

Many other principles exist, such as the symmetry principle (where symmetrical components will tend to be grouped together), or the convexity principle (stating that convex, rather than concave patterns will tend to be perceived first).

All of these principles are used together when perceiving a scene, and thus in some cases the principles may be working in favour for the same grouping of perceptual units, but in some other cases they will disagree and one principle will win over the other in order to perceive the scene (or if there is no dominant principle, the scene's organization will be perceived as unclear).

The usage of these principles is not something new in the art world. Artists have used them one way or the other throughout history (willing or unwillingly), although only from the first part of the 20th century they would have a proper theoretical background to base upon, and to construct a critic discourse [6].

2.3 Modular New Media artworks

We will start with a brief explanation of what sort of new media art pieces we will look into, and why.

We are interested in new media art installations that are built using well-defined atomic elements, meaning something (a component) that repeats itself along the installation. In addition, in some cases they provide the spectator with some sort of explicit channel of interaction.

One may also relate some of their aspects with the synthesizing aesthetics of the impressionist movement, and with the use of Gestalt's principles of the visual perception in order to create recognizable visual patterns.

One could say that Gestalt theory's visual principles are always present while appreciating visual art, because by definition they are part of visual perception. But there are some artworks (those more visually abstract) in which the viewers' visual perception has to make more interpretation than others (those more realistic). Modular New Media artworks are embedded in the first kind, being usually abstract.

Now, it is necessary to understand what an atomic element is, and the role it takes in this kind on new media art installations.

An atomic element is something that repeats itself in a given configuration throughout the art piece and has some controllable properties.

These artworks are constructed upon at least one kind of atomic element.

The atomic elements, their spatial configuration, and the coordinated control of their properties are the main features used in these artworks to transmit the piece's essential aesthetics.

We will start by examining a few examples. This listing of art pieces show particularly relevant aspects, and attempts to provide context and insight, by no means comprises an exhaustive listing, and other similar examples may be found.

2.3.1 There must be a pattern in here

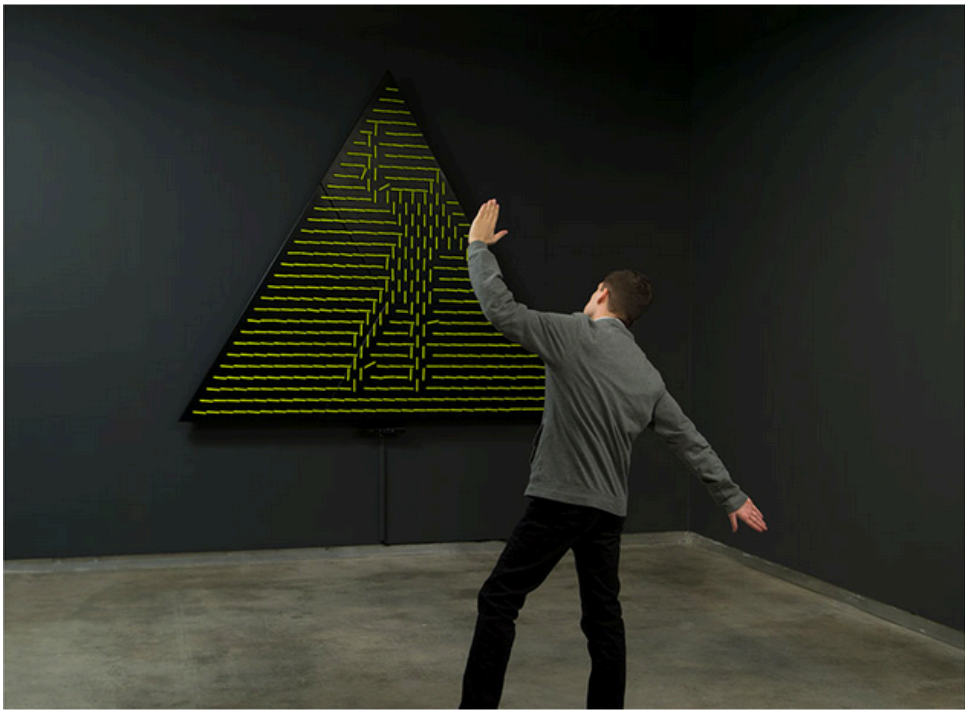

Figure 2.10: Angles mirror (Daniel Rozin, 2013).

Daniel Rozin's "mirror" series are a clear example of atomic elements working together to achieve a larger, more complex, perceptual experience.

In this series [71] [72], the artist uses mechanical mirrors to display the visitor's silhouettes. The atomic elements differ along the series (ranging from wooden tiles, or rusted steel tiles, to mirror glass tiles), as well as their controllable properties. In *Angles mirror*, the artist controls the orientation of hundreds of small plastic spokes attached to motors in order to create the final visual pattern.

Each plastic spoke and its motor comprise the atomic element used in the pattern generation.

The spectator is able to perceive the final animated pattern from a distance, in a process that most certainly involves gestalt's similarity, proximity, and continuity principles.

Similar artworks in which the atomic elements are displayed in an ordered grid, depicting screen, are not hard to find. These art pieces share their format to some extent, but vary in the nature of the atomic elements, and in the way they generate content.

Cubepix [85] is another low-resolution screen that uses cardboard boxes attached to servo motors, and that are being video-mapped using a projector. The piece uses video-mapping and movement to create recognizable patterns, it is also equipped with a Microsoft Kinect Sensor [87] to track users' movements.

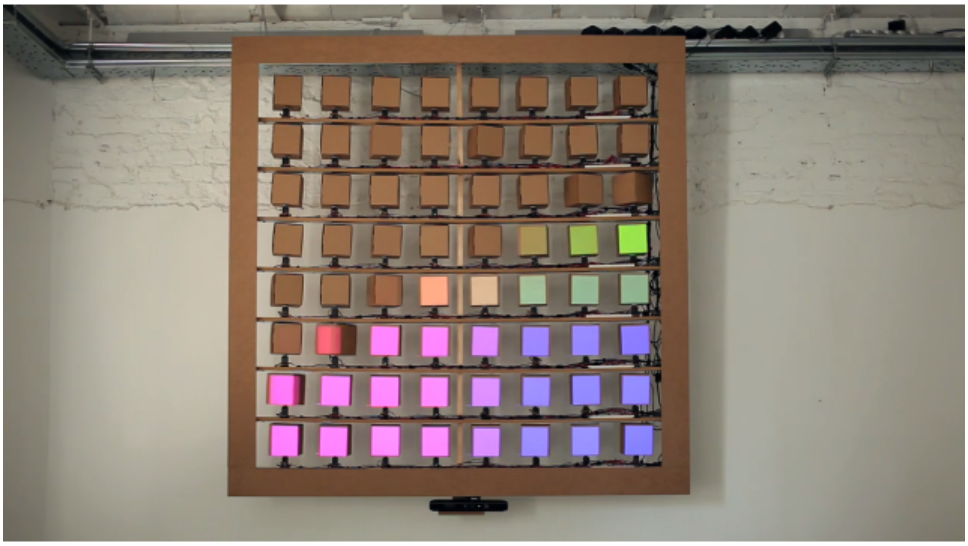

Figure 2.11: Cubepix (Xabi Tribó, 2013).

Type Case [35] [45] is another example. In it, the artist uses a European printer's type case (where the actual letters were stored) as the frame of a deconstructed screen of LEDs that obtains its data from newspapers' RSS [13] feeds and scrolls it from right to left. It is interesting to note that the size of the case's letters compartments vary according to the letter's occurrence in the language, and so this ends up altering the definition of the content as it passes though each case.

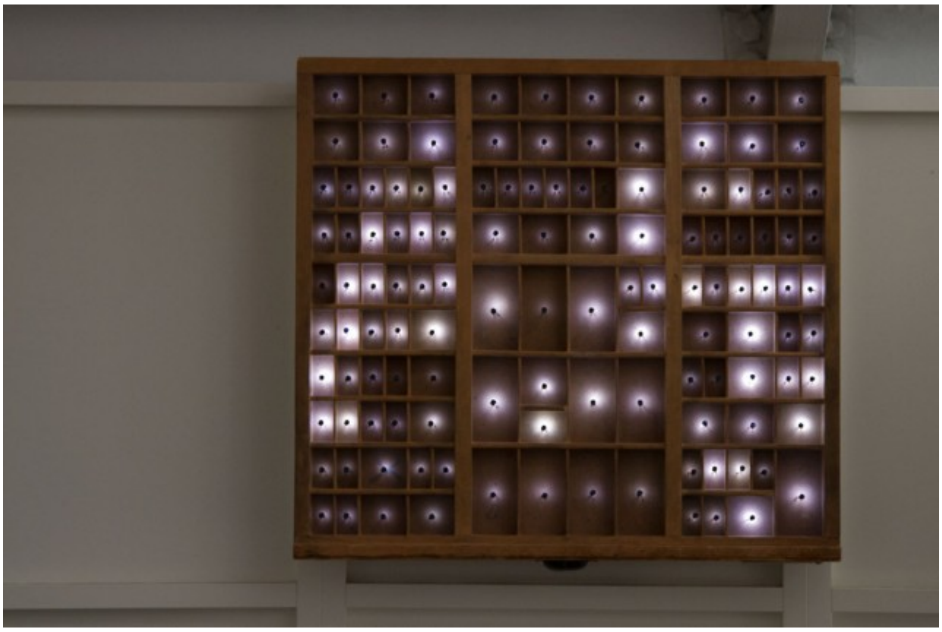

Figure 2.12: Type Case (Martin Bircher, 2010).

Listening post [14] is a "collaborative visual and sonic artwork" comprised of two hundred small electronic screens displaying conversations being carried out on thousands of Internet chat rooms. The piece is also capable of vocalising the contents of the screens as they are being shown.

In this example, each display being used corresponds to an atomic element, and their controllable property is the text being displayed.

But not all examples depict screens, *The Conversation* [35; 60] is an installation made upon ninety-nine solenoids arranged in a circular fashion, pulling radially from a set of rubber bands. Each solenoid individually pulls the bands in order to maintain an equilibrium.

In this piece, each solenoid represents an atomic element, and it differs from the other examples not only because of their circular distribution, but because the system is not managed by a single entity and instead it's final state is composed by the interaction of the atomic elements with no intervention of third parties.

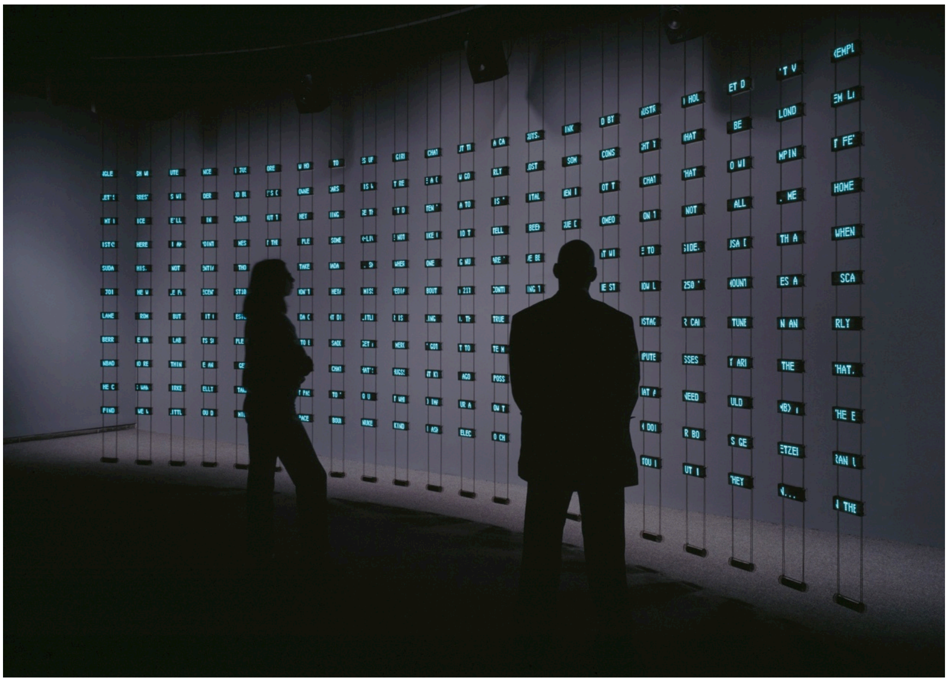

Figure 2.13: Listening Post (Rubin and Hansen, 1999).

Another set of examples is comprised by some kinetic sculptures such as the work of Joachim Sauter. In his vast catalogue of works [74] Sauter explores a number of variations of sculptures made out of hanging elements. The artist controls the element's height (and some times their orientation) to create form out of patterns that are sometimes intervened with light, and that usually can perceive sound and react to it.

Throughout these examples, it is not hard to see that the number of atomic elements, their spatial configuration, and the coordination of their controllable properties are essential. It is by numbers, configuration, and synchronization that the artists try to build patterns that will later be interpreted by the spectators' perception.

As it happens with impressionism, the pieces' visual appearance needs to be explicitly finished by the spectator and thus becomes part of the artistic language, and a great deal of importance is given to light treatment and abstraction. In many cases, the pieces either emit and mix light, or work with reflections and contrast to let the patterns be seen. Movement is also present, either perceived movement provoked by the fast changing properties of a set of static atomic elements, real movement of the atomic elements, or both.

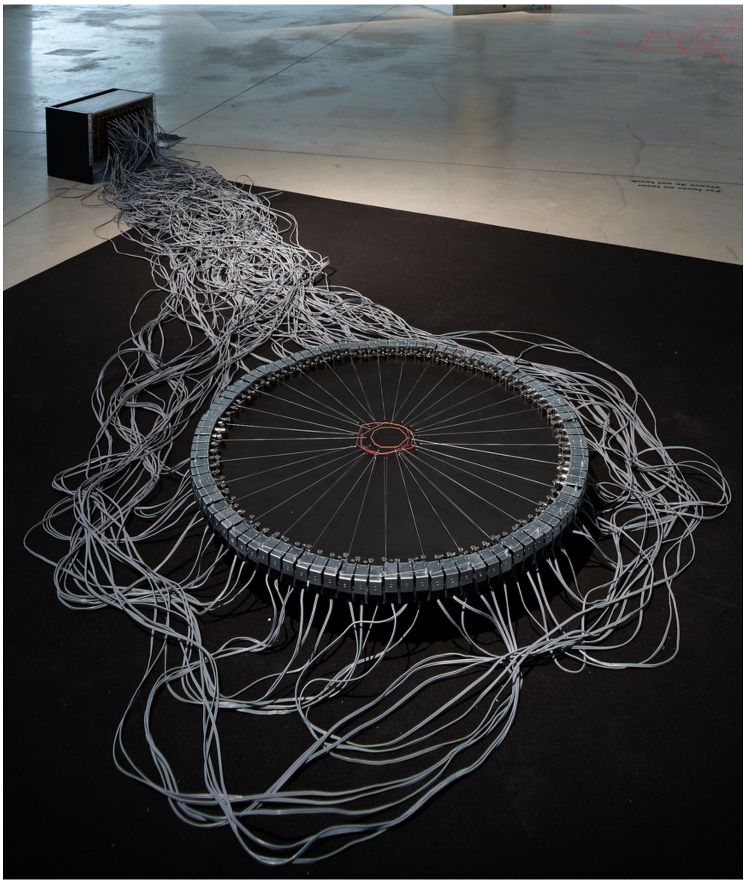

Figure 2.14: The Conversation (Ralf Baecker, 2009).

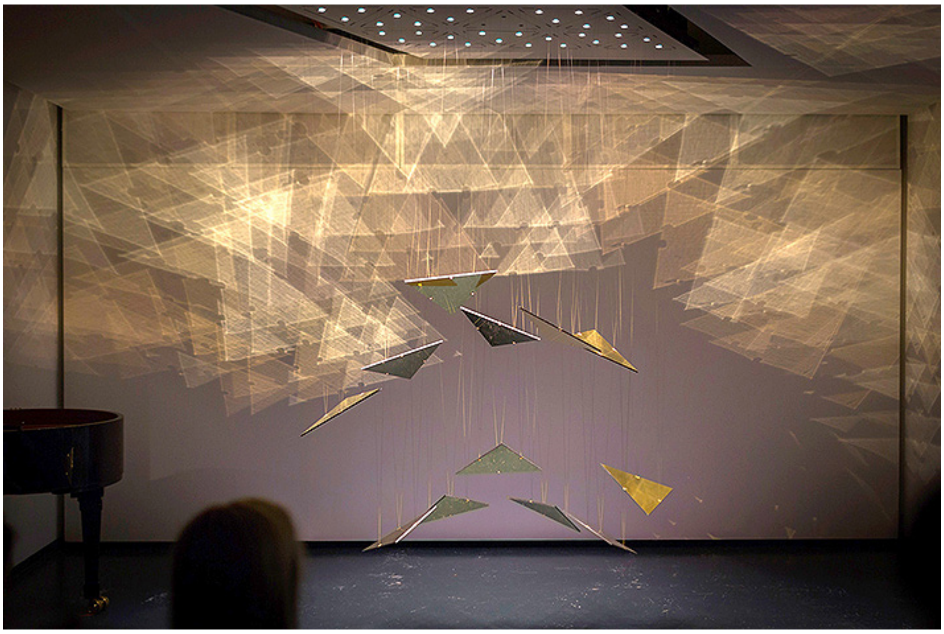

Figure 2.15: Tri (Joachim Sauter, 2013).

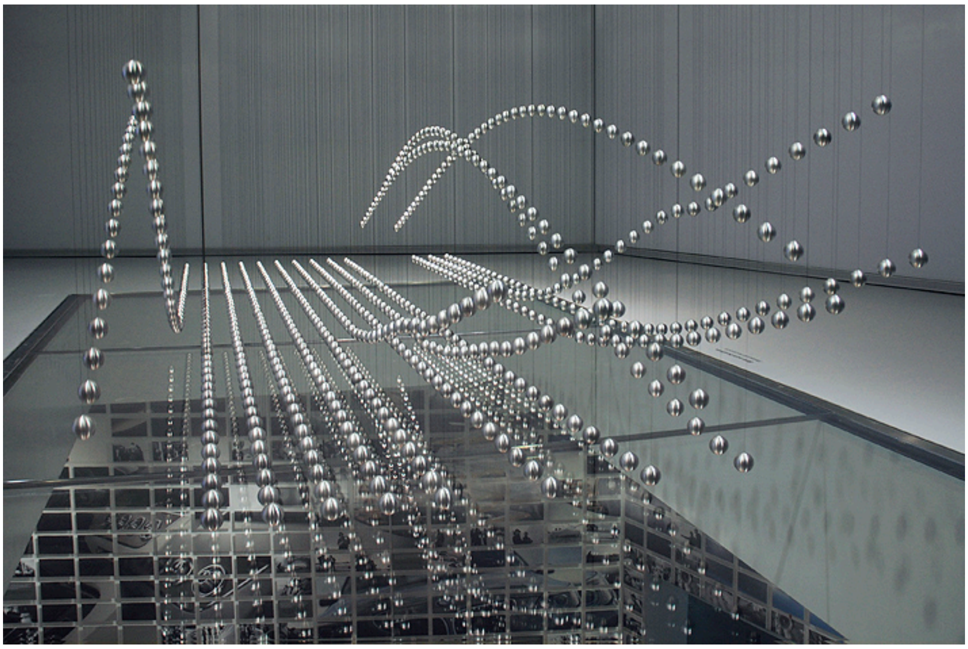

Figure 2.16: Kinetic Sculpture (Joachim Sauter, 2008).

2.3.2 Escalating

One important feature of Modular New Media art pieces is their potential capability of scaling up.

Given their nature of being composed by atomic elements, the artworks may be scaled up by either increasing the number of elements in display, by increasing the element's sizes, or by both. It is true that some technical difficulties may arise during this kind of escalations, but the central workings of the pieces can be maintained.

This capability makes them great candidates for big scale public settings exhibitions, and it also opens the door to immersive installations. In these, artists not only explore size and space, but also interaction schemes between the piece and the spectators.

There are a great number of examples of this fact; a very famous one is *Blinkenlights*.

Blinkenlights [12; 29] is an installation in which the façade of a public building is turned into a low-resolution screen. The piece was exhibited in the Haus des Lehrers (the house of teachers) in Berlin, Germany, during 2001.

Each of the one hundred and forty windows on the façade were equipped with a 150W reflector mounted on a tripod, a diffusing material, and the necessary electronic components to control each reflector.

The building is right in front of a public square from where the general public could gather and enjoy the installation and its contents.

In its first exhibition, the installation could only set windows on or off (no dimming function was used), and it provided a way in which spectators could send text-based animations and text messages that would end up being shown on the screen through e-mails. The artists also provided a phone-call based interface for playing simple videogames like Pong (in a very public way).

Blinkenlights uses the building's windows as atomic elements, and it controls the windows luminance property in a binary fashion.

Another example is *Forest* [1]; an installation composed by a hundred and fifty vertical rods with laser emitters on their ends, distributed in four hundred square meters. The rod forest can be transited and touched by the visitors, and all the vibrations generated by them as they touch the rods are converted into illumination patterns and sound effects.

2.3.3 Spatial configuration

The spatial disposition of the atomic elements has great influence in the aesthetic and finish of these installations, and provides the artist with a palette of possibilities to play with.

At the extremes of these configurations one can find pieces that are either completely regular, being those whose atomic elements are arranged in a known and predictable fashion (such as a grid), or they can be completely irregular where the elements are disposed in space without an apparent correlation (bringing up a more organic aesthetic).

In *eCould* [27], an installation on permanent exhibition at the San José international airport, hundreds of polycarbonate panels hang from the ceiling in an irregular fashion. By controlling the panel's opacity, the piece depicts real-time weather conditions of different cities around the globe.

Figure 2.17: Blinkenlights (Chaos Computer Club, 2001, Haus des Lehrers, Berlin, Germany).

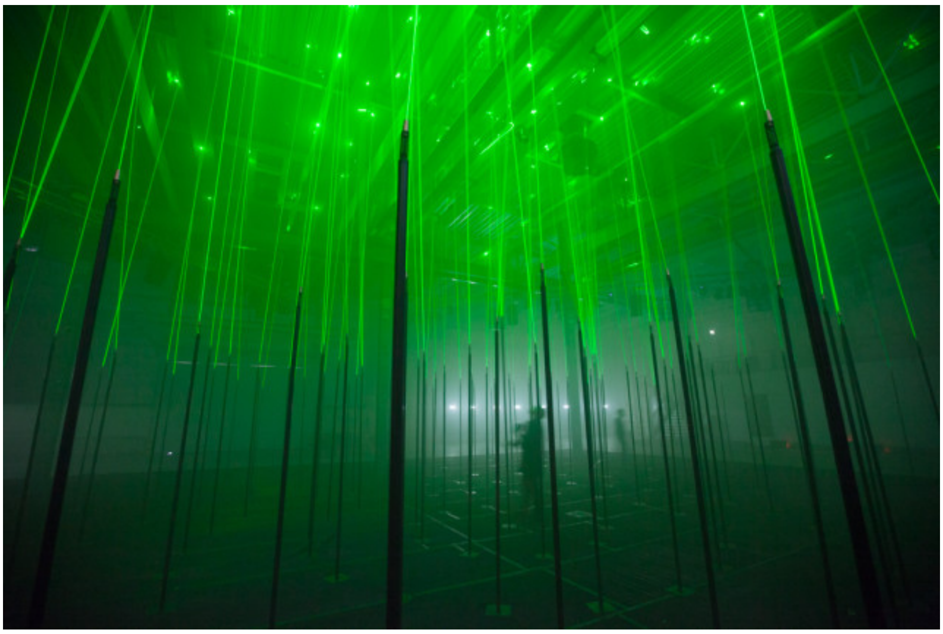

Figure 2.18: Forest (Akten, McNicholas, and Steel, 2013).

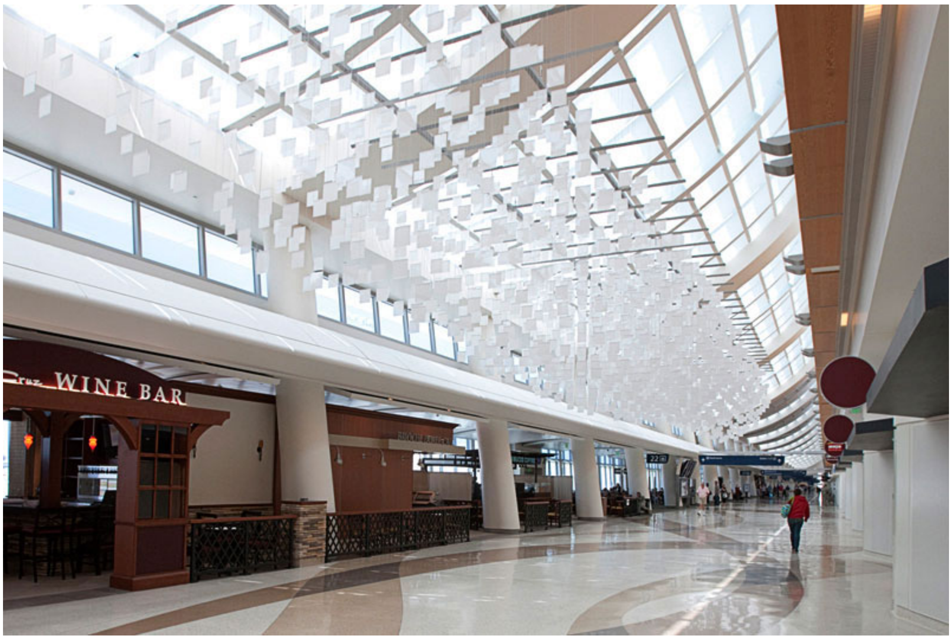

Figure 2.19: eCloud (Goods, Hafermaas, and Koblin, 2007).

Its irregular configuration helps the artists achieve a natural cloud shape. Another organic styled piece is *Fluidic* [82], an installation of over twelve thousand translucent spheres lit up by an array of laser projectors. *Fluidic's* control system tracks the spheres and projects on them. It also track's visitors' movements using a few Microsoft Kinect sensors.

According to the artists, *Fluidic* was thought to have an "organic aspect", and an organic behaviour.

This can be contrasted with a grid-like configuration such as the one used in *Swarm Light* [62]. This piece uses a completely regular configuration to represent swarm-like moving lights that react to visitors' sounds. In spite of being displaying a highly organic and natural content, it remains having a synthetic and clean look.

There is also the possibility of artworks that can rearrange their atomic elements in real-time, and potentially changing between regular and irregular distributions. An example of this feature can be seen in *Spaxels* [7] performances.

Spaxels are LED equipped quadcopters that are able to fly in swarm formations and create three-dimensional forms in mid-air; they can also change the displayed colour and intensity.

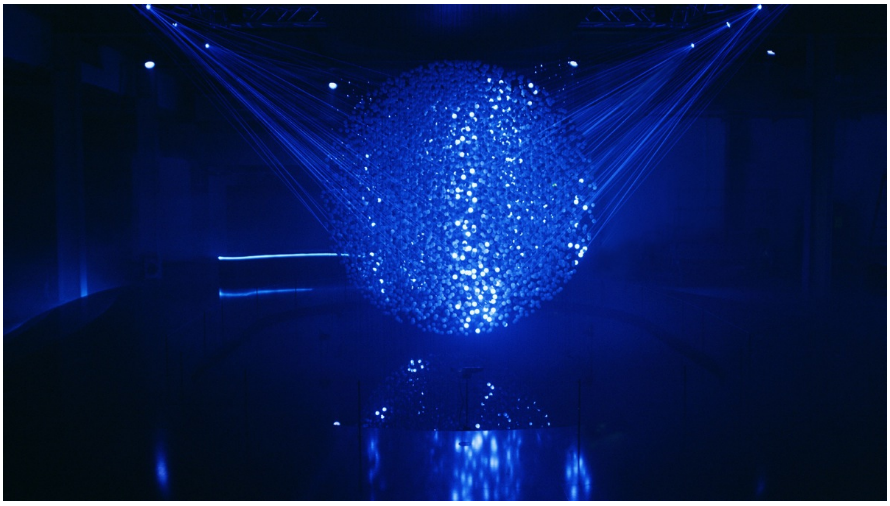

Figure 2.20: Fluidic (WHITEVoid, 2013).

Figure 2.21: Swarm light (Random, 2010).

Figure 2.22: Swarm light (Ars Electronica Futurelab, 2012).

2.3.4 Content generation

> *"Cézanne's structuralism reflected a world flooded with physical data. Our world is flooded with behavioural data. How does that grab you?"*
>
> *- Behaviourables and Futuribles, 1967. Roy Ascott*

In his essay "Behaviourables and Futuribles" [9], Roy Ascott poses an art in which behaviour is the focus of attention, and where constant change generation should be the artist's objective. In this scenario Ascott also gives special importance to software stating, "... *software predominates over hardware in the creative sphere*" and establishing its role as one of the artist's tools to provoke change and behaviour.

Modular New Media artworks have an important behavioural component. An installation may have well defined atomic elements, and a thoughtful spatial configuration, but without its behaviour it lacks of an important dimension. To create this behaviour, the artist needs to deal with content creation. In this context, content is the information that needs to be interpreted by the atomic elements, and its nature will depend on the characteristics of the atomic elements and on what the piece is trying to show.

Content generation is based on determining what should be the state of each of the atomic element's controllable properties for a given instant. Should the piece generate smooth behavioural patterns? Or should they be fast and glitchy? Should they be monochromatic, or adhere to a certain palette? Should the behaviour be predictable by the visitors? This kind of modelling helps to fill the behavioural dimension of the piece.

There is quite a range of alternatives when trying to generate content, such as working with pre-recorded values (like animations or video), or real time generated ones (completely synthetic or generated by data obtained from some sensor).

Real-time generated content has the advantage of not needing much preproduction effort. It can be obtained either by pseudo-randomized processes running on a computer, for example Perlin noise [58] or any computer based simulation, or by processing sensor data from microphones or cameras (or any data stream) and transforming it into new content for the piece. This latter approach has been widely used in many of the examples shown in this chapter.

This kind of real time content generation techniques are very suitable for artworks that are used in performances involving improvisation, since, by controlling a few parameters and the input data, the artist can create a great amount of original content on-the-fly.

On the other hand, it has the disadvantage of not being easily reproduced since content generation depends greatly on these pseudo-randomized processes (the sound perceived on a microphone, or the image from a camera might not be exactly the same, and in turn the produced content might be slightly different).

If the artist wants to have some fixed and well-defined behaviour, then reproducing pre-recorded data, or using seeded generative techniques seem like the way to go.

In any case, mixtures of these two techniques can be used to leverage their benefits.

In order to produce these contents, the art piece needs to have some computing capability; it needs to process data and needs to move data around to reach the atomic elements. Although similar functionality may be achieved by mechanical means, we will only focus on the computer-driven paradigm. Interesting dimensionalities arise from these aspects of the artworks.

Where is the data being processed or acquired by the piece? How does the artwork process this data? Is the way the data is being processed part of the artistic discourse?

First, we need to answer the latter question. If we look at the issue from the media appropriation posture, then clearly the answer is *yes*.

Media appropriation is at the heart of new media art, and means that new media artist use science and technology, and even produce science or technology as part of their artistic intent [40].

In some of the previous examples, the way content is generated and processed is essential for the piece. Such is the case of Type Case [45], where the physical medium (the type case) and the content generation (obtaining content from RSS feeds form newspapers around the world) leverage the piece.

In these artworks, a lot of data is generated and travels around until it reaches the atomic elements. Data may be acquired from sensors, processed in various ways, and then sent to the atomic element where it will be interpreted.

There are a few common data and process configurations that can be seen in some of the examples. First of all, many of the pieces have a central processing entity that is aware of all atomic elements.

This entity can be thought as a server that acquires and processes information from different sources, and then sends processed data to the individual atomic elements.

In this configuration, atomic elements are not aware of their neighbours, and are just dummy components. When a new atomic element needs to be inserted in the piece, the server needs to know about it in order to take it into account, and needs to know a way to communicate to it.

On another extreme, there are a few pieces in which there is no central entity, and where data process and acquisition is distributed along the atomic elements. These configurations are self-arranged and since they lack of a central control, their behaviour might be more unpredictable, but they present an interesting scenario to build more organic behaviours. In these systems, the atomic elements need to be equipped with some sensing ability, and need to have some data processing power and will make decisions of what his controllable properties should be by taking into account the sensed data. Most likely, the piece will not be fully aware of itself (it would not know how many atomic elements are, nor how are they distributed), in change, the information about the piece will be distributed in every atomic element.

The piece's behaviour will then be an emergent behaviour comprised by the individual behaviours of every atomic element.

These kinds of systems are very common in nature, and such is the case of bird flocks and fish schools that have been (and are) object of scientific interest [65-67].

Figure 2.23: Starling flock; an example of self-arranged system.

2.3.5 Interaction, and the spectator as content generator

Many of the artworks previously shown fall into what is called "explicitly interactive" [40] artwork or "interactive art". All art is interactive, as Duchamp stated:

> *"… the creative act is not performed by the artist alone; the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualification and thus adds his contribution to the creative act."* [22]

Meaning that the spectator engages in interaction with the art piece in order to complete it. But what we understand by "explicitly interactive" art, is art in which the act of interaction is an essential part of the piece, making itself explicit to the viewer.

As Myron Krueger says, we are referring to the specific "art of interaction", as opposed to "art that happens to be interactive".

Explicitly interactive art involves a dialogue between the spectator and the art piece in which both are permanently enriched by the exchange.

When evaluating one of his art pieces, Krueger stated "the visual responses should not be judged as art nor the sounds as music. The only aesthetic concern is the quality of the interaction" [36].

We must not confuse this definition with visually appealing interactive artworks. The interaction design of an explicitly interactive piece may not imply a "complex" of even "beautiful" interface with the spectator, it only means that the way the spectator interacts with the artwork is a component of the piece, and an artistic medium. The interface can be as "ugly" as one can imagine, and still be a "beautiful", meaningful, interaction scheme.

Modular New Media artworks usually use interaction schemas that impact on the pieces' behaviours, and thus involve the viewer in the content generation of the piece, sometimes in a very direct fashion, and sometimes in a subtler way. The important issue is that the spectator is in fact altering the piece.

Interaction schemas may differ from one artwork to another, and many of the examples displayed here are proof of the diversity of the medium.

Some pieces offer a style of passive interaction, in which the spectators do not need to engage voluntarily with the piece and still will be contributing to the final behaviour. Some examples of this approach may be sound reactive pieces, where all sounds from all spectators are transported in one medium that gets interpreted by the piece. Another would be pieces that track the users' positions without them noticing it.

More enlightening examples are pieces that use some sort of public data, for instance automatically extracted from the Internet. In this case people involved in the interaction might not be even aware of the piece, but still they are contributing to the interaction and to the artistic discourse.

On the other hand, there are some pieces that are based upon an explicit engagement of the spectators, and provide an interface that needs the spectator's initiative.

The interfaces may vary, of course, but they all share the fact that the spectator must proactively interact with the artwork.

Some examples might be artworks using smartphone applications, where the spectator must first of all install the program in his device, and then eventually run it in order to dialogue with the piece, or even artworks providing some sort of physical interface where one must press, punch, or move real objects.

In any case, the spectator will always be interpreted by the piece, transforming his or her input into the artwork's artistic and aesthetical language.

—

3 INTERACTION IN PUBLIC SETTINGS

3.1 Introduction

"You Can't Evaluate What You Can't Evaluate"

HCI Cannot Be Used To Evaluate Art, 2007. Eric Paulos [57].

The relationship between Human Computer Interaction (HCI) and New Media Arts (NMA) is quite interesting, and has been subject of much debate during the last couple of decades [23; 39]. On one hand there is a discipline researching and developing new technologies, standards and methods to understand, evaluate, and improve interaction between people and computers, and on the other an art genre using technology and interaction as artistic mediums.

Within this relationship, both disciplines have nourished from each other. HCI has used NMA to revaluate problems [24], and NMA has also used HCI as a source of inspiration, and as a way to evaluate and develop art pieces.

An example of the latter is Beta_Space [19], a collaboration between University of Technology, Sydney, Powerhouse Museum, and Creativity and Cognition Studios. Beta_Space is an experimental environment in which the public can engage with artworks at different stages of development. This engagement is used by the artists to collect information that will later be used for evaluating and refining the art piece. These evaluation methods are drawn from HCI and help the artists understand their work in action.

As Paulos states, there is no sense in evaluating the success of an artwork by using HCI evaluation methods and goals: "*If we demanded user evaluations of artworks, many conceptual works and numerous revolutionary art pieces such as The Fountain* [21] *would almost certainly not be part of our art history*" [57].

Thus, HCI must play another role in this relationship, and that is to provide a foundation of knowledge for designing, and refining interactive art, helping the artist conceive his or her vision.

One way to see it, is that it has to be the what the "*colours of paint are to painting*" [23].

This chapter will focus on this approach, and will make a revision of theoretical models for interaction in public settings and Computer Supported Cooperative Work, with the intention of generating a comprehensive set of tools that can be applied to generate a context in which explicitly interactive new media art installations can be designed, described, and discussed.

This section is based upon the theoretical model proposed by Stuart Reeves in his PhD thesis titled "Designing interfaces in public settings" [64], because unlike other models such as the ones proposed by Muller or Vogel [50; 79], Reeves proposes a theoretical framework for designing interaction in public settings strongly based upon the spectator but from a system's perspective.

On the other hand, the human-centred perspective of engaging new media art pieces in public settings will also be discussed using Zafer Bilda's [11] model for user experience in interactive art.

3.2 Searching for a model

Computer systems cover a wide range of applications and uses, but in this study we will focus on explicitly interactive new media art pieces, as computer systems that need to be designed to interact with many people either simultaneously or at different times, provide way for people to interact with each other, and are placed in public settings. These systems also have an inherent performative component, in the sense that they are the centre of attention of their users or viewers, and they are being contemplated by them.

In a first approach to better understand the characteristics of these systems we could first dive into the "many people" that may be interacting with each other element, by searching in the field of Computer Supported Cooperative Work (CSCW).

CSCW is a HCI field that emerged during the 1980s being an area initially focused on developing software to support the work (in the traditional meaning of the word, as in spending time and effort to achieve something) of small groups [28]. Its original main objective was to study how these small groups of people worked, by analysing them from an anthropological and psychological point of view, in order to augment and aid them with the use of computer systems. These systems are called group-wares, and some examples are: video conferencing applications, file repositories, and scheduling applications.

The scope of CSCW has widened since, and now it also includes the study of full organizations and even the application of social networks for CSCW.

There is still a lot of activity in developing a theoretical framework for CSCW, and so far there are a number of contributions on this matter [4; 10], but none of them applies entirely to our scenario.

CSCW holds two important differences with our context of interest. In the first place, it needs people to be working for a common goal or objective; this is fundamental since its conception and not always applies to new media art pieces because there might not be such objective, or the people involved might not be aware of being contributing to something.

And in second place it does not provide nor need for the consideration of viewers or spectators.

However, this field can still contribute to our search because of the fact that it deals with many people using a system. A seminal publication in this field, by Johansen in 1988 [34], proposed a classification that is still considered valid in which CSCW systems are categorized according to their time and space interaction implications.

	Same time	Different time
Same place	Face to face interaction.	Asynchronous interaction.
Different place	Synchronous distributed interaction.	Asynchronous distributed interaction.

Table 3.1 Johansen space-time matrix.

Explicitly interactive new media artworks can exhibit any of these space-time characteristics. Some art pieces can only be consumed within a certain place just like Rozin's mirrors.

Other artworks allow visitors to interact with the piece and other visitors at the same time (Rozin's mirrors series can also be cited as an example here), but there are also pieces that allow interaction with previous and subsequent visitors, just like some of the works by Lozano Hemmer.

Rafael Lozano Hemmer is a Mexican new media artist that has worked in art pieces that remember their visitors (amongst other themes), and thus they incorporate the visitor to the pieces' contents.

In Pulse [42], the heart rate of the visitors is stored in a pulsing light bulb, which will keep pulsing and jumping positions in a network of hundreds of light bulbs every time a new visitor stores a new heart beat, until it reaches the end of the network when it will disappear. Here, visitors interact with the piece, and indirectly (through the piece) with other visitors that have been (or will go) to the exhibition.

There are also many examples of artworks that are consumed from different places, like Sharing faces [38], from new media artist Kyle McDonald, in which two screens were simultaneously placed in Korea and Japan. These screens were equipped with video cameras and were placed in a mirror-like distribution (facing the visitors).

Figure 3.1: Pulse (Lozano Hemmer, 2006).

When visitors arrive, they are tracked by the camera and their image is stored and sent to the other location; there, information about their position in the scene is extracted for each frame. Finally whenever a second visitor steps in front of the piece at the other location, the artwork would search in its visitors' database for someone with a similar position and would display him or her as the visitors' reflection.

This is falls into the different place and different time category.

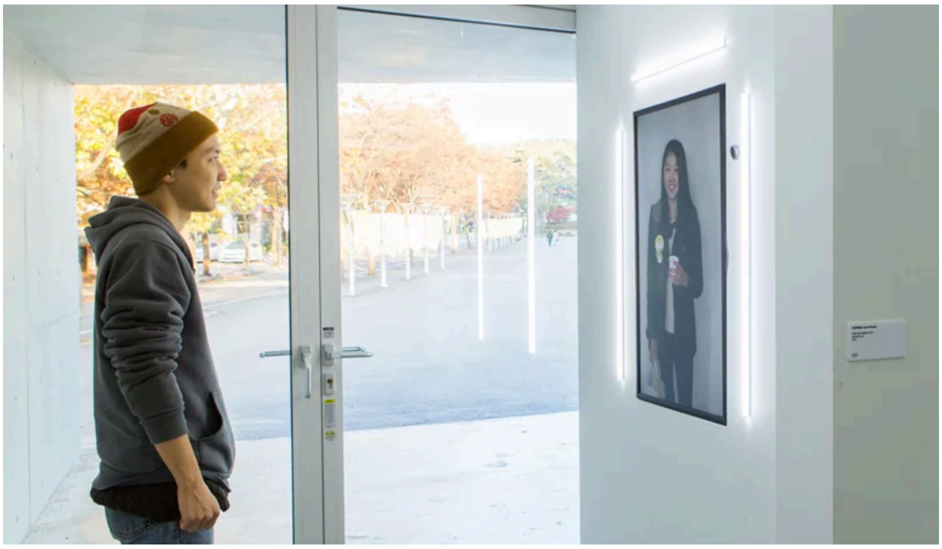

Figure 3.2: Sharing faces (McDonald, 2013).

3.2.1 The spectator

The spectator is a key element in our search, and has not been contemplated by CSCW theoretical models.

However, the spectator (or viewer) has been the subject of study in art for quite a while. In an approach centred in the artwork's consumption, Duchamp puts the spotlight on the spectator by stating:

> *"Let us consider two important factors, the two poles of the creation of art: the artist on the one hand, and on the other the spectator who later becomes the posterity."*
>
> - *The creative act* [22], *1957. Marcel Duchamp.*

As mentioned before, Duchamp is stating the importance of the spectator's role at completing the artist's work by interpreting the artwork.

Other art fields have also delved into the spectators' role, and such is the case of theatre and performative arts (since the times of Plato[15]), in which the spectator has been seen from a mere consumer role, to a participant of the art work as it happens with some theatre plays where the spectator takes an active part [61].

In our scenario, interaction in public settings can nurture itself from both HCI and art worlds, and thus must contemplate the concepts of system and user, and of performer and spectator.

In explicitly interactive artworks both set of concepts are valid, since there is still a system interacting with its users, but there is also a more explicitly-staged interaction, in which the act of interaction is witnessed by spectators and the interactor becomes the performer.

The theoretical model introduced by Reeves [64] merges these two paradigms by focusing on the spectator's role. Reeves's model uses a system's perspective, in which the users, zones, and manipulations are analysed by the roles they have in reference to the system. Using the system's perspective implies that the model is based from the system point of view of the interaction, and thus it contemplates system's elements such as zones, and the system's classification of people according to the role that they have on a given moment.

Another approach is to view the problem from the human perspective. Using this approach, the model is constructed from the human experience of interaction, and so it deals with elements such as the person's state of mind while approaching to a system. In this sense, we will revise a model proposed by Bilda et al. [11] that delves with the participants' expectations, and interaction behaviours when approaching explicitly interactive new media art works.

3.2.1.1 The system's perpective

Reeves defines a set of roles, and zones that are related to the act of interaction.

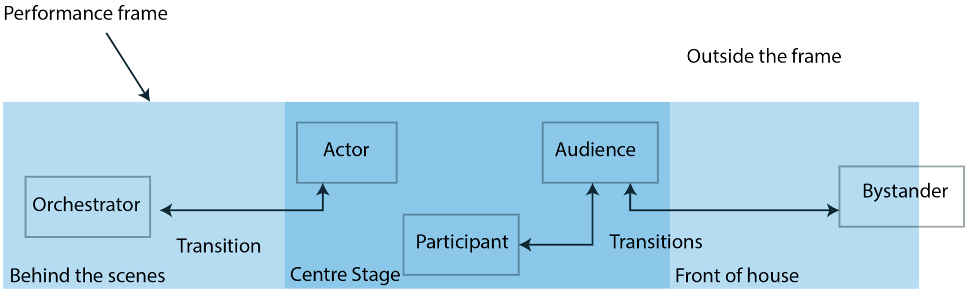

Figure 3.3: Main concepts in Reeves's model (zones, roles, and transitions).

3.2.1.1.1 Interaction zones

Reeves defines the following zones that should be contemplated while designing interaction for public settings (and in our case: explicitly interactive new media art installations).

- **Centre stage**: Where most of the interaction or performative action takes place.
- **Front of house**: Is the zone from which a bystander would discover the installation, and from where it would start to witness the performers or participants.
- **Behind the scenes**: Is a space in which control activities are performed, in order to support the act of performance or

interaction. It could be seen as a control room that is invisible to the spectators.

Performance frame. It is the union of all the previously mentioned zones.

3.2.1.1.2 Interaction roles

The model also defines a set of roles that a person can assume during the act of interaction or performance. There are two main role's categories: Spectators (all kinds of visitors), and Performers (someone involved in the execution of the installation or performance).

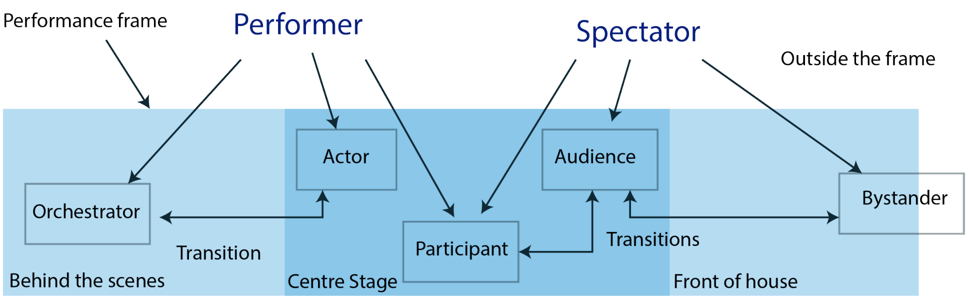

Figure 3.4: Roles of interactors.

3.2.1.1.2.1 Spectators

- **Participant**: An audience member (or many) who temporarily takes on the role of a performer or engages in interaction, for example taking his or her turn with an interface in a public exhibition.

- **Audience**: The audience is defined as a spectator who is inside the performance frame, and is aware of the performance taking place, and is also able to interpret it.

- **Bystander**: A spectator who is outside the frame but can be engaged in observation of the performance or interaction taking place.

The common transitions for these roles are likely to be:

Figure 3.5: Transitions between roles.

In this transition schema, the bystander gets attracted by the installation, and becomes part of the audience, to finally become the participant when he or she takes control of the interaction or performance.

3.2.1.1.2.2 Performers

- **Actor**: Role assumed by any person directly visible to the spectators that has effect on the installation and its execution.
- **Orchestrator**: The people that designs, manages, directs, or facilitates what happens within the performance frame, most likely without being seen by the spectators.

3.2.1.1.3 Describing the behaviour of the installation

Reeves's model also categorizes systems by the characteristics of their manipulations (users' or spectators' inputs) and effects (systems' or installations' responses).

This categorization is centred on the privacy characteristics of manipulations and effects, meaning how visible and understandable (by whoever provokes them or witness them) they are.

In particular, Reeves poses these systems' categories:

1. Secretive: Interfaces hiding both manipulations and effects.
2. Expressive: Interfaces revealing or amplifying both manipulations and effects.
3. Magical: Interfaces that reveals the effects of the system, but hide the manipulations that led to them.

4. Intriguing: Interfaces that reveal users' manipulations, and hide system's effects.

3.2.1.1.4 Some considerations on Reeves's model

Although Reeves's model gives us much to work with, it is important to notice that the model has a very strong physical foundation, in the sense that it was developed to account for physical spaces like a room in a museum, or a public square as the platform of interaction.

This physical approach is very useful for installations, but leaves a few loose ends when dealing with virtual spectators and performances, meaning Internet-based interfaces for consuming artworks. How should the model treat a virtual audience and participants? Should they be treated the same (in the model) as real spectators? How should we define a virtual bystander? How does a spectator witness a virtual performance?

Even interaction zones become a bit blurry when turning to virtual spectators, and the virtual appearance of the artwork.

One other thing is that since the model is based on the system's perspective of interaction, some aspects of the spectator and its relationship with the artwork are being left apart. What are the spectator's state of mind while interacting with the piece, and how does the state of mind evolve during the act of interaction?

These aspects of interaction will surely be of interest to describe or design an experience, as we will see on the next section.

3.2.1.2 The human perspective

Bilda et al. [11] focus on understanding and evaluating the people's interaction experience of an artwork. This human centred approach relates to works by Norman [51], in which the user experience is partitioned into the following levels: visceral, behavioural, and reflective.

The visceral level is perceptually based and delivers immediate judgment on some situation (it is about initial reactions), such as if it is good, bad, safe, dangerous. It represents the first impression of a user in front of a system.

The behavioural level in the interaction act is about the use of the interface, how does the user operate the interface in order to perform the desired action. This level is mainly expectation driven, so in turn a positive effect on the user comes from feeling in control of the system, and from anticipating the system's response to a certain action. In this level, the user has built a mental model of how the system operates, and uses it to make such anticipations and forecast system responses.

Finally, the reflective level is about the message and the meaning of the experience. It is intellectually driven and involves the user's previous experience, personal significance, and self-image to evaluate the interaction experience.

Bilda et al. propose a model for "creative engagement" (which suites our scenario) as a transformative dialog between the audience and the interactive art piece, that builds upon the behavioural level of Norman's user experience.

The engagement model presents "interaction modes" and "interaction phases" relative to the participant's experience. Bilda states that the key to understand interactive experiences is to deal with user's intentions and expectations.

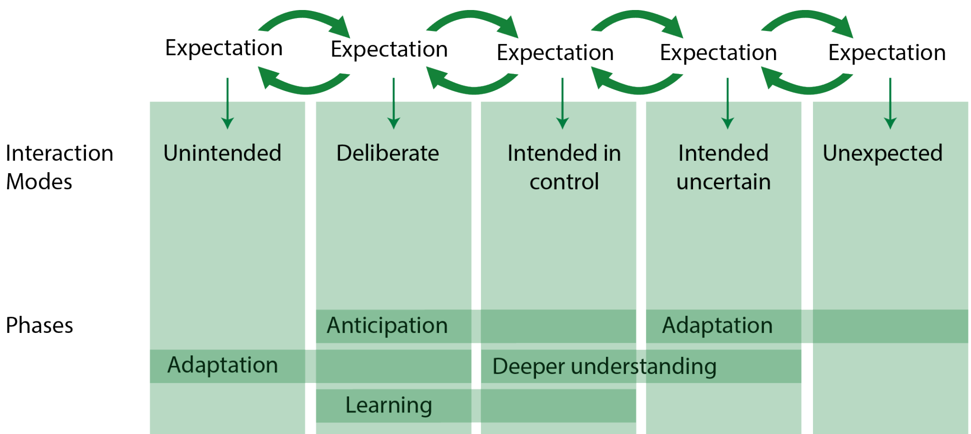

Figure 3.6: Bilda's model of engagement.

3.2.1.2.1 Interaction modes

The interaction modes represent different mind states of the spectator, and his or her expectations during the act of interaction with an explicitly interactive artwork (although Bilda poses any interactive system as example).

As the spectator interacts with the artwork, he or she will be situated in one of these modes.

- ***Unintended***

Unintended mode represents the initial interaction with the system or artwork, in which expectations are not already set, meaning that the spectator has no prior knowledge about what the system does. In this stage, the visitor starts to interpret the artwork's affordances.

- ***Deliberate mode***

This mode is present when the spectator gathers some knowledge about the artwork or system, which enables him or her to explore the act of interaction with concrete expectations.

In this mode, the spectator starts to build a mental image of how the system works, and what it is capable of doing.

- ***Intended/in control***

According to Bilda, this mode refers to a stage where the spectator is capable of setting a purpose to his or her actions, and expectations about the outcomes, and feels comfortable performing some actions.

At this stage, the spectator feels he or she has an understanding of the system and feels in control.

- ***Intended/uncertain***

As the spectator performs a more in-depth exploration of the system, there may be some incongruences between his or her expected responses, and the system's actual ones.

When this happens, the spectator's confidence on his or her model diminishes, and a dialog between that model and the system's responses arises.

- ***Unexpected mode***

In this mode, the spectator may question his or her intentions and expectations, and may doubt whether the system does what he or she thought it was designed to do.

In this stage, the conflict between the spectator's mental model and the system's responses collide at fundamental levels.

3.2.1.2.2 Interaction phases

Another element of Bilda's model is the definition of interaction phases, which represent periods during a spectator's interactive experience based on his or her cognitive and perceptual states.

- ***Adaptation***

At this phase, the participant is adapting to the changes in the environment, and does not know how to set his or her expectations yet, or his expectations are being challenged. This phase is mostly seen during the unintended interaction mode, and whenever the mental model of the system does not hold.

- ***Learning***

The learning phase represents the moment in which the spectator builds his or her mental models about the system, and it occurs during the deliberate and the intended/in control mode.

- ***Anticipation***

During this phase, the spectator's mental model of the system is not challenged, and it allows him or her to predict or anticipate system's responses.

- ***Deeper understanding***

In this phase, the participant reaches a more complete understanding of the artwork and what the act of interaction means, and starts finding the meaning of what the artist was trying to convey.

3.2.1.2.3 Some considerations on Bilda's model

Bilda's model helps us to understand the different mind states of the spectator while he or she interacts with an explicitly interactive artwork.

By considering the different modes and phases, an artist could be able to articulate the artistic interaction discourse by introducing events and responses that confront with users' expectations, provoking interaction mode changes. Such as a song may have its moments (intro, verse, chorus, and coda) or as a novel may have its structure (introduction, development, and outcome), interaction modes can be used to script and give structure the art of interaction.

Having structures provides an artistic language (such as in pop music or classical literature), and knowing these structures can help the artists express their selves better within the language; this is what Bilda's model is providing.

But, as there are songs and novels without structure, the same can happen in NMA, and is up to the artist to consider or discard these structures, languages, modes and phases.

An important consideration is that Bilda's model was not particularly built taking groups of spectators and their interrelations into account. In a many-spectators scenario other implications may arise from having other users, and the act of interaction may be influenced by social constructions, or group behaviours, that may develop in a restriction to the users' final behaviours. These extra elements should also be taken into account while designing the artistic interaction.

3.3 Conclusions

We have dealt with a very broad spectre of elements, and we have done so in an introductory way with the objective of creating a set of categorizations and models to describe, design, and possibly analyse explicitly interactive new media artworks installed in public settings.

It is important to note that these are not the only tools and models available to this purpose, in fact many models exist and continue to arise, and with them the need to standardize some aspects becomes important in order to maintain a common language in the field.

First of all, the utilization of Johansen's space-time matrix is proposed to categorize artworks according to the characteristics of their interactions.

This categorization may be useful to describe the artworks' capabilities in terms of how they let users use the system, and interact with each other.

Next, in order to describe and design installations in public settings, the utilization of Reeves's framework provides a common ground to describe interactive installations from a system's perspective. It provides elements to define interaction characteristics and to predict results.

As we saw, Reeves's framework does not delve into interaction semantics nor its artistic meaning, but it does provide a descriptive image of what is happening; however, it also has some weak spots while trying to describe virtual interactions since it was conceived mainly from a physical view of the installation.

Regarding this weakness, it might be interesting to apply it on a virtual environment combining it with Harrison and Dourish approach to virtual spaces. In their paper "Re-place-ing space: the roles of place and space in collaborative systems" [31], Harrison and Dourish discuss the importance and the definition of place and space, being space the physical definition of space, and place a social construction over that space that has incidence on the act of interaction between people inside it. A good example of this social construction (and the one provided by the authors) is the bedroom, which is nothing more than a room, but when defined as a bedroom has intrinsic social meaning (of privacy, for example).

Harrison and Dourish also provide an analogy between physical and virtual places, and explain how these analogies help users understand the system and provide a better ground for interaction.

For instance, one could design the application users' need to interact with the artwork by creating application sections that map to the zones in Reeves's performance frame. These applications could also include users roles, and transitions as they move from section to section. This scenario seems to fit our needs, but more work is needed in the matter.

Next, since the system's perspective does not cover all aspects of interaction, this chapter suggests the use of Bilda's model to describe, design, and analyse the act of interaction from the spectators' perspective. This model describes different moments in the state of mind of the spectator, and intends to help the artist script and guide interaction moments.

—

4 ARTWORKS AND TOOLS

4.1 Introduction

This chapter will present a selection of new media art pieces developed during this master's degree. We will describe their characteristics, and their technical details.

It is important to note that all of these artworks are constructed upon atomic elements and make implicit use of Gestalt's visual perception principles, and therefore fit within the Modular New Media artworks explored in the previous chapters. With the exception of Bosque Estroboscópico, all of the pieces are examples of explicitly interactive artworks:

Celebra.

An installation comprised by a network of two hundred LED lit balloons that reacts to its spectators.

Barcelona.

An interactive sculpture depicting a pentakis dodecahedron structure in which every edge is a controllable pixel.

Son and Réunion.

Two pieces that create an abstract reflection of the spectators' silhouettes.

Bosque Estroboscópico.

An installation (and a performative instrument) containing more than thirty fluorescent tubes arranged in a plantation fashion.

This chapter will also present two tools for the artistic production developed during the construction of the artworks.

Sendero.

A LED lighting system, which provides a software and hardware solution to controlling large numbers of RGB LEDs at fast refresh rates.

N.IMP.

A tool for creating visual content in real time though a node-based image processing architecture.

All of the projects presented in this chapter were developed by teams of people, composed by engineers, architects, designers, artists, and electronic technicians. Specific credits will be presented when explaining each project.

This chapter makes use of some excerpts of “Celebra – ISEA 2013 T. Laurenzo, C. Clark”, published in the ISEA 2013 proceedings [41].

4.2 Artworks.

4.2.1 Celebra.

Tomás Laurenzo – Art direction and software development.
Christian Clark – Production and software development.
Pablo Gindel – Electronics.
Fabrizio Devoto – Structure.
Germán Hoffman – Software development.

Figure 4.1: Celebra (2011), first exhibition at Espacio de Arte Contemporáneo, in an abandoned prison yard. Photo by G. Berta.

4.2.1.1 Description of the piece

Celebra is a new media art installation developed as part of the celebrations of the bicentennial anniversary of Uruguay's emancipation process.

It was funded by Universidad de la República (through its Medialab), the Bicentennial Commission (Comisión del Bicentenario), and by the interaction design collective Bondi. Celebra was developed from April of 2011, and premiered on November of the same year at Espacio de Arte Contemporáneo museum in Montevideo, Uruguay.

The installation is comprised by an interactive network (or cloud) of two hundred white balloons made out of latex with RGB LEDs inside of them. The balloon thus, acts as a diffusor lighting itself up as a single light source in an even fashion.

The piece is situated in an area of a little more than two hundred square meters, with balloons hanging at different heights (between two meters and floor level).

Figure 4.2: Celebra (2011) at Espacio de Arte Contemporáneo, Montevideo, Uruguay. Photo by L. Mateo.

The visitors can walk around and through the balloons, avoiding cables, moving balloons and provoking stimuli that will be interpreted by the piece. The spectator is immersed in the artwork, with his visual field restricted by the surrounding balloons, appreciating lighting patterns provoked by him or her and by other fellow spectators.

The colour patterns being displayed are the result of a mix of certain inputs that the piece can perceive.

The installation reacts spatially to sound intensity and predominant frequency through an array of microphones placed throughout the location. The balloon cloud can also track the visitors using cameras and reacts to their presence painting balloons near them as they move. It also has the ability to process video files to generate new content, and is equipped with an Internet interface which allows people with smartphones to see and navigate the piece, and to intervene in the colour pattern generation.

Our work in Celebra is framed within three main axes: media appropriation, explicitness of interaction, and the geographical and socio-political contexts of the piece.

1) Media appropriation. As we saw before, media appropriation is a key element in NMA.

This appropriation effectively expands the artistic possibilities, allowing for the search for new solutions, and for the incorporation of technology production to art practice.

Celebra not only brings technological production to the table (hardware and software), but also leaves all of the hardware components at plain sight making the usage of technology very explicit.

2) The explicitness of interaction. Celebra is an explicitly interactive artwork, and offers various ways in which the spectators can dialogue and contribute to the piece.

3) The geographical and socio-political contexts: In Uruguayan engineer Eladio Dieste's words [20], "Each problem [...] should be faced with a

sort of ingenuity, [...] with an attitude humble and vigilant. It should be thought again, with the basic body of knowledge that is now the heritage of all men." From our perspective, Dieste's assertion implies a radical change of attitude towards art and technology production. Media appropriation permits the creation of art that both reflects its context, and also reflects on its context.

4.2.1.2 Previous works

There is a vast background in balloon art, and balloon-lit pieces date back to the ancient China [86], but maybe the most relevant contemporary example is Open Burble by Haque et al. [30].

Open Burble is an open specification for building a balloon installation made out of hundreds of weather balloons filled with helium, which are illuminated from the inside using LED modules.

The balloons are held together by a modular structure of steel cables tensioned by the balloons floating force. This piece is of giant magnitudes, and achieves heights greater than twenty meters. In Open Burble, users can participate in the creation of colour patters by shaking handles that are available at floor level, and thus provoking a colour change effect that will climb to the top of the installation.

Celebra takes a different approach regarding aesthetics and construction, but most notably on the interaction design.

Figure 4.3: Open Burble (Haque et al., 2006), Singapore.

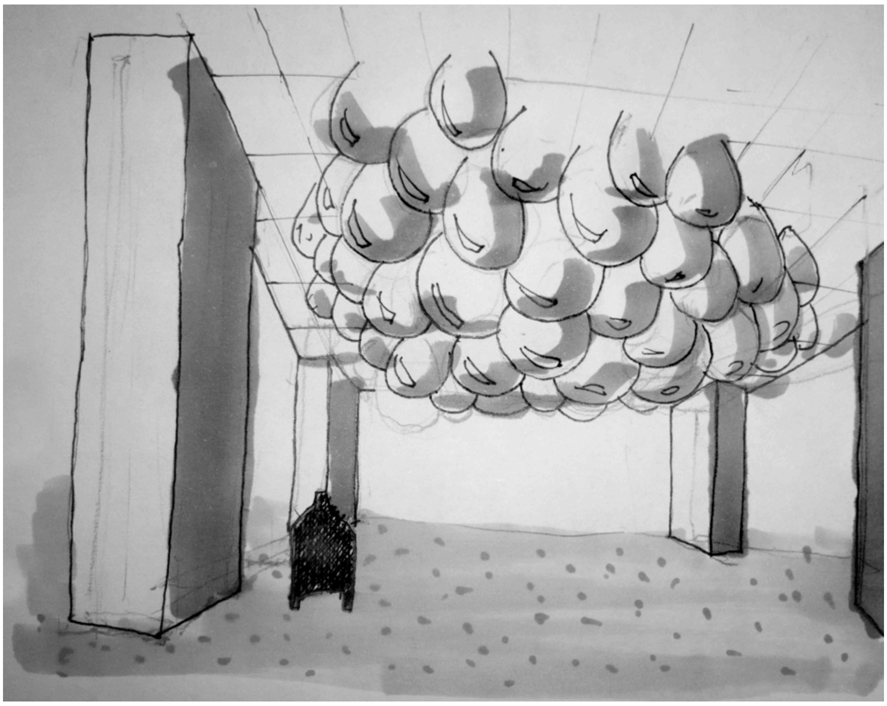

Figure 4.4: Celebra, sketch #1 by F. Devoto a E. Magnone. Installation's perspective.

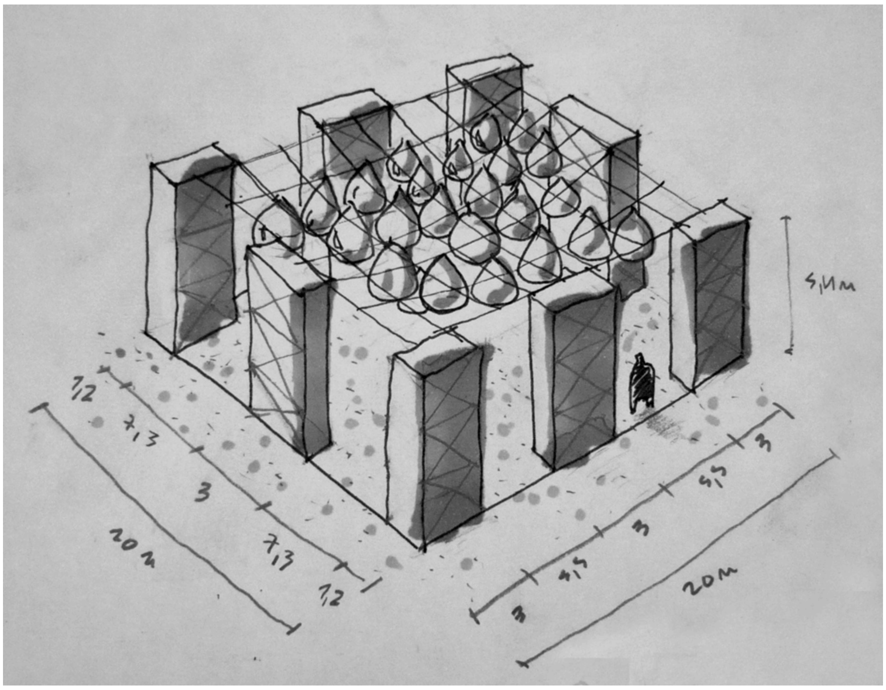

Figure 4.5: Celebra, sketch #2 by F. Devoto a E. Magnone. Floor plan and dimensions.

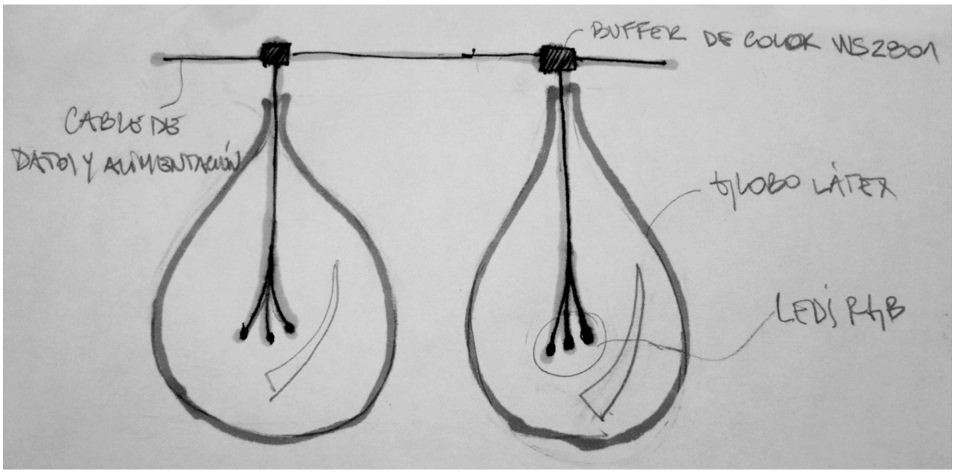

Figure 4.6: Celebra, sketch #3 by F. Devoto a E. Magnone. Balloons, LEDs and electronics.

4.2.1.3 Aesthetics

Celebra embraces two aesthetics that are frequently seen as contradictory: on one hand, much effort has been put into the design and construction of its very refined control interfaces, interaction design, and visual output. On the other, it embraces a rough aspect that arises from its components and their interconnections, and achieves a grunge appearance seen in many DIY (do it yourself) projects.

All the physical, functional components of Celebra are visible, and spectators can trace the flow of data from the computers to the balloons, following the cables and seeing how the controllers group sets of balloons. When necessary, the circuit boards are covered with transparent protection (made out of recycled plastic bottles), maintaining the visibility of all parts.

The piece does not only involve a substantial amount of original technology, but also exposes it and makes it immediately perceivable, in an overt attempt to reaffirm that it is not only pertinent, but intrinsic, to the aesthetic proposal.

Media appropriation occurs not only in the expansion of the functional spectrum, but also at a pure aesthetic level: by showing these functional components, the appropriation becomes evident.

Celebra's elaborated visual behaviour somewhat collides with the aforementioned "grunginess" of the installation, creating a tension that is left for the public to resolve, and that becomes central to the artistic proposal.

As an additional element, Celebra was conceived taking into account its location. It is a site-specific piece initially displayed in an abandoned prison yard. Therefore, it creates yet another conflict between its theme, its title, its materials (that imply celebration and joy) and the prison where it is exhibited.

4.2.1.4 Technical details

Three major items compose Celebra's technical solution: the physical structure, electronics hardware, and software.

The structure solution is achieved by using ropes, wires, tensors, and wooden posts, which all together build a net from which the balloons and the electronics are hanged. In subsequent installations, the structure solution was improved in order to make it more transportable, by using a big net made out of plastic rope.

For the electronics and software solution, Celebra uses the first version of a lighting system called Sendero that will be explained later on this chapter.

The main hardware component of Celebra is a commercially available LED driver called Octobar [52], and its accompanying RGB LED module, the S-001 [73], both produced by the company Macetech.

4.2.1.5 Interaction and content generation

The artwork can generate content and provide interaction in six ways. These content generation techniques can be controlled by an orchestrator or a performer during operation.

4.2.1.5.1 Video

The installation allows for the mapping of a video stream on the balloon cloud's geometry. Each video frame will be projected on the cloud in order to assign colours to the balloons.

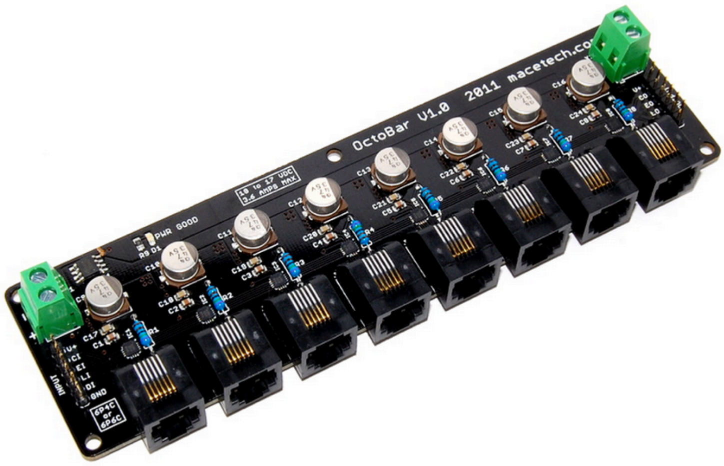

Figure 4.7: Macetech's Octobar.

Figure 4.8: Macetech's S-001 RGB LED module.

The system supports a maximum of three video inputs that can be alpha blended. It also provides some common VJing tools such as scratching, blend control, pause, and speed control.

4.2.1.5.2 Sound

The artwork simulates a set of virtual illuminators orbiting the installation's geometry. These illuminators react to the sound intensity in different frequency bands being captured by the installation's microphones.

A user can modify the amount of illuminators and their sound responsiveness in real time.

4.2.1.5.3 Noise

Celebra can create a colour pattern from generating Perlin [58] noise that will be applied to the entire balloon cloud, changing colouring in a smooth way.

It also allows the user to change some of the noise generation parameters.

4.2.1.5.4 Spatial sound

This is another kind of sound-driven content generation. In this case, the artwork is aware of the three-dimensional position of a collection of microphones in the installation, and then uses sound intensity coming from each microphone to colour balloons that are close to them.

4.2.1.5.5 Presence

The artwork is able to recognise spectators as they walk through the installation. A number of Microsoft Kinect [87] sensors are used to this purpose.

By knowing the three-dimensional position of every sensor, the piece is able to determine the global position of each sensor's tracked users, and in turn can generate position aware lighting patterns.

4.2.1.5.6 Internet interface

The art piece offers a way in which participants can directly manipulate balloons' colours from an Android or iOS smartphone or tablet.

These smart devices connect to the artwork via Internet, obtain the installation's geometry in three dimensions, and get updated information with the current colours of every balloon. They also provide a way to navigate the installation's three-dimensional scene, and to assign colours to balloons.

Figure 4.9: Celebra (2011) at Espacio de Arte Contemporáneo, Montevideo, Uruguay. Photo by G. Berta.

4.2.2 Barcelona

Tomás Laurenzo – Art direction and software development.
Christian Clark – Production, software development, and electronics.
Pablo Gindel – Electronics and software development.
Fabrizio Devoto – Structure.
Tatjana Kudinova – Industrial design.
Marcela Abal – Industrial design.

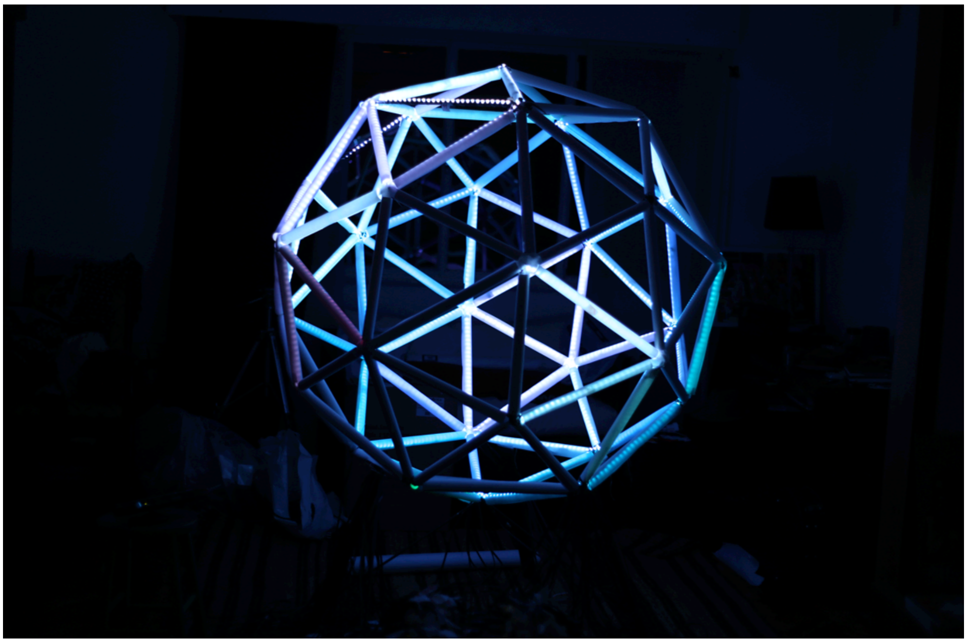

Figure 4.10: Barcelona (2013). Photo by T. Kudinova.

4.2.2.1 Description of the piece

Barcelona is an interactive sculpture comprised by a dodecahedron structure with illuminated edges. Again, this is an artwork funded by the Uruguayan government and was developed during January, February, March, and April of 2013.

It was created for Uruguay Encendido, a series of conferences held as a government initiative to promote innovation and knowledge exchange between Uruguay and foreign institutions.

The art piece consists of a two-meter tall iron structure depicting a pentakis dodecahedron in which every edge is equipped with a high-power RGB LED strip, and thus each of its ninety edges can display a different colour.

The sculpture is capable of perceiving sound, visitors' presence, and it publishes an Internet interface from which the piece can be seen, navigated, and the light patterns can be altered by its virtual spectators. All of this functionality was inherited from Celebra's previous work.

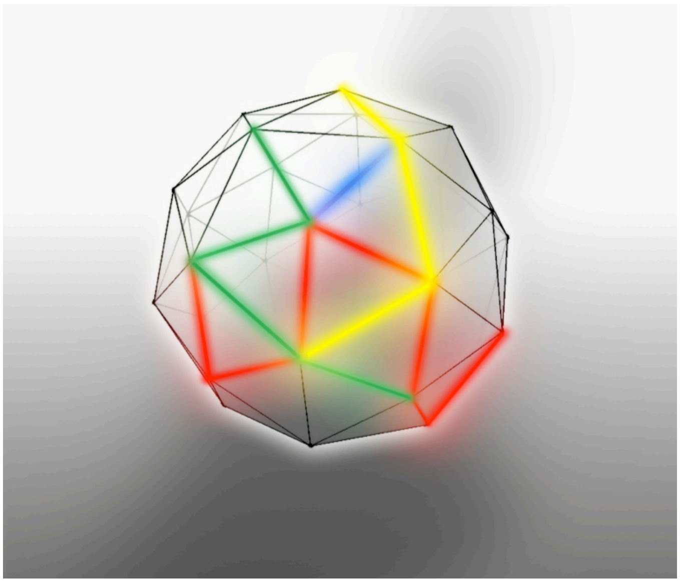

Figure 4.11: Barcelona (2013), early sketch.

4.2.2.2 Aesthetics

Unlike Celebra, Barcelona proposes a clean and well-defined aesthetic, due to the usage of a regular polyhedron structure, and by using a smooth and perfectly white paper diffusor.

This pureness is intentionally contrasted by the chaotic and unpolished layout of the electronic components controlling the artwork. The cables connecting the LED drivers and the LED strips are introduced into the structure in a messy and organic fashion. This is intentionally contrasted with the complex visual patterns being displayed by a chaotic control system that functions in a very refined way.

As it happens with Celebra, Barcelona leaves all electronic components at plain sight inviting the spectator to follow the data paths from the computer, through the electronics, and finally into the structure.

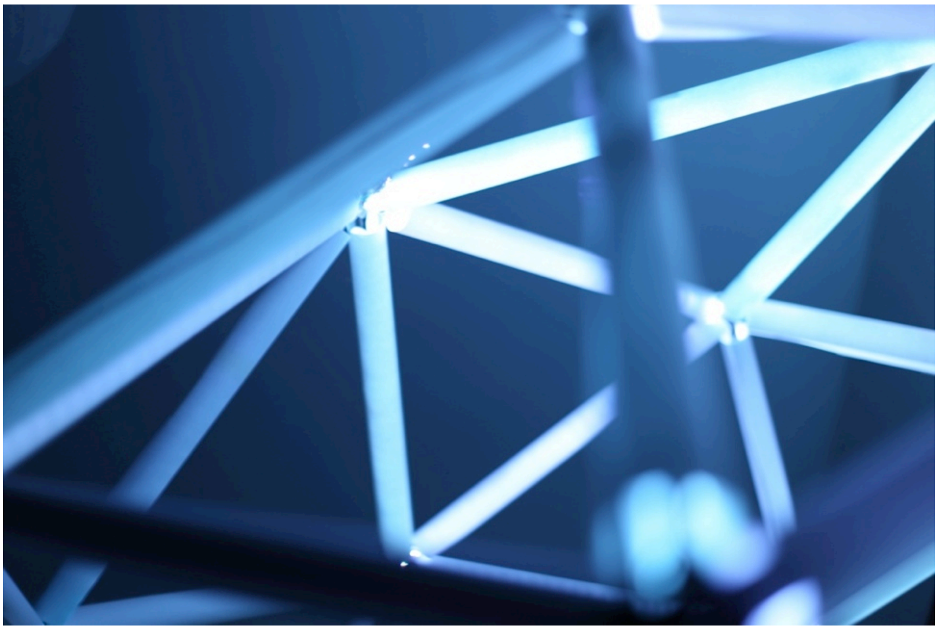

Figure 4.12: Barcelona (2013), sculpture close up while operating. Photo by T. Kudinova.

4.2.2.3 Structure

The iron structure of the pentakis dodecahedron is built upon identical pentagonal modules. These modules are put together with the help of plastic laces, and they rigidise in order to form the final structure.

Figure 4.13: Barcelona (2013). Electronics' and cable's grunginess. Photo by T. Kudinova.

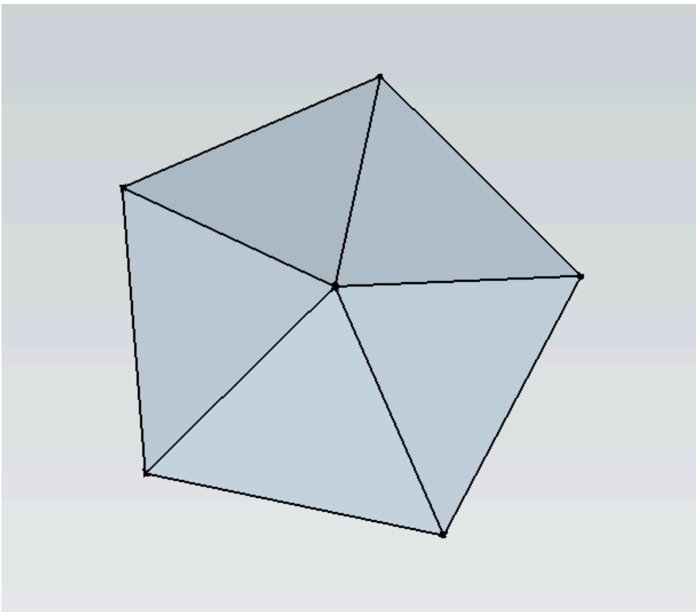

Figure 4.14: Pentagonal module.

The high modularity allowed the pieces to be manufactured in parallel, and also allows the piece to be very transportable.

The structure has a special module with legs that acts as a base and needs to be positioned first.

The RGB LED strips and the cables are canalized throughout the structure using more plastic laces, and finally the paper diffusors need to be set up (conventional A4 sheets of paper were used) covering the strips and the cables.

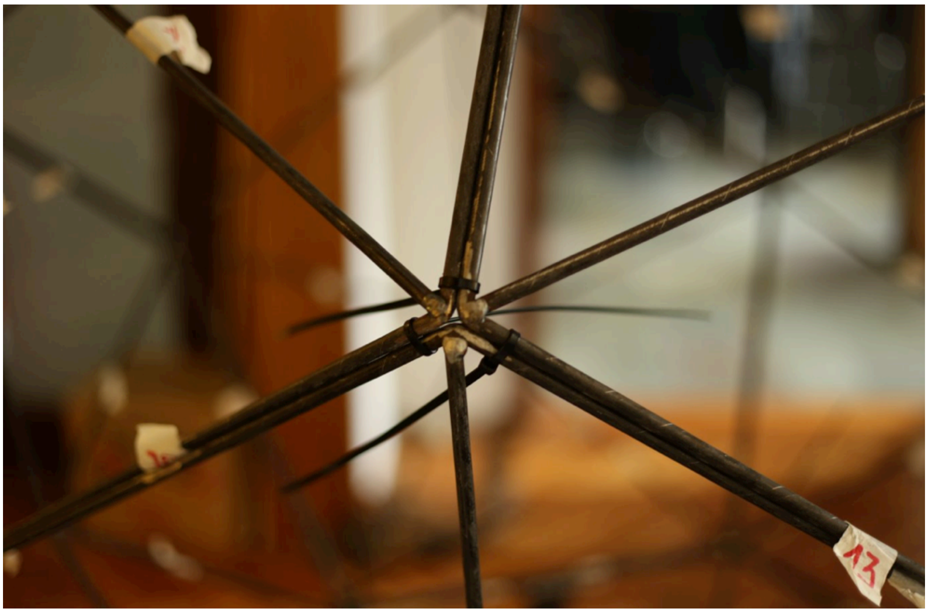

Figure 4.15: Structure detail: three modules are joined together by plastic laces. Photo by T. Kudinova.

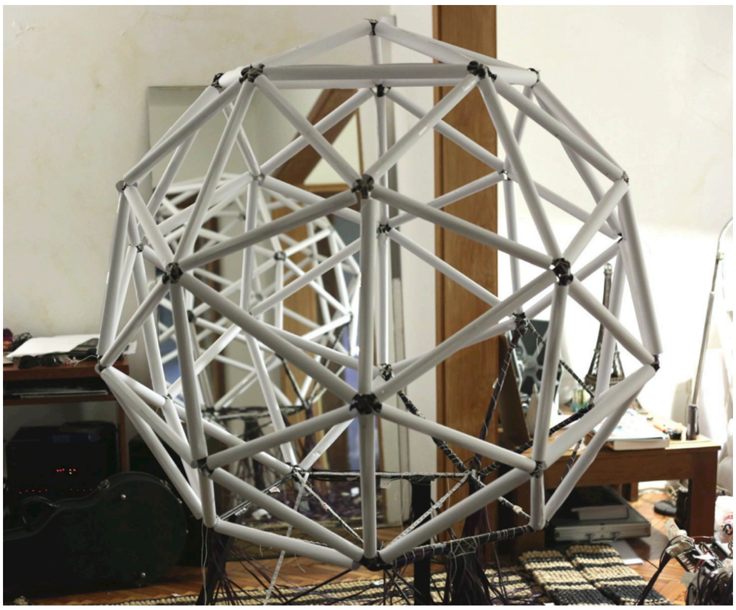

Figure 4.16: Diffusor set up almost completed. Photo by T. Kudinova.

4.2.2.4 Relation with Celebra

From a technical point of view, Barcelona is an evolution of Celebra, mainly at a hardware level.

For this installation, we decided to change the LED driver and the LED module in order to be able to use more powerful and standard LEDs, and thus we created the Bondibar.

The Bondibar is an original design of LED driver based on some common features of the Octobar and other mainstream components of this kind.

This hardware platform change also provided a more robust solution, improving power and data cables, and connections.

Regarding software, Barcelona uses the same software features as Celebra, although some necessary changes were done to Sendero's server due to the hardware platform change.

All of these changes were merged into Sendero, the lighting system used by both pieces.

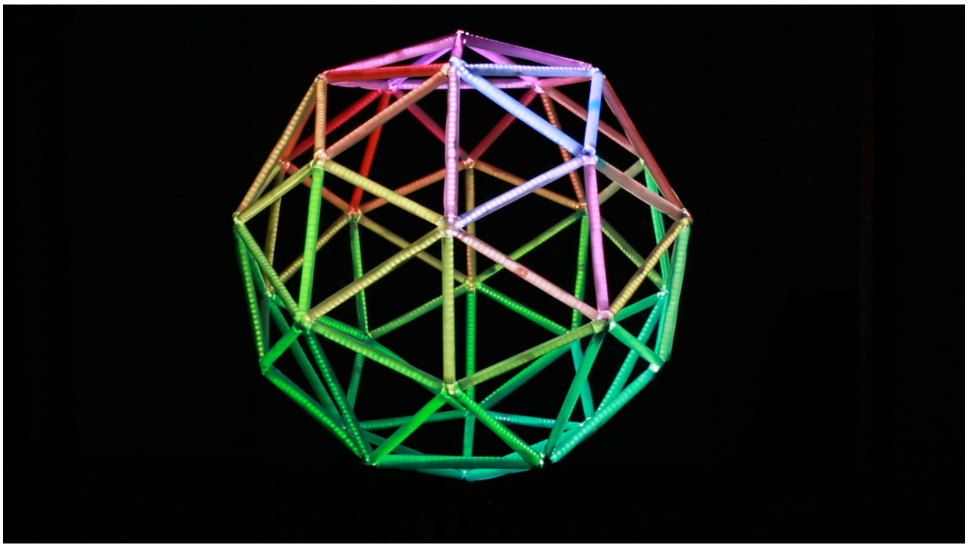

Figure 4.17: Barcelona on display. Photo by T. Kudinova.

4.2.3 Son and Réunion

These artworks are two examples of interactive art in which the piece displays a representation of the spectator's silhouette in a mirror fashion.

The participants must approach the piece to a certain point in which the artwork recognises them and they engage in the interaction. Then, they can consume the piece by moving around and adapting their selves to their representation.

Both artworks make use of the Microsoft Kinect Sensor, projectors, and projection screens, but they have some differences in the underlying technology.

Similar prior artwork exist, including works of Myron Krueger in his Videoplace series [37], and many works of David Rokeby [68]. These pieces share many aspects but above all their share the way of engaging the audience. As Rokeby states:

> *"The medium not only reflects back, but also refracts what it is given; what is returned is ourselves, transformed and processed. To the degree that the technology reflects ourselves back recognizably, it provides us with a self-image, a sense of self."*

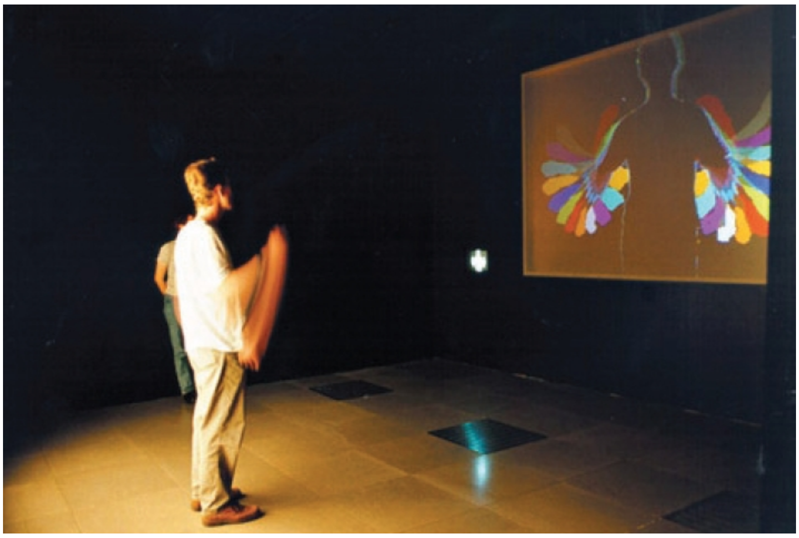

Figure 4.18: Videoplace series (Krueger, 1972-1990s).

4.2.3.1 Son

Tomás Laurenzo – Artistic direction and software development.
Christian Clark – Production and software development.
Pablo Gindel – Sound design and software development.

Son was developed during 2011 and represents visitors' silhouettes with a minimalist aesthetic based on white particles that are being simulated over a black background.

The piece simulates particles moving freely in a three-dimensional space, being attracted by the visitors' bodies.

This way, the visitors' silhouettes are represented by the attracted particles, and since the piece can interact with at least six visitors simultaneously, these particles are shared by the visitors' representations. Particle flows can travel to one participant to the other, generating a virtual exchange.

The piece also emits sound, which is provoked by the position, speed, and acceleration of the participants' and particles' movements.

It can also perceive sound, triggering particle acceleration, and size change, and this way closing a feedback circuit between sound generation (from speed and acceleration) and sound perception.

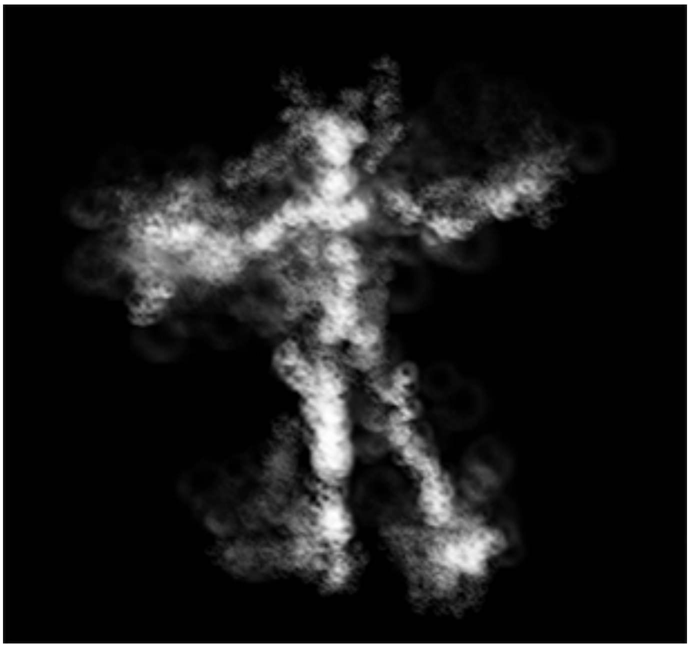

Figure 4.19: Son. Sketch of the art piece.

4.2.3.1.1 Technology and design

Son was developed using Processing [59] libraries over Java for particle simulation, scene rendering, and user tracking.

User tracking was performed using SimpleOpenNI [75] (in its first version at the time of development). SimpleOpenNI is a Processing wrapper for OpenNI [56], a framework that exposes all Kinect sensor's functionalities (such as RGB camera images, infrared images, depth could points, microphone array information, and servo motor control), and that provides additional information about the scene and the detected users (such as user identification, user tracking, gesture detection, floor detection, amongst others).

In particular, this artwork uses the user tracking functionality to obtain information about the location and pose of the visitor's body.

4.2.3.1.2 Sound

The piece generates MIDI [47] messages out of the spectators' and particles' positions, speeds, and accelerations. When a certain threshold is met in one of these dimensions, a MIDI note-on message is generated (with its note-velocity and note-number), and the consequent note-off message will be generated when the values become lower that the threshold.

These MIDI messages are directed to a virtual instrument using VST interface (Virtual Studio Technology) running inside Reaktor [63] (a sound synthesizer commercialized by Native Instruments). Unlike other synthesizers, Reaktor is particularly well suited for instrument design.

Figure 4.20: Son. Techné, National Museum of Visual Arts, Montevideo, Uruguay, 2011. Photo by J. Schroeder.

4.2.3.1.3 Layout

The main element dominating the scene is the screen, which must be located in order to allow for a square interaction zone of five meters of side.

A retro-projection system is used to allow participants to be close to the screen without casting shadows, which also provides a floor-level full screen increasing the resemblance to a mirror.

The stereo audio system´s speakers are located at both sides of the screen in order to take advantage of panning and modulation sound effects in the VST instrument.

The Kinect Sensor must be placed at floor level, right in front of the screen.

4.2.3.2 Réunion

Tomás Laurenzo – Artistic direction and software development.
Christian Clark – Production and software development.

Réunion (2012) is a technological iteration over Son that also presents some visual variants.

The interaction scheme is basically the same: participants in the interaction zone are tracked by the system which in turn processes their silhouettes, letting bystanders witness their engagement.

Unlike Son, which used white particles, Réunion simulates coloured ribbons that travel through the scene and its participants.

The ribbons are attracted by the participants' bodies, and have a variable length, colour, and lifespan.

4.2.3.2.1 Technology and design

The development of Réunion was separated from Son by a little less than a year, in which many developments on Microsoft Kinect Sensor's technology were introduced. In addition, the available frameworks were more tested by the community, and more robust.

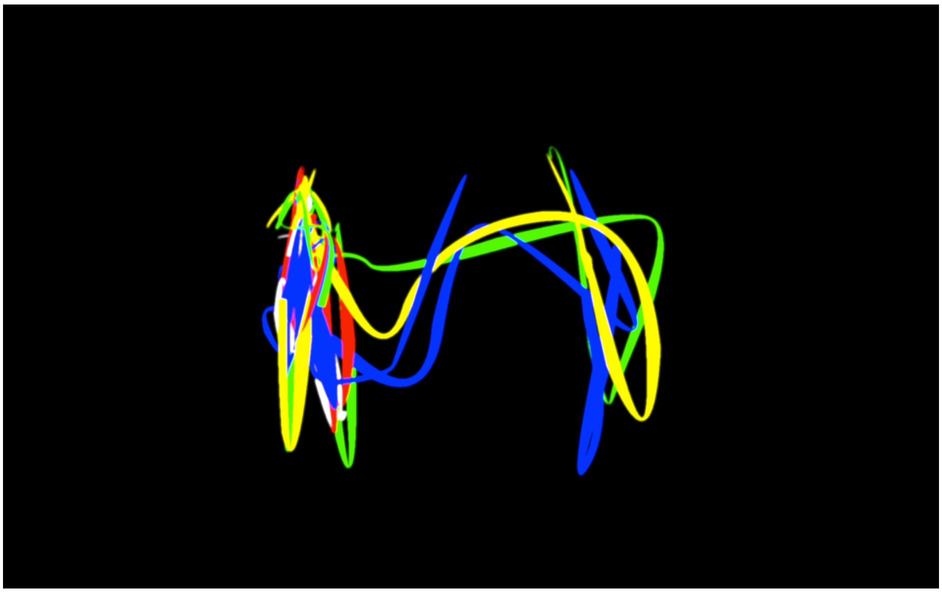

Figure 4.21: Réunion. Screenshot showing two participants exchanging ribbons.

In this case, no wrapper was used, and instead the piece uses the C++ OpenNI API (in this case, OpenNI 1.5) directly. The rest of the system was also developed in C++, using OpenFrameworks [55].

Another main difference lays in the fact that the system was developed as a set of two applications: the tracker, and the renderer.

The tracker tracks and identifies users, and sends the users' body information to the renderer via a TCP socket, using a simple *adhoc* protocol.

The renderer then interprets the information and renders the ribbons.

An important feature is that the renderer allows many trackers to be set up. In turn, the renderer must maintain a model of the scene, knowing the spatial location of each tracker's sensor, and this way it can translate the tracked bodies to a global scene.

The renderer also implements a user handoff algorithm (a way to know when a user leaves one sensor field and starts to be tracked by another) that uses overlapping sensor zones and some of the bodies' positions to determine a handoff match, and then uses the body with more confidence index (a value provided by OpenNI for each user that determines how trustable a tracked user is).

In this scenario, inter-sensor interference may occur. Since these sensors use a real time structured light algorithm to calculate scene depth, they emit an infrared pattern. Overlapping sensors will produce overlapping infrared patterns, which in turn will induce error in the readings.

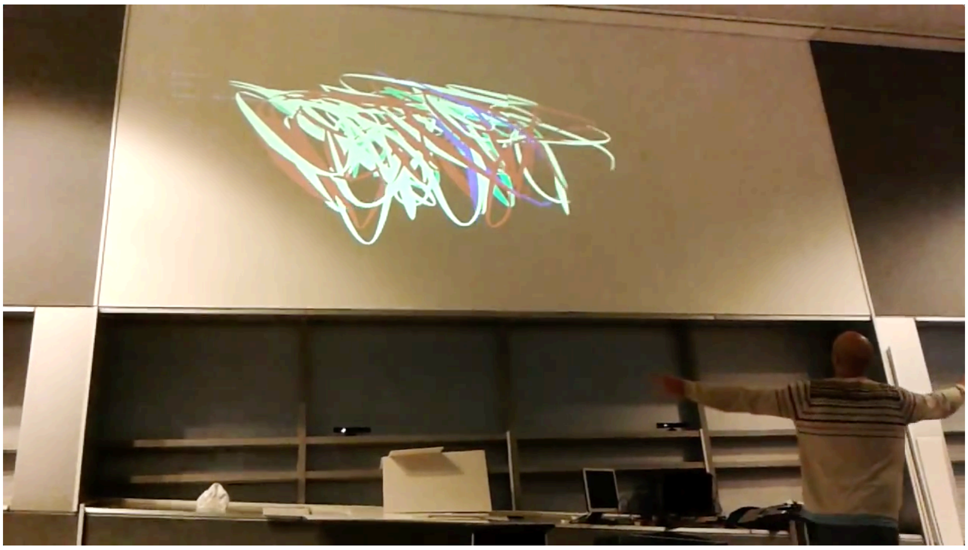

Figure 4.22: Réunion. Operating with two Kinect sensors. Photo by M. Abal.

Maimone and Fuchs [43] devised a simple mechanism in which a small constant movement is applied to one of the sensors, alleviating the interference.

This can be achieved by attaching a low cost, unbalanced, direct current motor to the base of the sensor.

Although contemplated, the interference in Réunion was not relevant enough to apply this approach.

With this schema, the artwork can potentially achieve an area of interaction of arbitrary length, creating long interaction corridors (although the renderer is not currently able to handoff ribbons or users to other renderers).

Réunion also uses an array of projectors that complete the piece.

4.2.4 Bosque Estroboscópico

Christian Clark – Artistic direction and construction.
Lucas Mateo – Artistic direction and construction.
Paco Hernández – Construction.

4.2.4.1 Description of the piece.

Bosque estroboscópico (stroboscopic forest) is an artwork funded by ANII (the Uruguayan agency for investigation and innovation), and consists of more than thirty fluorescent tubes arranged in a plantation or forest fashion.

The piece is both an installation and a performative instrument, since it allows an artist to control the flickering and intensity through a panel of control knobs.

It was exhibited twice during 2014, the first time at Teatro Solís, Montevideo, Uruguay, during a piano performance of Luciano Supervielle and an ANII event, and lastly at the Architecture School of Universidad de la República, also involved in a musical performance.

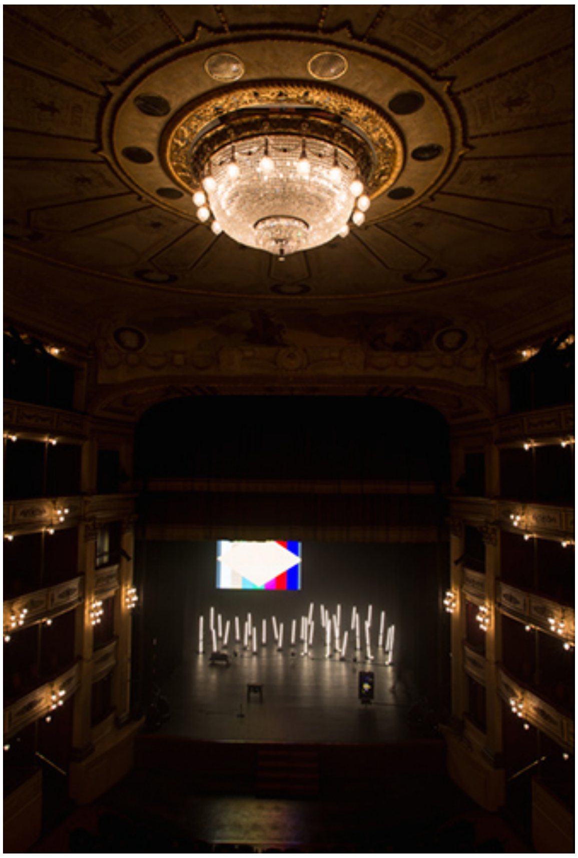

Figure 4.23: Bosque estroboscópico at Teatro Solís, 2015. Photo by L. Mateo.

4.2.4.2 Aesthetics

The piece exhibits a contraposition between the purity and sobriety of white fluorescent glass tubes, and the randomness of their behaviour, their operational sound (the tubes make a distinctive snap sound when they start), and electrical components.

The tubes are laid in an oblique fashion that contributes to this randomness.

4.2.4.3 Construction

The fundamental part of the piece is the fluorescent tube and its base.

Each base is built using a square wooden plate, and a small wooden rod in which the tube and its starter are attached.

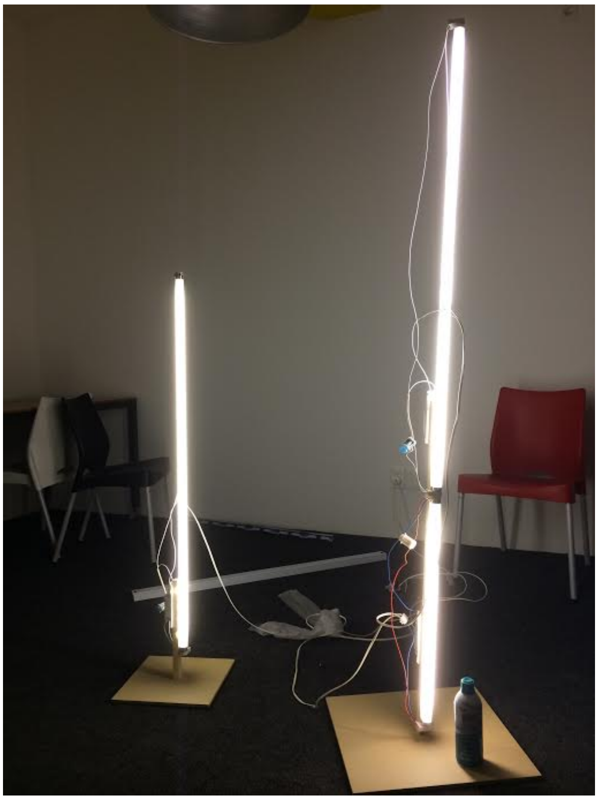

Figure 4.24: Tubes and bases. Photo by L. Mateo.

Each base is also connected to an electrical control line. This is a very simple schema, in which a number of tubes are connected to one line, and the line is in turn connected to a dimmer.

By dimming the electrical flow to the tubes, they will start to flicker as they reach a certain voltage threshold.

For this piece, mechanical tube starters were used (because of budget restrictions). Although this is a cheap solution, it creates some control restrictions since the mechanical starters may fire the tubes at different speeds (depending on many factors such as system's heat, electrical supply characteristics, and mechanical starters' delays), and in turn no automated control scheme was possible.

The dimmers needed to be operated by a performer, either through the dimmers themselves, or by a MIDI diming console (as was the case at Teatro Solís).

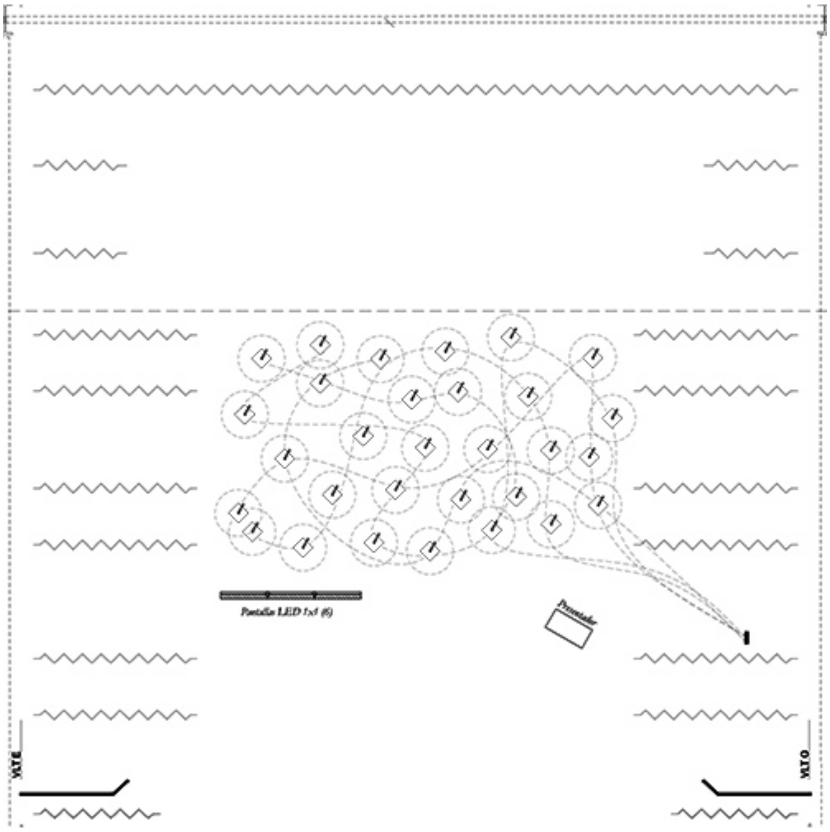

Figure 4.25: Floor plan, Teatro Solís, 2015.

Figure 4.26: Teatro Solís, 2015. Photo by L. Mateo.

4.3 Tools for artistic production

4.3.1 Sendero

Sendero is the result of the work done in Celebra and Barcelona. It is a lighting system developed for artistic production.

It is an open source project in which the main contributors are Christian Clark and Tomás Laurenzo, and has valuable contributions by Pablo Gindel and Germán Hoffman.

Sendero includes both a software and a hardware solution. The latter one was designed and developed by Pablo Gindel, with the assistance of Christian Clark in some production tasks.

4.3.1.1 Hardware design

In the centre of the hardware solution there is a microcontroller that operates as the interface between the high level software and the hardware components of Sendero.

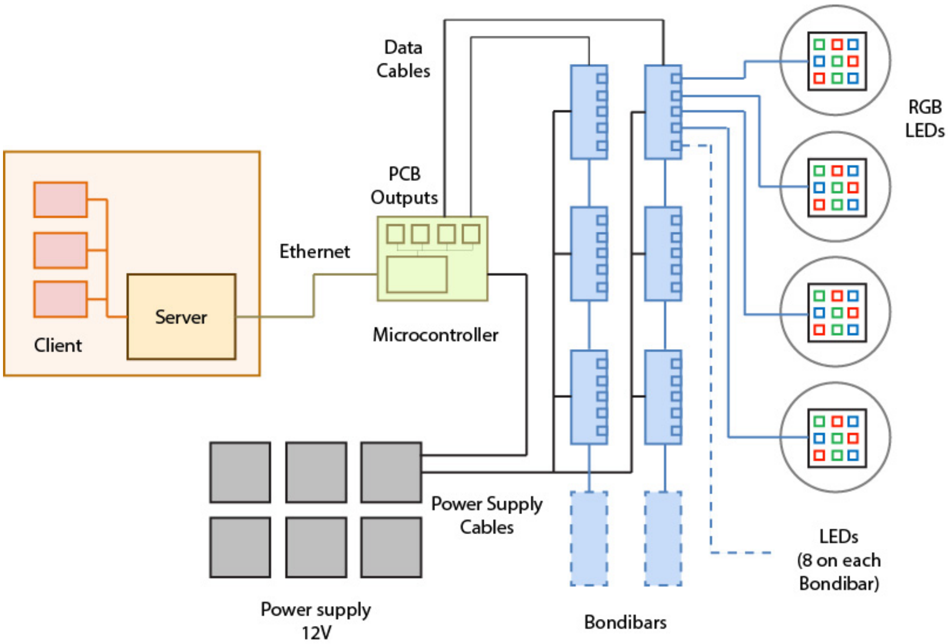

Figure 4.27: Sendero. Component schematics (adapted from Pablo Gindel's explanation of Sendero [25]).

An mBed NXP LPC17680 [46] microcontroller was used for this purpose. It is a device powered by a 32-bit Cortex-M3 processor, with an integrated Ethernet chip, that offers developers a wide variety of software libraries including a full implementation of the IP/TCP, and IP/UDP protocol stacks.

This microcontroller runs a software (previously developed by Gindel et al. [25]) that makes it emulate a DMX lighting device. In particular, it implements the ArtNet-DMX [8] protocol, which is a variant of DMX-512 [16] over UDP.

ArtNet-DMX is a widely use protocol in the lighting industry and a great amount of tools and applications can be found to use it and test it.

Additionally, an expansion PCB is used in order to facilitate the microcontroller connections (Ethernet and 12V power supply), and also provides multiple output connections to the LED drivers.

The microcontroller must be configured with its IP address and the amount of lights connected to each of the four outputs, and will then start to listen on the standard ArtNet UDP port (port: 6454).

4.3.1.1.1 Bondibar

The Bondibar is Sendero's LED driver. It is the component that lies between the mBed microcontroller and the actual RGB LEDs. Each Bondibar is capable of controlling eight LED outputs, and retransmitting the received information to other Bondibars connected in a daisy chain fashion.

When the mBed microcontroller receives an ArtNet-DMX packet, it will decode it and will send TTL (transistor-transistor logic) signalling through the corresponding PCB output. That signalling will arrive to the first Bondibar in a chain, which will extract the first eight pixels from the message, and will retransmit the rest.

The main component of any PCB LED driver is some kind of PWM (pulse width modulation) signal generator. The most commonly used chips for generating PWM's for LEDs are the WorldSemi 2801 [84] (or any of its variants), and the Allegro A6281 [2] chip.

Any of these two chips have three channels for PWM generation (one for each of the red, green, and blue components). In the case of the A6281, the chip has a colour depth of 10 bits per channel (two of these 10 bits are usually used for colour calibration, leaving a more commonly used 8 bit real depth), and the WS2801 has a standard 8-bit colour depth.

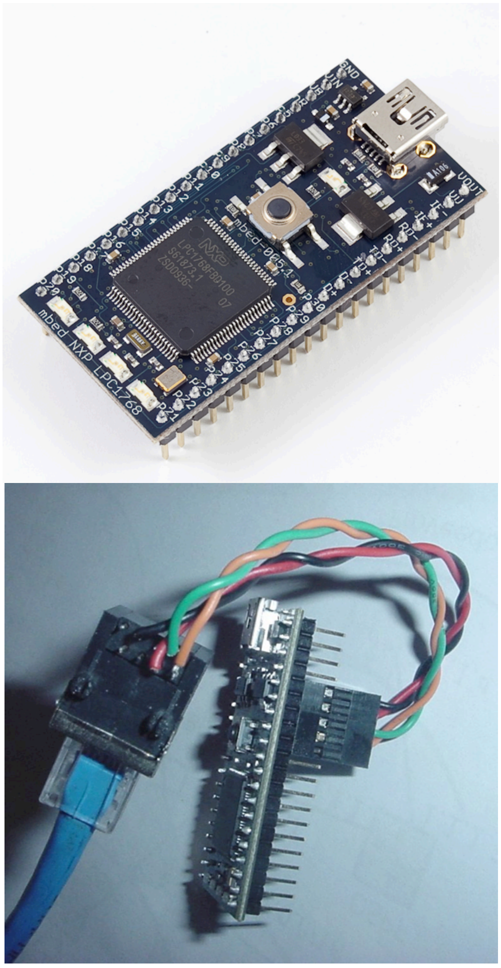

Figure 4.28: mBed LCP17680, with and without the Ethernet jack adapter.

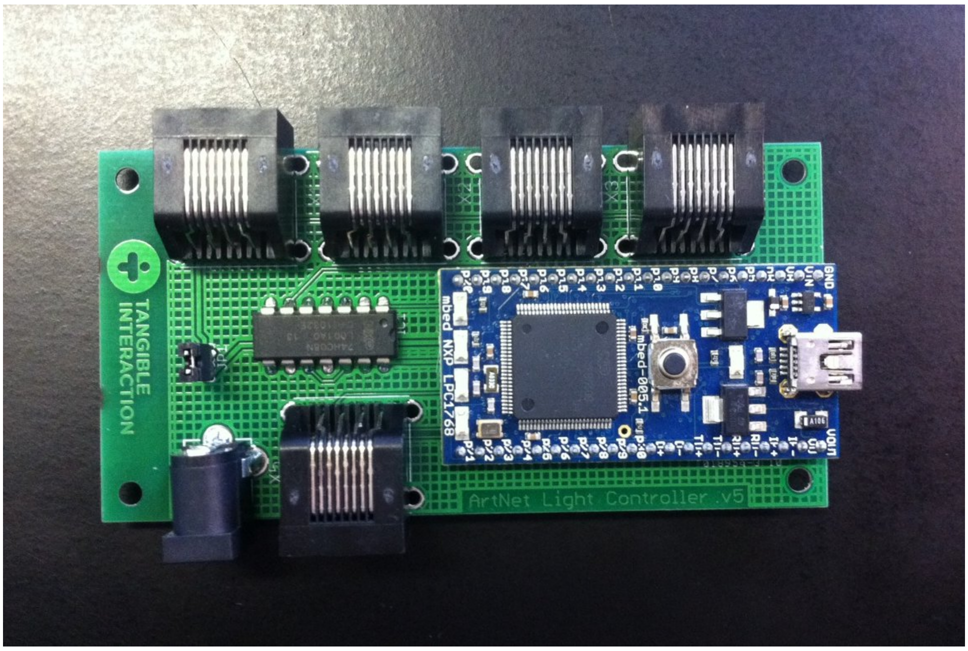

Figure 4.29: Microcontroller mounted on the expansion board. Photo by P. Gindel.

Both chips have the capability of storing a current PWM value for each channel, and maintaining the value (and the transmitted pulse frequency) until it is instructed to change it. These chips also have the ability of retransmitting the signal to the next chip.

The Octobar PCBs (used in Celebra) use eight A6281 chips to control their eight output pixels, and can retransmit both data and power to the next Octobar in the line.

The Bondibar is an RGB LED driver based upon the features of Macetech's Octobar, but introducing a brand new board design with the following improvements:

- The electronics are based on the WS2801 chip, because it is a cheaper and more reliable option. It has better interference robustness and more compatible hardware.
- It is designed to support big power loads, and different kinds of 12V LEDs. The Octobar has a power limit of 3W per pixel (at 10V per pixel), which can sometimes be insufficient for powering an LED due to excessive light contamination on a scene, or just because of the scale of the piece. The Bondibar can power up to

72 W per channel (at 12V), which is the power consumption of a standard high-brightness RGB SMD 5050 LED strip of five meters length. To drive this amount of power, the Bondibar uses one IRF520 transistor per colour channel (three per pixel). To connect the LEDs, the board uses standard 4-pin LED connectors.

- USB cables for data transmission. In all of Celebra's installations, a large amount of problems was suffered because of data transmission errors, and almost all of them were due to a poor cable solution (bad welding, breakups, and interference with AC electricity). TTL signalling requires shielded, good-quality data cables when dealing with distances longer that a meter (in Celebra's case, the distances were in the order of six to ten meters). To avoid this problematic, the Bondibar uses standard USB A-A cables, which are cheap, shielded, come in various lengths, and are available anywhere.

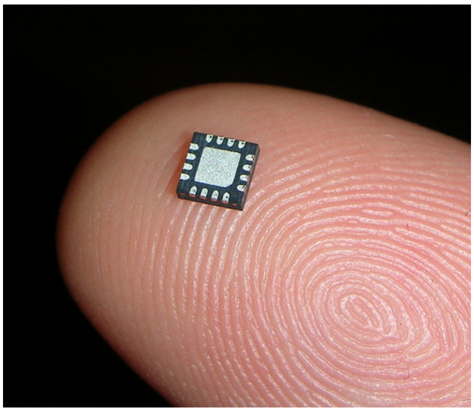

Figure 4.30: A6281 and WS2801 respectively.

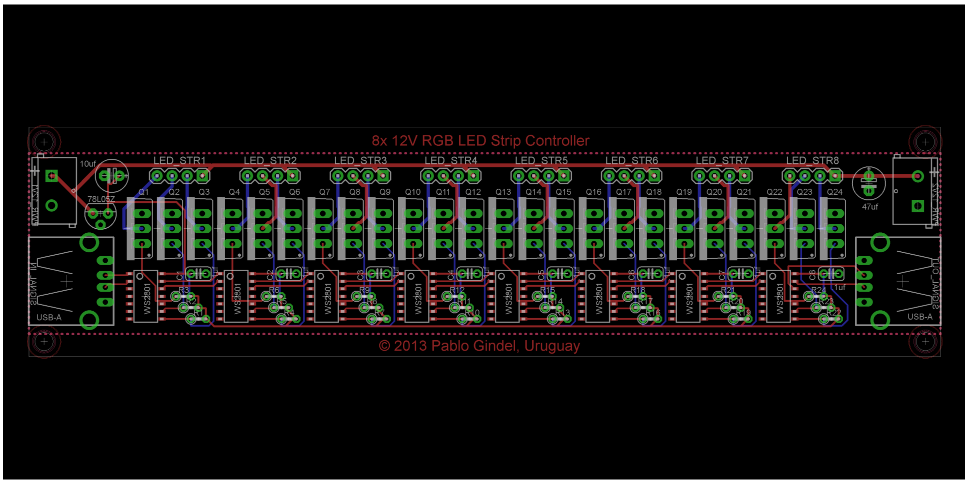

Figure 4.31: Bondibar design schematics.

- New power supply connections. The Octobar uses bare cable screw-in connections. The Bondibar uses a clip-in connector, facilitating the initial setup, and avoiding the use of tools (such as clippers and screw drivers) during installation.

This board was designed to be manually assembled. All of its components use DIP (or Through Hole) mounting, with the exception of the WS2801 that uses a SMT mount (surface mount technology).

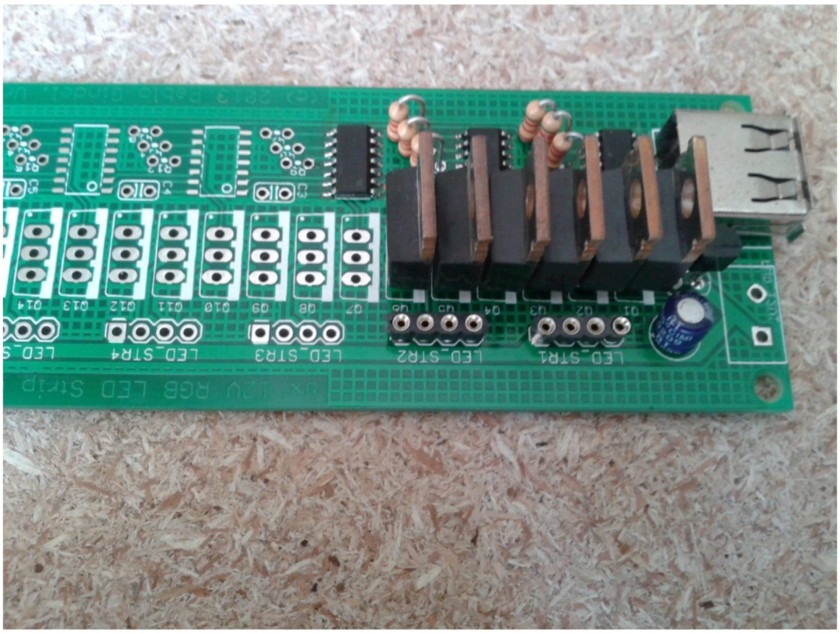

Figure 4.32: Bondibar prototype partially built. Photo by C. Clark.

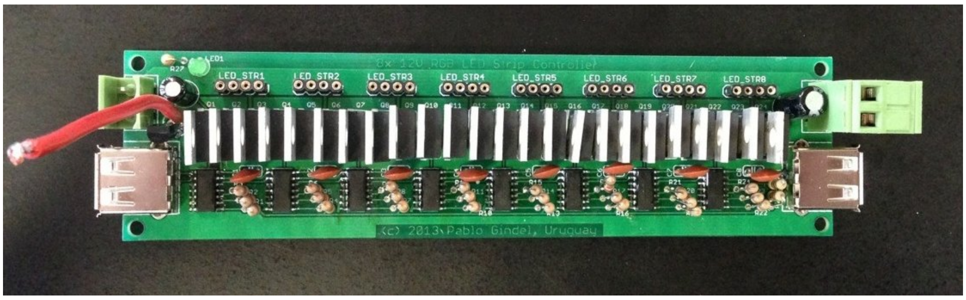

Figure 4.33: Bondibar fully assembled. Photo by P.Gindel.

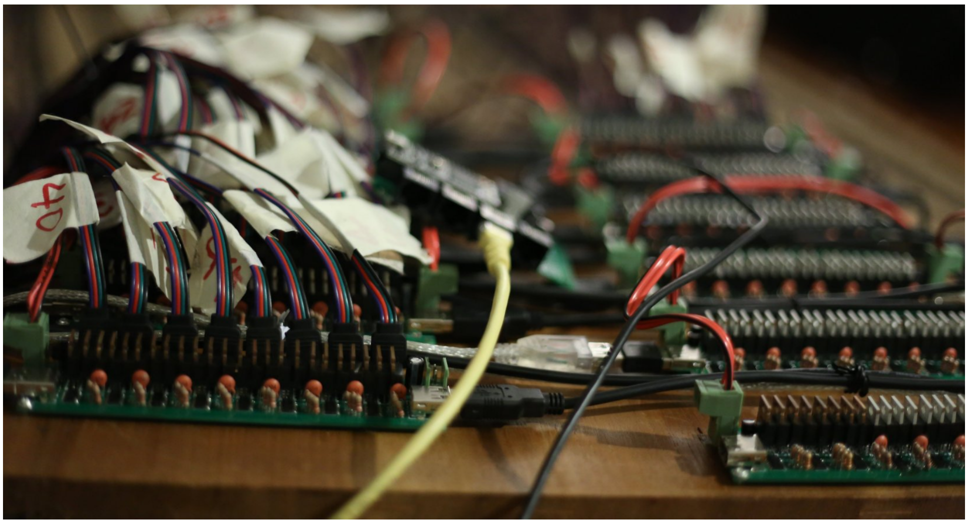

Figure 4.34: Bondibars partially connected during a Barcelona installation. The mBed microcontroller with its expansion board can be seen in the middle of the image. Photo by T. Kudinova.

4.3.1.2 Software design

4.3.1.2.1 Sendero server

Sendero server is the central component of Sendero's software solution. It is an application built over C++ using OpenFrameworks, which has the following main functionalities:

1. Provides information about the physical characteristics of the installation (pixels' three-dimensional data, and pixels' shape).
2. Gathers complete colour frames from client applications in charge of generating content.
3. Blends received frames according to the current blending settings.

4. Sends the corresponding fragments of the final blended frame to a set of mBed microcontrollers using ArtNet-DMX protocol (each microcontroller will receive only the information it needs to operate).

5. Transmit the entire final blended frame to a streaming server in charge of the Internet interface communications.

This server holds the main installation settings, including the definition of pixel types (each pixel has a three-dimensional model with which it will be represented in the graphical user interface), the definition of LED types (since the Bondibar allows the use of standard LED strips of different manufacturers, each LED type needs to have an associated colour correction matrix in order to perform colour correction), the definition of the client applications that will be sending colour content, and lastly, the position and orientation of every pixel in the scene.

All of these elements can be configured through an XML.

When a new client connects to the sever (via a TCP socket), the server will transmit all pixel related information so that the client can build its own representation of the installation (a three-dimensional scene), and it will also send a UDP port number to which the client will have to send colour content that will be processed by the server.

The server will keep the initial TCP connection with each client open, and will use it to send network congestion avoidance messages. Upon the detection of subsequent packet losses in a time span, the server will assume that the network is being saturated or that he is not being able to process information on time; in any case, it will try to slow clients down to a frequency it (or the network) can manage.

There are currently two ways for a client to send its contents: an XML based protocol, and a binary packet protocol.

The text based XML protocol has a very poor performance due to the large amount of data it generates, and should only be used with less than two hundred pixels, or for debug purposes.

In any other case, the binary protocol should be used (protocol selection can be established on the server's XML configuration).

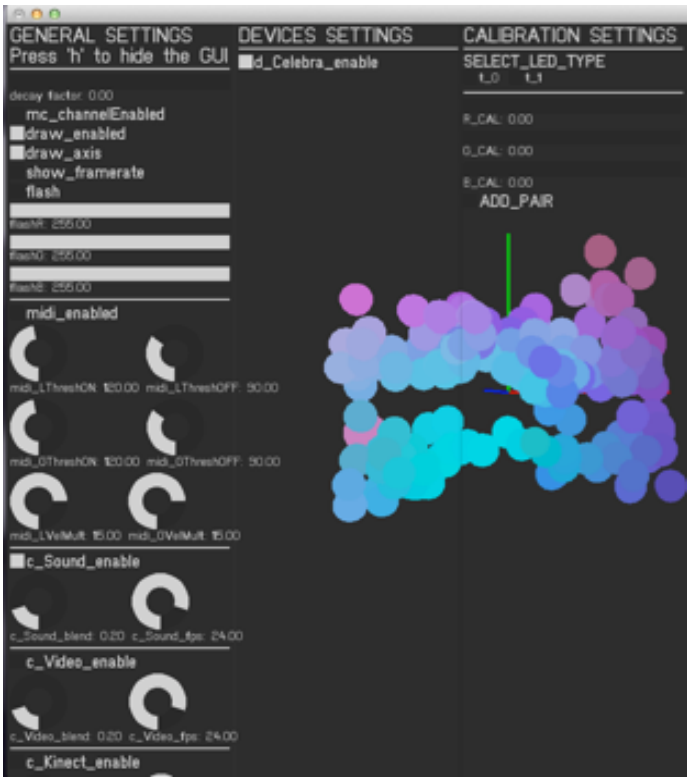

Figure 4.35: Sendero server during a Celebra installation.

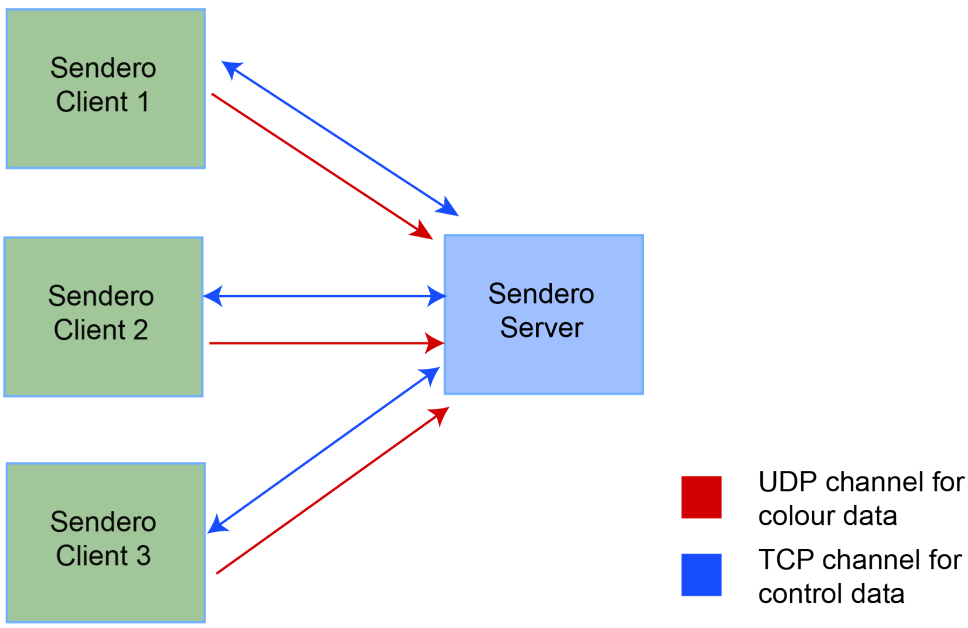

Figure 4.36: Sendero client-server communications.

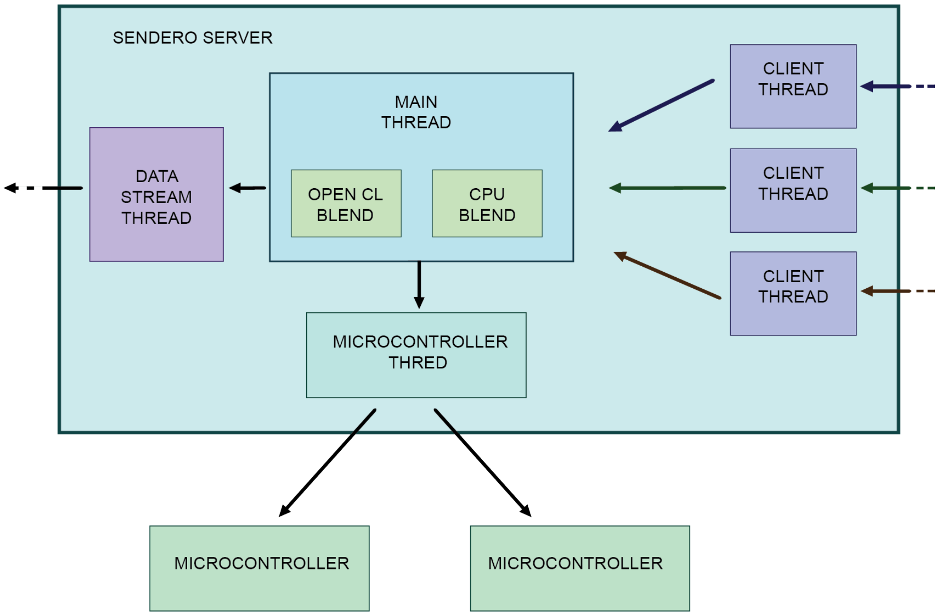

Figure 4.37: Sendero server. Thread schema.

Since the server has to deal with potentially big processing demands, it has been designed to run with the following thread schema:

- Main thread. This thread manages the main colour blending by processing information from all clients; it is also in charge of controlling network congestion, and of drawing and maintaining the graphical user interface. It has the capability of blending frames either using the CPU, or the GPU through the usage of an OpenCL [54] kernel (for the time being, OpenCL functionality is only available on MacOSX).

- Client secondary threads. The server will launch a thread for each of the clients defined in the XML. These secondary threads have the responsibility of pre-processing all incoming information from its specific client, so that it will be easier for the main thread to blend the frame, and it is also in charge of sending all control messages to the client.

- Microcontroller secondary thread. Since the server can send partial frames to different ArtNet-DMX devices (in our case: the mBed microcontroller), each device has its own thread in the server, in order to speed up processing of data in the main thread.

- Data stream secondary thread. As mentioned before, the server needs to publish the final blended frame information to a streaming server that will take care of retransmitting the data to the devices using the Internet interface. This transmission is also delegated to a secondary thread.

This thread schema is very important in order to maintain a high frame rate of processing, since it alleviates the main thread from time consuming operations like network communication and datatypes construction. Each secondary thread runs at a speed of thirty frames per second (unless it is slowed down by the network congestion control).

4.3.1.2.2 Sendero client

Sendero clients are applications in charge of generating visual content that will be blended and displayed by the server.

Clients connect to the server via a dedicated pre-configured TCP channel, through which they will receive the installation's configuration data (pixel information, and the UDP port to transmit to).

Then, each particular implementation of the client will colour the pixels in the ways it sees fit.

Many clients have been created for Celebra and Barcelona (such as the sound clients, video, and Kinect client), but none of these are included in the Sendero distribution.

What in fact is included in Sendero's release is a set of template projects that will help developers to code new clients. Sendero offers a C++ client template based on OpenFrameworks, and a Java template, based on the Processing libraries.

These client templates include classes that will take care of communicating with the server, including the handshake procedure, sending colour information, and responding to network congestion commands.

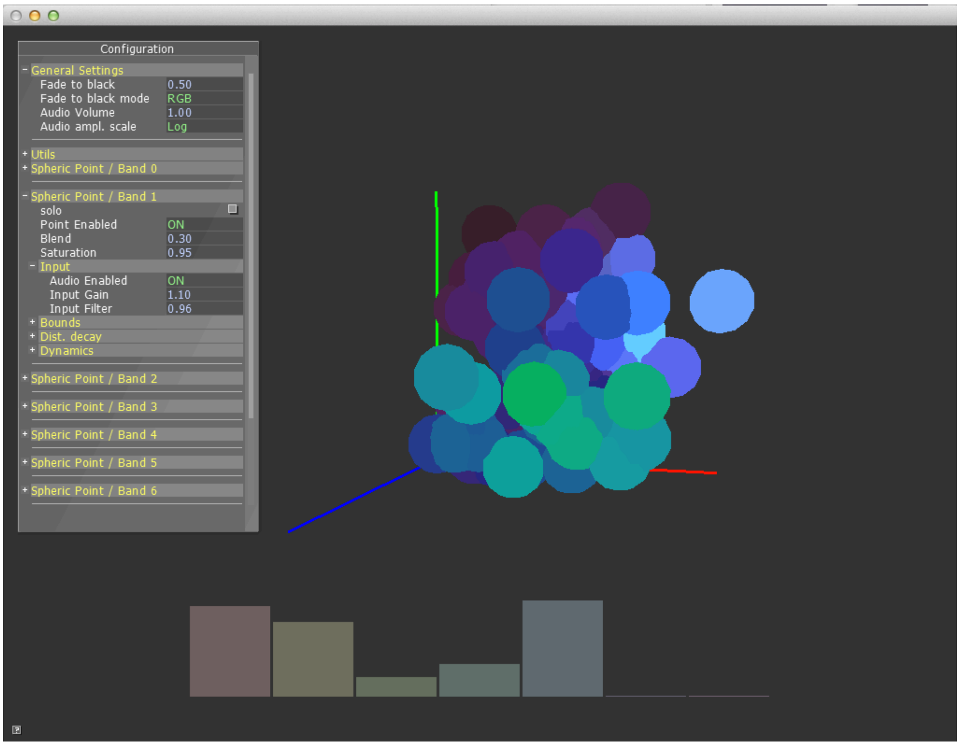

Figure 4.38: Sendero sound client, on the left the user can control virtual illuminators that orbit the scene in response to the perceived sound.

This way, the specifics of developing a Sendero client are abstracted from the developer, who can concentrate in coding the behaviour that will interact with the visitors, and that will generate the visual content for the server.

One important consideration is that the server will never know what a client actually does in order to generate a colour frame. This means that all interaction logic must reside on the client application.

4.3.1.2.3 Internet interface

Sendero's Internet interface allows the lighting system to have virtual spectators and virtual participants that consume the piece from the Internet, and may be located anywhere in the world.

Through the Internet interface, users can either see the artwork in real time (experiencing the lighting patterns being displayed), or intervene in the pattern generation by submitting commands to the server.

Five actors participate in this communication schema: Sendero's server, a streaming server, a web server, a specialized Sendero client managing a message queue, and the smartphones running the Android or the iOS application.

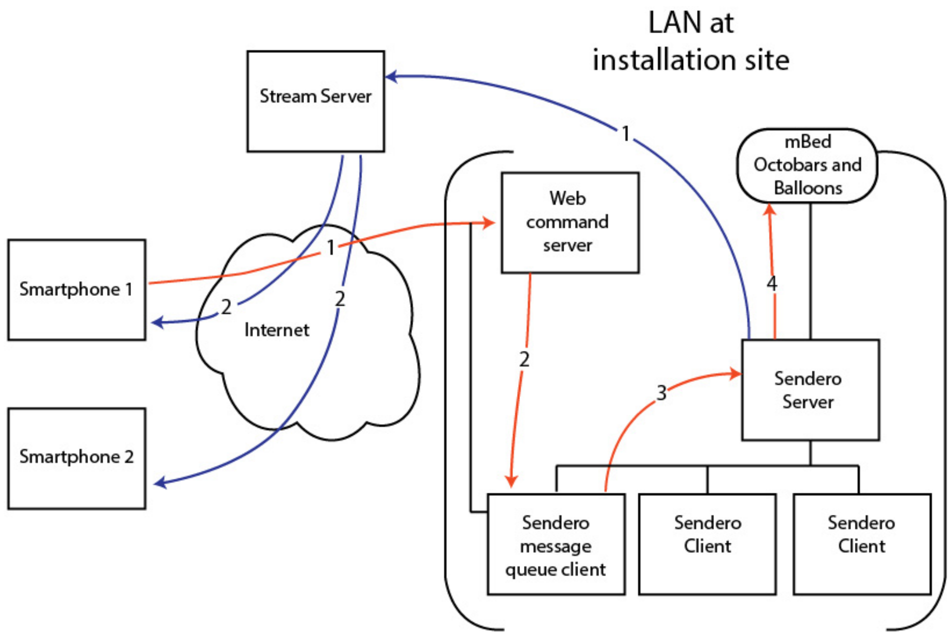

Figure 4.39: Sendero's Internet interface.

In order to publish colour frame's data to the Internet (the blue path in the image), Sendero server will transmit the final blended frame to the Stream server (hosted on the Internet). This communication is done through a UDP port using the same binary protocol used by Sendero clients when they send complete frames to the server.

Next, the Streaming server will retransmit every incoming frame information to all connected smartphones through a UDP port, also using the same protocol as before.

On the other hand, when a virtual spectator sends a command to the server (trying to modify some pixel's colour), the smartphone will send a HTTP POST message to a Web server in charge of receiving the commands, located in the installation's LAN network (red path in the image). This web server will process the input message, and will store it in a message queue. Then, a specialized Sendero client will read from that message queue extracting all virtual spectators' commands, and will create its own colour frame that will later be sent to the server (as any other standard client does).

In the current implementation, the web server was created using DJango (a web development framework for Python), and RabbitMQ was used as a message queue solution.

The feedback cycle is completed when Sendero server blends the new frame and sends it back to the stream server.

This communication architecture has the following advantages:

- Low upload data exchange rate between the installation's LAN and the Internet. This allows Sendero to be installed in locations with standard DSL connections, since the more demanding data transmissions are being performed from the Stream server (that may be in another location) to the smartphones.
- High scalability. If the installation's Internet infrastructure needs to scale, then it will only need to have more Stream servers. Stream servers can retransmit Senderos server's current data stream to other Stream servers, therefore the Sendero server does not have to upload more information while scaling the system up.

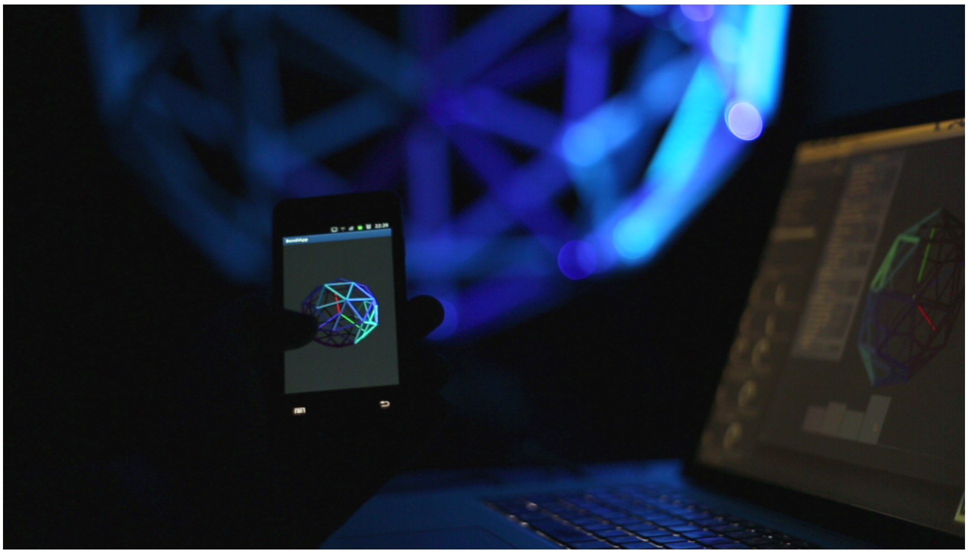

Figure 4.40: Sendero's Internet interface smartphone application running on an Android device during a Barcelona installation. Photo by T. Kudinova.

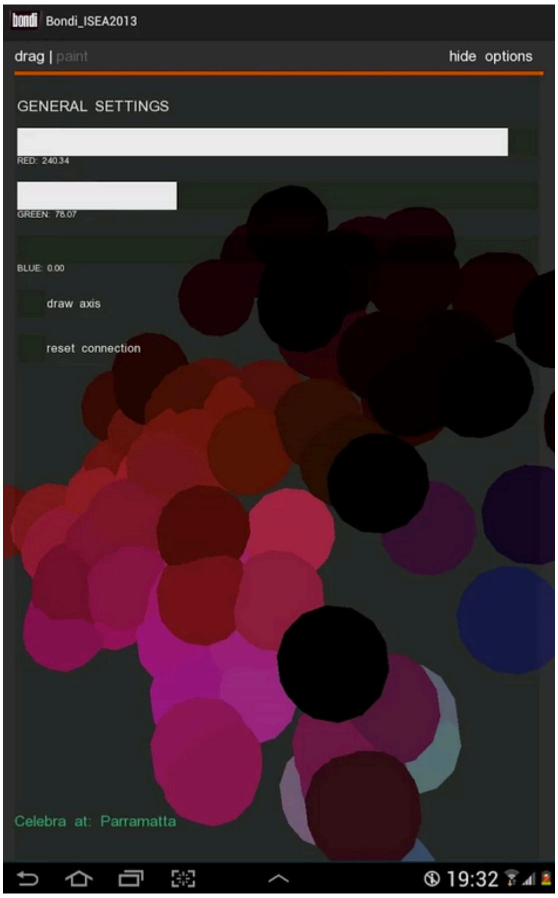

Figure 4.41: Sendero's Internet interface smartphone application closeup.

4.3.2 N.IMP – Node based image processor

N.IMP is an open source image processor application, developed using OpenFrameworks for MacOSX. The application allows the user to generate contents and process them in many stages, and the contents can be exported in real time to other applications (such as video projection tools, and VJing or video-mapping applications).

The system is designed upon the usage of content input nodes, processing nodes, and mix nodes. All kinds of nodes receive images as input, and generate another image as an output.

In order to achieve real time processing and rendering, N.IMP uses the GPU capabilities, by using textures, frame buffer objects, and GLSL shaders.

N.IMP was designed and developed by Christian Clark and Brian Eschrich.

4.3.2.1 Design

N.IMP uses a processing graph in order to generate contents. Nodes are attached to one another, and they process the incoming image and feed the result to their output nodes, establishing data paths or content generation paths.

Every node has a set of parameters (that vary depending on the node type), which the user can control in real time altering the processing path to his will.

Every data path has to start with an input generator node. Input generator nodes have the task of generating the first image in the data path, and by definition they do not accept any incoming connection from other nodes. This kind of node can be something as simple as a node that constantly outputs a static image, a camera feed (as shown in the image below), or something more complicated like a node that simulates a three dimensional scene and a camera and outputs the camera's rendered image.

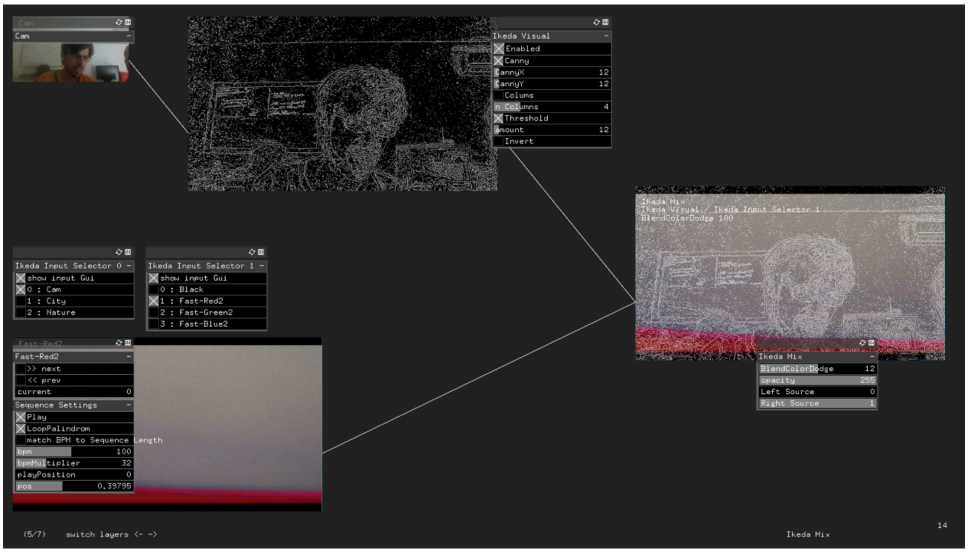

Figure 4.42: N.IMP. Graphical user interface showing a section of a data path. The image displays four nodes, their preview, and their specific parameters.

The following variants of input generator nodes can be found in N.IMP's current version:

- Static image. This node loads an image in memory, and feeds the data path that same image on every new frame.

- Image collection. Loads a set of images in memory and changes them periodically. This way the data path is fed with more than one image. This node has some user-controlled parameters that allow the user to trigger an image transition at will.

- Video. This kind of node allows the user to load a collection of videos into a reproduction list, where the user can select which video to play and has some standard VJing functionalities such as play, pause, speed control, and scratching.

- Camera. Camera nodes take the input from a camera connected to the computer running N.IMP, and use the video stream to feed the data path. N.IMP allows using many cameras connected to the computer, by letting the user establish which camera input should be used at every node at configuration time (through an XML file).

- Particle system. This node simulates a two-dimensional particle system in which the artist can control the particle's quantity and can set attracting or repelling forces to make the particles move in the scene.

Once a data path has an initial image to work with, it will be processed further by the processing nodes.

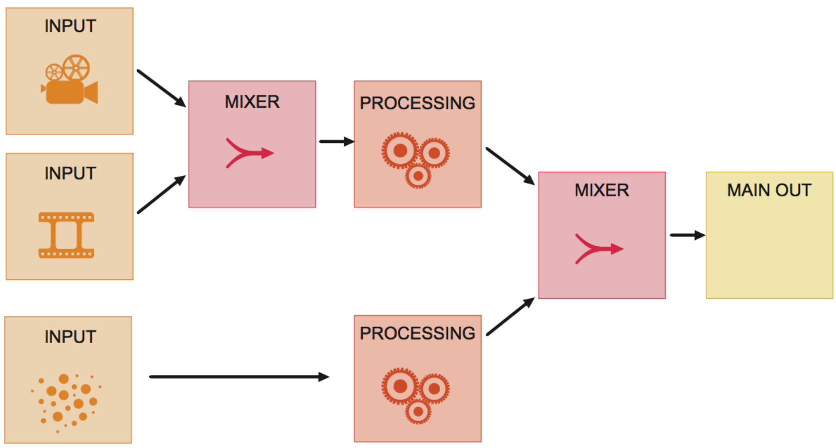

Figure 4.43: Processing graph.

Processing nodes lay in the middle of a data path, and in the current version they can take one input node connection and output to one output node connection.

Once they get an image, they run a specific processing algorithm that varies depending on which kind of processing node we are dealing with.

The current N.IMP version allows the user to work with the following processing nodes:

- Glitch. Takes an images and processes it in order to generate a glitch effect, like the one caused by a corrupted JPEG compression. This node allows the user to modify the level of image distortion in real time.
- Image processor. This node holds a GLSL shader library, and for each shader it allows the user to set a collection of parameters. It includes some effects like blur, edge detection, bloom, pixelation, and colour adjustment, amongst others.
- Ikeda processor. This is a node based on OpenCV, inspired in the minimalistic and monochromatic aesthetics of artist Ryoji Ikeda [33].

Lastly, we have a type of node specialized in blending multiple frames. These nodes allow merging data paths in many ways, they can accept many inputs (more than two), and can blend the frames using different techniques like alpha blend, additive blend, and multiply blend.

Mixer nodes can be positioned in the middle of the data path (meaning they can not start a data path), but they always have to finish the path. A mixer node needs to always be the last node in a data path because they are the ones that can export a final frame.

As it happens with the other types of nodes, mixer nodes also have a set of parameters that can be controlled by the artist, but most notably they have a parameter that determines which one is outputting the current primary mix. The primary mix is the mix that will be exported to whoever is consuming N.IMP generated content, and is that mixer node the one that will determine N.IMP's processing schedule.

Since N.IMP maintains a graph of nodes, it has to be able to determine the right way to compute all nodes, without repeating, and without generating cycles.

At the time being, N.IMP uses a regression technique in which it starts from the final mix and travels backwards through the data path by iterating on every node's input connections. Once N.IMP encounters a node that can be processed, the node gets processed and marked. N.IMP will only process unmarked nodes on a given iteration.

Once all incoming nodes are processed and marked, N.IMP will process the last mixer node.

At the moment, N.IMP has the following types of mixer nodes:

- Simple blend. This node takes two input images and blends them using one of the following blend techniques: alpha blend, additive blend, and multiply blend. The user is able to control all blending settings on each blend technique.
- Switcher. This is a special kind of mixer node that behaves like a channel selector, allowing the artist to select the output from many inputs. It allows the user to modify data paths in real time. This node does not alter the incoming images.
- Mask mixer. The mask mixer allows two inputs to be blended using a mask. This way, the user is able to blend parts of images. The node offers the user the capability of setting which mask to use, and allows mask transformations to be performed, so the user can rotate or translate the mask in real time.

4.3.2.2 Connection with other applications

N.IMP uses the Syphon [77] framework for Mac OSX for exporting real time generated images to other applications.

This framework allows the definition of servers (applications generating images), and clients (application consuming those images).

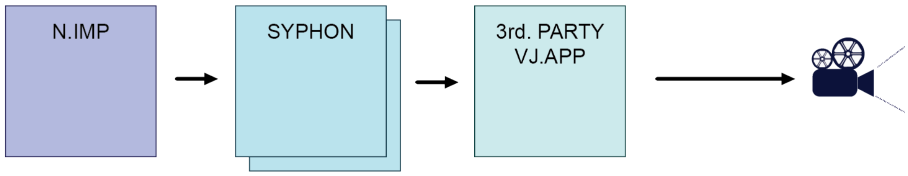

Figure 4.44: Syphon's connection schema.

N.IMP behaves as a Syphon server, exporting the main mixer's output image to be consumed by other applications such as Modul8 [49] (a very popular VJing application for MacOSX) or Millumin [48] (a video-mapping projection tool for MacOSX).

In this schema N.IMP acts as a content generator, leaving the final purpose and functionality to more specialized applications. This allows N.IMP to concentrate in content generation, user interaction, and content manipulation.

4.3.2.3 Graphical user interface

The first version of N.IMP's graphical user interface (GUI) is of limited capability, since much of the effort was put in developing the core functionalities.

At the time being, N.IMP's GUI allows for viewing node previews, node connections, and the node's specific GUI parameters.

Since showing a graph all at once with potentially dozens of nodes would be uncomfortable for the user to control (without a proper refined approach), the initial GUI was designed to display sections of the graph. These sections are called node views, and can be defined in N.IMP's configuration XML.

The GUI can have multiple node view definitions, and the user is able to switch between them during execution.

For each node view, the user must establish which nodes to display, at which size, and in which position on the screen.

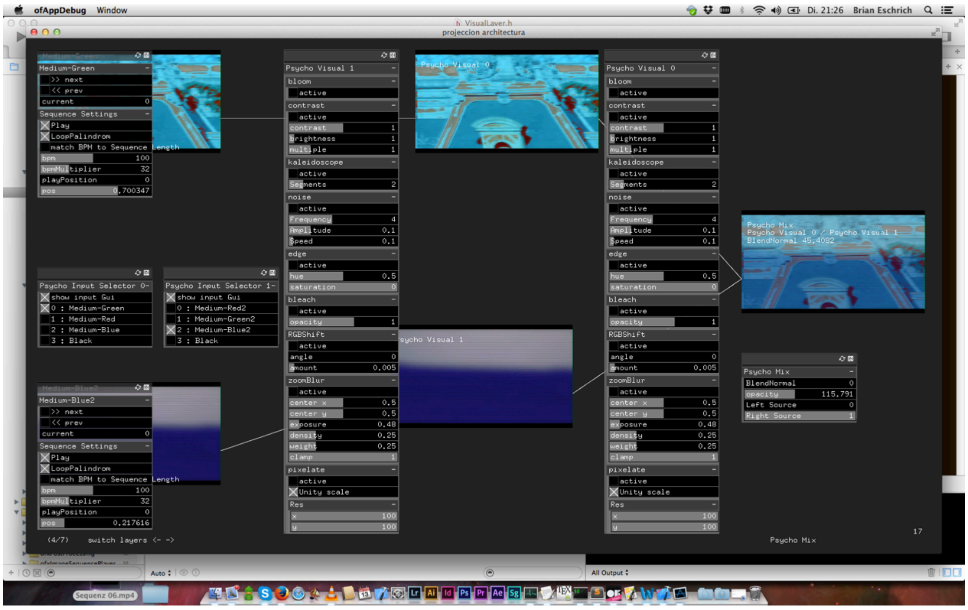

Figure 4.45: N.IMP. Node view titled "Psycho Mix".

The selected node view's name is displayed at the bottom right corner of the screen, and the total amount of available node views can be seen on the bottom left corner.

4.3.2.4 Input sources

N.IMP has a subsystem dedicated to allow GUI control using various methods including MIDI messages, OSC messages, audio input signal, and potentially any other measurable magnitude that may be interpreted by a computer.

An input source is a component dedicated to the reception and process of an input signal, which will later be translated in a N.IMP internal command that will be interpreted by the system. Any node's parameter can be remotely controlled using this subsystem. In fact, this subsystem allows for different settings per GUI node view, letting the user map a different input scheme depending on what is being displayed on the screen. This is convenient for setting up different parts of a show where a different set of nodes may be involved.

Each input source uses its own processing thread for receiving the input data from a source (for instance a MIDI port, a UDP port, or an audio stream), and for processing the data in order to generate internal N.IMP commands. This way, the input data can be processed without diminishing performance in the main thread.

This way, a MIDI control identification code can map its value to the alpha blend parameter of a specific mixer node, or an OSC [53] (open sound control) message can be bound to trigger a switch node to select one of its inputs.

N.IMP currently offers the following input generators:

- MIDI messages. With this input generator, any MIDI message can be associated to any node parameter. This way the application can be fully controlled using a MIDI device (or many MIDI devices).

- OSC message. OSC messages can also be bound to parameters for triggering or modifying values.

- Audio FFT. An audio input stream is processed using FFT to generate twelve independent bands. Any of these bands can be associated to a parameter, making the parameter sound responsive to a specific frequency band.

- TUIO. TUIO messages are a specific kind of OSC message used for communicating touch surfaces with applications. The TUIO protocol informs the application of contact points and their movements transmitting position, speed, and acceleration amongst other things. N.IMP has a TUIO input source specifically built to control the two-dimensional particle system simulated by the Particle System input node. With this component, the performer can use a touch-enabled device (such as a tablet or a smartphone), and control attracting or repelling forces on the simulation. Each finger acts as a force generator, and a global attraction/repulsion switch controls which kind of force will be generated with each contact point in the touch surface.

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5 CONCLUSIONS

5.1 Introduction

This thesis has reviewed a selection of artworks that we believe have some characteristics in common, which we also found in other works, in order to better understand their language, their possibilities, and their interaction design capabilities. We have referred to them as Modular New Media artworks.

These artworks are built upon atomic elements, have some connection points with the impressionist movement, and they make implicit use of Gestalt's principles for the visual perception in order to build visual patterns.

Secondly, in an effort to better understand the design, description, analysis, and artistic language of NMA interactive installations in public settings, a revision and adaptation of the current theoretical models was performed, using models and tools from different HCI areas. This revision takes into account the system's (artwork) perspective, and also the user's (spectator) perspective, and has collected a set of models and categorizations to be used.

Lastly, during this master's program, a valuable set of New Media Art artworks were created, along with tools for artistic production.

This last chapter will discuss these artworks, and will also analyse them using the selected models.

While working on this thesis, some research lines have been left open to further analysis and work. These future works will be also presented.

5.2 Artwork's analysis

5.2.1 Characteristics

As mentioned before, all of the artworks created within this research are Modular New Media artworks, and share some distinctive properties with the examples previously shown.

Celebra uses LED-lit balloons as atomic elements, each of them with a controllable property: colour. In almost the same way, Barcelona uses each of the dodecahedron's edges as atomic elements.

Son uses simulated white particles that move in a three-dimensional simulated space, and are able to vary in size and speed. In turn, Réunion simulates coloured ribbons that are able to change direction and speed.

Lastly, in Bosque Estroboscópico each fluorescent light tube constitutes an atomic element that can be turned on or off.

Regarding atomic element's spatial distribution, Celebra uses a very irregular three-dimensional configuration that contributes to its organic aesthetic; conversely, Barcelona presents itself with a very regular one. The pentakis dodecahedron structure gives the piece a clean and pure appearance.

Son and Réunion both present an irregular arrangement of atomic elements that also bring an organic aspect to the pieces and to the participants' silhouettes.

In the same way, Bosque Estroboscópico also presents an irregular distribution of its elements, contrasting with the clean and glossy fluorescent light tubes.

All of the artworks make use of real time content generation methods, in Celebra and Barcelona these methods reside in Sendero Clients that take data input from sensors to process it into colours for the different addressable pixels in the installations.

In Réunion and Son, the content is generated by the simulated particles and ribbons systems and the attracting forces generated from each spectator's tracked bodies.

Bosque Estroboscópico has only been used as a performative installation, in which the performer controls power lines that set different tubes on and off, and in turn the content generation is real time by definition.

Of all these artworks, the only ones that explore more complex ways of data processing distribution and that expose the way data travels through the installation are Celebra and Barcelona. In these two artworks data paths are explicitly shown to the spectators so that he or she is able to perform the exercise of following cables and electronics to the main computer controlling the piece. Then, the inner software components of the piece deal with information processing in a very distributed way (involving many Sendero clients and one Sendero server).

5.2.2 Interaction characteristics

5.2.2.1 Johansen's matrix

Regarding interaction design and characteristics, Celebra and Barcelona share the same schema. They both fall into the "same place – same time" category of Johansen's matrix since they are systems that allow multiple spectators to interact with each other through the artworks. In both of them, the spectators need to engage the artworks at the same time since the artworks do not have the capability of remembering visitors, nor the content they generate.

If we also take into consideration Sendero's Internet interface, then both pieces also fall into the "same time – different place" category, since spectators in the physical location may be interacting with virtual spectators consuming the artwork from the Internet.

Son and Réunion are inscribed in the "same place – same time" category, since their set up as a magical mirror is meant to let spectators see each other, and appreciate their reflections.

5.2.2.2 Reeves's model

Reeves's model can be used to describe Celebra's interaction zones and role transitions in the following way.

People standing far away from the piece can be catalogued as bystanders, and as they approach the piece they become audience, and later participants when they are at a distance that lets them interact with the piece either by producing sound or by letting the artwork track their bodies.

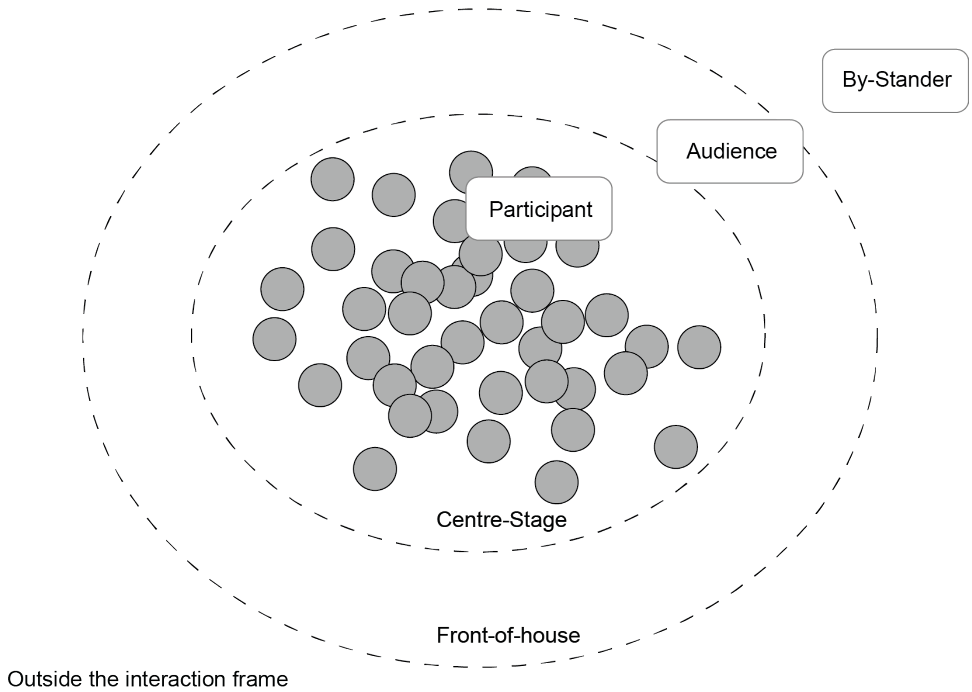

Figure 5.1: Local Celebra installation description using Reeves's model.

If we introduce the virtual spectators into Reeves's model we have at least two options, on one hand we could include virtual spectators in the physical performance frame of above, in this case virtual spectators and real spectators would share a performance frame.

On the other hand, we can model a virtual performance frame to include virtual spectators. This is a better way to do it because in these artworks virtual and physical spectators are not directly aware of each other, but only perceive each other's effects, and the only medium they share is the actual artwork.

The latter approach also has a few variants. The virtual performance frame could be unique, as in one for all virtual spectators, or it could be modelled as a single virtual frame per spectator. In the case of these particular art pieces, a better way to model this is using independent virtual performance frames, because virtual spectators are not directly aware of other virtual spectators either.

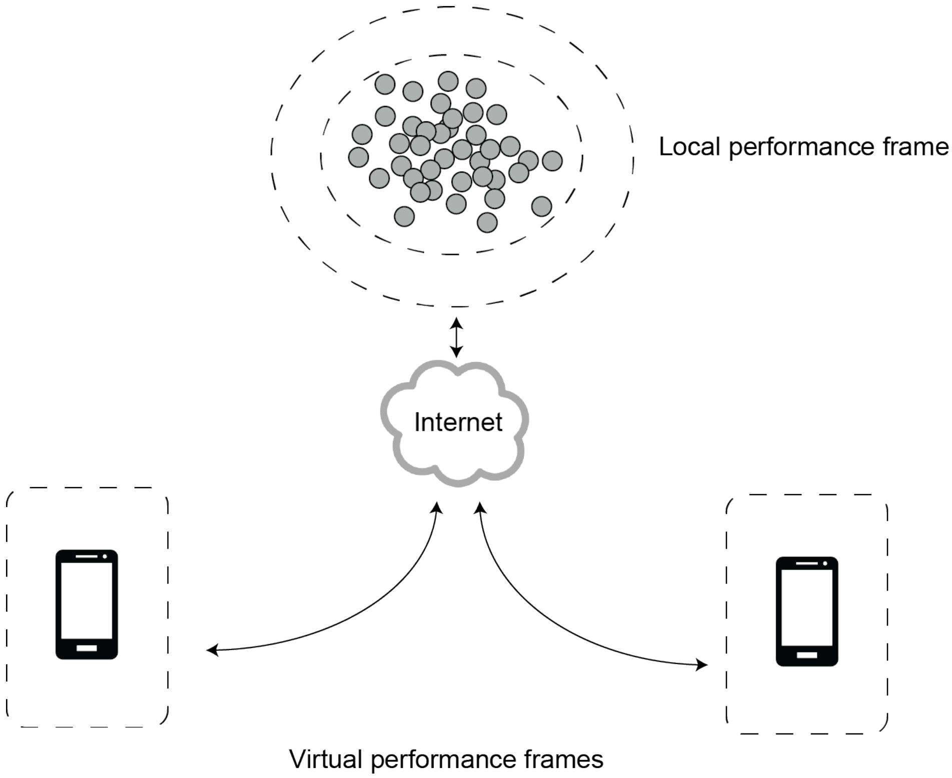

Figure 5.2: Local performance frame, and individual virtual performance frames in Celebra.

As mentioned before, Reeves's model is not very suited to dealing with multiple, remote, and virtual spectators, and this is an aspect of the model that deserves to be reviewed and generalized.

All of these modelling considerations can be applied to Barcelona in the same way, since both pieces share fundamental interaction schemas and underlying technology.

In the case of the "magic mirror" pieces, Reeves's model is also similar between them, but with a minor variant.

Son and Réunion are presented using a screen as a main component of the installation, and participants must engage the artworks by standing in front the projected side of the screen. Audience and bystanders will be situated beyond the depth sensor's recognizable area.

In the case of Son, the centre stage zone is determined by the range of one depth sensor. Réunion, on the other hand, allows the use of multiple depth sensors in an array configuration, and in turn the centre-stage can become a corridor of arbitrary length.

Interestingly enough, during Son's exhibition at the National Museum of Visual Arts in Montevideo, Uruguay, the centre stage and the front of house zones were recognised by the spectators without any help or additional markings.

Lastly, Bosque Estroboscópico has a performance frame with a main actor in the centre (the performer), and the spectators participate only as audience.

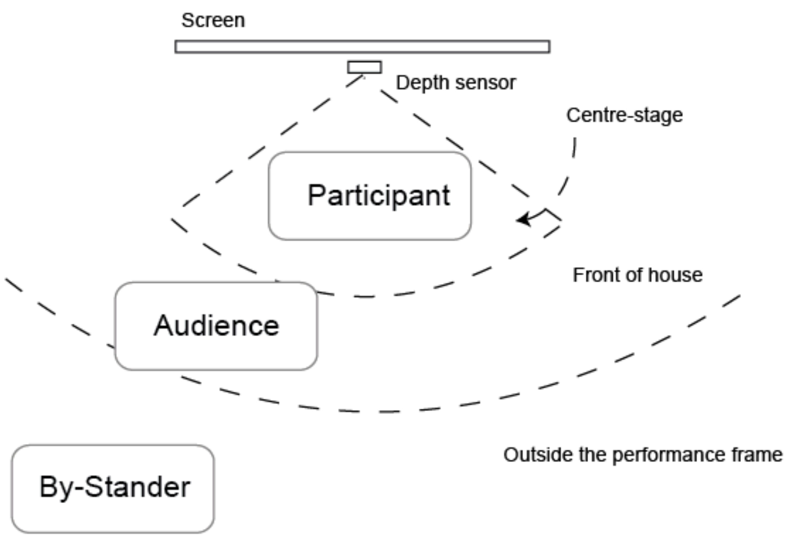

Figure 5.3: Son's performance frame.

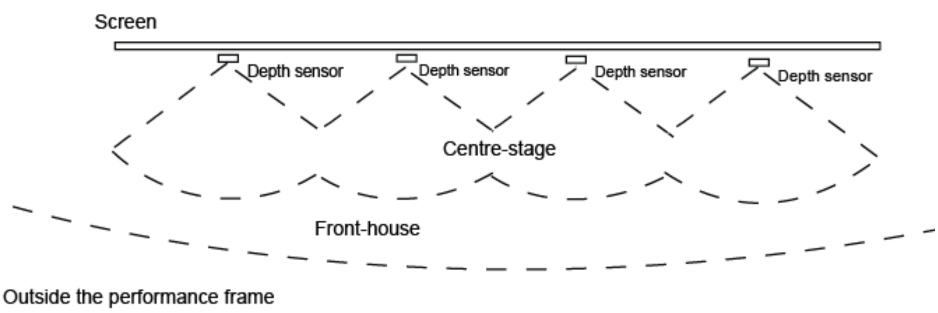

Figure 5.4: Réunion's performance frame.

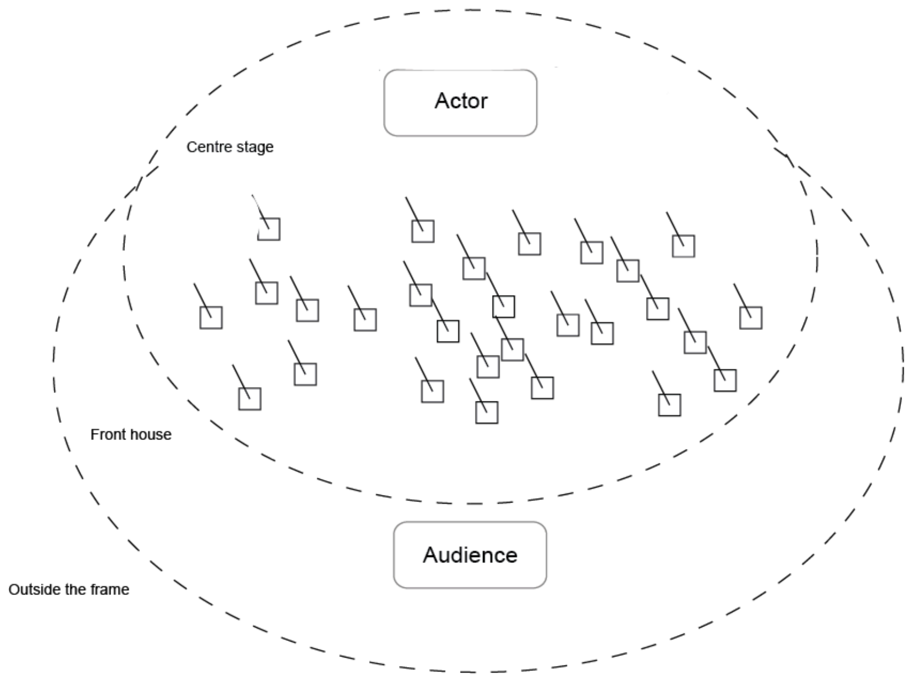

Figure 5.5: Bosque Estroboscópico's performance frame.

Regarding Reeves's behaviour classification, all of these pieces can be classified in the magical, and expressive categories. Celebra and Barcelona are both magical and expressive, because they produce very explicit system's effects (the visual patterns) but sometimes it may not be clear whom or what has provoked them. Since there is no way for an actual spectator to know about virtual spectators and the way they are manipulating the piece.

Son and Réunion both can be categorised as expressive systems, since users' manipulations are very explicit thanks to the mirror interface analogy.

Lastly, Bosque Estroboscópico is an example of magical systems. The system's effects are very explicit to the audience, but the performer's manipulations are not, since he is manipulating knobs in a small panel that are not visible to the audience.

5.2.2.3 Bilda's model

We could also use Bilda's model in order to try to describe the artworks' interaction experience from the human perspective. We will do so using Celebra as an exercise, analysing from a local spectator perspective. Although no empirical data of the spectators' behaviours or experiences was recorded during any exhibition, it will help us to understand the role of Bilda's model in the artwork design process.

Unintended mode: During this mode, participants engage the piece in an exploratory way. For this purpose, the artwork offers sound and position driven reactions. This way, as the spectators approach the centre-stage area they start to engage the piece by emitting sound and by walking around. In this mode, the organic and complex aspect of the artwork will also influence the spectators' initial actions.

Deliberate mode: As the spectators get acquainted with the artwork, they start to imagine how it works, and what it does. Sound and movement exploration and repetition will help them during this task. They also are able to observe what other participants do, and how the piece reacts to them. This will contribute to build and stabilise a mental model of the artwork.

Intended / in control: As soon as that mental model of the artwork is stable, spectators are able to start analysing the artwork in a deeper way, by exploring different zones and how the piece reacts differently from different positions in the centre-stage area. They notice the microphones and cameras and how the artwork's visual patterns are affected by the position of these elements.

Finally, during this deeper understanding phase, they could start to notice what the cables and electronics do for the artwork, and will start to follow them and to think on how data is being transformed and delivered to each component of the piece.

Intended / uncertain: Once that deeper understanding matures, spectators start to notice that there are some visual patterns that they cannot explain with this model, and that seem to be generated by something or someone else. What is actually happening is that these unexplained patterns are being produced by virtual spectators, and by the piece itself (synthesizing content with the Sendero's Perlin, or Video clients).

Unexpected: In this mode, the spectator is mostly sure that his or her mental model is not accurate, and will start to question the model, and re-examine the artwork. This will probably induce the spectator to return to a previous mode in which he or she will revise his mental model.

5.3 Tools for artistic production

As a product of this master's degree, two tools for artistic production were developed.

Sendero was used intensively during the construction and many subsequent installations of Celebra and Barcelona. It has already been improved, and its development is still active.

In addition, Sendero was used in the design of the interactive lighting solution for a real architectural project (Arq. Casaravillas's project for the Antel Arena building [5], obtaining a mention).

On the other hand, N.IMP was also used during live performances, and despite its short life span, it presents itself as a interesting platform for experimenting on performative interaction.

5.4 Future works

During the development of this thesis, a few lines of investigation worth exploring were identified.

First of all, the data paths and the information processing distribution aspect of New Media Art present themselves as interesting fields to carry on working. There are numerous examples of art pieces and artists that use data, and data processing as part of their work. For instance, Ikeda's work on his Datamatics series [33] show visual representations of everyday data, and he also explores data paths.

Figure 5.6: Casaravilla's project for the Antel Arena stadium. Image by J. Casaravilla.

In Modular New Media artworks, data flow between the controlling entity and the atomic elements, or between the atomic elements themselves can become explicit, presenting itself as another component of the piece. The search for an artistic language in this area is of particular interest.

Secondly, as stated before, the Reeves's model lacks of a well-defined application in scenarios involving physical and virtual performance frames. Combining it with the place and space concept provided Harrison and Dourish [31] presents an interesting opportunity to explore, however further investigation on the matter is needed.

Next, on the human perspective of the theoretical framework here presented, Bilda's model poses itself as a viable way to script and design the spectator's experience. This is a very important affirmation, and needs further testing and development. An interesting exercise would be to design brand new artworks using Bilda's model, to later analyse if the model holds, and how it will be reflected on the final artwork.

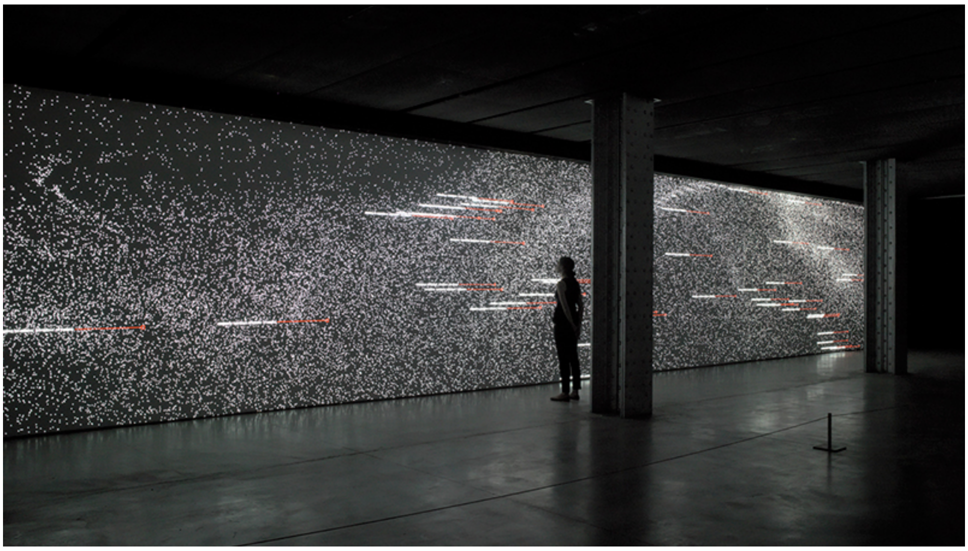

Figure 5.7: Ryoji Ikeda Datamatics series (2009).

There is still work to be done in Sendero and N.IMP. Sendero is already being improved by updating the entire communication scheme between smartphones and the stream server. Nowadays, this communication uses non standard TCP and UDP ports, which are usually blocked by carriers and firewalls, and is now being migrated to use Websockets (a web technology that emulates a TCP channel over HTTP).

Sendero's hardware is also evolving, thus the Bondibar will be doted with a wireless module for data transmission, to eliminate cables and to make the installation procedure easier.

At the moment, Sendero obtains the three dimensional positions of every pixel in the scene by reading an XML configuration file; this XML needs to be created manually by an operator, and therefore not only the pixels' position are not exact but this makes the system's configuration quite tedious. An automatic generation of the XML could be performed by using a three-dimensional pose detection technique [78; 83].

Finally, N.IMP is also in need of a new graphical user interface for viewing and editing the processing graph. As mentioned before, N.IMP represents an opportunity to investigate, even more, the performative aspect of NMA.

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Montevideo, May 2015

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