UNIVERSIDADE CATÓLICA PORTUGUESA

# ADAPTIVE INTERFACES FOR LIVE PERFORMANCE OF GENERATIVE GRAPHICS

( ARTE GENERATIVA: INTERFACES COMPORTAMENTAIS
NA MEDIAÇÃO ENTRE IMAGEM E SOM)

Dissertation submitted to the Portuguese Catholic University in partial fulfillment of requirements of the Doctoral Degree in Science and Technologies of the Arts – Computer Music

by

*Joana Ferandes de Carvalho Gomes*

ESCOLA DAS ARTES
December 2014

UNIVERSIDADE CATÓLICA PORTUGUESA

# ADAPTIVE INTERFACES FOR LIVE PERFORMANCE OF GENERATIVE GRAPHICS

( ARTE GENERATIVA: INTERFACES COMPORTAMENTAIS
NA MEDIAÇÃO ENTRE IMAGEM E SOM)

Dissertation submitted to the Portuguese Catholic University in partial fulfillment of requirements of the Doctoral Degree in Science and Technologies of the Arts – Computer Music

By Joana Fernandes de Carvalho Gomes

Dissertation supervised by Professor Álvaro Mendes Barbosa

ESCOLA DAS ARTES
December 2014

This Doctorate Research was partially supported by the Portuguese Science and Technology Foundation (FCT), trough the award of the Doctorate Grant reference SFRH/BD/61298/2009

To my dad

# Abstract

While attempting to find new ways to create art, artists transgress the traditional notions of creativity and art. Computers start to have creative behaviors in which the artist conducts his work. Both, generative practices and interactivity have a special impact on the creation of Art and in its new relationships. Interactivity and generative processes can create a space for genuine innovative creative practices in art where the artwork is the result of collaborative work between computers and users.

Is our goal to express generative practices not as a static creative process, but instead as an iterative communication between system and interface/ interface and user. This collaboration between system, user and artist gains higher relevance through the creation of an interface that is capable of synthesizing these expressions.

In the process of identification of a new way of relating generative graphics systems and user/performer, an application for mobile devices was developed where interaction takes into account the need to express the generative processes through the interface, generating a greater connection between the three parties (generative system, interface system and user). This need comes from the generative system itself since it is semi-autonomous and is constantly undergoing modifications exhausted in any type of static and rigid interface .

Sliders and buttons take away the freedom of a system that aims to expand connections and collaborations, where the authoritarian act of

the user/performer overrides the choices of the system by imposing their own. ALIVEART proposes a new form of communication where the generative graphics interface adapts depending on the characteristics of an artificial living system. Thus, the parameters set by the system are modified on the interface showing only those that the user may interact. Over time these choices cause modification of the a-life as well as the interface. The result is a system that algorithmically, via sound inputs, draws graphics that are modified by an adaptive interface.

Rather than change the operation of the interface, we sought to create new interaction paradigms in which the user's interference is revised by proposing a more conscious way to interact with artificial living systems.

Via a survey of three areas of expertise (designers, performers and user interface experts), ALIVEART was assessed. New areas of interest were identified that confirmed the necessity to implement interfaces that adapt to systems and users thus allowing new forms of relationships and creative processes in the creation of digital art.

# Resumo

No processo de encontrar novas formas de criar obras de arte, os artistas conseguem transgredir as noções tradicionais de criatividade e arte. Computadores desenvolvem comportamentos criativos em que os artistas decidem exploram capacidades externas a eles para alcançar novas expressões artísticas. Ambos, práticas generativas e a interatividade, têm um impacto especial na criação da arte e nas suas relações. Nesta conjuntura, interatividade e os processos generativos são um espaço de práticas inovadoras, criativas e originais para a arte em que a obra é resultado de um trabalho colaborativo entre artista, computadores e utilizadores.

É o nosso objetivo demostrar que as práticas generativas não como um processo criativo estático, mas sim como uma comunicação que se repete entre sistema e interface / interface e usuário. Esta colaboração entre o sistema, usuário e artista, que ganha maior relevância através da criação de uma interface que é capaz de sintetizar todas estas expressões gerando uma nova visão artística que resulta dessa articulação.

Através de uma detalhada revisão bibliográfica conseguimos datar as primeiras modificações de paradigma que foram decisivos na criação dos conceitos que trabalhamos nos dias de hoje. Dos 60 em diante, a arte e os aspectos socioculturais sofreram mudanças muito importantes permitindo que os artistas rejeitassem as práticas artísticas tradicionais e que introduzissem novas ideias. Essas ideias mudaram a forma como os artistas produziram arte e até mesmo aquilo que era considerado arte. Artistas dos movimentos artisticos Fluxus e Arte Conceptual foram reesposáveis por criar uma clivagem ainda maior entre antigas e novas práticas através da introdução de ideias que são a base para a arte como

a conhecemos hoje. Essas ideias foram essenciais para gerar nos anos 90 o espaço em que os artistas por computador encontraram para explorar novas mídias na produção de arte.

Uma das maiores mudanças que ocorreram durante os anos 60 advém da obra de arte deixar de estar relacionada com o artefacto, passando a ser mais relevante as ideias e os processos relacionados com o ato artístico. Artistas conceituais começaram a expor as suas instruções para a construção de uma determinada obra de arte como sendo a própria obra de arte. Este processo de separação das práticas artistas e das técnicas, incentivou novas estratégias de arte e deu um novo significado para o papel do artista. O processo tornou-se o aspecto mais importante das práticas artísticas alterando por completo a relação entre arte e artista.

Com o uso do computador essas ideias ganham forma através da introdução de sistemas interativos (resultado directo da arte particiativa) e através da criação de comportamentos semiautónomos que surgiam das regras estabelecidas no computador. Muitos artistas contemporâneos desenvolveram tais obras de arte e foram capazes de criar um novo tipo de criatividade que emerge destas três entidades: o usuário, artista e sistema generativo. Apesar do computador permitir aos utilizadores novas formas de criar, muitas vezes verificamos que as estratégias utilizadas não conseguem desfrutar de forma completa da autonomia de sistemas externos devido a forma como se estabelece a interação.

Em resposta, surge a necessidade de buscar uma nova forma de se relacionar sistemas gráficos generativos e utilizador/performer de uma forma que explorasse as capacidades dos sistema de vida articial dando-lhe realmente alguma autonomia sobre a sua condição. Optou-se por desenvolver uma aplicação para dispositivos móveis onde a interação toma em consideração a necessidade do sistema de se expressar através do interface, gerando uma maior conexão entre as três partes (sistema generativo, interface e utilizador). Essa necessidade advém dos sistemas generativos serem semiautónomos e estarem constantemente a se modificarem, se esgotado num interface estático e rígido.

Sliders e botões esgotam a liberdade de um sistema que pretende ampliar conexões e colaborações, onde o ato autoritário do utilizador/performer aniquila as escolhas do sistema impondo as suas próprias. ALIVEART propõe uma nova forma de comunicação com sistemas de gráficos generativos onde o interface se adapta consoante as características de um sistema de vida artificial. Essa adaptação significa que os parâmetros definidos pelo sistema se modificam no interface mostrando somente aqueles que o utilizador pode interferir. Ao longo do tempo as escolhas do a-life vão modificando assim como o interface. O resultado é um sistema que através do som desenha algoritmicamente gráficos que são modificados através de um interface adaptativo.

Esta interface adaptiva apresenta ao performer os elementos visuais que podem ser controlados excluindo os que, naquele momento, são irrelevantes permitindo mais foco no ato performativo e permitindo que o utilizador/ performer seja capaz de uma maior imersão no sistema em si. Mais do que manipular parâmetros buscamos metáforas que sejam capazes de ampliar a comunicação entre mundo virtual e actual permitindo até criar uma ligação simbiótica entre os três elementos envolvidos.

Mais do que alterar o funcionamento do interface, buscou-se criar novos paradigmas de interação onde o próprio acto de interferência do utilizador é revisto, sendo proposta uma forma mais consciente de interagir com sistema artificiais vivos e consequentemente explorando mais profundamente as propostas dos sistemas vivos artificiais através de tomam decisões ao definir a informação que é partilhada com o utilizador através do interface.

Através de testes realizados com especialista das três áreas que sustenta ALIVEART (design, HCI e performance) foi avaliado a adequação dessa proposta e definidos novas áreas de interesse confirmando a necessidade de implementar interfaces que se adaptam ao sistemas e ao utilizadores para expandir novas formas de relações e processos criativos na criação de arte digital.

Concluímos em nossos experimentos que tal tipo de interface Alcançou resultados importantes na promoção da colaboração e do compromisso do utilizador com sistemas generativos, promovendo uma interação mais dinâmica e fluida com um sistema que é, por definição, semiautónomo. Como que se espera das práticas generativas e interativa abordadas na revisão de literatura, ambas características foram muito importantes no processo de definição do conceito de criatividade. No desenvolvimento da interface de ALIVEART notamos que interface adaptável não só torna a tarefa para ambos os sistemas mas fácil como também muda o processo de criatividade em si, permitindo que o usuário defina e implemente num sistema externo à ele habilidades que promovam a criatividade.

Apesar dos resultados positivos obtidos com este primeiro protótipo conseguimos apontar novos caminhos de investigação que se desenrolam do trabalho aqui desenvolvido. É nossa proposta que se amplie as possibilidades de escolha do sistema, colaborando ainda mais com o utilizadores apostando nas escolhas do sistema para o desenvolvimento de novas formas criativas de gerar gráficos. Acreditamos também que técnicas como Music Information Retrieval (MIR) são de grande importância para esta linha de trabalho uma vez que permitem que o sistema reconheça e se adapte mais livremente ao estilo musical de cada concerto.

# Acknowledgments

Some people contributed substantially to this research and enabled my growth both professionally and personally.

I'll start by thanking my Professor and Advisor Dr. Álvaro Barbosa for his pragmatism and extensive scientific knowledge towards enabling the completion of this research. I also want to thank the Director of the School of Arts, Professor Laura Castro, the Sound and Image Coordinator, Professor Luis Gustavo Martins, and the Director of the Doctoral Program in Science Technology and the Arts, Professor Paulo Ferreira-Lopes. I also want to thank my colleagues and former teachers Helder Dias and Cristina Sá who played a substantial role in the development of my interest in interactive arts.

To my classmates with whom I shared the office and many good times, André Baltazar, André Perrotta, João Cordeiro, Mailis Rodrigues e José Vasco Carvalho - Thank you!

I want to also thank all the experts who participated in the questionnaire allowing me to gather important data from the mobile app ALIVEART and from which I was able to draw important conclusions during this investigation. Thank you, Vinicius Vecchi for collaborating in the migration of the code to c++.

On a more personal side, I would like to thank Helena Figueiredo, Maria João Neves, Ana Luisa Santos, Joana Pestana e Sandra Ferreira for their friendship, affection and for giving me much needed support in my difficult moments that unfortunately coincided with the development of this thesis.

A special Thank you to my family, Maria Luisa Gomes and David Gomes who have always given me strength to continue and for their unconditional support, Without you, none of this would have been possible.

# TABLE OF CONTENTS

# List of Figures

# List of Tables

# Acronyms

AI: Artificial Intelligence

A-Life: Artificial Life

CA: Cellular Automata

DMI: Digital Music Instruments

FFT: Fast Fourier Transform

GA: Genetic Algorithm

GUI: Graphical User Interface

IUI : Intelligent User Interface

MIR : Music Information Retrieval

OSC: Open Sound Control

TUI: Tangible User Interface

VR: Virtual Reality;

# 1 Introduction

From the 60's, art and social cultural aspects underwent important changes. Artists rejected the traditional art practices and introduced new ideas which changed the way they produced art and what was considered art. Fluxus and Conceptual Art caused an even bigger cleavage between the new and old practices by introducing ideas that are the basis for art as we know it today. These ideas led to the use of new media and computers in art production in the 90's.

One of the biggest changes that happened during the 60's was the idea that art wasn't about the artifact, but about its ideas and process. Conceptual artists started exposing their instructions for the construction of a given artwork as the artwork itself. This process of separating the artist practices from the technical ones encouraged new art strategies and gave new meaning to the role of the artist. The process became the most important aspect of artistic practices.

In parallel, the idea of participation also emerged, in which the final artwork was not presented to the audience but instead was done collaboratively between the artist and the spectators. Many Fluxus artists engaged with their audience and constructed the artwork. These two ideas emphasize process over artifact but as we are going to see, they are the pillar of support of two very important contemporary practices: generativity and interactivity.

Through the introduction of interactive computer systems, these ideas gain form. Interactive systems coupled with semi-autonomous behavior based on rules established by the Computer are a step further over participation. Many contemporary artists developed such artworks and were able to demonstrate a new type of creativity that emerges from the three entities: the user, the artist and a generative system.

As a result, the relationship between artwork and artist changed. Art became interactive and gained the ability to change on its own. This changes reflected about the process of using this strategies (interactivity and generative processes) and not about the technical aspects involved in the creation of the artwork.

Many artworks used interactivity and generative processes to make the user rethink his own characteristic, others embraced these tactics to produce new aesthetical paradigms, but all had the same purpose of creating in the machine a semi-autonomous system that interacts with the audience producing an engaging experiences.

It is important to consider that many of these systems are trying to adapt to the user in a variety of possible ways (including by learning from by their previous behaviors or by analyzing their emotions through effective computing) but normally we can find artworks that are actually adapting to the generative system. This issue becomes highly relevant in live performances.

From our experience, it became clear that this adaptability from the interface in which is considered that the interaction is not happening to a static system, but instead, is happening to a generative one, is enhancing not only the system possibility of better expressing itself but is actually enhancing the performative art and the creative process created by the three entities.

From a series of experiences, we are able to propose a different way to interact in live performance, especially for generative graphics that react to sound input. As a result of this research, we developed an app for iOS mobile devices

ARTALIVE is a system that triggers generic graphics based on musical input. Depending on the features of the music, the graphics develop algorithmically through an artificial life system.

The behavior of these generative graphics can also be controlled by an interface that introduces another level of performance (beyond the musical performance) controlled by the visual artist. However, this interface also adapts to the musical features and the development of the a-live system.

This adaptive interface presents the visual performer with elements that can be controlled excluding the ones that are irrelevant at that moment, allowing more focus on the performative act.

By the development of such an interface, we hope to create innovative ways to develop interactive generative graphics. We hope that by changing the interaction we can change the relationship between user and the system and find a new space for collaboration where the creative act is shared in a fluid and comfortable way.

## 1.2 Motivation

From previous experience gained from developing generative systems for art, it was possible to verify the potential of such practices. Interesting innovative patterns emerged and new graphical aesthetics were discovered in the new systems.

During this time, we were able to develop a series of generative artworks, which ranged from interactive art installations to live performance. Considering the multiple possibilities of such practice, we applied our efforts in transgressing the limits of the digital by giving life to virtual entities. In our work, this life always wishes to get a form on this side of the window and be able to transgress its own virtuality.

Even though the characteristics and necessities of an interactive installation and a live performance are very different, we felt that in both cases, there was sufficient complexity in enabling the systems to express themselves. We couldn't actually fell the a-life system interfering in the actual world given it is normally badly expresses in the interface.

This inability to fully transgress the virtual into the actual world led us to believe that we weren't taking full advantage of capacities of such practice. Through all the work developed, we felt that even though generative art was a branch of artistic expression capable of expanding human capacities, this transgression is only going to be possible if we are really able to overstep these limitations of the interface creating ways to represent such systems.

## 1.3 Objective

Given the motivations identified, the objective of this research is to understand how we can establish a communication that is not only concerned in the characteristics of the user (here the research is more developed) but also concerned with the characteristics of the generative system. In recent times, the interface is constantly being developed to better understand its user, by learning from his previous choices or even by reading his emotions through Affective Computing. However, the current technology is not geared towards adapting the system.

Although user adaptive interfaces are a very important field of work, we have to realize that when we are dealing with a generative system, we also need to take into consideration, the system and its behaviors. We believe that the only way to really fulfill the goals of the generative art is by ensuring that the entire work in developed in a way that the system is adapting to both the living system (humans) and the virtual entities generated by the generative system.

Hence, the objective of this research is to find ways to use the maximum potential of the generative art by allowing the system to also influence the interaction. The goal is to develop an interface that is capable of adapting not only to the user but to the A-life system as well.

## 1.4 Methodology

During the research, we followed seven steps. Every one of them was essential to achieve the conclusions described in this document. They are:

1) Research problem formulation;

2) Literature review;

3) Preliminary research experiments;

4) Formulation of the objectives;

5) Experimental research project;

6) Analyses of the results and

7) Conclusions and future work.

As described in the previous sections, based on a series of works developed in the years prior to this research, we felt that interfaces for live performance weren't able to convey to the performer, the adequate characteristics when dealing with generative systems. Thus, we dedicated ourselves to identifying literature by other artists and researchers that could help us identify the best possible solution.

We dedicated ourselves to the study of generative art and interactivity, not restricting ourselves to live performances but addressing all areas where both these practices are prevalent. Through these efforts, we were able to comprehend contemporary art practices and creative processes and were also able of enunciate the state of the arts of both branches.

After reading and analyzing some proposals (that until today are still very limited), we performed a set of preliminary experiments to collect important information about our goals. From these experiments, we were able to formulate a set of elements that had to be necessarily represented in the proposed system.

Based on data extracted from the experiments, we were able to formulate the experimental research project (ARTALIVE). We opted for empirical research in which we distributed the developed mobile app to a set of 15 people. To obtain expert opinion, we selected only Performers, User Interface experts or Designers. Each one of those users was provided the app on their devices along with a brief description of the work and instructions. They were able to try the app for a whole week, followed by inquiry (see in APPENDIX A).

The results from the inquiry were populated into tables to conduct statistical analysis. The results support the proposal.

## 1.5 Main challenges

Some of our main challenges during this research were:

1) Achieving a balance between autonomy of the system and user interference, reinforcing the idea that the user is just interfering with the system, instead of changing the parameters as the user pleases or without making the user an irrelevant part of this system; and

2) Sound analysis.

An area of focus in this research is to determine means of using live system simulations to create interesting graphics. The key difficulty was not in achieving an appealing aesthetic but the development of something autonomous that the user can interfere without disrupting its autonomous nature. In most cases when dealing with generative systems, when the user interferes, he is actually transforming the results of the world in a very dictatorial way. Instead, we wanted to ensure that when user selects any parameters shown on the interface, he is only stimulating the system to change his trajectory. This change may or may not modify the system trajectory. Achieving this balance was one of our main challenges.

Another challenge that confronted us in the development of the first version of the app was with sound analysis. We wanted to ensure that different sound sources had different impact on the graphics since different sounds differ in their qualities. While working with laptop users and orchestras, we realized that sounds generated by different devices had very different quantity of harmonics. This identification of various sounds was harder than we first thought, leading us to significantly simplify the sound identification process.

## 1.6 Thesis Structure

This thesis has been constructed to enable the reader to easily navigate and understand the most relevant concepts and ideas related to this research.

Chapter 2 identifies generative art practices through the explanation of some key historical points including furthering the understanding of cultural and social changes in the 90's with the introduction of computers in the art practices. These changes had social impact by renewing the idea of artwork and the role of the artist.

Chapter 3 is an analysis of interactivity. We defined the interface as the most important element through which it is possible to establish communication with computers. We reviewed the evolution of the most relevant artwork interfaces and synthesized the ideas reflected in chapters 2 and 3.

While chapters 2 and 3 focus on literature review, the following chapters are dedicated to the experimental process. Chapter 4 analyzes four experiments developed during this research. Each experiment allowed us to identify the considerations when developing an adaptive user interface for live performance of generative graphics.

Based on discoveries per the experiments identified in chapter 4, we formulated a proposal describing the characteristics of the interface described at chapter 5.

Based on a working application, a series of tests were performed and carefully analyzed. Analysis of the data helped us deriving conclusions as well as the identification of future work to be done in this field ( chapter 6 and 7).

# 2 Historical Survey on Generative Art

> " Generative art is about the organic, the emergent, the beautiful, the imprecise, and the unexpected" (Pearson, 2011)

In generative art, the artist sets tasks to the machine, and establishes in the machine an extension of him/herself. Those extensions can be biological or psychological (McLuhan, 1994) (Benjamin, 1970) once the medium can establish actual physical extensions or it can allow the user access different possibilities in the artist him/herself. It provides a semi-autonomous system (Todd & Latham, 1994) (Whitelaw, 2004) where the artist can be the agent that selects or gives a program the ability to execute a selection through the rules he/she builds-in.

The relationship between art and science has always been very close and generative art is no exception valuing and bringing together these two domains. From principles of biology, where we can understand evolutionary concepts and selection principles (Dawkins, 2006), and the acquisition of the external process of the human comprehension, it allows the creation of artificial replicating structures that don't belong to the human domain.

Generative art is a branch of artistic practice that uses resources from biology, mathematics, physics and other scientific fields for its simulations such that are able to generate new paradigms that until then were beyond the artist's reach.

New characteristics such as learning, adaptation and mutations are typical of those systems. Normally, the most adapted ones perpetuate the skills more valuable and desired for the system in that moment (Holland, 1992).

The rules are the algorithms generated by the artists and the rules applied are the parameters that shape the behavior of a certain individual, population and habitat. But like in living beings those rules can be transgressed and the process reacts in a lot of different ways. This unpredictability, typical of complex systems (Gouyon, Barbosa, & Serra, 2009), gives the artist the possibility of action and results that are beyond the ones he is capable of comprehending through his natural systems of perception: vision, touch, smell, etc.

Thus, the processes and the relations between humans and machines become closer. The interactions become more fluid and adapted. The intelligence of some of those systems allows that each individual gets better responses to his/her/its and more evolved and optimized actions.

The changes due to the introduction of the computer in art practices led to significant changes in the contemporary world. These changes influenced important cultural aspects such the definition of artist and self. New relationships between computers, user and artists emerged opening the elements required for the development of important artworks.

Before digital media, Ben Laposky and John Whitney highlighted the capabilities of generative art. In digital media, tools like Processing (Fry & Reas, n.d.) and OpenFrameworks (Lieberman, Watson, & Castro, n.d.), brought artists and designers together in developing such projects. Artists popularized this art through graphic works (Joshua Davis and Casey Reas), sculptures (Marius Watz) and interactive installations/performances (Christa Sommerer and Laurent Mignonneau

(Sommerer & Mignonneau, 1999a) (Sommerer & Mignonneau, 1998), Golan Levin and Zachary Lieberman, Karsten Schmidt). The generative processes most often are not exposed to the eye of the beholder. Often these processes are embedded in the form of interaction with the artwork. Pattie Maes, Christa Sommerer, are artists who have created artworks based on generative processes.

## 2.1 Definitions

> "Some works pursue an absolute, self-sufficient autonomy;
> others use an appearance of autonomy to provoke empathy
> or raise questions about human agency" (Whitelaw, 2004)

The generative art is an art form widely known within contemporary arts and has gained increasing presence in the art world. Featuring works in several areas, the generative art is still very poorly understood by most people, mainly because it is so comprehensive and therefore its efficacy can be very difficult for a group meeting with very narrow parameters.

What is generative art? According to Philip Galanter "Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art." (Galanter, 2003) Galanter's definition is the most accepted. Galanter states that the difference between a generative artwork and any other computer program is in the artist's decision to cede part of its control over the piece to an external system.

The external influence of such practices and the rule based organization of this type of art is founded in the 60's artists. In conceptual art (Alberro & Stimson, 1999) the artist transfers the function of the construction of the object and decides to give instructions. Just like in the early days of conceptual art, where artists like Yoko Ono and Robert Barry defined letters with instructions as their artistic works, a generative artist define rules that are implemented by the computer.

In fact the term generative art is a definition that cannot be only related to technique (McCormack et al., 2014). It takes more than the form and rules to "build" the art object: it is the decisions of the artist on the results generated by the algorithm developed. One of the difficulties that emerge when trying to define this type of practice is the fact that generative processes can be used by designers, artists, architects, scientists, etc, creating a large number of varied outputs. This comprehensiveness causes complexity in grouping the various elements. The variety of possibilities causes elaborate questioning by the spectators. The possibility of uniting such diverse work in one branch, lead Galanter to also realize that: "what generative artists have in common is how they make their work, but not why they make their work or even why they choose to use generative systems in their art practice". (Galanter, 2003)

> "Contemporary new media artists use a-life in a variety of contexts, to a variety of ends: some works pursue an absolute, self-sufficient autonomy; others use an appearance of autonomy to provoke empathy or raise questions about human agency. Many of the artists using a-

> life strive for a supple, engaging form of interactivity and a work that draws the audience into an active relationship; others present aesthetic artifacts that arise through their own intense engagement with a-life processes." (Whitelaw, 2004)

These types of work played a significant role in the current definition of the role of creator / artist. While developing the code that generates the construction of the work, the artist's role is no longer direct and is quite distanced from the final work. As these systems gain their own life, the artist ends up losing total control over the subject, contrary to what was happening, for example, in more traditional forms of painting or in any other more traditional artistic technique.

> "Generative art redistributes traditional notions of authorship and intention, introducing autonomous processes and agents and allowing us to appreciate the systemic aspects of contemporary art production, exhibition and consumption from an illuminating perspective." (McCormack et al., 2014)

They produce, moreover, the small contours and surprisingly unpredictable results giving a special glow to the final object. The possibilities beyond human perception plus a few random acts are some of the reasons why these kinds of pieces expand (rather than reduce) the role of the artist. By introducing randomness the artist is also introducing humanizing art because it destroys the stiffness typical of computer programs

> "Randomness is often used to "humanize" or introduce variation and imperfections to an underlying rigid, deterministic process, as when a sequencer program plays back a musical score with slight random timing variations."(McCormack et al., 2014)

The artist gives life to something that has a relative autonomy, which allows the construction of an object within the parameters set. Despite the artist's distance from the work, he is the one that defines which images are to be presented to viewers. His distant perspective, almost like a god over his world, allows you to see it and understand it, permitting the selection for its best results. Despite the author's role to delegate tasks to the "machine", it ceases to have the leading role for the end result. In the case of digital arts such software becomes a kind of performative extension of the artist (Stelarc, 2007).

Another issue that causes some controversy over the generative art is the interest declared by some artists to do work where the only concern is aesthetics. The beauty in contemporary art was eventually perceived as an empty resource and devalued. The generative art found in the roots of pop art combined with electronic music led to the possibility of creating objects where the primary purpose is aesthetics. Generative art looks for natural forms and harmonies - where there is a return to nature or "nature like" approaches. Already Galanter said, "the universe itself is a generative system." (Galanter, 2003) Some pieces end up falling in the mistake of becoming "Art of screen savers."

Each generative work piece is unique for each performance. Artists from the 60's such John Cage always incorporated such features in their work, allowing a state of constant remaking / rethinking of the work. Despite the work being executed a thousand times, it always takes a new form. Everything depends on the purpose of the artist.

## 2.2 From Analog to Digital

The generative art is therefore a very broad field of art. Its main feature is using mechanisms external to the artist to achieve partly autonomous tasks following a set of rules defined by the author. Such concepts are not new. We can see the use of generative processes already for a few decades. Some works, despite being about 40 years old have results very close to generative digital art created in recent times. The contributions of major contemporary artists, Ben Laposky and John Whitney is paramount as they are considered the "fathers" of generative art for digital artists. Although many earlier artists (from Minimal, Conceptual and Fluxus) also developed some generative ideas, John and Ben were the first artists to really create art with this purpose.

The artist Ben Laposky (1914 - 2000), born in Cherokee, Iowa, was a mathematician, an artist and a pioneer in computer use in artwork. He was responsible for creating abstract images during the 50's. In his first experiments he used a device called analog oscilloscope Cathode Ray Tube (CRT). His work, called "oscillons," were beautiful mathematical curves based on the waves used in analog computers. The analog computers were first used in the 20's and were able to perform calculations much faster in a very short time. The technique for building the code was a continuous variation of current allowing calculations in "real time" (unlike the technique used today by digital computers that makes use of finite signals). In the 40's, analog computers began to be replaced by digital due to their affordability. The images produced were photographed, resulting in an interesting work that was both aesthetic and technical strong. It became an icon for those who appreciate the generative art because images were organic, elegant and yet simple.

Another very important example is the American animator John Whitney. He and his brother James started in the 40's to study moving images, working on that throughout his life. They managed to combine success in commercial work with more experimental work. One of the best-known works was the introduction of the film "Vertigo" by Alfred Hitchcock. In the 60's John formed a company, which specialized in making computer animations made for commercial purposes, an innovative strategy while still using an analog computer. In 1966, he began working on digital computers in residence at IBM that lasted three years. It was during his entire career as a constant innovator that led to increasing levels of complexity and to achieving what he called "harmonic progression."

Both these artists were extremely important for the development of generative processes, as was the potential they identified that charmed digital artists. The way we studied the movement and behavior of the particles was also essential in the study of visual processes generated through generative systems. Both, John Whitney and Ben Laposky are important references; especially for artists who seek proceeding harmonics based particles.

With the advent of computers, the generative processes emerged in different art practices. Artists like John Maeda, Marius Watts, Golan Levin, Zachary Lieberman, Ben Fry and Casey Reas, Joshua Davis and many more were responsible for popularizing it.

John Maeda and his colleagues in the Aesthetics + Computation Group (ACG) were the first to advocate the use of computers as a tool in creating objects of art and design. At that time many argued that the computer processes distort, easing through the copy-paste and other techniques, the creation process and thus generating failures caused by lack of process, intensity and rigor. Contrary to what the analog purists defended (including very prestigious graphic designers such as Paul Rand) that the computer brought to the arts important development that modified the processes of creation, John Maeda managed to make many of his students important artist, making them relevant in generative and interactive practices. They include: Golan Levin, Casey Reas and Ben Fry.

Marius Watz (Watz, n.d.-b) is a renowned creator of pieces in the area of generative art. He began working with software (to create visualization with code) in his early 20s after taking up a course in computer graphics. With the computer's graphical and computational ability, he began to develop projects for Raves while doing design projects. Working in different media, Watz left his mark on generative art's digital features for his aesthetic choices and their presentations in large formats (such as presented in Sao Paulo at the center "Itaú Cultural on July 18, 2006). Marius is the symbol of new artists who work with the new brushes of the digital age. While in some projects, he used sound as source of data, in others he appropriated data from the government to feed his system. In "Drawing Machines 1-12" (Watz, n.d.-a) Marius shows the flow of information in the server of the Norwegian government, distinguishing between micro and macro structures of information transfer. The result is a constantly changing construction with a visual result in 2D images. This project was developed in Odin, a public space, lasting two years.

Particularly interested in systems creation and manipulation of sound and images, Golan Levin created performances and innovative digital systems through dialogues between man and machine. He and his staff created highly innovative and aesthetic works, which went beyond the expected boundaries and interlinks of digital media.

A renowned artist, through the creation of many interactive and engaging works, Golan is responsible for making generative art a little more tactile and fun. With several recognized works, Levin created projects that go beyond the aesthetic. Based on extremely complex interactive processes, the artworks are transmitted to the user in a straightforward manner, without the need for much explanation.

Golan created projects that fulfilled all the vital aspects of a project. He is also known for his collaborations with famous artists such as Zachary Lieberman and Fry (among many others).

A 2003 performance entitled *Messa di Voce* (Levin, n.d.), which is a collaboration of Golan Levin, Zachary Lieberman, Jaap Blonk and Joan La Barbara, uses speech, shouts and music generated by two opera singers to create interactive visualizations. With an extremely interesting result in terms of communication between performers, this system is a reference in the field of art. Inspired by the relationship between the song lyric (from which is derived the name *Messa Di Voce*, a name given to a singing technique where there is a gradual crescendo and decrescendo always in the same pitch) and visual creation, the performers create a variety of particles ranging in terms of size and movement, which can then be changed again according to the settings of the artist on the forms previously created. During the performance artists were able to create different visual representations. This project resulted in an installation presented later also called “Messa di voce”.

Casey Reas, well known designer and artist is one of the creators of Processing (programming software for artists) and one of the pupils of John Maeda. He studied design at the University of Cincinnati, which he left for MIT where he studied with Maeda and met his co-worker Ben Fry.

His work is based on the construction of art objects by algorithms. Currently his works serves as reference to works of Conceptual Art such as Sol LeWitt, searching for concepts developed by the vanguards of the 60s as minimalism and conceptualism. With Structures (2004) (Artport, n.d.) he relates software art and conceptual art and arises the question: "Is the history of conceptual art relevant to the idea of software as art?" Having built three possible structures, Reas offers new interpretations. His colleague Ben Fry, on the other hand, explores generative practices in data visualization, resulting in new forms of data presentation.

Some important artworks are analyzed in chapter 3 for example, Interaction and Interfaces for Art. We will analyze this later because it is important for us to have a more detailed account of generative art that takes particular care in its interfaces. These interactivity characteristics are taken into account if they enhance the generative process by expanding on the concepts being developed here. Christa Sommerer and Laurent Mignonneau, Karls Sims, Kruger and others are a few artists, whose work will be elaborated upon later.

## 2.3 Some Generative Methods

### Complex vs. Simple

Although we discussed in the previous sections that generative art is not about technology or technical aspects, but about its process, it is relevant to this work to identify some of the strategies. We would like to emphasize that our approach in this thesis is dedicated to the use of generative practices specifically in Interactive Digital Arts.

To begin, we will distinguish complex and not so complex systems (chaotic and order). These concepts are important to understand the different degrees of autonomy of our generative system. In this description, we don't intend to qualify either of them.

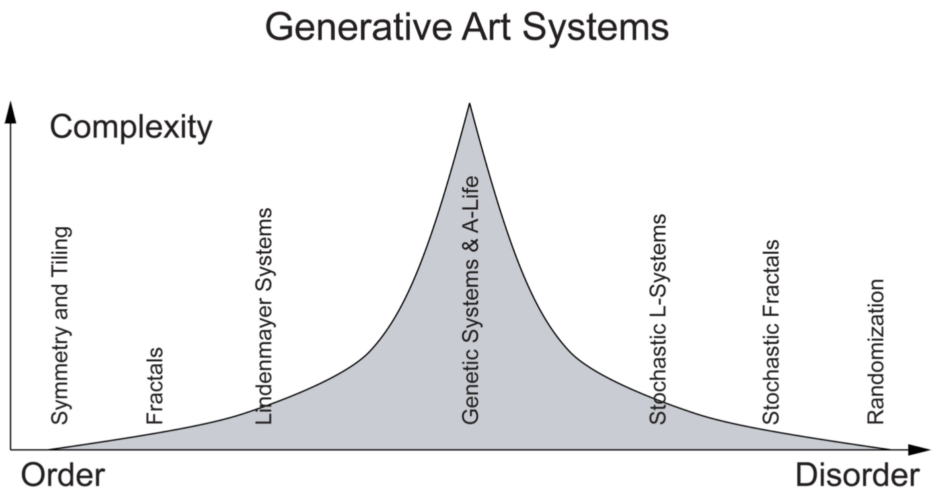
While simple systems normally have few components and their interactions generate a predictable response, complex systems have much higher number of elements and their interactions produce emergent characteristics (Burraston, 2007). In reality, we know that complex systems are the result of the interactions between simple systems in which unpredictable behaviors emerge.

Lets think about two concepts: something completely random (chaos) and something very organized (order). Both of them are considered simple systems because when we analyze a section of their behavior, we can relatively easily find its pattern (completely inexistent or extremely defined) (Galanter, 2003).

On the other hand, in Complex systems, the pattern is neither non-existent nor defined. They are somewhere in the middle, where events are a result of multiple interactions, generating transformations that most of the times are not immediate. We call this emergence: the interactions of simple components into the creation of complex behaviors.

In,Table 1 we can examine different types of methods and the relationship between order, disorder and complexity, where we conclude that every complex system needs a certain range of order (linearity) and Chaos (non-linearity) (Bedau & Humphreys, 2008)

Table 1 Graph that reveils different systems going from order to disorder and passing through complexity. (Flake, 1998)




> "Thus something almost entirely random, with practically no regularities, would have effective complexity near zero. So would something completely regular, such as a bit string consisting entirely of zeroes. Effective complexity can be high only a region intermediate between total order and complete disorder" (Flake, 1998)

In complex systems, some of the most used strategies in the arts are: genetic algorithms, swarming behavior, neural networks, cellular automata, L-systems, chaos, fractals and a-life. Each one of them differs in the degree of complexity. For the purpose of this research we will focus on one the most complex systems: A-Life. Although we understand that most of the time, adaptability is associated with Artificial Intelligence, we consider that A-life systems are more reliable given that they are based on existing models (Whitelaw, 2004) and for its bottom-up approach.

## A-Life

> "A-life regards the complex dynamics of living things across all scales as phenomena that arise from the interaction of multitudes of smaller elements." (Whitelaw, 2004)

A-Life art, as all other generative approaches, is a multidisciplinary field where scientific knowledge is applied to mimic living beings by the use of the computer. It is a research field defined by Christopher Langton based on the process of creating programs that evolve over time through the use of a computer.

Many of those methods can be seen in artworks. Some take this mimicry more literally, reinforcing the scientific apparatus behind the artwork and others don't, showing the artist's goal to transgress them. For most of them, it is a place where they can find the necessary elements to question our notion of life and at the same time, contravene the boundaries of the actual world into the virtual. It is a space for questioning while communicating the cultural and social changes generated by digital media.

> "Artificial Life techniques offer a new type of interactivity in which there is the potential for systems to respond in ways that have not been so explicitly defined. Unlike previous mimetic art practices, in this work the dynamics of biological systems are modeled more than their appearance. These works exhibit a new order of mimesis in which

> "nature" as a generative system, not an appearance is being represented." (Penny, 2009)

A-Life is the perfect place to unite technological, scientific and philosophical into an artwork while transgressing the boundaries between this two worlds (actual and virtual). It is the possibility of creating a complete system that plays and adapts itself that attracts artists to develop such artworks. It is an opportunity to dive into the nature and to get in touch with its parallel quality where its behaviors emerge.

The main goal isn't to replicate living beings but to use those rules that work in actual living beings and transgress them. It is a process that permits us to expand our boundaries and explore the insides of digital technology. It is a place where we can navigate and understand more about ourselves since this system can simulate many characteristics such social behaviors (swarms and agents based systems), genetic characteristics (Genetic Algorithms) and many others.

Use of A-life by artists started in the 90's. They were attracted by the conjuncture "when artists and theorist were struggling with the practical and theoretical implications of computing" (Penny, 2009). Some of the artists had the required knowledge, which permitted them to develop the first experimentations with the goal of better understanding this new era. For these artists, it was initially a struggle to understand the culture at a time of extreme changes. They started playing with such strategies and becoming interested in identifying some form of autonomous art. It was the promise of finding computation creativity that lead artists to start using such methods.

Through out these last twenty years, may different art works were developed. Each artwork explored artificial life in a very unique way. We have to remind ourselves that the most important part of these artworks is the process, not the final result or the technique they explore. From complete autonomy to assisted, from strictly realistic simulations to adapted systems, all these artworks mimic living systems with the goal of creating art. The most popular approaches in art are: Genetic Algorithms (GA); Agent-based systems and Cellular Automata (CA).

GA is a technique where the Genotype (code) represents itself into a Phenotype that gives form to a digital entity. Through reproduction and mutations new Genotypes and Phenotypes are generated and later selected by a fitness rule. The fitness rule is the most traditional way of evaluating the capacities of each individual according to what are the most wanted qualities in a given system. This strategy is used to generate a large range of new entities but is not adequate to achieve optimum choice.

Some cases of GA can get complex by transforming it into Agent-based systems through the use behaviors. These simulations are closer to an ecosystem since Agent-based systems introduce a dynamic between the elements of the system, in opposition to traditional GA that don't take into consideration the relationships of the system. These dynamics generate a global behavior (the behavior of the ecosystem) that characterizes this technique, ranging from more complex (the ones using genetic algorithms and complex behaviors) to less complex (typical predator/prey) (Whitelaw, 2004).

Cellular Automata is another example that is frequently used in the process of generating art with an artificial life system. CA is developed through the use of a grid in which the cells can be alive or dead over time. The surrounding cells dictates if the adjacent ones are alive or not. A variety of self-organized behaviors emerge dictated by rules, creating very interesting patterns. The most famous example of CA is Conway's Game of Life (Pearson, 2011).

Artists have chosen between these techniques primarily according to the conceptual aspects of the artwork. Each one of them produces very different results and represents different approaches to the process of creation of art. In other words, by choosing any of the previous techniques to simulate an artificial life, the artist is expressing his conceptual choices more than the actual technical features. If the theme of the work is more related with our traces of humanity, the artist will probably elect GA, while the artist that deals with social interactions will more likely prefer Agent-based systems. This practice allows the user, by its process, to reinforce the conceptual features of the artwork and not serve merely as a tool.

Independent of the system the artist chooses to use, the “why” which according to Gallanter is the common characteristic of all generative artists respected. All artworks, independent of the generative process, interactive or not and no matter which purpose it is developed, they maintain their main goal of establishing in the computer a semi autonomous behavior that goes beyond the artists choices. We took special attention describing a-life systems because it is the focus of our work.  Many other simpler approaches achieve amazing results as well.

## 2.4 Digital Creativity and A-Life

Generative art is constantly raising questions about originality, authorship and so on. We also observed that the first artificial life artists attempted to understand more about computational creativity. In this section, we will attempt to define our main characteristics of creativity in the practice of generative art.

One key characteristic that is normally associated with creativity is originality. Novelty can be achieved by different techniques and although we believe that in some cases, the process developed by the generative system is not sufficient to be called creative, we can still find shades of creativity being enhanced. Independent of whether this is a true creative system or one that is only enhancing human creativity, this collaboration between user/artist/artwork has changed artistic practices. These transformations are very important to understand the idea of self in the contemporaneity and the notion of art that emerges through the connection of these three elements, making them the focus of our research.

If we look into the human creativity we realize that although it is a process that seems to be focused on each individual, it is actually a very interactive process. According to Madhav Kidao, creativity is given by the interactions of cultural and social aspects in a certain community in which an expert validates possible creative responses. As we see can see, not even human creativity is a one-on-one process (Kidao, 2010).

With the introduction of the computers, contemporary society adopted to the new relationships that emerged from the new media. New cultural and social images were defined, allowing the construction a new contemporary Self in which creativity related to this new cultural aspects, the computer. Artists saw in computers the possibility to transgress and create new interrelations.

We believe that all generative artists are looking for ways to produce creative characteristics in the system.  While searching for ways to create these abilities, the artist is not looking forward to copy human creativity, but actually, he is searching for ways to implement new paradigms creatively. (Carvalhais, 2010) It is by ceding control and creating an iterative relationship between system, user and artist are creating a shared creativity. Depending on the characteristic of the system and its interactions with the artist, this shared creativity can be combinational or emergent[1].

Of course, the generative art is the starting point for this creativity since this practice allowed artists to have external systems that are able to generate artworks. Nevertheless generative process alone is not enough for emergence of new creativity. From what we have been analyzing, creativity is an iterative process between user, artist and system. Thus, to understand the real impact of computation practices in the contemporary art, we have also to understand the idea of interactivity.

> "Creation is no longer solely understood as an expression of the artist's inner creativity, but instead becomes an intrinsically dynamic process. Linking the interaction of human observers (visitors) directly to the dynamic and evolutionary image processes of an artwork allows us to create artworks that are under constant change and development." (Sommerer & Mignonneau, 1999b)

Along this line of thought, we are led to believe that the most important characteristic of contemporary creativity emerges from the interactivity of three elements: artist, system and user. Majority of the thinkers normally refer to an idea of computational creativity, but like we just

[1] Combinational creativity refers to a process in which new comunitations between known elements generate a new paradgm. Emergent criativity is when from othe paradgims emerge new ones. (Boden, 2004)

saw, creativity can achieve higher plane if human creativity and computational creativity is combined. By this, we are not diminishing the efforts of some artists to find a completely autonomous creative processes in the machine. Instead, we are proposing to enhance it by making this process an extension of the interrelations established by humans and computers.

These ideas shall be described in more detail in the next chapter where we discuss ideas related to interactivity and interfaces.

## 2.5 Conclusions on Generative Practices

Code provided almost magical power to artists enabling their expression in several different ways without depending on their drawing skills alone. By allowing generative practices in creation of artwork, the artist embraced the unexpected that enabled him to go beyond the human mind. The result is artworks that are focused on the process rather than the artifact. Hence, the artifacts are constantly changing due to the variations produced by the system. The generative process also prevents repetition thus making every presentation a new and unique experience.

We notice that the desire of the artist is to overcome their own limitations by finding in programming languages new ways to achieve new paradigms that exceed the things encrypted in the code (Whitelaw, 2004). They look for ways to embrace new communication while exploring the unknown.

While rethinking his own practices, the artists seek desirable abilities of the machine that he can collaborate with to enable his creation. The manner in which they use the generative in their artwork can vary significantly. Each artist that embraces this process of creativity is searching for a constant recreation of the piece, thus becoming an endless process where some decide to introduce interactivity and others don't.

> "(…) regarding agency, originality, creativity, authorship and intent in generative art. Clearly these concepts also impact how we understand art and the art world in general."
> (McCormack et al., 2014)

In the process of finding new ways to create artworks, artists also manage to transgress the traditional notions of creativity and art. Computers begin to demonstrate creative behaviors that the artist may decide to support or adopt. Thus, new complex artworks are developed, resulting in experimentation where humans seek to better understand living beings and their own relationships by the use of artificial life simulations.

A-life is the most popular approach adopted by artists. This process raises conceptual questions about the process of mimicking life because it deals ways to transgress the machine.

The possibility of using methods that are complex, an therefore, efficient in transgressing the limits of normal interactions, transforms the multiple choice type of interaction into a large range of possibilities that are mutating as time goes by.

Generative art practices gain more strength when associated with interactivity, which allows communication between all elements (user, artist and system). In the next chapter, we will introduce concepts of interactivity and relate them to the ideas addressed here.

# 3 Interaction and Interfaces for Art

To understand the purpose of this thesis, it is very important to understand all the ideas related to the interactivity and interfaces, since they have a major impact on the conceptual and the technical aspects of this work. We shall explore the history of the arts to better understand the context in which interactive art emerged, followed by an analysis of how those changes affected art practices.

We are going to start by defining what we understand about interactivity. We will look into paradigms of interaction followed by a description of the Interfaces allowing us to understand the role of the interface in those practices.

To exemplify these ideas, we will demonstrate advances in the interface by making a mention of the most relevant ones. We will focus on the interfaces that had an important role in construction and its future. The interface trends and its application in today's art practices will also be studied.

After analyzing some of the artwork most relevant to our field of study, we will formulate the concept of adaptive interface and introduce new paradigms in live performance of generative graphics.

It is out hope that through this chapter, we are able to understand the main concepts in this field of study and the most relevant artworks that have been developed. Our end goal is to substantiate the proposal of ALIVEART.

## 3.1 Formulating the concept of interactivity in Arts

The term “Interactivity” can be analyzed from multiple points of view. Being part of Technical and Social Sciences domain, it has been used most of the time in a loosely way. Given that it is a term we use frequently in our everyday lives and is a concept that applies to a variety of moments, it is important to clarify its effect on today’s art practices and its consequences on present society. In the process of becoming such a present idea on our lives, raise the necessity to clarify it, avoiding its trivialization and misuse. For us, it is important to dive into the process of development of interactive art, relating it with social and historical key points. By defining “interactivity” in arts, we expect to clarify some characteristics that are essential to this thesis and thus be able to formulate a proposal of an interface that responds to those necessities.

Unlike Andrea Zapp, we disagree with the purely technical approach. We attempt to deviate from the idea of “dynamic hands-on-experience”. On the contrary, we believe that interactivity has a major impact on today´s society and hence cannot be as trivial as a tool or a mechanism. For this reason we will look into interactivity not as a tool (Dixon, 2007), but as a process of reconfiguration of art.

To formulate the concept of interactivity, it is important to understand how this idea emerged. By comprehending the context we will be able to understand the changes that happened, artistically and technically, from the 1960’s, allowing us to realize the social landscape of those times. This landscape was an important aspect since it created the necessary conjuncture in which the first elements that defined participatory art emerged.  Participatory Art has created the conditions, along with technological advancements, to what we now understand about Interactive Art.

It wasn't until the 60's that artistic practices were drastically questioned. It was the beginning of very important changes in the artistic practices, where artists were trying to rupture from traditional values by questioning topics like the massification of the new media and consumerism. This necessity to break from established paradigms of art practices gave space to what we believe is the beginnings of interactive art, much before the digital technology emerged.

Viewer participation, acquired mostly by artistic movements in the 60´s challenged the notions of consumer/user and the artist, exploring new relationships between viewer/art and art/artist. Although previous artistic movements had already explored important aspects and were key elements in this process of rupture, the first participatory artworks were exhibited during Happenings and Fluxus (Sommerer, Jain, & Mignonneau, 2008).

Beside the social conjuncture and the necessity to break free from traditional values, participatory art seeks a solution for a strong necessity to engage with the audience, and by consequence, to make each experience more unique. This process of allowing intervention by the viewer gave space to new type of art that Umberto Eco calls "Open work of art" (Eco, 1989). One famous example of this type of artwork is the piece entitled 4'33 by John Cage where all the sounds of the concert are composed by sounds made by the audience. Like we saw in the previous chapter, this process of delegating part of the creative act also brings some unpredictably, adding to the artwork an external process of creation. This process in participatory art and generative art differs only on the type of the agent.

Thus, the idea of interactivity was present much before the technology emerged although it gained form substantially with the development of computers. Although the rupture happened in the 60's and it was already faced by concerns with the media, new technological advances allowed possibilities to transform from participatory art to interactive art made possible with the emergence of digital technologies and the need to communicate with the computer.

Accordingly to Peter Weibel, not only do these changes in the early 20th century reflect cultural and social changes but also constitute the transition from modernity to postmodernity (Weibel, 1996). We believe that these important changes in our society are a reflection of how these arts based on new media modified the relationship of the artist and the viewer, modifying not only the relationship between art and viewer but also modified people's experiences.

> "Electronic art moves art from an object-centered stage to a context- and observer-oriented one. In this way becomes a motor to change from modernity to postmodernity. The transition from closed, decision-defined and complete systems to open, non-defined and incomplete ones, from the world of necessity to a world of observer-driven variables, from mono-perspective to multiple perspective, from hegemony to pluralism, from text to context, from locality to non-locality, from totality to particularity, from objectivity to observer-relativity, from autonomy to co-variance, from the dictatorship of subjectivity to the immanent world of the machine." (Weibel, 1996)

Interactive art emerged as an outcome of this process. We will view interaction as a space of experimentation that has generative and open characteristics (Ridgway, 2004). David Rokeby expresses his concerns regarding this openness. He argued that most of the time, this interactivity is not as open as they first seem. He defends that although users like to think that they have endless options, they actually prefer to have a certain degree of limitation. According to him, the best interaction is achieved when users have fewer options and possibilities to chose from than is available to them.

> "It is ironic that wide-open interaction within a system that does not impose significant constraints is usually unsatisfying to the interactor. It is difficult to sense interaction in situations where one is simultaneously affecting all of the parameters." (Rokeby, 1996)

We assume that interactivity will be more or less open according to the artwork itself and will emerge from a rhythmic relation between artwork and user. Jaron Lanier defends that the most important characteristic of an interactive system is the rhythm of interaction. Although we don't agree completely with the augment, we concur with the concept of a process of communication that is more effective or less depending on its rhythm. This rhythm is created by several factors that will be further analyzed in the next section when we describe the interfaces.

The interactivity, beside being a communication between artwork/artist or artwork/user is also, and maybe foremost, a space for collaboration were user and piece are composed by its relations (Stern, 2011) where the performative act is as well part of the artwork. To guarantee that to happen interaction between artwork and user "should be easy to understand at the very beginning but also rich so that the visitor is able to continuously discover different levels of interactive experiences."

(Sommerer & Mignonneau, 1999b)

> "The contemporary artist-researchers who create what is called interactive art are concerned with how interactivity itself "matters," a relatively new concept in artistic creativity" (Rokeby, 1996)

This changes in the process of the creation of artworks is a result of change in social and technical paradigms that modified the process of experience and as Rokeby argues, these transformations in paradigms are not only a reflection of the social and technical aspects but also a representation of human desires to find ourselves through the engagement. (Rokeby, 1996).

> "Technology mirrors our desires; interactive technologies, in particular, reflect our desire to feel engaged. We feel increasingly insignificant, and so we desire the affirmation of being reflected; we are tired of the increasing burden of consciousness, and so we are willing to exchange it for this sense of affirmation"(Rokeby, 1996)

While clarifying concepts of interactivity, some authors try to classify the different types of interaction. Since we believe that interaction is related to the piece itself and its relationships, we won't try to systematize the interaction in those terms. In the next section, we shall review some of the most important interfaces developed.

## 3.2 The interface

> “The interface translates the operations between, the hardware, the software and the user. Even when internal operations in these entities are different. Since we are dealing with black boxes, we use an input and an output” (Sommerer et al., 2008)

Per our analysis in the previous section, interactivity is a process that happens between artist, artwork and user. This relation is only possible thanks to the interface.

Interfaces are part of our everyday life. They are present in any type of communication between systems that don’t “speak the same language”, like for instance turning on the light. They are a very important element of any interactive practice, and especially important to interactive art. In this section, we shall review some of the most important concepts related to interfaces, dedicating ourselves to understand its necessities in the application of today’s artistic practices. In addition to defining it, we will also analyze the most relevant artistic pieces when designing interfaces for live performance of generative interfaces.

Like we described in the previous section, interactivity modifies social cultural aspects because it changes the user experience. The experience of interaction is allowed by the interface, given that it is responsible for guaranteeing this relationship between systems that are strange to each other. This communication, that according to Christa Sommerer “translates operations between hardware, software and user” (Sommerer et al., 2008) or between natural and artificial (Sá, 2012) are essential to understand how Human – Machine interaction model our experiences and how it models our relationship with the artwork.

This interaction is very important since it is responsible for "social construction" since it is through interaction that today's society is creating new meanings. This means artworks are generated in this malleable space (Sommerer et al., 2008) of construction of the communication we call interface.

The interface is malleable and dynamic (Sá, 2012) because it is in constant adaptation given its endless necessity to became more transparent and more opaque in every interaction. Like Cristina argues, a completely transparent interface is very natural because we tend not to feel it. Natural comes with signs that are already incorporated. But humans need to perceive their impact into what they are acting upon and that is achieved through the reflection of the user. If the interface is completely transparent, the user won't perceive his actions thus losing interest and engagement. Thus, transparency allows the user to dive into the art piece, while the opacity reflects his presence and promotes his engagement.

> "A sua plasticidade confere-lhe a capacidade de moldagem dinâmica e a possibilidade de composição e manipulação molecular – a técnica de encapsulamento permite-lhe acolher heterogeneidades no seu texto sem prejuízo da sua unidade." (Sá, 2012)

This constant remodeling of the interface into something more opaque or something more transparent creates a rhythm between artwork and user.

This rhythm creates in the interaction, a space of construction of the experience and new meanings to the self and its construction.

These new meanings generated by the interface and, therefore, by the interaction, is a process where the user establishes new relations with things that aren't present in the real world. This process enables the user and the artist to exceed his own capabilities and enhance them.

This knowledge is the result of a process where the user employs his previous experiences in the next artwork. This iterative process is part of the interface and gives access to the artwork by transforming the relationship between art and artist, amplifying his own understanding of the reality.

After analyzing five artworks that represent the most important characteristics to our research, we shall attempt to identify the type of interface that can group all these elements. The results will allow us to propose (in Chapter 5) a new interaction paradigm for live generative graphics. We will first start by reviewing the first interactive artworks and their interfaces and then looking into interactive pieces that introduced generative aesthetics. To conclude, we will discuss two artworks that changed the relationship of the art object with the user by making it possible to adapt the artwork to the visitor.

Many types of interactivity are established through different user interfaces. TUI, GUI, IUI and NUI are few of the most discussed and analyzed art practices. Each one has it advantages according to the type of artwork. Based on conclusions derived from analysis of artwork, we will focus on IUI, more specifically Adaptive User Interfaces. In the next section, we will be able to describe it and conclude why such interfaces can be of great benefit to live generative performance.

## 3.3 Most Relevant Examples of Interactive Artworks

In this section, we will review some relevant interactive artworks following a chronological order. We will make a brief description of each of the artworks followed by an analysis of its importance for the interactive art practices, in general, and for this research in particular.

The selection of artworks was made in accordance to the characteristics we think are important for this research. Each artwork has very important contributions to different aspects of this research and will eventually support our final proposition.

We shall start with interactive installation. We chose VIDEOPLACE, an artwork inserted in the series "Responsive Environments" developed by Myron Krueger as the first piece for analysis. It is one of the first examples of interactive art and was important in defining VR's first ideas.

The following work is A-Volve by Christa Sommerer and Laurent Mignonneau. It isn't the first generative installation but is very relevant due to the manner in which the interaction was thought and how the A-life system interacted with the user. The use of multi-touch interaction and how the user interfered in the a-life system are our main focus.

Galapagos by Karl Sims is a very famous artwork in which the computation creativity is reflected through the creation of visual simulations that were selected according to the interest of the visitor. The large autonomy given to the system and the role given to the visitor as selector of the most attractive compositions were very innovative concepts that had a major impact in these practices.

Boundary Functions is an artwork developed by Scott Snibbe and was selected given how the interface is designed. It is an artwork that is able to make users think about their interactions and rethink of himself in a very engaging and easy manner. It served as a huge inspiration in the manner we decided to divide the areas of the interaction on ALIVEART.

Lastly, we describe the work Bion by Adam Brown and Andrew Fagg. We took special attention to this piece due to the manner in which the simulation of an ecosystem reacts to the visitor that comes into the installation. It is important to note that Bions reacts to the user and changes itself by changing their behavior as an ecosystem.

Through all this artwork, we plan to understand different approaches to the concepts we have been developing so far, assisting us to find the best possible solution for this research project. Many other artworks were rejected mainly due to their non-interactive generative artworks, since our main goal here is comprehend these systems according to the interaction and not just their generative art or computational creativity. It is important to see how interactivity reinforces the relations between the system and the user and how other artists did it.

### 3.3.1 VIDEOPLACE (1974)

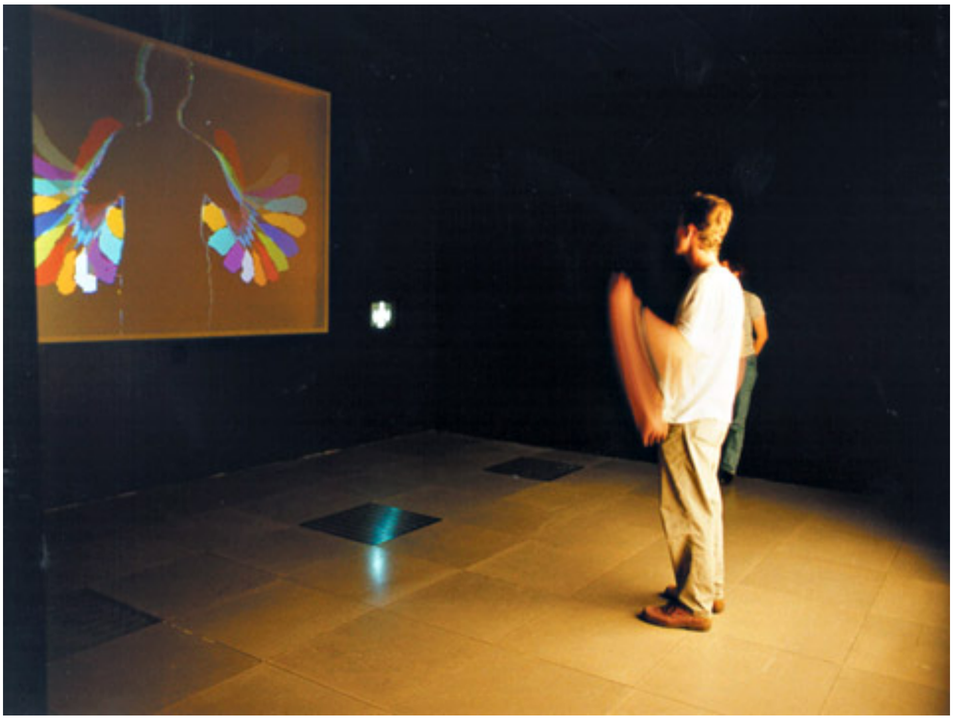


Figure 1 VIDEOPLACE picture taken from:
http://thedigitalage.pbworks.com/w/page/22039083/Myron%20Krueger (22/10/2014)

In 1974, Myron Krueger created a group of projects where the participants interacted with the computer through an audiovisual medium called "Responsive Environments". One of his most famous pieces, Videoplace, consisted of a simulation of virtual realty. It was the first artwork to deal with such subjects. It constituted projectors, cameras, and a screen.

In VIDEOPLACE, the user's body is displayed in a graphic world made by the juxtaposition of his body image and the graphical objects on the screen. This body representation was allowed by a computer vision system in which body and graphics interaction created the illusion of modifying themselves (Wexelblat, 1993). Since the number of environments and users could vary, users from different locations could interact with each other without physical proximity.

Kruger was a pioneer in the creation of full body interaction, and is considered the first artist to deal with the idea of Virtual Reality (VR). At the time, he called it “Artificial Reality”. His developments not only brought engaging new interactive artworks but also altered the notion of space and body by allowing user to use their whole body to interact with the computer and users that were in different places. This series was very important for introducing new paradigms of interaction between user and computer.

Kruger was really interested in the capabilities of the medium and how it can change the art practices. His innovative view of the art and how users can interact in different locations is very popular today. It has completely changed the way we perceive space, thus introducing the idea of virtuality (Krueger, Gionfriddo, & Hinrichsen, 1985).

In our research, this artwork is very relevant given the role it had in the development of today’s interactive art, and the role it played in the emergence of virtuality concepts.

### 3.3.2 A-Volve (1994)


Figure 2 A-volve image taken from http://musicasc.com.br/noticia/mercado-udesc-recebe-artistas-de-renome-internacional-para-palestra-sobre-arte-ciencia-e-tecnologia/ (22/10/2014)

Developed by Christa Sommerer and Laurent Mignonneau, A-Volve is an interactive art installation where users can interact an a-life system by creating new living beings or by interacting with existing ones.

Both these artists have always explored the boundaries of art by introducing new paradigms in terms of interaction and as well as in the manner in which the artwork unfolds during interaction. It was a very challenging task to choose amongst the work these artists have developed since they've had a major impact in interactive and generative art. We decided to choose A-Volve given how the user influences the a-life system.

Through a multi-touch screen that simulates an aquarium, Christa and Laurant invite users to draw artificial creatures. Each time a user draws something on the screen a new creature is created, gaining life in the virtual aquarium. Their physical characteristic given by the forms drawn on the multi-touch surface, dictates their abilities to swim and therefore its capacity to survive and be fit.

The more fit a creature is, higher is the probability to have more energy and reproduce. The energy is determined by the amount of food they get: the strongest (predator) creatures win the dispute and eat the weaker ones (prey). The user can interfere in this process by protecting the weaker creature. When two strong creatures meet, they mate, generating by crossover and mutation, new creatures. These new creatures created by the a-life system can interact with the ones drawn by the user. (Sommerer & Mignonneau, 1999b)

Like we saw through this chapter, this new way of interactivity completely changed the way we look at art as well as the introduction of generative process. It is a clear example that art looks for interactivity to establish new connections to the user but also looks for autonomous systems to be a part of this creation. The interface brings these three elements together and guarantees that all these different entities are able to work together to create an artwork. It is an artwork that is the result of the interference of the a-life system and user.

For our research, it is really important to understand how these two systems (humans and a-life) coexist and influence each other without dictating over each other.

### 3.3.3 Galapagos (1997)

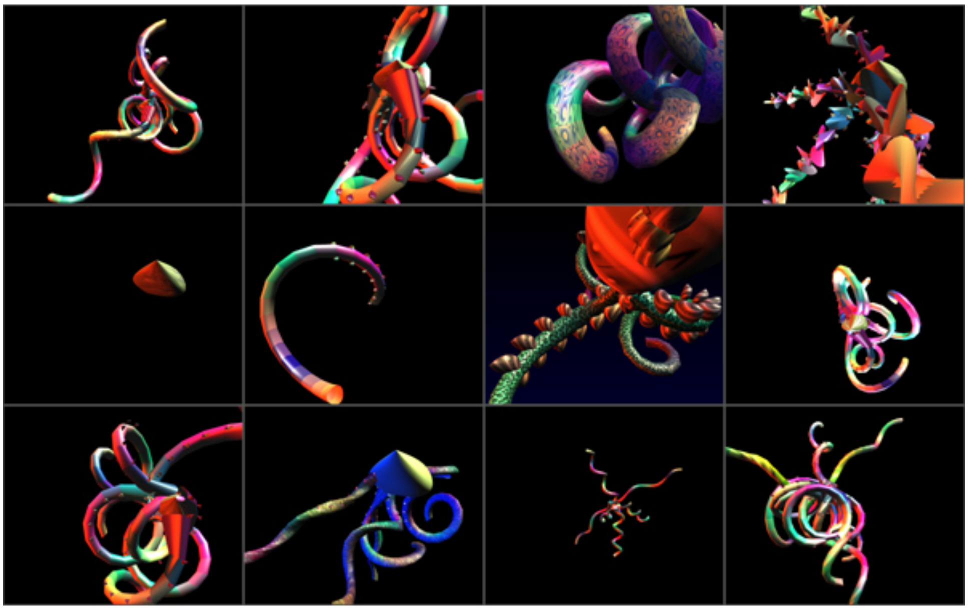


Figure 3: Different outcomes generated by the system. Taken from http://www.generativeart.com/on/cic/papersGA2004/3.htm (22/10/2014)

Galápagos is an interactive artwork based on a genetic algorithm and inspired by Darwin's law of evolution. Each of the Computer generated images has genotype and phenotype characteristics and are presented in a series of screens distributed in an arc across the exhibition room. On the floor in front of every screen, there is a sensor that detects the amount of time each user stands in front of it. The screens in front of which a user stands more time, is the one the artists considers to have a higher fitness (more visually interesting) and chance of survival. The ones to which the users didn't pay much attention end up dying. Through crossover and mutations the surviving images generate new images. The resulting images some times are better then their parents and at other times, they aren't. A new process of selection begins and new individuals and the parents again go through an evaluation process by the users.

Through this process, Karls Sims simulates a living system in which he searches for the best computer generated image. According to him:

> “This process of interactive evolution can be of interest for two reasons. First, it has potential as a tool that can produce results that can not be produced in any other way, and second, it provides a unique method for studying evolutionary systems.” (Sims, n.d.)

We find this artwork especially important for interactive generative art practices because it confronts the user with this potential of the computer to create images by itself. The user interaction is only needed as it creates the fitness rule. The fitness rule is the result of a collaborative process in which all users that enter the installation construct together. The creation of the image is a computational process in which the artist doesn’t have any type of control.

This project is not only changing the way the an artist creates his images or the relations between system and user but is also amplifying the possibilities of creative practices by transgressing human design limitations and by forcing a collaboration between users to define the best aesthetics for these images.

### 3.3.4 Boundary Functions (1998)

Figure 4: Picture take of Boundary Functions
fromhttp://www.snibbe.com/projects/interactive/boundaryfunctions/ (22/10/2014)

Developed in 1998 by the German artist Scott Snibbe, Boundary Functions is an interactive Art Installation where the artist obliges the user to rethink his notion of personal space (Snibbe, n.d.).

The installation consists in a selected area on the floor in which a line is projected every time someone enters. The lines are drawn according to Voronoi diagrams in which the space is divided in equal areas depending on the number of users in the interaction zone. These diagrams spontaneously occur at all scales of nature, being present in every natural system and are interesting and natural metaphor to the division of interactive artworks.

The users are detected by a computer vision system where a camera and projector are fixed on the ceiling on top of the users. Since this installation is concerned with the relationship between users and their space, the installation only works when two or more persons enter.

By creating the diagram on the floor the artist hopes to make the users rethink their relationships by realizing that their notion of space is always related to the others surrounding them. In other words, the notion of self is given by the interaction, resulting in a very dynamic artwork where the lines move according to the user movement and to the interactions between them.

Another interesting thing about this artwork is the fact that it relates these natural generative qualities of the natural world by simulating divisions inspired on the Voronoi diagrams, passing on to the virtual some of the real world characteristics.

The notion, that by establishing interconnections between users, we are defining each on of them is a very important and relevant way to discuss the process of interactivity. It is also a nice example of how the interface can adapt itself according to the user. The interface and artwork are one. These characteristics are relevant to the work we are developing in this research making it a big reference through the development of our interface.

Scott Snibbe since then has been developing very interesting sound apps for mobile devices. He has been working with artists such as Bjork, Metric and Philip Glass in the creation of interactive music applications in which the user can interact with these musicians' works. Another interesting work developed by Scott Snibbe's studio is an app called MotionPhone in which the user can create live animations.

### 3.3.5 Bion (2006)

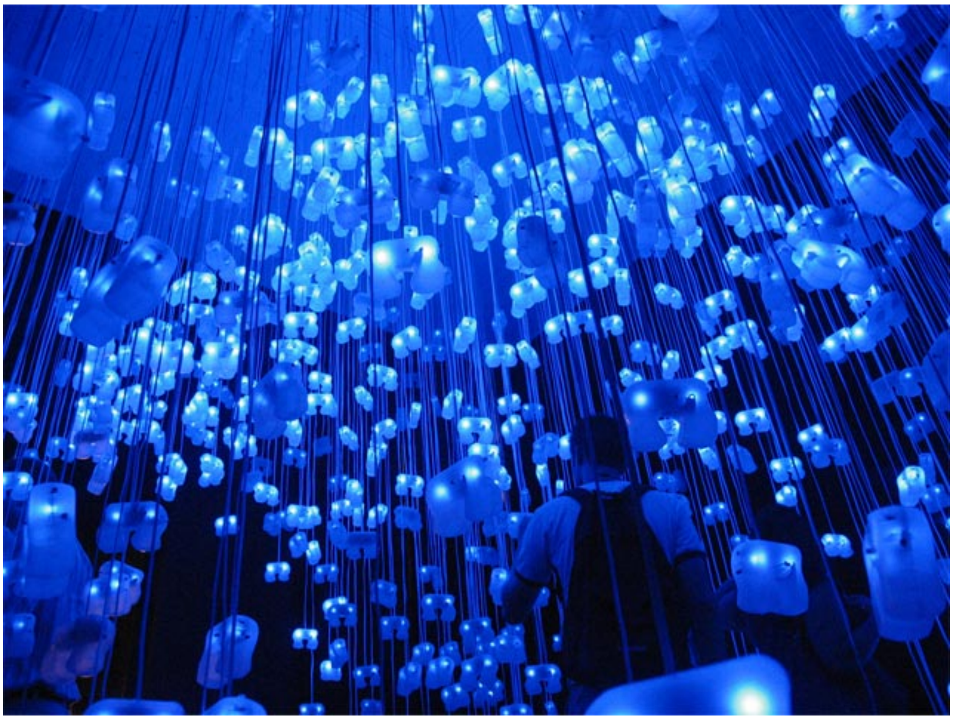


Figure 5: Bion taken from http://www-symbiotic.cs.ou.edu/projects/bion/ (22/10/2014)

Bion is an interactive art installation developed in 2006 by Adam Brown and Andrew Fagg where an artificial ecosystem is reproduced under the form of blue creatures suspended from the ceiling. Each one of the individuals from this a-life system produces sounds and light, creating their own behavior and communication.

Hundreds of Bions are composed in an ecosystem where each one of them is made from 4x3x2 ½ inches semi transparent plastic which are filled with LEDs, speakers and sensors. The sounds and flickers of light establish their communication that change according to the presence of the visitor.

Their disposition allows users to navigate through them. When the sensors detect approximation from any living being, the Bions change their behavior and communicate amongst them. Their responses change through time, according their familiarity to the new entity (visitor) until it is completely incorporated.

This interactive artwork shows us very interesting approach to interactive a-life systems by making the presence of the user change its responses. By allowing the system to have an autonomous adaptation to the entry of a new entity, we are creating a different paradigm of interaction where the user is not taking the decision over the a-life, but instead is having an impact thus modifying the relationships and promoting new interactions.

We believe this approach is very appealing specially when interacting with systems that simulate living beings. If we want their autonomy, it seems contradictory to oblige it to have parameters that can be changed at any time by the user. Instead we believe that a-life systems should suffer some influence by the user that the system can choose to adopt or not.

### 3.3.6 Final Considerations about the Projects

During the analysis of these five artworks, we took important references to our research. We were able to understand how previous artworks were able to represent in their work, some of our concerns.

We began with artworks that were very important in defining the first ideas about interactive art and virtual reality and with artworks that introduced the artificial life in the process of creation of a complete artwork. We saw how these artworks were able to respond in interesting ways in which a user could communicate with the computer by developing interfaces that responded the necessity of each artwork. The way Christa and Laurant emphasized the necessary metaphors to establish in the user, a sense of natural in dealing with artificial life creatures made us realize that the boundaries of virtual and actual were modeled on relationships established between them.

Artworks such Galapagos reinforced the idea of computational creativity, with the advantage of keeping the user in the loop. He was able, through this almost unconscious interaction, to create a collaborative notion of human rules to computational aesthetics. His choice of making a process defined by all visitors instead of his own decisions supported what we believe is the goal of every interactive artwork.

In Bion, we were able to identify ways in which the system can treat interaction and respond to it according to some reformulation of the system itself. We leave the actual interaction in which the user manipulates or controls the system into a interaction that suggest options and the system is able to respond to it, adapting his responses to it.

In Boundary Functions, we identified a way to establish relations in a system that is always changing, without making it completely chaotic by limiting the configuration of the space of interaction.

These ideas helped us articulate a possible solution to the type of interface that would better suit the relationship between an a-life system and user in a live performance of generative visuals. We need an interface in which the a-life system is able to express itself.

## 3.4 A New Approach to Adaptive Interfaces

During this process of analyzing the generative processes and the interaction, we realized that for this research we should dedicate ourselves to the study of a particular type of interface. As established in the previous sections, interaction is very important. Its most important quality is the capacity of creating significance to the artwork, to the user, and to our experience in the world.

This means that the type of interface changes our experience and by that the meaning associated with each experience. The way we chose to engage with the user and the information we decide to share from the system, constructs the formulation of significance of each artwork.

Given the proposition of this research, we decided that we should focus our attention on adaptive interfaces. This field of research is normally classified as Artificial Intelligence and is concerned with the creation of a system that can be modified according to each user's practices.

### 3.4.1 Main concepts and applicability

An interface is adaptive when it has the ability, through some system of intelligence and pattern recognition, to facilitate the user task, making the interaction of the user easier with the system. According to Edward Ross, adaptive interfaces improve the relationship between user and system based on a method in which is constructed the ability to recognize patterns from each user choices while interacting with it (Ross, 2000). These interfaces are able to modify their structure, contents and elements depending of the user necessities and capacities.

> "An adaptive user interface is an interactive software system that improves its ability to interact with the user based on partial experience with the user" (Langley & Simon, 1995)

Each time, the amount of the information we receive is larger. The online market is replete with options and each time, the user has increasing difficulty in selecting from amongst the available options. However, fundamentally, users are different; each one that accesses a store or a newspaper online tends to make different choices. These varied choices make every user unique. The ability to distinguish each user's characteristics to enable the user while making a selection helps him achieve his goals faster and the service to get more satisfied clients. This is the principle of adaptive interfaces applied in our everyday life.

There are different ways and different aspects by which the interface can adapt to the user. Some are more complex than others in the way they adapt to the user behavior and choices, but all of them look for ways to best engage with the user by facilitating his decisions or his making his path more direct.  The balance between the automation of such modifications is a key element for making the interaction satisfactory for the user. (Gajos, Czerwinski, Tan, Weld, & Way, 2006).

Greenberg and Witten presented the first successful adaptive interface in 1985, followed by the very critiqued interface in 1989 by Mitchell and Shneiderman. (Gajos et al., 2006). The poor user response destroyed the hype thus providing endorsement to static interfaces over adaptive interfaces.

In recent times, again, adaptive interfaces seem to be perceived as the future of interaction, especially for the web. The developments in this field over the past 20 years since Langley defined machine learning (Langley & Simon, 1995) weren't as great as expected. Most examples can be found in online stores (such as Amazon), operating systems (Windows 2000) and some medical software (Jameson, 2007).

The potential of such interfaces is enormous. Each time, the technology is more capable of generating ways to learn better from its users. Affective Computing is an area of research that has been given tremendous support for these interfaces by interpreting the user will by interpreting human emotions through interpretation of facial expressions (Nasoz, Lisetti, & Vasilakos, 2010). Eye tracking technologies are being implemented to recognize eye patterns to ensure that the amount of information being presented is sufficient or needs to vary in a determinate area (Steichen, Carenini, & Conati, 2013). Some adaptation in gesture recognition tries to comprehend body movements over different moments of a performance (Caramiaux, Montecchio, Tanaka, & Bevilacqua, 2014).

One of the qualities of these interfaces is the capacity to detect common and predictable chores and make them accessible. Another benefit of such type of interface is helping the user by providing the best solutions or options thus teaching him. By pattern recognition, these interfaces can predict actions and act on themselves. It can also change the graphical setup or the information presented. All these capacities are very interesting when dealing with such a variety of users and information.

However, the ability to predict choices and modify information can be dangerous as well. Some adaptive interfaces are pleasing and other become unbearable to work with. The most common problems in interfaces that make the interaction frustrating are: 1) total unpredictability of the interface; 2) too many changes regarding the navigation or information; 3) choices that make the user unable to experiment outside his previous choices.

Per our observations in the previous sections, we need to recognize the interface and we need to identify ourselves on it. By making too many changes, the interface can lose its sense of know and thus make the user's interaction very frustrating. In some cases, the information flow and /or content is changing too rapidly. Also, sometimes the user cannot find anything new to discover because all his previous interactions led to one direction. The lack of novelty makes the interaction dull and limiting thus preventing exploration.

Simplification of the interface seems more and more difficult with the possibilities of information and type of users. This simplification is a required strategy to improve ubiquitous computing by allowing the user to have a more natural interaction with the system. These interfaces aim to make their interactions easier and dedicated to each user's necessity and individuality. Thus the user can achieve his goal more easily or due to the content, he feels more inclined to explore. All these concerns are dedicated to the user.

### 3.4.2 Adaptive vs adaptable

Although it seems this type of interface can be of great use to artists and live performers, there is not much sign of its use..

Even though the practices of visual and sound performance have changed profoundly in the past few years, not many changes can be seem in the way artists choose to interact live with their system. From more independent to a commercial approach, the interfaces have only acquired the capacity to be adaptable and not adaptive.

To start, we will differentiate adaptable and adaptive interfaces. It is very important to make this differentiation since it defines the agent of modification of the interface. While in an adaptive system, the software translates the user previous choices, being the software the agent responsible for the interface adaptation, adaptable interfaces allow the user to configure certain parameters in a way that suit his personal necessities. (Jameson, 2007)

Adaptive and Adaptable are very different approaches although the goal of both approaches is to improve user relationship with the system. In some cases both approaches work together being at the same time an adaptive and adaptable interface, by making automatic changes and suggesting some for the user to do himself.

> "One promising application of both adaptable and adaptive methods involves taking into account special perceptual or physical impairments of individual users so as to allow them to use a system more efficiently, with minimal errors and frustration" (Jameson, 2007)

It is more common for commercial applications to be adaptable interfaces. In some of these applications, the user can setup their interface according to the most used tools or their best arrangement on the available space.

Although the goal of making the software interface adaptable is to give more comfort to the users, they are still very closed into themselves. They don't offer something new or any new proposition to the user during the performance.

By concluding that most live performance software do not adapt to the user, we see the need for exploration of better live experience especially when dealing with systems that are producing new content on the go or changing their level of importance, like we saw in generative art practices.

## 3.5 Conclusion on Interactivity

In this chapter we reviewed the emergence of interactivity and the consequences in terms of creative practices. We also understood the importance of the interface and analyzed some of the most important examples from the 90's until today.

In this process, we realized that interactivity in the arts has in itself the quality of delegating part of the creative process from the artist to the user and also changing its dynamic. It is also evident that while interactivity brought about many changes, the use of generative processes also had a big impact on the new creative processes, and thus was also responsible for changing the relationship between artist and artwork.

Both, generative practices and interactivity have a special impact on the creation of Art and in its relations. In conjuncture, interactivity and generative process can be a space of genuine innovative creative practices for art. By uniting both ways to engage in new forms of creative practices to bring the creative process to the artwork can extrapolate this idea of the machine as an extension of the human.

> "Interactive artists are engaged in changing the relationship between artists and their media, and between artworks and their audience. These changes tend to increase the extent of the audience's role in the artwork, loosening the authority of the author or creator. Rather than creating finished works, the interactive artist creates relationships. The ability to represent relationships in a

> functional way adds significantly to the expressive palette available to artists." (Rokeby, 1996)

We hope that this generative practice can produce not only new graphic or sound output but can also change interactivity in itself. We expect that the generative practices can change even the way we interact with the machine by allowing the system to express itself not only artistically but in the interface as well.

We propose that more than generative ideas, we evaluate a process in which these systems are able to express themselves in the construction of the experience. More than using generative practices to produce content, we hope to incorporate this process in the interaction, allowing the computer to propose new relations and establishing new paradigms that are not present in the human domain. Is our goal to express generative process not as a static creative process, but instead an iterant communication between system and interface and interface and user. This collaboration between system, user and artist will gain its higher expression through the creation of an interface that is capable of synthesizing all these expressions.

In the next chapter, we will analyze some projects developed through this research. Each one of this experiments led us to important information regarding how ideas of an adaptive interface and generative graphics could best be implemented. Our experimental project is titled ALIVEART.

# 4 Preliminary Experimental Developments

During the development of the practical research, four art pieces were created with the goal of providing experimental prototypes that address the formulated proposition of this thesis. These pieces were designed to explore different fields of artistic creation in the production of generative visuals and in parallel understand the missing links in the interaction between performer and system in live performance. Choosing different types of sound sources, concert setup and parameters of the generative systems, gave us the information required to develop an interface to adapt to entirely different situations. Taking into account each one of those pieces and their limitations, provided us a better understanding of the impact of these characteristics when considering the live interaction of a performer with a generative system with sound input.

This chapter is organized in a way we could establish, in a clear view, problems of interaction in a live performance, with a generative system, and expose the type of data that is more relevant for each approach. Thereunto we are going to describe each aspect of the most relevant pieces, starting with Untitled*, followed by *2+n*, *Fantasia sobre Fantasia* and finishing with *The Grinch.*

The first piece we are going to analyze in this chapter is an interactive installation/performative tool called *Untitled**. This piece is especially dedicated to tangible interaction with a generative system in an installation/performative model. From the experience of developing and interacting with this piece, we were able to define important aspects of tangible interaction. It was an important starting point for the other three pieces given that it established the type of the interaction for all the other pieces thus making it possible to focus on defining the generative system itself.

After *Untitled** we shall focus on three concerts. The first performance is **“**2+n**”**. It was the first concert in this context and it had the participation of two other musicians. In “2+n”, the main idea was to explore the visual generative creativity when working with musicians that only produce computer generated and systemized music. Beside the traditional sound input, the musicians shared data with the visual artist through Open Sound Control (OSC). This protocol (Wright, 2005) allowed the visual artist to access certain generative processes used by the musicians and to experiment with them in real-time. This setup with multiple inputs of data distinguished this piece from the other two.

The third concert, The Grinch was the first to experiment with different musical instruments. Composed by a group of researchers of CITAR, the main goal of FVLC (Formação Variavel de Laptopers do Citar) was to understand how we could create a piece that had a unity despite all the different elements being produced by those instruments. The control given to the visual performer was a challenge in a sense of how to organize all information (being generated and received) since each instrument had it own requirements.

“*Fantasia sobre Fantasia*” was presented at Casa da Música with their Symphonic Orchestra. In this concert, the challenge was to achieve interesting graphics based on the sound mass created by the Orchestra and the complexity entailed by it. In this performance, the focus on the sound analysis had to be completely different from the other two concerts since the relevant aspects of computer generated and acoustic music differ in a way that the parsing of the sound could never be the same.

To understand the necessities of visual live performance was important to explore different contexts of live performance and with different sets of data. In a field where there are enormous possibilities, the decision made on each parameter affected the piece in ways that had to be taken into account when proposing an interface that could deal with all that variety of context and data. From these four experiences, we were able to take the key points to be valued in the development of the adaptive interface ARTALIVE. These series of projects exposed a variety of concert setups and sound sources: from computer generated or computer synthesized to acoustic music and from multiple type of inputs or just one source. Each concert created the experience needed to formulate a question for this research and to emphasize the questions most appropriate for an initial prototype of an adaptive interface for live performance.

After the description of the pieces, we will analyze them (individually and as a whole), to derive the guidelines and characteristics for a new adaptive interface for live generative graphics.

## 4.1 Untitled*

Figure 6 UNTITLED* during exhibition at Serralves 2009

Developed originally at the Music Technology Group (MTG), at Universitat Pompeu Fabra, along with the creators of *reacTable* (Jordà, Geiger, Kaltenbrunner, & Alonso, 2007) and later at the Research Centre in Science and Technology of the Arts (CITAR) at Portuguese Catholic University of Oporto, this project is an interactive installation/ performative tool based on a generative system fed by sound input.

This artwork originated from the need to create an engaging and fun experience to investigate interactivity from the viewpoint of multiple users. From the necessity of experimenting with generative practices arose an installation that is both an experimentation of forms, colors and their composition, as well a proposal for a collaborative artwork. In other words, the goal became to develop a piece where the user could achieve a nice graphical composition through a collaborative and generative system. The result of the graphical composition would not only be presented at the interface itself but as well on a second projection next to *Untitled** allowing it to be used as a performative tool as well as an installation.

Forms generated by the generative system of *Untitled** create the graphics and function like a particle system where a set of forms create a volume (Reeves, 2009) that are drawn as soon as the interaction commences. The generative aspects permit a playful experience with the composition where these autonomous particles interact with the user in a dynamic way. Thus, the graphics are not a result of drawings but the arrangement of a group of particles that are defined by their size, color and movement. Since it's a generative system, each one of those particles has their own behavior that represents a semi-autonomous quality. Even tough the particle has it own parameters; the user is able to modify them through the use objects and hand moment.

With the desire to implement a space for collaboration, it was defined that the interaction should be based on a tabletop type interface. The table paradigm is known in many cultures and is normally associated with a moment of gathering and sharing. The table also enables a space where no user is leading the session since every user is on the same level and there is no special position (Kaltenbrunner & Bencina, 2007). From every side of the table, the user is completely aware of all interaction, meaning there is no privileged place to interact with this piece that guarantee no hierarchical differences between the users (Jordà et al., 2007).

Using reacTable, (Jordà et al., 2007) the interaction in *Untitled** was possible through objects or the movement of the hand on that table surface. Even though each object has its particular characteristics (further described ahead), they can be divided in two large groups: the Generators and the Tools. The Generators create particles and the Tools transform them. The hand movement on the table could be related with an object or with the particles, representing in the first case a transformation on an object parameter and on the second a change on the interaction or trajectory of the particles on the surface.

Since this piece had the goal of creating graphic compositions, it was important to find a way of exploring the tabletop but at the same time create a canvas with the results. For that reason were implemented two video outputs: one on the tabletop (the interface itself, where the interaction took place) and another on a screen to show the non-participant audience the visual composition being created. Even though *Untitled** was initially developed as an installation, this setup allowed it to be both installation and a performative tool for live visuals depending of the context in which it was shown. The major difference between the two projections is that the interface had the design of the tools and interactions feedback while the second screen only showed the composition itself. The design of the tools and interactions is important to establish some reflexivity in the interface (Sá, 2012) that wasn't necessary in the general projection, and therefore hidden from it.

Beside the variation of screen amount in an installation or performative setup, the sound input also varies in each situation. Since this piece is fed by sound, it was important to create a coherent relationship between the piece and the sound being received. In a performative setup, this kind of problem doesn't exist since the sound and graphics are being developed side by side, therefore they are articulated and coherent. In an installation setup, this turned out to be more complicated. It became clear to us that being the space such an important characteristic of an installation (Kwon, 2002), that it was the element that could create this coherence and at the same time give a site-specific character to the piece. But when considering the sound of a space, or in other words the ambient sound, it wasn't enough once the elements found in such sounds couldn't feed the system in an interesting way. To resolve this situation, each time *Untitled** is presented, the sound of the space where the piece is shown is recorded and transformed by an application called RjDj. This application permits the creation of site-specific music putting recorded sounds of the space and transforming it by a generative process. The elements of the sound were transformed in a way that the result was music with all elements such rhythm, melody, harmony, timbre and loudness, keeping as source sounds of the space itself. The music, live or generated, acted directly on the creation of the graphical composition thus modifying the movement of the elements on the screen.

Through movement of the user's hands or objects associated with the sound elements, visual compositions are created, establishing a very direct and intuitive relationship between the work piece and user, a result of the "integration of physical representation and control" (Ullmer & Ishii, 2000) very typical of a Tangible User Interface (TUI) . This relationship established by the user with the surface and the composition is even more interesting when performed in a group with multiple users (in collaboration) reinforced by the tabletop based interaction.

All work was carried out with free tools (opensource): Processing was used to create the graphics. TUIO (Kaltenbrunner, 2009) and reacTIVision (Kaltenbrunner, 2009) is the software responsible for the computer vision.

### 4.1.1 The system behind *Untitled**:

As already mentioned, this project aims to create an interesting graphic display that results from the interaction of multiple users. Based on conventional generic forms, this is another project within the generative aspect since searches for some autonomy established through initial rules of a system. In this section, we are going to explore the specificities of this system.

In *Untitled**, the generative algorithm has the function of defining the characteristics of the particles by treating them as living beings that respect some parameters such as: lifetime, direction, speed and color. Reinforcing the idea of a piece that is not only controlled by the user, but has some of its own choices, we explore the machine as a medium that could open different possibilities in creativity given its emergent possibilities (Penny, 2009) thus expanding the possibilities by using resources that machines have that are more trivial to the machine and more complex to humans.

To find this space where human creativity is enhanced by computer, it is important to ascertain a degree of autonomy to the system, specially because what we are looking for here isn't new tools but different forms to explore the creation of graphic compositions. From the experiences we described over the previous two chapters, this autonomy can be achieved through some techniques that seek in nature life's rules that can be implemented in the digital world. Using a generative algorithm, *Untitled** is defined by a set of rules implemented in *Processing.org* allowing it to be a dynamic piece where all elements have their own semi-autonomy.

In *Untitled**, this autonomy didn't require complexity. Particles are created when an Object of the type "Generator" is placed on the interaction zone. Those particles try to function as living beings, where some presets are common to every particle and others not. One example of a characteristic that is equal to every particle is "lifespan", since every particle generated has a life of 100 cycles. Even though "color" is a characteristic that can be changed by the user, it is also a parameter that is initially equal to every particle created. All other characteristics of the particles can be altered but they are always specific to each particle as they are originally given by the system (size, direction and velocity). The user influence over the particle shall be explained ahead. Here we are going to focus on characteristics that are originally made by the generative system of *Untitled**.

Lifespan is a characteristic equal to every particle and isn't variable through any change made by the user, but is incremented over time. Every particle starts from zero cycles and is drawn until it reaches a value of 100 cycles. An important characteristic of the "lifespan" is the visual reflection of the particle aging. Each particle already presents some transparency when born that increases relative to lifespan. Even though that fading aspect of the particle was an aesthetical choice, it is also a representation of its death. This choice was made to guarantee a renovation of the graphical environment and to give some layers to the graphical composition.

Ensuring that all the particles had some transparency permitted that particles with the same color could be detached from one another. Even though they were initially all born with the same color (black), it is possible for the user to alter the color of those particles. This change is made through the Object "Generator", making it possible to create particles of any color presented at the color wheel drawn around each object of that type. All the color changes were covered by the alpha (transparency) associated with the particle, meaning that independent of the color change made, the alpha channel will always be guaranteed.

Besides the color and the life spam, other characteristics are given by the system and can be changed by the user at any time. The size of each particle generated is given a random value between 1 and 10 and multiplied by the value referent to the result of the sound analyses at the moment each particle is drawn. By relating the size of the particles to the sound, it is possible to reinforce that all particles are related to the sound generated. That site-specific music feeds the particles of the system changing the dynamic of their movements. The object Generator can increase the size relatively to its initial value.

The direction of the particle movement is also given by a random function that comprehends the angles around the object. In other words, all the particles can start its movement to any direction. The direction can be changed after the particle is drawn through hands movement over the particles or with the use of objects called Tools. The functionalities of the objects are described ahead.

The final aspect of the particles that is delimited by the system is the velocity in which each particle navigates in the canvas. Velocity is always given from a random function as well but in this case is also closely related to the object that is producing the particles, since previously made movements interfere with the initial velocity. In other words, the velocity of the particle is a random value defined by the system and is amplified by the velocity in which the generator object is moving.

From a grey canvas to a multicolored one, filled with different sizes of a variety of geometric forms, emerges a proposal for creating a graphical composition.

### 4.1.2 Establishing the interaction

To this piece, the interaction design was crucial. Revisiting the aspect we mentioned before: it is important to create a piece that could explore a multi-user setup in the creation of graphics aided by a generative system. Assuming this is a tool that can explore, assisted by a generative system, new forms and models of creativity, it was essential that the interaction should be coherent in establishing this connection with the user. Thus, beside the will of creating an interesting collaborative artwork, was decisively that the integration of machine and humans permitted that the system and the multi-user could be coherent in the attempt to achieve a symbiotic creativity.

Revisiting ideas explored by Hiroshi Ishii and Brygg Ullmer on “Emerging frameworks for tangible user interfaces” we can comprehend that TUI allowed the transformation of digital representations into something graspable bringing the digital and physical models together (Ullmer & Ishii, 2000). This possibility enables the user to access the information from a different level, permitting a better integration of the virtual and real world. This hybrid space, capable of resolving both real and virtual world (Sá, 2012) makes possible that the system and user explore more naturally the idea of contribution.

The interface becomes the piece itself and allows the user to grasp the information with hands and through objects. These possibilities of TUIs allow a different relationship with the machine. This hybrid space is essential to explore the possibility of a dynamic process of creation where the machines open options unknown by humans.

In this section we are going to understand the mechanisms used in *Untitled**, relating it with the system descriptions of the previous sections in search of the best way to establish this creative relationship, describing the possible interactions and its characteristics, including TUI: object’s material, the functionality and all the choices made for them and the design choices associated with hand movement and interaction feedback.

### 4.1.3 Hand movement

When defining the type of interaction that best suited *Untitled*,* we decided that although Natural User Interfaces (NUI)[2] are the actual trend, it was important to maintain a graspable quality to the interface. Even though no haptic feedback[3] is present, the simple act of touching the table and the objects is giving some type of response to the user that we believe for this project is still very important.

The metaphors that we want to highlight were more coherent with a tangible interface since we need to guarantee: 1) that is established a collaborative interaction permitting users to take elements that another user created and modify it; 2) an integration between each user and system making possible the state of symbiotic creativity we want to explore. To do that, the abstractions of a NUI could interfere and even disturb those possible relations between users and between user and machine. By touching table/objects, this relationship is reinforced permitting a more dynamic interaction between various users, and even permitting new users even when the session has already started.

When reflecting about the hand movement, it became clear that the parameters given by it could only modify existing elements instead of creating new ones. When we decided that no gesture that was drawn on the table had to be analyzed, it was complicated to create new forms or parameters. By defining that hand movement would only be changing the existing objects, the gesture didn't have to be understood and the only association with it was a result of the path created by that

[2] Some times also called "Gestural Interfaces " is a form of interaction that is possible through a system of computer vision and that the interface itself is invisible to the user.
[3] Being haptic feedback a type of response of the system in which motors acquire behaviors that through touch make possible to identify certain objects.

movement on the surface. In other words, if the hand movements were associated with a specific response of the system, it would be necessary to have gesture recognition software to associate different gestures to certain commands. Once we defined that the hand movement was only analyzed for path and velocity, we simplified the system and the information that resulted from this was enough to modify any particle's trajectory. In this case, more important than the recognition itself was to establish a more intuitive relationship between system and user, not being necessary almost any time to learn to interact with it. This necessity to find a fast learning type of interface resulted in a system that relies on metaphors that are already know by most possible users, like the relationship we described with the hand movement in opposition to more abstract and complex relations.

So, with the fingers on the tabletop the user can shape the surface causing the particles to move to a given position or in a certain direction and velocity. This movement leaves a trace on the tabletop that vanishes after a short time. This vestige allows the users to understand the movement made and the effect it had on the graphic composition, mainly because some things are not controlled by the user and we want to make sure in some part the user understands that they are having some effect on it; making clear the interaction and reflecting the human interference and actions.

Beside the option of changing the direction and the movement of the particle by transforming its parameters into the parameters of the hand movement, there is the option to make a hurdle that is equal to the shape of the hand on the surface. When the particles hit the hurdle, the particle reacts as a bouncing object (some velocity but in opposite direction) permitting, for example to clear certain zones of the canvas or create a direction for the particles.

Another possibility regarding the hand movement on the tabletop is the interaction with the objects. Some objects have associated with them a possibility to transform certain parameters and this change is made with finger movement around the object. Those functionalities we are going to explore ahead when we define the "Objects"

To summarize, the hand interaction with the system added to it a more playful experience since hand and particle look completely connected. Even though the interaction is manly through objects, it was clear that this direct effect on the particle was important to establish a better engagement with the artwork.

### 4.1.4 The Objects:

Figure 7 Image of the final objects

In the beginning of each session there would normally be a set of 16 objects which we could separate in two main group of objects: 1) generators: 10 objects that create particles on the canvas/tabletop 2) Tools: 6 objects which transform the particles on the canvas. Even though those objects have different functionalities in the interaction with the piece, they all have some common characteristics that are important for the proper functioning of the system. Those characteristics are related to the object itself. Shape, color, weight and texture were equated when choosing the right material this piece: Acrylic. Other characteristics are particular to each set of objects and they shall be described ahead.

In *Untitled*, it* was important to have objects that had some kind of unity and at the same time could be easily identified by the users. We believe that to establish a dynamic and collaborative experience, it would be necessary that the user could learn fast which object is responsible for doing what and identifying it undisturbed while creating their own composition. With this in consideration, the choice of the material of those objects was an important aspect to be evaluated. Every set of object demands was listed and equated to identify which material had the necessary characteristics.

The choice was to work with Acrylic since it responded to the necessities of the project once all four parameters were achieved: weight, color and shape.

Acrylic is light, enabling a large number of objects at the table at the same time. Since one of the main goals is to explore with collaboration, it was important to guarantee that multiple objects could be placed on the surface. A heavy material could even damage the surface, deforming or breaking it, or even interfering with the interaction once at some moments may be important that the objects slide promptly on the surface. Heavy objects could delay those moments and interfere with the velocity required by the user.

Even though the shapes of the object in this case are very simple, from the interaction point of view, it was important that the user could identify each object as fast as possible. When interacting in a surface that may be filled with different objects, the fast recognition of each object can be crucial for a more dynamic and efficient interaction with the piece. Acrylic can be cut in all shapes necessary for *Untitled**.

Another important element of those objects is the color. Since the initial sketch of *Untitled**, it was clear that the objects, in some moments, had to transform themselves. Since they can't be physically changed while the interaction took place, it was important to find ways to create the illusion that they were changing when they weren't. The only way to do it was using the projection into the object itself, allowing, for instance, a change of color when that parameter was modified. To make it possible each acrylic object was sanded so it could became semi-transparent, making possible that the object could incorporate the color given by the projection. With this semi-transparent feature, was possible to achieve a visual cleanness required for this interface that couldn't be accomplished if the objects had a fixed color. This transformation of the object characteristic also makes easier to detect the characteristic defined at that moment. The physical objects became more dynamic and gain more plasticity.

Beside the aesthetic and the design of the objects, there is an element that is essential to this piece and it is present on the bottom all of the objects. It is called Fiducial and it is a symbol that allows the system to detect the elements placed on the table and that retrieves important parameters to feed the system. The camera on the other side of the tabletop is capable of seeing trough the semi-transparent surface and identifies each fiducial/object. With this computer vision technology, the software is responsible for the recognition of the fiducials (reaCTIVIsion) retrieving information about each object (such as position, angle, velocity, section ID…). This information is parsed in a very simple way though a protocol called TUIO to a variety of programming languages and media environments where the information can be manipulated.

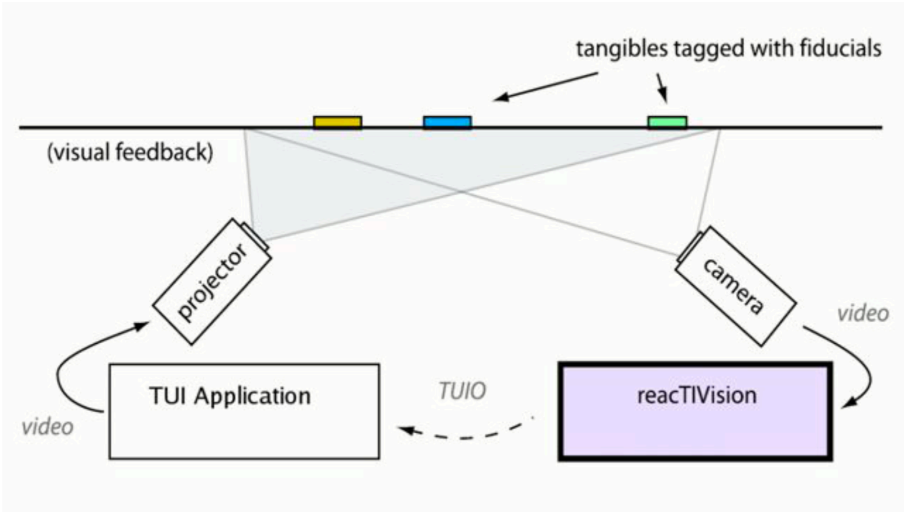



Figure 8 reacTIVision from reacTIVision: a computer-vision framework for table-based tangible interaction (Kaltenbrunner & Bencina, 2007).

Generators:

From the set of objects, we have 5 different generators. One common characteristic in all of them is that the shape of the object "Generator" has a direct relationship with the particles generated by that object. The particles are like a reflection of the layout of the object placed on the table. In other words, the gray surface (empty canvas) of *Untitled** is modified when an object of the type "Generator" is placed on the surface, making replicant shapes of itself. Square objects make square particles, circles make circles, and so on. The characteristics of those replicant forms are established by the object and can be modified by tuning, shaking or choosing a color from the color wheel around it.

The generator type of object is responsible for initiating a session. To activate a generator, it is necessary to put it on the delimitated part of interaction on the tabletop, resulting in the creation of replicant particles. Thus, when an object is placed on the table, particles that resemble that same object will be drawn on that surface. In other words, this type of objects generates the system that is responsible for drawing the figures on the table. In this version of *Untitled**, there is 5 different “generators” and each one of them draws one of the following forms: squares, circles, triangles, pentagons or octagons.

In addition to producing the particles, the objects can also modify parameters of the particles being generated at that moment. There are three parameters that can be modified by moving those objects. They are: size, color and velocity of the particles. All those changes affect only the particles being generated from that moment on. All the ones that are on the canvas aren’t affected by any generator modification. After a particle is drawn the only way to change them is using a “tool” object or through hand movement.

When the user turns a “generator” around itself clockwise the size of the particles being generated is going increase. Turning the object counterclockwise will decrease the particles size. For this piece, it was necessary to establish a maximum and a minimum size for the particles since it wouldn’t be interesting for this graphical composition to present such extreme values. For that reason when the particle size reaches a maximum or minimum value while turning the object, the size of the particles created from that moment on will be the same as when a new object is placed on the tabletop.

Another option for the user is to alter the velocity of the particles displacement on the screen. Since each particle is given an initial velocity, when moving the object around the table, the velocity of the particle is going to be relative to the velocity of the displacement of the object on the surface, resulting in acceleration or deceleration of the particles movement. Each “Generator” object is responsible for the change of the speed of its own particles and the particles have the tendency of returning to their initial velocity. Since the velocity of a particle is given by a generative process, this rapid movements made to the object only amplify the existing movement. For this functionality of the object, the same rule applied for the size is valid. Only the particles that are generated after the change the velocity will be affected.

The color of the particles is another parameter associated with the object. Each time a new object is placed on the table, a color wheel appears around it. When the user's finger is positioned over any part of that wheel, it assigns a new color for the particles being generated and to the object itself. Like we already mentioned on the description of the qualities of the material chosen for the objects, it was important to maintain a virtual plasticity to the object itself. This plasticity becomes very clear when dealing with the color of the object since the projection made into the object transforms this colorless semi-transparent object into a multicolor one. The design of the color wheel allows an intuitive way to interact with the object and enables fun experimentations like moving rapidly the finger across different color producing a "rainbow" like effect.

To summarize, each "Generator" is responsible for initiating a session and for drawing new elements on the surface. Even though that is its main functionality, the generators can also change a set of parameters related to "unborn" particles. This changes made on the object Generator affect the next particles drawn but never the existing ones. Every time an object is taken from the surface the initial set of parameters is reset.

Tools:

Not all objects create particles. Some shape the surface with features such as: 1) attraction of particles for a given location (Imam); 2) expulsion, preventing them from moving for a given area (Barrier) and 3) Deleting existing particles (Eraser). We are going to call those objects “Tools”.

Like we already described, it was important to develop a system that had some autonomy, but at the same time could be transformed and modeled according to the user will. The set of elements available for constructing this visual composition permitted some manipulation but never to insert new elements. This choice was made because the main intention was to explore how multi-users could explore the geometric forms to create an interesting composition, instead of creating new forms. To do that, the Tools would come especially handy for the users since they were the ones that permitted the organization of the forms and their positioning. There are three types of Tools: Imam, Barrier and Eraser.

The Imam Tool is responsible for attracting particles to its center. While the object is on the table, the particles will stay “trapped” inside the tool and will maintain their age, speed, size and color. When the Iman is lifted from the table, an explosion of those particles will create a completely different dynamic on the canvas. The main propose of this object is to continue to explore the particles living in the canvas. This was the user can activate different zones of the canvas, without having to erase particles or to create new ones.

The use of the Imam tool is normally associated with another tool called Barrier. The barrier prevents particles from moving to certain regions of the composition according to a perimeter established by a clockwise or counterclockwise rotation of the object into itself, being the perimeter bigger or smaller. When a particle reaches the zone drawn on the surface around the tool, it bounces into opposite direction creating a space on the canvas that is free from particles.

The last tool is the Eraser. Working similar to an analog eraser, this tool is capable of erasing the particles from every place of the canvas.

To summarize, these three tools are essential to manipulate the composition and are responsible for any change made to the particle after they are born. All the changes associated with other objects can only interfere on aspects related with the unborn particle.

### 4.1.5 Conclusions about Untitled*

Generators are objects that are displaced at the tabletop and that are able to generate particles. They are responsible for initiating a session In general, each time a new generator is added:

i) The initial color of a particle is black. The color can be changed through movement of the finger around the object. The finger movement only changes the color of the particles generated from that moment on. The color projected onto the center of color wheel represents the color that is being assigned at that time to the particles;

ii) The speed is associated with movement of the generator on the tabletop. In other words, when the object moves faster, the speed of particles generated are amplified. The particles have the tendency of returning to their initial velocity.

iii) The size of the particles is initially given by the system but changes according to the sound analysis (FFT) and is proportionally altered according to the rotation of the object around itself until it reaches a maximum or a minimum size.

iv) Lifespan: (from 0 to 100 cycles) is represented through particle's transparency. Each unit of life added, the greater becomes the degree of transparency of that particle. When the transparency is 100, the particles dies.

v) Direction is random from 0 to 360 degrees (except when a tool or fingers modify/define a new direction).

## 4.2 The Grinch

Figure 9: Image taken during the performance example from "Drawing 1"

With the development the new technologies in various fields, a variety of technological approaches have emerged in art practices. These approaches not only adapt ideas that already exist in the analog world but should also rethink the whole process of creation, performance and experience of art. These technological changes affect not only the production or post-production of art, but also entail new concepts to extend field study in the experience[4] of art itself. In this process, it becomes necessary to rethink the definition of concert and the traditional practices.

In this search for new paradigms, emerges a necessity to explore art assisted by a variety of multidisciplinary artists that can construct an entirely new palette of techniques that weren't possible with the traditional instruments for live performance. In digital music, the computer gave the contemporary musician a chance to transform sounds in a less limiting way, allowing new possibilities of composition from macro to micro temporal and spectral universes (Miranda and Wanderley, 2006). The visual elements used in live performances also changed, becoming mutable and connected to the other elements of the performance. All those changes that appear with the new technologies pave the way to a coherent and enlaced experience, instead of being a group of elements that are merged in time/space.

For "The Grinch", the main focus was to explore with those technologies (especially new music instruments and interfaces) to comprehend this effect on the creation of art with those new practices in a live concert since it interacts in an engaging way with the concepts and goals of such type of performance.

### 4.2.1 The ensemble

[4] We understand experience as the result of many processes where the emotion has a crucial impact and works with several other human processes such perception, action, motivation and cognition in relation with the surrounding world.

Formed by a group of laptop users, the Ensemble is dedicated to the composition of graphics and music in the contemporary electroacoustic music scene. Computers, *iPads*, *iPhones*, DMIs and other interfaces developed by the members are versatile instruments. These instruments permit a space for experimentation of new sonorities and types of interactions where the intersection of this multiple trifling conducts to the construction of new relationships between the artists involved, as well new experiences regarding the concert itself. Due to the diversity of its members, this Laptop ensemble creates a unique and eclectic sonic and visual landscape that stimulates experiences and entices people to embark on a sensory journey. The goal is to explore multiple fields, creating a complete experience for the spectator instead of adapting multiple experiences in one setup like most performances have done until now.

At the research center of the School of Arts of the Catholic University of Oporto, there is a group of artists that investigate different fields in the technology of the arts. They explore diverse approaches in a large range of disciplines where the common goal is to understand the role of contemporary artists on the creation of art through technology. Since each one of these researchers had complementary abilities and were working in a multidisciplinary field, we decided to form an ensemble that could lead us to respond some of our questions. Since every performance has its own necessities, this ensemble is variable, receiving the name FVLC (an acronym for Formação Variavel de Laptores do CITAR), meaning that the members were selected to participate depending on the context or the piece that was going to be presented.

The artists had varied backgrounds. They were musicians, composers, videos artists, sculptors and graphic artists where some musicians worked with traditional instruments while others worked with computers. Some others even developed their own instruments (virtual or real). The variety of backgrounds made the ensemble very mutable, making it possible to explore different setups and to contribute to a larger array of experiments. Each one of the concerts developed contributed to the quest for an answer to the questions proposed by each member in their own area of expertise.

Amongst the concerts made by this ensemble, we selected the performance "The Grinch" to be analyzed in this thesis dissertation. The performance happened at the Catholic University of Oporto on the 20th of December and had the participation of Adrian Santos, André Baltazar, Diana Cardoso, and Joana Fernandes Gomes, José Vasco Caravlho and Mailis Rodrigues. During the following sections, we are going to explain the goal of this performance, the role of each one of the members and the conclusions achieved.

### 4.2.2 The Live Performance

The Grinch was a concert that combined sound and video to satisfy the audience's senses while providing new perspectives on live performances. Music and graphics were focused on collective creation of artistic expressions based on emerging digital technologies and consisted of a 15-minute audio-visual presentation.

The starting point for this performance was improvisation[5]. Since each member made use of very unique instruments and the whole project

[5] We are using a the term improvisation as referent described according to Roger Dean and Hazel Smith as based on some "structure, procedure, theme or objective which dictates some features of the work" where work is developed in live presentation and in most cases to an audience. The improvisation in general regards the small elements of the piece instead of making reference to bigger elements. This process of developing improvisation is very related with all the creativity process since in creativity we also explore in an on-going basis the elements available and not something closed or defined (Smith & Dean, 1997)

being experimental, it become clear that it was necessary to establish some guidelines for the performance, thus defining a structure. To guarantee structure while embracing a space for improvisation in which every member of the ensemble was comfortable, it was necessary to develop some kind of score that could take on both sides. We chose to work with Graphical Scores.

Graphical Scores are a type of notation that convey information to the musicians in a wider way than traditional scores. Developed between the 50's and 70's by Karlheinz Stockhausen and John Cage, graphical scores represent an innovative art expression by merging visual art with written and musical languages. Very aesthetical, the scores are a result of a variety of artistic practices and try to express music in a more complete rather than traditional notation. In Abstract Graphic Scores, the indications are more open to the musician interpretation in comparison to traditional notation, where the musician knows which note to play and its characteristics.

Even though in traditional notation, the composer has more control over the piece, the degree of power given by the composer can also vary between different types of Graphical Scores. This quantity of influence is defined by different amount of detail presented in each score, allowing more or less improvisation/interpretation to each musician. The composer can chose the degree of detail presented and how the performer expresses them. Figure 10 and Figure 11 are examples of two very distinct abstract scores developed by José Alberto Gomes for this performance.

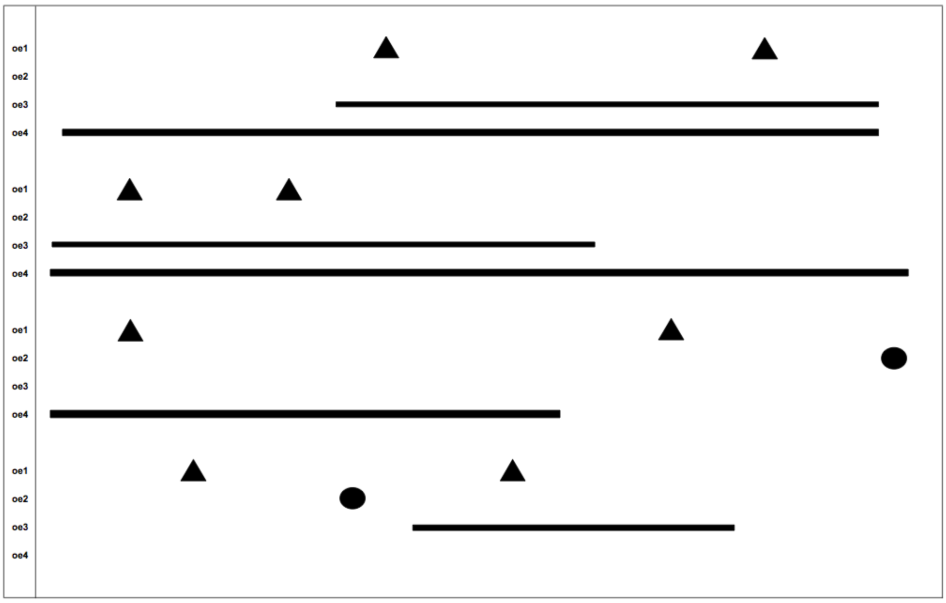



Figure 10: Graphical score by José Alberto Gomes

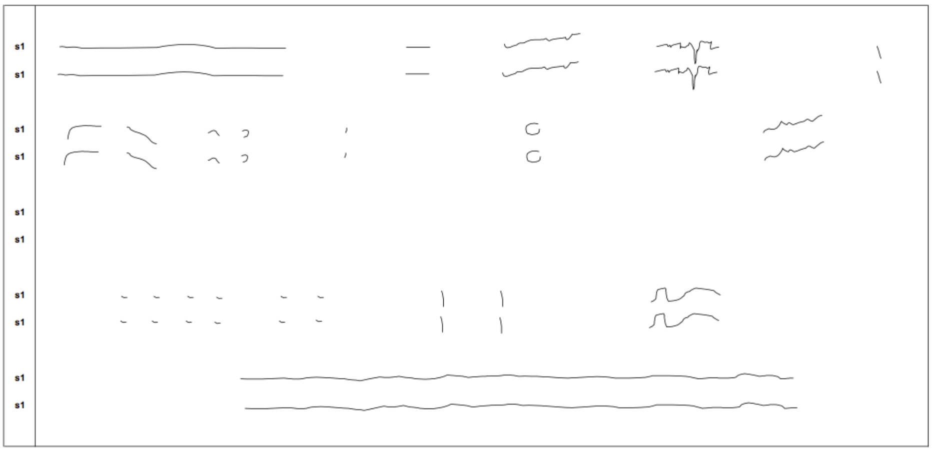



Figure 11: Graphical score by José Alberto Gomes

With his help, we decided to use the first Abstract Graphic Score (Figure 10) for this performance. The score in various ways structured the piece and established where each one of the musicians should be more present and which type of sound should be produced. The elements drawn on the score also helped the artists to search for some types of sounds and dynamics. The generative graphics was also being developed live and followed the same score as a guideline for the performance. The score was inserted in a small patch in MaxMSP/Jitter and shown on a screen so all the artists could follow it.

Each artist was given a layer of the score in which they prepare adequate material. During the course of several rehearsals, each one of the artists began to explore the score possibilities according to their instruments and their artistic views. The result was a more appropriate choice of sounds to balance with sounds generated by the rest of the musicians and a better overall structure. These choices helped the ensemble to create a coherent piece that had grown until the end of the exhibition.

### 4.2.3 Instruments

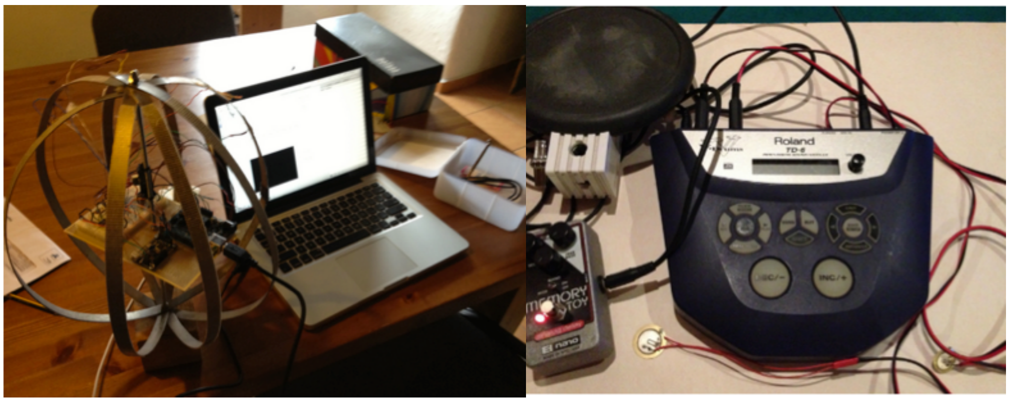



Figure 12: Intonaspacio and SoundWalk on the day of the performance

The use of several different musical instruments in the performance defined a singular setup for this performance. Computers; prototypes of digital musical instruments (DMIs) such as the Intonaspacio (Figure 12) (Rodrigues and Ferreira-Lopes 2012) and the *SoundWalk* (prototype)

(Cardoso and Ferreira - Lopes, 2012); (Figure 12)*;* as well as the *ReacTable* and other interfaces developed by the members, completed the ensemble FLVC for "The Grinch".

Intonaspacio (Rodrigues, Wanderley, & Ferreira-Lopes, 2013) is a DMI that is being designed under the research of Mailis Rodrigues with the goal of creating site-specific sound through the integration of space in the sound composition by the performer. In her own words, Mailis describes:

> "Intonaspacio let's you use space and its acoustics in a creative way, mediating your action as a performer and the influence of space in the sound you produce. It is a sphere made with 8 arcs of CP Titanium covered with fabric. The fabric is more or less translucent and it's easily detached from the structure so you can have access to the sensors. All the electronics are in the centre of the sphere, placed in a platform, except for the two piezos that are glued to two of the arcs. It has a xbee and a wireless mic integrated in the interface, so you can grab it and walk around the space. I also use an IMU (Inertial Measurement Unit) for orientation, two piezos (for impact and percussive gestures) an IR (infrared) for measure distance between the performer body and the instrument."

According to Mailis, her inspiration for The Grinch was the work "I'm sitting in a room" by Alvin Lucier where he records his own voice reading a text. He reproduces it and in a continuous loop records again each time a new version. At the 5$^{th}$ reproduction, the influence of the modal frequencies of the room are quite perceivable, and eventually in the 10$^{th}$ repetition, only rhythm of his speech is retained. (LaBelle, 2006)

In The Grinch, she used a Max MSP patch that read and interpreted the values of Intonaspacio, where the process was divided in two steps: 1) recording the sound 2) information from the sensors. The result was that the recorded sound was treated as Lucier's sound in "I'm sitting in a room" while the other parameters of the Intonaspacio modulated that sound.

Another DMI developed for this piece was SoundWalk. It consists of a carpet that generated sound when force is applied. The sensors in the carpet capture the movements of the user and the data extracted from those movements were used in Max/Msp by controlling synthesis and/or sound from the repository in real time. This DMI, still in a prototype phase and was placed on a table top instead of on the floor. The performer and developer Diana Cardoso used her hands across a set of 4 pressure sensors to trigger sounds.

For The Grinch, Adrian Santos utilized some original sounds synthesized using the ReacTable (Samplers and Oscillators) and some textures that he developed using the object Loop Player. Controllers like LFO (Low Frequency Oscillator) and Sequencers affected the sound generators. The LFO shaped the sound in four different forms according to the frequency and amplitude and the Sequencer set some sequences that could have up to16 steps.

The sounds generated were also transformed through a variety of effects and filters including: Dalay, equalizers, wave shapers, pitch shifts and reverse pitch shift.  These filters and effects shaped the sounds in various ways with the purpose of creating an interesting composition.

Adrian took special attention in the development of a sound base for the piece. With the ReacTable, Adrian had an important role to create elements that allowed the piece to have some continuity, connecting all the other sounds during the exhibition and creating a texture coherent with all the elements present in this performance.

Another member of the ensemble was Vasco Carvalho. He used two iPad apps, one that worked as a sequencer and another as an additive synthesizer. Playing with sounds from the bank of the apps that were created through additive synthesis, he modified tone and timber while selecting the elements and organizing them in a 24-sequence loop. He also used the mixture table as he explored the panoramic effect of sound.

Using this setup and sounds, Vasco explored digital sequencers adapted to industrial interfaces such iPads and it's applications. The sounds generated were very minimal and played loops of similar sequences. The result was a very digital sound escape of synthesized sounds.

By the description of each instrument and interfaces involved in the development of this piece, we can comprehend the multiplicity of sounds and possible outcomes that could be achieved by this ensemble. For this reason, it was a challenge to understand how all these different ideas and sounds could create something interesting and coherent. Some structures like the graphical score helped the development of a improvised piece. DMI embraced the concert space while helping others members discover their own sounds through collective creation. The concert room became a different type of space connecting the performers in more complex ways. New ideas emerged from music creation and the concert experience, guiding new lines to audiovisual performances.

### 4.2.4 The visual system: The a-life, the sound, aesthetic and the interaction

As mentioned before, the artists involved in the creation of this performance came from different backgrounds. They all tried to explore innovative forms of art expression in live concerts. Through the creation of different types of instruments, it became feasible to explore new possibilities in terms of new artistic practices and as well new performative paradigms. DMIs altered the relationship between the musicians and the experience of the concert. These changes made possible a space for new ideas and created the context necessary for new graphics for live performance to emerge.

From this point on, we are going to understand how the different instruments and this different concert setup altered the development of the graphics since these changes had a larger impact on this live performance compared to the discovery of new sonorities or interaction. The most important change was however, the dynamics between the artists and the concepts behind the final concert. For the graphics, it is felt that these new dynamics established the balance of the elements such as sound input (that relates the piece with the musicians), system (system with its own semi-autonomy) and the performative results itself.

The graphics developed for this performance are based on a generative system feed by a real-time sound input, i.e., the graphics are controlled by three different agents: a) sound generated live by the musicians of the ensemble; b) the generative system; c) visual performer acting real time on the result generated by the previous two elements.

During these sections dedicated to describe the piece “The Grinch”, we have been constantly reinforcing an idea of a piece that is complete in itself and that as a unit, concept that is going to be developed on the section dedicated to the piece “2+n”. For now, we are considering that this unit is achieved by the creative process based on collective development of the piece where each one’s choices are relevant to the development of the whole exhibition. Rehearsals of the whole ensemble and the sound and the interconnection between sound and image make a piece that is all interlaced and with a high degree of interdependency.

### 4.2.5 Using the sound:

When working with graphics for live performance, we assume that sound and image are somehow connected. Like we saw for instance in the work of other artists, this relationship can have different degrees of interconnection and this connection can be established in a variety of ways, where in most cases the intention is to represent the music graphically, more or less literally. In this piece, we chose to work in a less direct way.

When trying to create a system to draw the graphics for “The Grinch”, we decided it was very important to be clear about the type of representation we were aiming for. In this piece, it was vital that the sound had a very intrinsic relationship with the graphics, working almost like a fuel to the image being generated, but never making this connection so obvious that the music became literally represented on screen. Thus, it was essential to establish the parameters and how would interfere with the graphics to establish its effects the whole performance The influence of the music elements over the image needed to be balanced avoiding any type of over representation. It was important to work with the idea of something that stimulates the system, like a fuel. This “fuel like” effect created what we call an emergent behavior that resulted from the unexpected outcome of the interactions between all the elements.

The “fuel” is responsible to keep the piece operational by establishing a relationship of dependency between the graphics and the music. Although the effects of these interactions are not direct related to the content being generated, the interconnections reflect how important this relationship is for the performance. More than the elements that are connected, we seek the unit of all elements produced during the length of the performance. We seek a performance that can be seen as a whole and not as parts that are glued together.

This technique of creating emergent processes to create graphics was very limiting in this first experiment. It was further developed in the next two projects. The first steps were taken in the creation of The Grinch.

The generative system for “The Grinch” was developed at Processing.org with the help of a library responsible for sound analysis called Minim (“Minim,” n.d.). Since the sound was received in two channels, we used a function in Minim to transform the received sound into a single channel and then extract the data through a process called Fast Fourier Transform (FFT), retrieving frequencies and sound amplitude. This technique has been used in all the projects presented in this thesis.

### 4.2.6 Aesthetics

In this section, we shall discuss what we believe is the creative expression in graphics for live performance: emergent systems. Although the emergence in this piece is very incipient, we searched for a graphical representation that some how was the result of a combination of effects instead of representing each moment of this simple A-life system. This idea is present in all performances described in this thesis. It was hard to find a balance given that having a perception of cause and effect without being too literal was hard to achieve. From the experience of the previous project, we found that too much correlation is too obvious and dull and too little is boring and senseless. This sense of balance between what we call direct representation of the system elements is going to be relevant through out all the experiments and is a key aspect of defining the aesthetics of each piece.

The aesthetical choices made for this performance required maintaining a balance between all elements and therefore be coherent through all the phases of the concert. Since we had five possible graphic outcomes, it was important that all of them could relate to each other. The choice of colors, style of lines and the general glitch aspect of the canvas, guaranteed that all pieces could communicate and created a feeling of a single unit even when there was transition from one visualization to another.

All the visual outcomes were in black and white - the background was black and the drawings were white. Although the drawings were always white, the values of the alpha channel varied according to the sound input. The different values of the alpha channel were responsible for giving more depth to the canvas, the composition and at the same time to establish a more direct relationship with the sound aspects. The forms were geometrical and with thin lines where a modern, clear appearance was confronted with a glitch that disturbed the lines and forms.

The glitch look we developed in this piece was what Iman Morandi described in his book entitled "Glitch Aesthetics" as Glitch a-like.

According to his definition Glitch a-like is deliberated, planned, created, designed and artificial. In “The Grinch”, this aesthetic was designed with the goal of disrupting the digital and opening to the spectator, the non-digital aspects of the piece.

> “Glitches expose the media behind the delivery technologies. They are always concrete, and make the medium become concrete, because they break the ‘fourth wall’ and lead the audience to experience hypermediacy” (Carvalhais, 2010)

Given that the graphical choices were different for each visualization, and therefore the relationship between system and graphics was also different, we decided that the best way was to describe each one of them and make clear the most relevant aspects. It is always important to take into consideration that for all visualizations, the data taken from the system and the sound input were responsible for drawing the graphics on the projection screen, and that the elements drawn represent the data from the generative system while the variation of the sound amplitude and frequencies feed the system stimulating the movement and dynamics of the graphics. In other words, the a-life provides information that is responsible for defining and drawing the graphical elements, while the sound modifies their movement and intensity. This rule was not valid for all of the visualizations except one. This exception is described ahead.

The following scheme illustrates how the system operates:

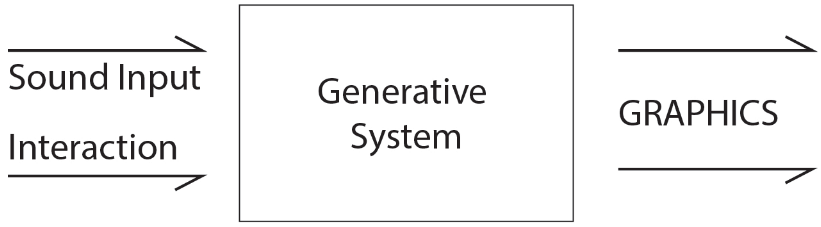



Figure 13: Scheme illustrates the input information (sound and user interaction) that is received by the generative system, retrieving the generative graphics.

If we look for example at Figure 9 (that we are going to call drawing 1) we can recognize that the sound relates to the image in the dynamic nature of the lines and in the intensity of movement, while the parameters of the a-life system are responsible for the number of lines, size, color, relationship with the dots, etc.

Whereas drawing 1 used the parameters provided by the a-life in this way, other visualizations have different forms of representation. This is only applicable to the data provided by the generative system because it is the only one responsible for defining the elements, while the sound only changes the intensity like we can see in the Drawing 2 (Figure 14) and Drawing 3 (Figure 15). In Drawing 2, we still have the lines but they don't have different sizes. While in Drawing 1, we have smaller lines that are randomly drawn between a range of values of the coordinates x, in Drawing 2, all lines have the same length that are drawn in a given range of values of the coordinate y. Even though the lines in each drawing machine are different, the data behind them is still very connected and have the same origin. For both this two drawing machines we determinate that the lines are representating the members of elements of the a-life population.

In Drawing 1, we have small dots on top of some of the lines. They represent the amplitude of the sound in the moment they are generated. Although we say that the sound doesn't generate elements, in this case particularly, it is reinforcing the idea that a variety of elements are affecting the piece. At some points in this drawing, it was a bit difficult because several elements overlap. Another element that exists in Drawing 1 is a filled circle in the center of space where the lines are being drawn. This circle doesn't ever move or interact with other elements, serving only as an aesthetical detail.

Like in Drawing 1, Drawing 2 is constituted of lines with small dots on one of the ends of the line. Each is randomly chosen to start from the top or the bottom of the projection screen and they are distributed all over the x coordinates. All the other elements work very similar in both Drawings.

In Drawing 3, all the lines have the same size and, as in Drawing 1, other elements are inserted to create more impact on the graphics. The nine triangles move and change their alpha channel value according to the sound. Their movement creates interaction between the triangles and their superposition draws new triangles on the canvas. Those new triangles and their disenrollment attract the attention of the audience to these small points of intersection. All these drawings want to engage with the spectators in the small details since there aren't any major transformations on the canvas. It's only small relationships between the lines and other elements that constitute the graphical composition.

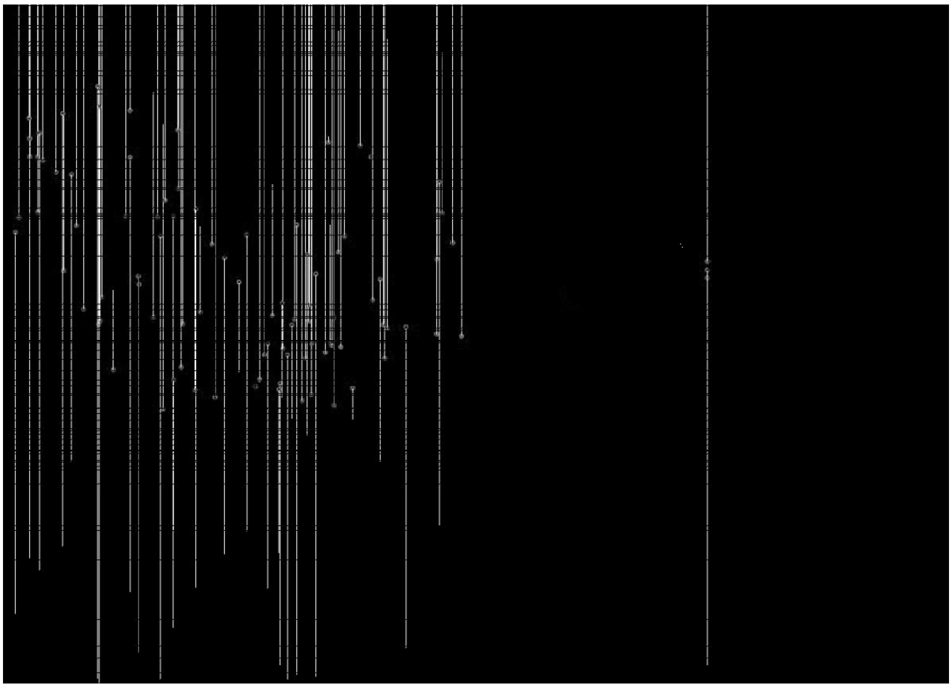


Figure 14: Image of the output of Drawing 2

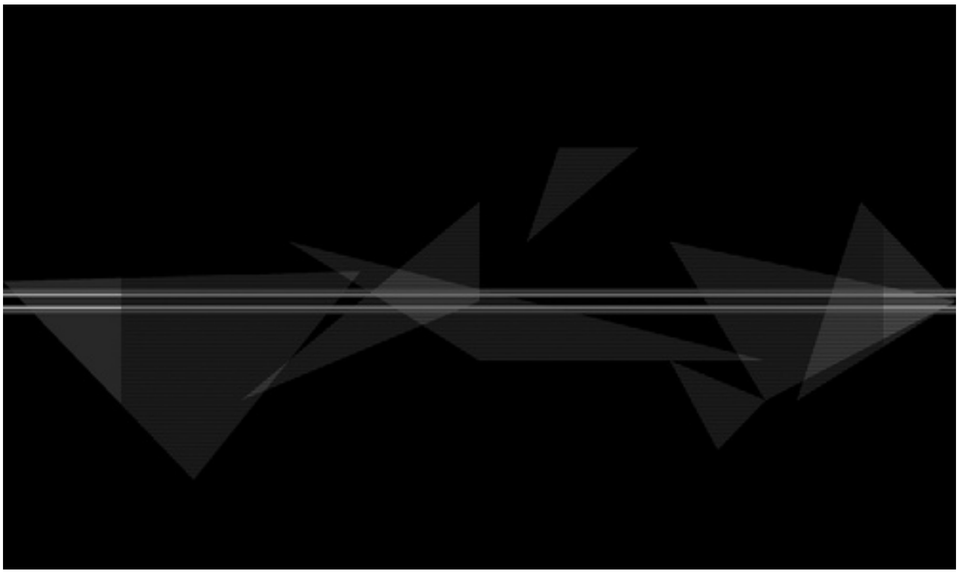


Figure 15: Image of the output of Drawing 3

Figure 16: Image of the output of Drawing 4

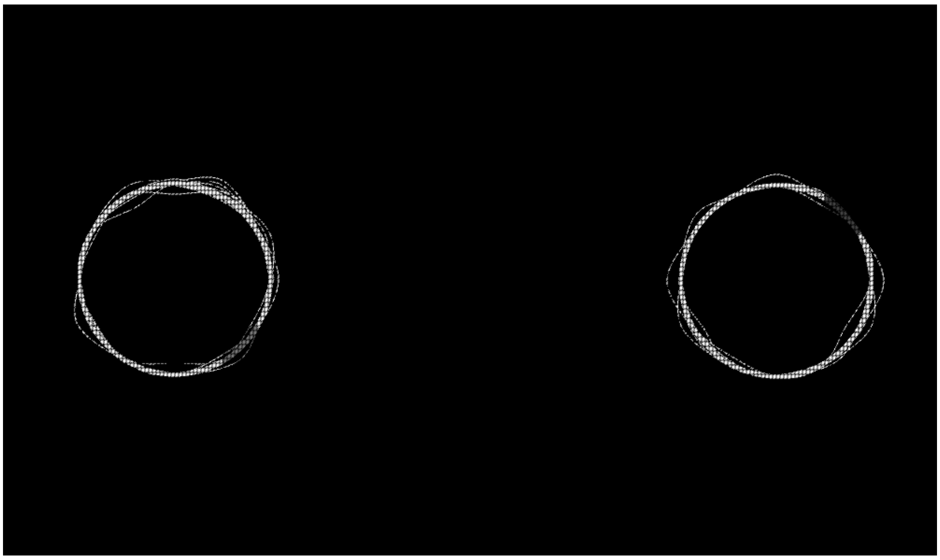


Figure 17: Image of the output of Drawing 5

Drawing 4 and 5 are very different from all the other drawings. In Drawing 4, the lines drawn by the population don't exist here. Instead, what we have are a few lines overlapping that have small intersections that are activated by the population. Those lines act like the branch of a tree where the smaller branches on the end of tree move according to the variation of amplitude. Like all the other drawings this is also very minimal and suffers small variations. The sound only affects the movement of the smaller branches; other movements are provided by the system.

Drawing 5 is the reunion of all the lines representing the population organized as a circumference. The diameter of the circle varies according to the amplitude of sound and small variations of the lines are produced by the presence of certain frequencies.

The movement between the five different visualizations creates a dynamic necessary for this piece. Thus the choices made by the performer is proposing different naratives during the exhibition The interaction of the system, graphics and performer is described in the next section.

### 4.2.7 The interaction:

Since "The Grinch" was one of the first experiments of it's kind, the best type of interface for controlling this kind of system in live performance wasn't clear. One of the problems with this performance was that the system was created prior to the interface being visualized. Thus, the system ended up being limited in its potential.

The system had five types of different drawing output options. Because of these five visualizations, we needed to have an option for choosing between them. Another thing that the performer would have to control was the possibility to stimulate this simple generative system by increasing or decreasing some of the parameters and thus change the visualization.

Given the knowledge at the time on the development of interfaces and the characteristics of the system, we agreed that even though an tangible interface (like the one developed for Untitled*) was an interesting option in terms of interface, it wasn't the right option for this piece. It was clear to us that buttons and sliders could be used to easily control the possible effects and parameters of the system and that the implementation of more complex interface wasn't going to be effective or improve the piece.

Given the characteristics of the system and our thoughts on the type of interface that could resolve our problems regarding this piece, we agreed that the best option was to use something that we knew very well: the computer keyboard. The keyboard is very limited and doesn't even have all the functions and in the way we need, and still it was our best option. As has been said through out this section, it was very difficult to draw an interesting interface for a piece that wasn't taken into consideration from the beginning. Thus, for this piece, we settled on using an interface that is familiar to us.

Beside the keyboard there was the option of using one of the several MIDI controllers available on the market. Even though MIDI controllers have sliders, after a few tests it was clear that they were making the performer work even harder. The sliders were meant to control parameters of the system that can be changed by the performer and by the user. In a classic MIDI controller, the slider can only be modified by the performer and never by the system and this could cause some confusion. In this piece, the system was also intended to influence values and these values varied through the performance even when the performer wasn't making any changes. When the knob or slider didn't move according to the fluctuation of the values, the value represented on the interface wasn't compatible with value on the system. The slider was maintained at the same value as the last time at which the performer changed its position.  Without the ability for the system to change the interface, the MIDI controller wasn't determined to be inadequate for this performance. We needed an interface that was able to modify itself according to the system parameters.

With the keyboard we managed to overcome this problem. Five keys (from 1 to 5) selected one of the five possible visualizations. Pressing the arrow key up or down after selecting the key for one of the parameters (one key was attributed to each parameter of the system) transformed the value on the system by increasing or decreasing it.  By the use of the keyboard keys, we managed to solve the problem that appeared with the use of knobs or sliders. The absence of design on the keys and the physical interface led to a very challenging use of the piece during the live performance given that the performer would need to remember the keys to use.

After this experience we noticed that this technique was limiting to the performer and the performance wasn't as fluid as it was supposed to be. For a piece whose goal it was to explore new artistic practices and enhance the experience in a concert, it was necessary to achieve a better relationship between the system and the performer. In the following sections, we describe two performances that take these ideas into consideration to try to solve problems such as this one.

### 4.2.8 Conclusions about The Grinch

This ensemble was born at the intersection of a variety of questions that arose in the research room of the Art School of Catholic University of Oporto. Those ideas merged and became a series of concerts. The variety of backgrounds and artistic expression made possible a dynamic where they relied on each other to define solutions to answer complex questions regarding their research. Uniting sound artists, musicians, visual artists - all with very different points of view generated an exchange of knowledge and resources that enriched the development of each project.

In a process that involved very different instruments and interfaces, innovative sounds were created in a variety of ways. Some used space to create the sound from their instruments; others generated their music through the sound created by their colleagues; some innovated in how the musician accesses the elements through the interface; and all served as fuel to the graphics. The sounds enriched the graphics by creating new dynamics and sonorities that were received and analyzed by a library of sound analyses. The sound analyses made it possible to draw graphics on the projection screen.

The graphics had a positive outcome. The images were visually interesting and cohesive playing with the contrast of a minimalist design with a glitch aesthetic. The thin lines in black and white were transformed by the effect that looks like minor errors and dirt. Confronting this clear trace of digital with minor human errors reinforced the necessity of combining these two forms of the creative process.

The interaction of the performer, the generative system and the sound produced by the musicians shaped a concert room experience that was specially chosen given the neutral visual characteristics. This concert happened at the MOCAP, a room that is shaped like a cube. Here, only a table was placed for the artists and chairs for the spectators. This neutral setup made it possible for the audience to observe the processes and the New Digital Instruments. After the concert, the spectators were invited to see what each member developed and experiment with it.

From multiple types of new digital instruments to new interactions and intersections in art, this concert was a motivating example in terms of new paradigms in live performances. Even though much of the work done here was still in a prototype stage, it achieved interesting sonorities and allowed the identification of problems with each project to facilitate further development.

## 4.3 2 + n

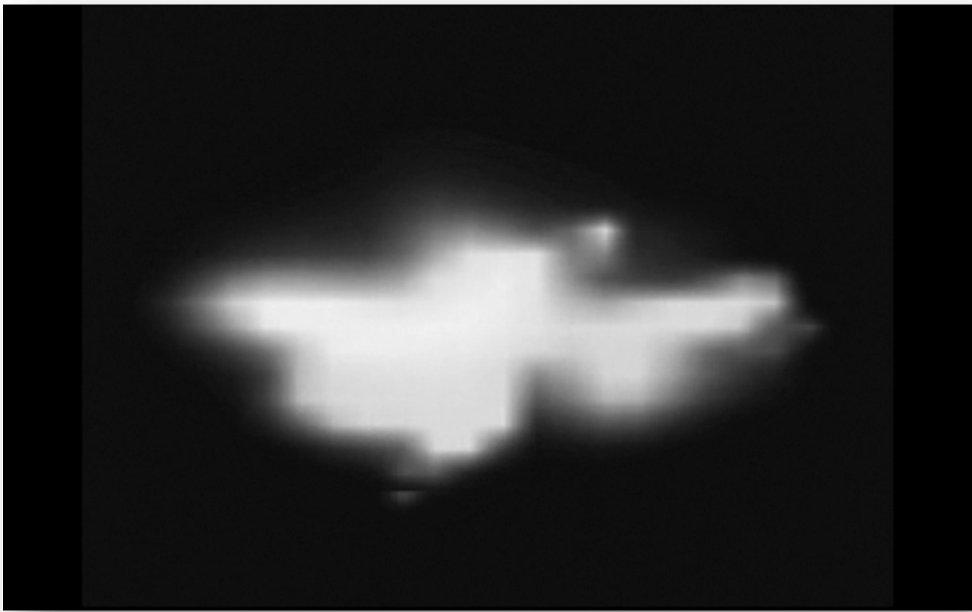


Figure 18: Image taken from the graphics during the exhibition at Culturgest Lisboa

2+n started from the desire to share the process of creation and transformation between sound and image in live performance. Miguel Cardoso and Ricardo Guerreiro searched in interactive algorithmic sound composition on different realities in the interval between 0 and ∞, where "n" reflects the number of members invited to collaborate in this project. Here, the generative visuals transform the “n” equal one, where the generative process was present not only in the creation of sound but also in the development of the graphics.

The generative process manifested as a visualization in a musical dimension through its opening to the acoustic phenomenon by using Fast Fourier Transform in real time. It shows a work operated at the threshold of noticeable, between the composition and the performance situation and constituting itself as the exclusive subject of interactivity and communication with the structures of perception, and therefore allowing the development of a field in permanent expectant tension.

It is a work where the text takes on multiple roles, while managing relations of opposition and interdependence in algorithmic processes and at the same time extends physical into code; and always remembering the poetic unity and the composition of space. If the artistic practices related with the computer seem to imply the spectacular, it will allow us to operate out of the show and re-pronounce the beauty. The result is a space where computer generates elements that are modified live by the three performers. They communicate through the result of each ones own creation and by data they send between each other via OSC. Beside their own elements this piece tries to incorporate as well the space and the audience to take the performative space into a mixture between concert and installation, something that was already explored in Untitled* and us further developed in this project.

### 4.3.1 Interaction

In this system, the interaction was a concern from the initial stages. From the previous performances, we learned that it was important to rethink two elements: 1) the performer interaction with the system and 2) the dynamic of the system itself. These two points made the previous performances very challenging since the relationship between the performer and the system was not sufficiently fluid or engaging. In this subsection, we are going to walk through the development of the interaction and its consequences on the creation of the graphics.

From our past experience, we agreed that a multi-touch interaction permitted us to achieve a system with a higher natural navigation. This type of control with fingers on the screen was important to create a much more fluid graphic that enabled easier passage between each state of the system. Much of the problems we had in the previous performances were related to the manner in which the performer communicates with the A-life system thus demonstrating and revealing what is truly relevant to the performer.

Until now, all the performances were entirely focused on the process of creating the graphics, or we might say the process of the creation – the generative process – instead of how the results of the system could be modeled by the artist/performer. Although the generative process is still a large part of the work we have been developing, we realized that unless our system is completely autonomous (meaning that it is suffering some kind of external regulation), the manner in which this regulation is specified is as important as the system itself. The manner in which the elements are being manipulated is interfering in our understanding of the system and most evidently in its working.

Both the problems we understood from the other experiences seemed to be related with interaction and with the relationship between the elements that were being modeled by the performer in real-time and not about how the working of the a-life system. This enabled us to understand that further work was to be done to address these concerns.

As a starting point, we defined that the easiest way to create a better relationship between the system and the performer was to define an interface that incorporated graphics within itself. We started developing pieces that are the same time the final graphical output and the interface. This means that interaction happens over itself, on the one hand more direct since there is a correlation between piece and interface, and at the same time maintaining this type of interaction that is based on the idea that some changes affect the now and others have a distant time effect.

Even though we were very satisfied in Untitled* with a more tangible type of interaction, we agreed that the setup and carrying these interfaces would be more complicated and less compatible with a live performance. We learned from previous experience that the time to setup for live performances in most cases was very short. Since this performance was filled with sensors that needed to be calibrated on the location, it was important to guarantee that the setup of the interface wasn't too challenging. Currently, the reacTable is very portable but at the time of the earlier performances it wasn't as portable thus requiring a lot of effort to transport and to setup. To make it easier for preparation at the concerts, it was important to have something that is compatible with the time and technical requirements of such an event.

From this experience, we decided that for a live performance, the iPad was the best choice once it permitted the performer to explore a multi-touch type of interaction without the other complications a setup like Untitled* could generate, while taking advantage of using a device that is really robust and easily found all over the world. We took into special consideration the reliable nature of the interface while the technology available concerning multi-touch interfaces is vast. The iPad being used all over the world ensures that given any problem is easily fixed or replaced. It is also a reliable platform that has many people using and developing for it. This choice was the best balance between an interesting interface and a practical and portable device.

Apart from the normal worries about the use of the interface, we also had to deal with a system that is receiving so many different inputs and hence it was important to understand the effect of such inputs on the control/interface. Although in this performance, we didn't implement any learning, ideas related to adaptive interfaces were taken into account. It was important at this point to find new ways to understand how to control and access parameters that aren't static.

Although we are always making reference to three elements that control the graphics (sound, system and performer), we need to clarify that they don't have the equal power over the final composition. Considering that the system is producing the graphics with the sound resources and, in this specific piece data is sent via OSC, the control over all these elements is given only to the performer. The artist/ performer has always had the final decision over the final result and therefore is the most important piece of the whole setup.

Here is a scheme illustrates the input and outputs of this performance:

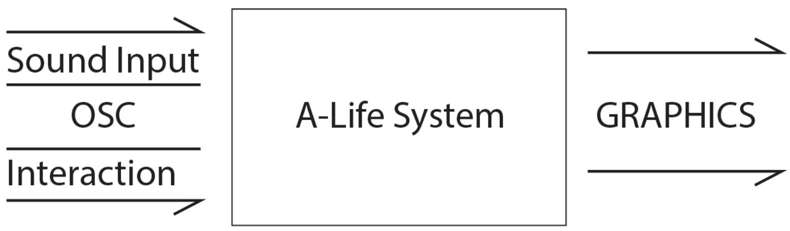



Figure 19: in this exhibition beside sound input and the interaction of the performance, were also received messages via OSC that were sharing data from the generative process that were producing the music.

The different degrees of power over the piece reflect in the creation of the interface. Selecting the good characteristics for the graphics imply that the type of control was dedicated to activate or not some choices that the system was producing. For this reason, we agree that the way in which the interface reflects all the choices and interconnects all the data is more important than the data itself.

We defined that for now, it would be interesting to control:

I) Position where the system emerges (were they begin to grow);
II) Presence of the system on the screen;
III) Activity of the system;

It was important for us that the performer could choose the amount of representation of the living system in the graphics. This means that independent of the choices made by analysis of sound in conjunction with the artificial system, the performer defines how representative these characteristics are. This option is controlled by the number of spots (areas) on the interface that are selected. In other words, the number of fingers/hand used in the interaction defines how much this system is emerging. The pressure, or in this case the area selected by the performer also restrain the system in projection.

The performer more than controlling the position on the screen, also increments or decreases the concentration of individuals and their life span, affecting the dynamic on the system and their representation on the screen.

The parameters can interfere and change characteristics of the system beyond its own since it changes the balance of the artificial system and therefore alters other elements over these. This dynamic is a typical response of a complex system when the relation between the elements is loosely coupled[6]. The effects are not clearly connected to the actions once other facts interfere and change the panorama/prospect of the system.

Here, we are only defining the interaction. The detail of the system and the result of the interaction on the screen shall be further defined in the following subsection dedicated to this topic.

### 4.3.2 The System

A habitat and a population characterize the A-life and their interactions result in parameters leading to creation of graphics. Every single aspect of the population was taken into account to deliver the graphics for this piece since the design of the graphics is the representation of the artificial life system in association with the result of the sound analyses and the performer interaction.

Like we already described in the previous section, the finger selection was responsible for defining points where the graphics were generated. The selection of one or more points on the screen initiated the process of creating graphics. Without sound or the selection of a zone on the interface, no graphics were drawn.

An element that affects the graphics without a clear correlation is sound. Like in the works previously described, the elements of sound are not directly represented in the graphics but are always present in the process of drawing the graphics through the values retrieved from the FFT that result in parameters that feed the A-life.

[6] Loose-coupling is a term used computer science to describe system that communicate but aren't dependent of each other.

Different from the performances developed before, 2+n is taking into consideration a new interpretation of sound. Like we described before, until this point, we have been using the actual frequencies and amplitudes taken from sound over time. Here, we focused on the variation of those values, meaning that the relationship between the frequencies and their respective amplitudes were feeding the system, instead of using the exact values of each sound element. The values given by the variation in time of those two elements corresponded to the parameters responsible for feeding the A-life and were related to "quality of the life" of the population. These parameters influenced how the individuals interacted, by representing the general satisfaction of the population in terms of relationship between the individuals and their adaptation to the habitat.

These metaphors established between sound and graphics reinforced the idea of dependency of each other and at the same time gave them some characteristics that are related with actual living beings. Conceptually, it was important for us to make correlations between living and virtual lives, reinforcing their qualities to transgress their digital characteristics. We emphasize this idea by naming the A-life system parameters with qualities of actual living beings.

Another important element is that each one of those parameters is responsible consecutively for the creation of individuals (population of the a-life) and resources. In other words, the number of elements created and their ability to generate more or less of their own is always controlled by the music and what we call "quality of life". Everything from the creation of new population members to production of new resources is related with this parameter, when it is responsible for establishing the probability of creating new elements (food or individuals) or not during the time the system is working. This means that the tax of reproduction and the tax of productivity are defined over time by the result of sound analyses.

### 4.3.3 The graphics:

The colors chosen for this performance were black and white. This choice of colors was a reflection of basic characteristics of what we understand as digital world. It relates to the binary aspect of the performance and it's own digital trait. At the same time, the black and white allowed us to perceive this mass as some kind of smoke and darkness that was being unveiled. The metaphors of discovering this world from the dark side that emerges in the form of a smoke that spreads and some time later disappears. Without any traces, this artificial system is capable of coming to the surface and disappearing like a group of individuals that come to the surface depending on their state and their relationship with both worlds.

This smoke also makes reference to the fluidity of such matter. It is dynamic and spreads easily around the space as this A-life. It makes reference as well to the idea of a conjunction of elements into something more complex without the necessity of defining each one of the elements. This unit is very relevant to this piece.

The smoke is also made of transparencies and degrees of surface. It becomes easier for the audience to relate with the piece since has its moments of emerging from the digital to the actual world and vice-versa.

In other words, the graphical aspect of this performance tried to incorporate important concepts. For us, the use of a-life system to create art opens the possibility of simulating life to engage in new creativity paradigms and as well as a place for questioning our human condition by confronting ourselves with living beings that are living "on the side" (Gomes, 2009).

## 4.4 "Fantasia sobre Fantasia "

Figure 20: Picture taken during the performance at *Casa da Música*

*Casa da Música* is one of the most renowned concert halls in Portugal and it is the first building in Portugal dedicated to music performances and its study, creating an eclectic program with projects from classic music to contemporary performance.

To celebrate Christmas, Casa da Música developed a series of presentations dedicated to Disney's movie *Fantasia*. The Symphonic Orchestra interpreted songs from Tchaikovski, Paul Dukas, Mussorgski and Beethoven. All but one were animated prior to the exhibition with traditional animation practices. L'Apprenti Sorcier, on the other hand was a live performance of generative visuals in which a visual live system was designed to analyze the sound produced by the Orchestra.

Based on "Fantasia" scene in which the music “L'Apprenti Sorcier” is featured, an algorithm was developed. The goal of the algorithm was to create a new interpretation of the song while also exploring a connection with the original excerpt of the movie. Like in 2+n, it is an a-life system that in conjunction with the sound input creates abstract graphics. Both this systems are very similar, changing only some aesthetical characteristics.

### 4.4.1 The graphics

Taking into consideration that this piece was inspired by something that was done previously, we decided to take into account the key elements of the traditional animation from the original movie and use them as reference to link both pieces. Since this film was very important in the history of animated movies, we considered it would be interesting to reinterpret the music and the animation. Even though the aesthetics and the techniques were very different, we found that both readings of the songs were coherent. In all the other animations developed for this concert, the choice was to do something completely different.

For this specific case, it wasn’t hard to find the aesthetical point that would link both pieces. The name of the song and the animation scene tells us about a sorcerer, being fume and water, two very present elements. They were both present graphically as well as conceptually. Since our work always related to this idea of fume and smoke, this concept became really attractive. It turned out to be an easy link between our creative aesthetic identity, Dukas’ piece and Walt Disney movie.

Two elements that seemed to need to be adjusted for this piece were the color and fluidity of the "smoke". The black and white adopted in the previous pieces didn't appear to be coherent with a Christmas concert or with a Walt Disney movie. The song also related to color and magical experiences, making even the sound representation more relevant given that it was the first time we were working with an orchestra and its extensive layers of sounds.

We also needed to change the fluidity of the smoke. This magic side of the music inspired something more ethereal and therefore more fluid. In the previous performance, we noticed that the fume was almost like something that was emerging, while in this piece we were looking for a magical smoke, softer and with more movement. Although in general the smoke was soft and loose, the performer could change some parameters to make it more or less stiff.

Although these changes seem small, they drastically modified the final graphical outcome. We were very pleased with the final result that was able to communicate completely with the piece.

### 4.4.2 The Orchestra:

The decision to use "Fantasia sobre Fantasia" to formulate the proposal for this doctorate thesis was more related to the Orchestra than to the system itself. Of course, the system suffers a great impact from the sound. Thus, the system is certainly a key point here,. However, we are going to take a special look into the sound source because it is a vital aspect of the system. With this concert, we realized that some aspects of the sound weren't being analyzed. Until this point, the music for all the concerts was done by laptop users. This one was the first one where the sound was created by an Orchestra, making it clear how such elements interfered with the development of the interface.

When we look back to the previous three pieces described in this thesis, it is clear that although there are a lot of different types of sound sources (ensemble of multiple digital instruments, multiple laptop users or just one), this piece is the first one where the sound is actually very different from all the other performances. We observed that although in some pieces the sound was generated by two laptop users and in another the sound was generated by an Ensemble of DMI, the resulting sound from all those exhibitions had similar characteristics. "Fantasia sobre Fantasia" was the first one that broke completely this pattern, introducing a totally different music input.

When we take a closer look at the previous work, it is clear that most of the sounds generated and analyzed by the system have similarities such as: have frequency attacks; in some moments some type of noise; or all together. In "Fantasia sobre Fantasia" that is not the case. The sound mass generated from the orchestra is very colorful and filled with a huge number of instruments and layers, creating a sound mass filled with harmonics instead of only having sinusoidal sounds. This sound complexity caused emergence of new questions regarding how these changes in the sound affected the system and the graphics, given that the sound is a key point of the system itself, working as a fuel to all the performances.

Although we managed to achieve a very interesting visual quality and we achieved a variety of aspects that we couldn't achieve in previous experiences, it was clear that we weren't exploring some aspects of the sound that seemed relevant only after we developed "Fantasia sobre Fantasia". When we started working with the orchestra, we realized that the interface and the whole system needed to be conceived for different sound sources, making it possible to change some aspects of the sound analyses live or at least enhance some aspects according to the type of sound source.

When exploring ways to enhance the differences between the sound of the Orchestra, the laptop users or the ensemble, we realized that we needed to change the way we treat sound. Although the system was the same, in this performance we realized that a key point to have a interesting interface for live generative visuals implied that the type of sound source had some influence on the graphics. From this point on, it was clear that we couldn’t analyze the sound generated by a contemporary laptopers and Enassemble the same way we did with an Orchestra.

We came to the conclusion in this piece that different sound sources have different characteristics and that the sound should be analyzed according to it, making possible to enrich even further the visual representation.

## 4.5 Conclusions Derived From The Experiments

During the time we have been developing the four pieces analyzed in this thesis dissertation, we came to realize that some elements are essential to take into consideration when developing a live performance of generative graphics. Using different setups and working with different groups of musicians, allowed us to play with different types of generative system, different sound sources, different data sharing and especially different interactions with the system. Each one of the projects brought new inputs about live performances and the consequences of each choice made by the developer of the generative system and the interface. From these considerations were constructed the guide to a proposal of an adaptive interface that we are going to demonstrate in the next chapter.

From our experience with Untitled* we realized that TUI were an interesting way to interact with any given interactive piece. The use of objects and the multi-touch, allows the user to easily learn how to interact by making use of already known metaphors. Another important fact was that the experience with tangible interfaces made us realize that the possibility of being able work with a multi-touch system gave the user the power to modulate a system directly, making possible for the user to comprehend more easily the effect he is having on each system. Instead of depending on traditional knobs or sliders we were able to achieve a fluidity that reflected itself, not only in the interaction but also in the graphical output.

Our experience with the reacTable also confronted us with the limitations of having a system that needed to be setup in the location of the concerts making us search for a more portable solution. The reacTable, nowadays is much more portable than it was earlier but still is a very expensive product, that is not available for a large set of people. We believe that in live performances people search for cheaper and more portable solutions that can be easily replaced or repaired. During trips, these large devices can suffer damage making it difficult to find the right replacement for it in short notice, putting at risk the exhibition and its quality.

As a solution, we decided to use the iPad given that it is a very portable and less expensive multi-touch device. Another important characteristic of the iPad is that it is a reliable device that can be found all around the world, making it possible to be easily replaced in case of a problem. Considering the possibility as an interface, its price is reasonable, allowing it to be used by a greater number of live performers all around the world. The commodity of how apps can be bought easily in any country allows a major number of users that can get to know it and interact with it.

From these experiments, we also realized that the interface could never be developed after the system or vice-versa. The interface and the system have to be developed side by side, allowing the system to express itself in the best way possible in the interface, and at the same time allowing it to create interesting ways to access the world via the interface. We believe that the system and the interface should be developed over themselves, allowing the most relevant aspects of the system to emerge according to the necessities of the system and allowing the performer to access this information in the best possible way. This concept is also very important given that this is the only way to achieve better metaphors to the way we interact.

Concerning aesthetical choices, we realized that the main characteristics important to keep through the performance was the fluidity, dynamic and unit. In 2+n, where we had graphics that had not evolved from one to another. Instead, there were actually different representations inside the same world, making it difficult to maintain a fluid passage even when the graphical language remained the same throughout the different drawings. We found these strategies didn't result as expected and instead of making the visual more interesting, it made them more difficult to create an unit piece. In all other pieces where the graphical outcome evolved during the whole exhibition, the resulting aesthetic and the dynamic were much more fulfilling and engaging. As a result we explored aesthetics that related to the digital world and its passage to the actual world, making reference of something that emerged through the screen (virtual world) and gain form on the other side (actual world).

Another aspect that we found important to take into account when formulating the system is to adapt this system to multiple types of sound source making it possible that they could interfere in an interesting way with the visuals. In other words, different sound sources have different qualities and most of the time they were not being reflected or even taken into consideration during the development of the system. By not making any difference between the sound of an orchestra or a laptop user, we are not taking advantage of having the sound as such an important factor of the visuals creation, making it plain and treating it always the same way. For us, the sound is not a small element in the performance. The sound is so important that it works as a fuel, feeding the system. For that reason, it is important to take into consideration ways of representing those changes in the system and into the interaction.

From these four experiments we can see that several changes can be made in the creation of live generative graphics. These experiments showed us that it is important to find better ways to establish this communication in these types of practices especially when we are dealing with a generative system.

Based on these conclusions, in the next chapter, we formulate ARTALIVE, an app for mobile devices in which the a-life system is triggered by music (in real time) and controlled by the performance through an adaptive user interface.

# 5 ALIVEART: a Framework for Live Adaptive Interaction for Generative Media

Per our observations in chapters two and three, generative and interactive practices changed not only the type of artworks or their characteristics, but also changed relevant aspects of the art itself. We noticed that generative art brought new paradigms related to authorship, creativity and originality. We also saw that interactivity changed the conception of Self by modifying and enhancing human experiences and by that, transforming himself. (Sá, 2012)

Many of the goals of a generative art seem to converge with interactivity by complementing themselves in this search for a shared creativity, where artist, user and system gather to construct an artwork. Besides the will to share, we can relate that both practices are based on the idea of process over artifact. Neither is concerned with the final object, both are looking for a continuous quest of emergence creativity.

In chapter four, we gathered information from live performance. We were able to understand the most important characteristics regarding this type of performance and the elements we considered important to allows us achieve a better performative and aesthetical experience.

The information we collected in these three chapters allowed us to formulate the experimental project of this research titled ALIVEART.

The goal of this experiment was to develop a system that was capable of using generative processes to produce generative live graphics according to sound input in which the user can interact with the system in a more symbiotic way. In this process, the user needs to be able to improve the aesthetical result as well as the performative experience of those types of graphics.

In this chapter, we will describe the pre-production, production and final result of the mobile app ALIVEART. The analyses of the results obtained during the validation of the experiments will be described in the next chapter (chapter six).

ALIVEART is an adaptive user interface for live generative graphics. Developed for iOS mobile devices, we hope to develop an intuitive adaptive and reliable interface in which live performers can express himself with the aid of an a-life system. Sound is a very important aspect of this project since depending on the features of the music, the graphics will modify over time. Both interface and graphical output are represented on the same screen allowing the user to have a more engaging relationship with the system and therefore a more fulfilling experience.

The code was developed in c++ .

## 5.1 Defining the Interface

During the course of our analysis about generative processes and the interactions, we realized that for this research we should dedicate ourselves to the study of a particular type of interface in which we were able to have a more symbiotic relation with the a-life system.

In this experiment, we decided to maintain the same type of generative system we developed in the previous experiments described in chapter four: an a-life system. The concept of a-life is very important to our work. To us, it is essential for the system to be more than any generative method since we want to transcend the actual world and unite both realities into something unique. We believe that these types of metaphors give qualities to virtual entities that are known by us, being connected to them more easily and establishing a relationship. The system we implement also defines the interface in real time given that it isn't a static system. These ideas were essential to define the interface.

Besides the metaphors and analogies we can make between both actual and virtual worlds, we also need to be conscious about the interface we use to connect them. Interaction is very important not only in technical aspects but it also adds significance to the artwork, to the user, and to the experience itself. The way we chose to engage with the user and the information from the system we decide to share constructs the formulation of significance of each artwork permitting more or less connection between both systems.

For this reason, the choices we made regarding the interface were important. They are responsible for allowing the artist to convey the right meaning to the artwork. The interface needs to communicate about the system, therefore, allowing to assign the right meaning to it. We decided that adaptive interfaces are the best choice to manipulate semi autonomous systems.

We concluded that an a-life system and an interface that could inspire a deeper connection between the system and the user were very important to this piece. Based on findings documented in chapter three, adaptive interfaces are the best option for this experiment since it would be able to reinforce the connection between system and interface by allowing the interface to properly represent the a-life system through its adaption.

However, as we saw in the same chapter, adaptive interfaces refer to interfaces that adapt to the user.  More important than creating an intelligent system that is able to predict the user choices, our focus regards an adaptive interface is to allow a better expression of the a-life system and allowing the user to have an easier interaction, and therefore, facilitating his task.

Although traditional use of the term adaptive interface refers to intelligent user interfaces, we will focus on the definition "adaptive interfaces, since they change their behavior to adapt to a person or task." (Ross, 2000) where the interface is adapting to the system by changing its parameters over time and also changing to facilitate user's tasks by showing only relevant information. In other words, we will consider our interface adaptive because it is an interface that is capable of adapting to the states of the a-life system and to the user ability to perceive those changes by allowing him to act over available parameters.

These considerations about the interface are more relevant if we think how we can interact with a static interface if it is controlling something that is semi-autonomous and changing over time?

Our most important goals in this experiment from the interface point of view were:

1) Finding a way in which we can interact with a system that is changing over time;
2) Create a symbiotic feeling between user and a-life system and allowing them to work with each others characteristics;
3) Reinforce an idea of transgression of the virtual into the actual world.

From the conjunction of these three points, we formulated an adaptive interface that does not have an intelligent behavior to predict user choices but is modifying itself according to the user and the a-life system. Most common adaptive interfaces are only changing according to the user choices without considering the system states.

The most common systems do not change the interface and neither is the interface changing according to the system. (Figure 21). In this type of interaction, the user is only manipulating the interface that is changing the predefined characteristics of the system. The interface is not changing according to the user or the system.

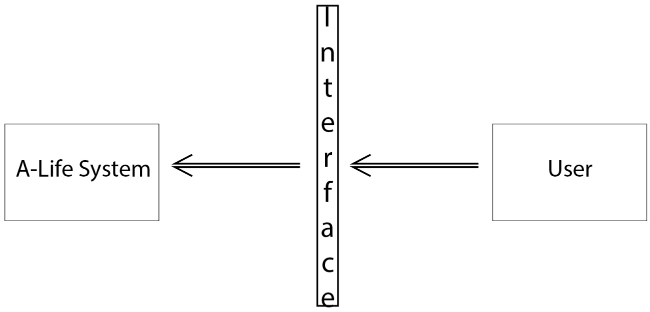



Figure 21: typical interface information flow

In traditional adaptive user interfaces what we have is an interface that is receiving users input and it is changing itself according to user necessities or previous behaviors. Although the interface is conscious about the user, it isn't changing its structures according to the system (Figure 22)

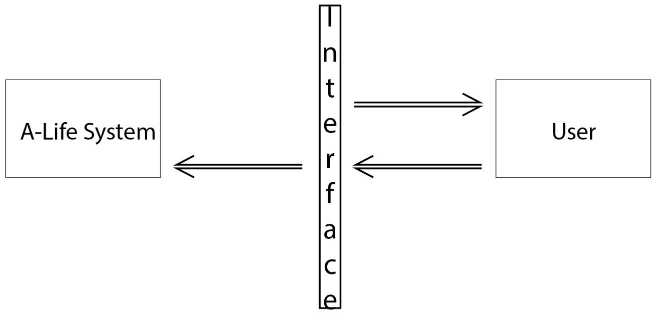



Figure 22 Traditional Adaptive User Interface

In our proposal, this type of adaptive user interface is not only changing according to what suits the user best while also considering convenience to the A-life system. In other words, we propose an interface that is able to change according to the characteristics of the a-life system while making the task easier for the user by concealing unnecessary information (Figure 23).

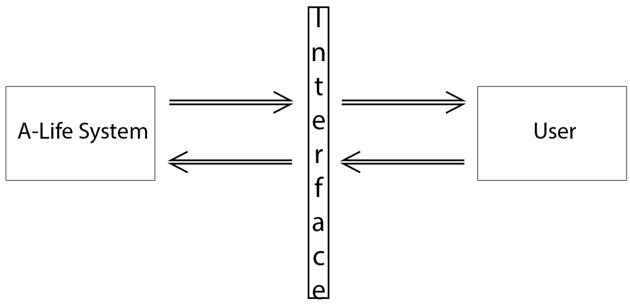



Figure 23: proposal of an adaptive user interface that can adapt both to the user and the a-life system.

By developing such ideas, we hope to enable live performances by allowing the user access to the right amount of the system without causing any disruption in his interaction.

### 5.1.1 Defining the space of interaction

After the definition of the logic behind our interface, we focused on implementation of the idea. We learned that a common problem with adaptive interfaces is that the interaction can be disrupted by extensive changes to the form and content of the interface. To prevent such occurrence, we analyzed these two points:

1) How the information was going to be displayed
2) How much information we would present.

We decided to use iOS mobile devices like the iPad and the iPhone. We are using these devices because we identified that multi-touch interaction is important to this type of artwork since the multi-touch screen offers a malleable structure. The multi-touch screen allows the interface to modify itself during the time of interaction. At the same time, it gives some feedback since the user can touch the screen where the graphics and interface are on the same level. It allows the interface to gain many forms. Many multi-touch systems are available on market but we chose iOS devices because it is a light and reliable system. In the future, the plan is to implement ALIVEART on Androids devices as well.

Our first challenge at this point was defining an interface design that could be interesting for both type of devices independent of the size difference between the screen of an iPhone (small) and an iPad (large). The second step was to determine the rule in which the system would organize the information and therefore avoid confusing the user during interaction.

In ALIVEART, we decided that the multi-touch screen would be divided in areas where each one of the parameters would be represented.

In other words, we defined that it was important to maintain a relationship between the size of the area of each parameter according to the number of available parameters at that moment instead of fixing the size of the area they would occupy. This way, the space for interaction of each parameter becomes relative to the number of parameters shown making the interface more flexible and fluid. The defined area of the screen where each of the parameters is drawn, allowing us to define the interaction zone and therefore allowing us to understand how we could implement a nice interaction between them without compromising the interaction while the interface was adapting.

By defining the area that each parameter occupies on the screen according to the number of parameters available at each moment we are guaranteeing that we are more concerned about the parameter than fitting a number of elements in a given space typical of an interaction that depends on sliders and knobs and other type of controllers consistent with these strategies.

In chapter three, we described an artwork called Boundary Functions in which the interaction zone was divided according to Voronoi diagrams (Aurenhammer, 1991). This division of the space really caught our attention because it is a very clear way to create divisions on the space while making references to the natural life. This is a strategy present in many living and computational systems making it an interesting rule to define the division of the space on the screen.

Although this type of division seemed like a very interesting principle, we realized that in certain moments, this organization of parameters wouldn't be very predictable for the user, i.e. this rule permitted a very interesting way of dividing space but wasn't easy to predict where a new parameter was going to be drawn since this diagram wasn't designed to divide the space in a orderly way, but instead was designed to use more natural patterns. Although we are very concerned in keeping this digital world very “natural alike”, we need to guarantee that the user doesn’t feel lost by constant adaptations. We didn’t want to define every part of the screen where every parameter would appear, but we wanted to ensure that the user could understand the rule that is making the changes thus making it easier for him to predict and therefore interact with it.

Although we didn’t adopt the Voronoi diagrams as the rule for defining the division of our interface, we looked for options that could achieve a similar overall aesthetic but functioned in a more linear way. Looking at some Voronoi diagrams simulations, we realized that the best way to ensure a more linear division was by obliging it to happen in a circular way having as starting point the center of the screen. This centralized approach created divisions according to degrees from the center of a circumference that occupied the whole screen. This trigonometric approach guaranteed us a starting point from which all lines would emerge until they reached one of the sides of the screen. The number of areas being drawn represented the number of available parameters that were always going to be drawn in this circular way.

From the center towards the sides of the screen, lines were drawn that respected a rule that 360º were divided by the number of parameters available. This strategy worked well for iPhone and for iPad, allowing the user to easily use the interface while it was adapting. This prediction learned during the first minutes that the user experimented with the interface was only possible because the logic in the appearance of the new parameters and in the disappearance of existing ones was sufficiently predictable. This predictability that any new parameter showing would be configured in a circular approach around the center of the screen was a very important solution to avoid problems like the ones we identified in chapter 3 concerning the user's reaction caused by excessive changes on the interface during interaction.

For this first version of the app, we decided to have a limited number of possible adaptations of the interface to better understand its effects over the interaction. For this reason, the system offered to the user the possibility of interfering with five parameters (one or more at a time) till zero parameters (see Figure 24), meaning that the maximum parameters available to be incremented by the user would be five, so the interaction zone would be divided in five equal parts, and as minimum the interface could present no parameter at all, having no division on the interaction zone.

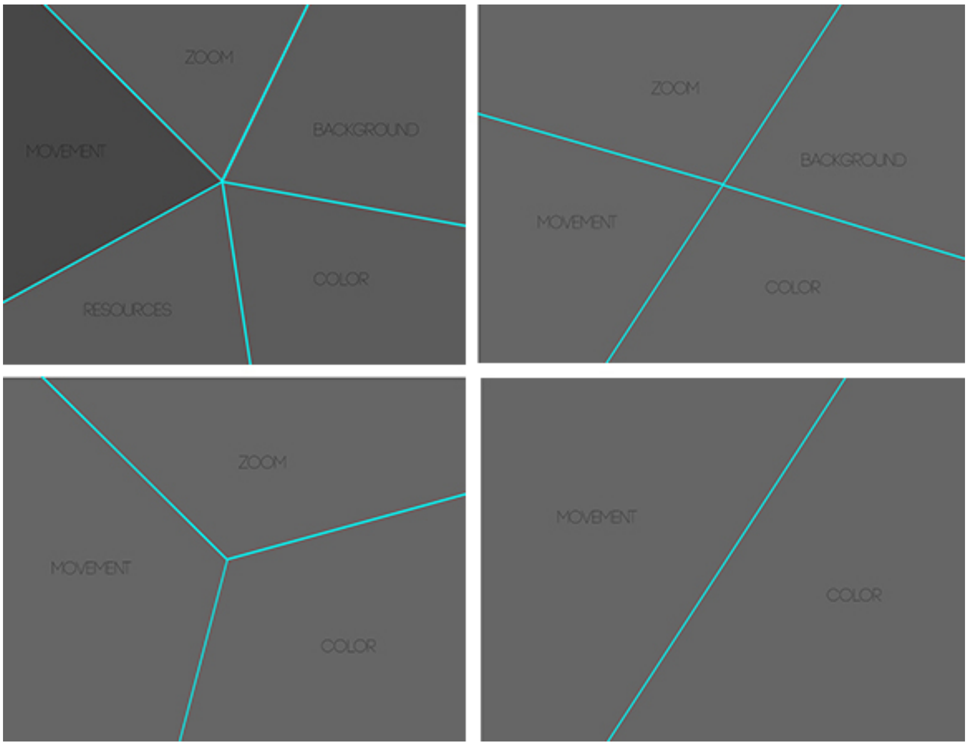



Figure 24 First sketches of interface according to number of parameters and an example when one parameter is activated.

### 5.1.3 Controlling the Parameters

A vey important aspect of the design of the interface is that it shouldn't present any type of knobs or sliders as controllers for manipulating the values of the parameters.

Since the beginning when we analyzed the first experiments and when we describe the type of relationship intended between the system and performer, we were sure that more than changing the reactions of the interface, we needed to create different metaphors for the interaction itself. Thus, it doesn't matter if only the interface is adapting. It is important to  establish the logic that connects the user and a-life.

Most of the time we have been saying that the system is generative and semi autonomous but we don't actually take into consideration its effects in the design of interaction. Why does it matter if it is a generative system if we can completely modify values of the system according to our intentions and desires? Where is the autonomy in such a case?

To emphasize this interaction in which the system and performer collaborate, we gave up on methods of interaction in which we can modify parameters and started looking for an interaction where the performer can propose new directions to the system instead of modifying them completely. The system gains more autonomy by emphasizing its ability to adopt the propositions made by the performer. i.e in this new interaction paradigm, we propose that the user doesn't have the decision over the a-life, but instead increments certain parameters that can stimulate changes in a given direction of the ecosystem as a whole.

The user decision over the system has two important characteristics that define what we propose with this interface. We developed an interface that is capable of communicating the needs of the user and the a-life system. Two important steps are present in this definition because we first need to know how this communication is made and secondly how the user interferes with the data. In other words, we need to describe the manner in which the system generated and modified the interface and the manner in which the user can interact with the available parameters.

We need to be clear about the representation of the parameters of the system on the interface. We know by now that the interface is adapting but we are not yet familiar with its actual working. Shortly, we will understand how this impacts not only the information demonstrated on the screen but actually changes the paradigm for the whole interaction.

This interface is adapting because it is able to modify its contents and its representation. While the generative system is modifying itself, we want to be able to access them by being able to access the elements that can actually receive some input thus removing from the user's view, elements in which the system doesn't need input. With this in mind, we determined that every parameter should be constantly evaluated allowing only the ones with values within a certain threshold to be drawn on the interface.

By presenting only certain parameters at a time on the screen (anything between zero to five in this first version) we were not only changing the interface but also modifying the possible parameters that could be incremented and, therefore modifying the outcome.

Searching for the most natural way to implement this concept, we debated upon a variety of ways in which we could not only describe such idea but could actually demonstrate it by exploring the right metaphors to sustain the interaction paradigms. While trying to find the right metaphor for this interaction, we come up with a solution where the act of stimulating the system would relate to the amount and number of times the user touched each area of the screen.

This idea emerged because we easily associate a stimulus with a touch and the amplitude of that touch with the intensity of the stimulus. By allowing the user to quantify his interference in this abstract way, we were allowing him to propose a change in which the system was not modifying any characteristic of the A-life, but instead, incrementing the the value of the parameter. All the interactions happened according to the state of the a-life at that given moment, making it impossible for the user to actually modify it completely.

The system responds to time and quantity of touches but we valued continuity in opposition to insistence since for a bigger stimulus the user needed to touch this specific parameter for a longer period of time making the impact on the system to increase exponentially. Although many touches also increment the parameters, it doesn't grow as much as a continuous single touch since the stimulus is getting bigger over time. If the stimulus of the user exceeds the maximum allowed value of the ecosystem, the parameter will disappear from the interface, preventing the user from interfering with that parameter until the system allows the parameter back on the interface. We decided to make it increase exponentially because it reinforces the idea of something that is natural in opposition to increasing in a linear way that relates more to something artificial.

So, by maintaining any of the areas delimitated by the blues lines selected, the user is incrementing exponentially the value retrieved by the a-life. The longer we keep any parameter selected, the bigger the value will get. Although the value of the a-life changes, it doesn't mean that the system will maintain these values. The living system can receive the new values and discard them by returning to the values prior to the interaction or the changes can reconfigure the characteristics of the system making it the reality of that system from that moment on.

The user cannot control the way the system receives or reacts to the variation of such values. It responds to the changes and adapts to the new environment. This way we are dealing with a real semi-autonomous system and not only a system that is changing by itself until the point the user decides to modify it.

From the moment the user selects any given area, since the changes are not drastic, we decided to implement features that would show the user that he is having some effect over the interface. This visual feedback, as explained in chapter three, is important to make the interface more opaque and therefore creating more engagement. In ALIVEART, we did that by making the selected area darker grey than the ones not selected. It doesn't matter if the user selects one or all parameters at a time, all the parameters being selected will get darker. The area is covered by a new layer of semi-transparent grey that still allows us to see the a-life graphical representation in the background of the interface.

### 5.1.2 Aesthetical choices

Since this is generative graphic app, we were, of course concerned about aesthetics. Aesthetics however is not only concerned with visual output but is also the result of balance between three important elements: 1) Allowing a good reading of the interface; 2) Clear perception of the a-life aesthetic and 3) interface aesthetic. These three elements were responsible for allowing the user to connect with the app and, at the same time, to have a more fluid and satisfying experience. In this section, we will focus on the aesthetics of the interface and his relationship with the graphics representation on the same surface. The aesthetical choices made for the representation of the a-life system shall be described in the next section. Of course, some aspects will belong to more than one area but we will try to explain it from all points of view and how they connect.

Our first concern was to find a color that could suit well as a background of the graphical representation of the a-life system and as a background for the interface. Based on our previous experiences, we chose the background to be grey. Some of these reasons related to the significance of colors and how we relate to them emotionally and others related to more practical aspects such as reading and clearance.

Grey is an unemotional color. It is detached, neutral and impartial, being neither black nor white (Heller, 2012). Although, we normally relate to a white canvas as the beginning of something or blank, we concluded that the grey canvas was a better space for neutral relations and without intentions being projected on the background. Grey is also emphasizing the idea of "in between" worlds and at the same time allowing an experience without preconceptions.

By using a color that is actually more neutral than black or white we were able to start to define the interface setting a strategy where the information of the graphical outcome wouldn't deprive the user of an understanding of the elements of the interface and, at the same, be interesting and visually appellative.

After defining the color of the background, we need to ascertain the color of the lines that make the division of the areas of each parameter. It need to be a bold color that could be seen independent of the graphics on the background making clear the division between all the parameters. Since the interface and the living system were going to be presented in juxtaposition, the color of the lines had to contrast with the colors of the living system, allowing the user a clear view of the elements of the interface and of the system.

The division of each parameter was made by blue lines (#00ffff) drawn from the center of the screen till one of the sides of the device, varying its position according to the number of parameters available. These lines were able to create the right amount of clarity to the divisions since no matter how intensive the graphics got, the lines never disappeared or got swollen by the intensity of things happening at the same time. Blue is a color that is calming and intelligent (Heller, 2012) and choosing such bold blue allowed us to have a energetic and yet soothing representation of the interface while it was making its adaptations.

Since we are dealing with an interface that is changing over time, we need to balance between energetic and soothing - energetic because we can get confused and calming because we don't want the graphical information to be all over the place. A balance between energy and tranquility was very important to provide the right feeling and information to the user.

Another important graphical element of the interface is the actual description of the parameters. Since the lines that delimited the space were bold, we didn't have to make the writing bold as well, allowing us to find an option that could be more easily read. From our experience with design, we learnt that some colors allow us to use thinner typography while others tend to be eaten by the background needing thicker lines. Hence, we were always looking to create something discreet but at the same time, the user should be able to discriminate well, even in the midst of all the information that is presented.

We opted to use traditional black since we could guarantee it would be the most contrasting with all the possible colors that could appear on our screen, including the color of the background and all the possible colors of generative graphics.

Beside the color for the description of the parameters, we also needed to choose a typography appropriated for the whole mobile app. We searched for something that could relate to the digital characteristics of the system. For us, the digital life always relates more to straight and clean lines. We found that Code Light was able to satisfy our aesthetics and conceptual needs. The size of the letters varied significantly depending on the app usage on either the iPad or the iPhone.

The sketches of these ideas,  the definition of all the graphical elements of this interface and its representation on the available space of an iPhone and iPad are illustrated in Figure 24. All the strategies of the interaction design previously described were also developed at this stage.

With these choices, we hoped to define a good space for interaction where all the messages were clear and they didn't create any extra confusion or distressed experience for the user. Given that we are dealing with an interface that can help the user but also make things difficult if all these elements are not correctly balanced, we needed to analyze the interaction in all its terms, including the graphical representation of the a-life elements and the ones from the interface that create a third manifestation where interface and a-life interact on the same surface.

## 5.2 A-Life : Characteristics and Functioning

Per our description through this entire document, the system behind our work is a simulation of an artificial life system that represents itself graphically on the screen/interface and separately on a projection. The characteristics of the system are both conceptually and technically important for this artwork, making it imperative to analyze the system step by step. In this section, we will show how the a-life system was conceptualized and developed, how it created the necessary dynamics with the interface and how it affected the system per se. We will also describe the graphical choices made towards representation of this artificial system.

Based on our observations in chapter two, it was identified that there are different approaches to artificial life systems depending on the type of simulation or the purpose that led us to use such type of systems.

For ALIVEART, we chose to use a very typical approach based on predator and prey method. Our first idea was to develop a genetic algorithm making it possible for us to develop elements that would make this system more complex but allow implementation of more human like features. We employed characteristics such as "will to move" and "sociability", which gave the system life like features. This technique attributes a vast group of characteristics that pass from one generation to another. They all have individual characteristics and a lifetime depending on the amount of available resources. If the resources drastically change, only those most adaptive to change survive. Subsequently, the future generations also become increasingly stronger.

Those characteristics have the goal of introducing in these simulations features that normally aren't used as paradigms in such virtual entities because they tend to humanize them. Although we give them such names to propel this humanity into our creatures, they actually tend to influence in a very practical way the whole behavior of the a-live system.

Following is an example to demonstrate the concept of sociability. Normally, it is perceived that non-humans don't socialize although we know that animals interact. By attributing a name associated with this concept to virtual entities, it creates an impression of the entities being alive. However, this concept also modifies the interactions of the system in several different ways. We believe that sociability influences the system to be either more organized in clans or each entity to be more independent. These changes in the socialization of the a-life changes the dynamics of the system by creating small groups or by allowing them to act individually.

Sociability also changes the rate of procreation of a system. The bigger the need to interact with others, bigger is the change within each individual to find the right partner to mate. There are of course many other factors that influence the system and the relationships between the entities that constitute this ecosystem.

Although we understand that this approach may seem very focused on the individual, it actually demonstrates the whole dynamic of a complex ecosystem that unfolds by the relationship between its members. We wanted to implement a system that is consistent with its own virtuality but also build into it real world qualities that help it establish a connection to the user. To dive deeper into these relationships between the actual and the virtual worlds, we identified the need for a group of entities that responded as an ecosystem even if it meant that the individual wasn't complex. The complexity of the individual unwinds in accordance to the relationships that are established. The space of those living systems modifies their behaviors, and therefore creates a complex dynamic defined by their features and the ones given by the environment.

These choices resulted in a different approach where the system was generating graphics in real time based on manipulation by the user and sound input. In the following sections, we shall dive deeper into the conceptual and technical aspects of a-life and the aesthetic characteristics of the interface that led to the origin of the ALIVEART app.

### 5.2.1 Basic knowledge about the a-life

Our goal here is to describe the overall functioning of the system.

We learnt that our generative system constitutes an A-life system that it is representing itself graphically. To understand the working of this system, we shall describe the initial characteristics of the system (individuals and ecosystem in general), their possible interactions, the effect of the sound on the system and the graphical representation. We will also describe the consequences of each user interaction and the impact of the available parameters on the functioning of the system.

We also learnt that a population of artificial life entities composes this system and that each one of them has their own characteristics. The system can change according to the number of resources that are available (distributed over the ecosystem space), to the music input, the interaction of the user with the system and also between the members of the a-life. These changes generate moving graphics.

#### The Ecosystem

Every time the app is initialized, a new world is generated. Its initial characteristics vary between an iPad (Figure 25) and an iPhone (Figure

26) considering the space for distributing the resources varies according to the size of each device. This space is responsible for receiving the resources and the individuals that will live and interact in this system. An example of an initial world can be seen in in the two figures representative of a system prior to any sound input. Upon sound input, the world changes due to the impact of sound on the appearance of the graphics. The system also changes our view by modifying zoom.

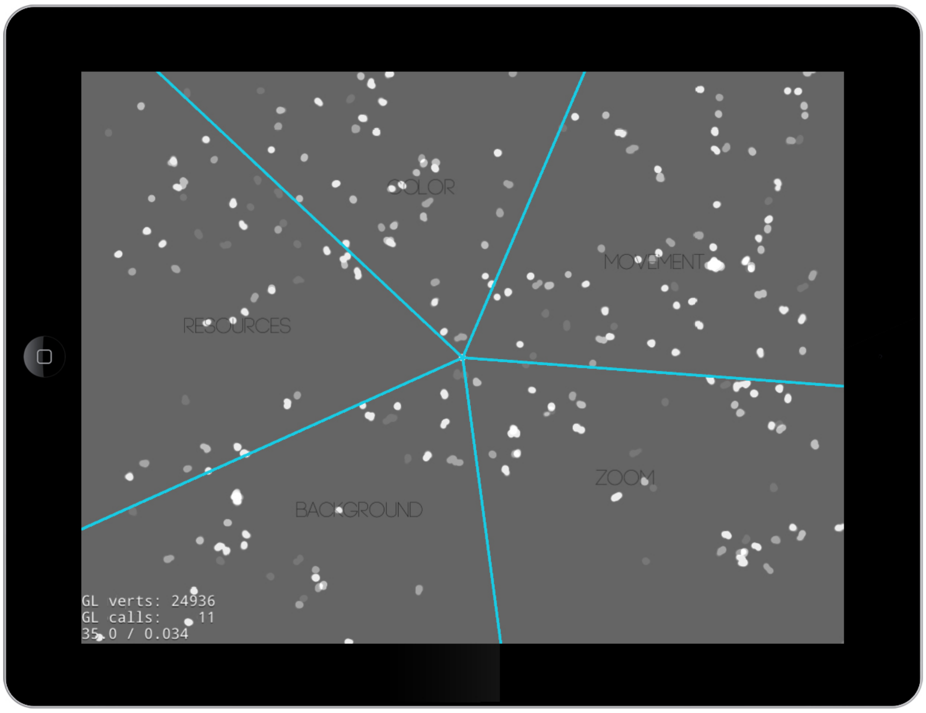



Figure 25 Initial representation of the a-life system without sound input - iPad version

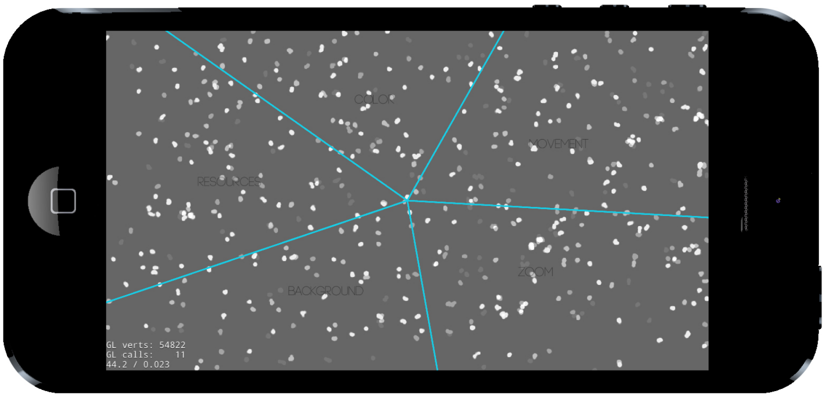



Figure 26 Same situation described in previous figure - iPhone version

All ecosystems are organized according to the cells of the grid drawn in the interaction zone. Each of them has a position, a size and specific resources available. An initial population of 200 entities is distributed over the cells where they obtain the resources and interact with their neighbors. The world provides resources for a maximum of 255 units.

The cells and the neighbors have important roles in the reproduction and in the growth of resources, changing the dynamics of the system not only in a larger sense but also in smaller groups defined by the cells they are in. While describing the population and the individuals, we shall better understand how these dynamics are generated.

## Population

Our initial population is composed of two hundred entities. Each one of them has a gender (female or male), a color, specification of maximum energy, food efficiency, a mobility level, time for reproduction and an initial position on the grid (area of the ecosystem). In addition, all other dynamics of the system depend on environmental characteristics changing over time.

As sound input is received, this population gains some color. Although the color is assigned at birth, saturation can only be seen when sound input is received by the application. The saturation increases according to the number of available frequencies in the sound being received each moment. The sound also changes our distance from the a-life by making our relationship close or distant and by modifying the user's perspective. The effects produced by the sound over the graphics will be further described in a section dedicated to sound input.

The characteristics of the world depend on the dynamic created by the population and the space where this ecosystem exists. The space doesn't change in size but is constantly being modified by where resources are available. The resources are the key element for this system to work since without it, the population dies (if the amount of resources is too low) or stops growing (minimum amount of resources available they don't reproduce).

The resources provide the entities with energy that is important for reproduction and allows the entities to move around. The amount of energy available to each individual is responsible its ability to mate. It also influences the degree of mobility, making easier or harder to find more resources. Energy is constantly being consumed thus causing death of the entity if food is not available in the vicinity.

Resources are being renovated in every cycle and distributed across the entire area of the ecosystem. Each individual has qualities that are unique and their ability to react to changes in the system. The individuals move around searching for better options to acquire resources and to mate.  Each of these qualities shall be described in the following sections.

### 5.2.1 The individual

In our a-life system, we defined two ways to generate a new individual. An individual can be created by the system or can be the result of reproduction. Every time a new world is created, two hundred individuals are automatically generated. Each individual is born with gender, color, position, energy, sociability, mobility, food efficiency, maximum energy that can be stored and a position on the grid.

All of these characteristics create the behaviors associated with the world and between the entities allowing the system to grow through procreation. These parameters also define the movement across the different cells. The individuals mate and move around as they get older. They can die from lack of resources creating a fitness rule where in times of rationing, the ones able to save more energy and that have better food efficiency will survive. These entities have a better chance of passing on qualities to the future generations.

To understand how each characteristic of the individual effects the system, we will dedicate ourselves to understanding them, making more profound relations in sections dedicated to the description of the reproduction and the movement.

Every new individual receives random values for his characteristics. They define, for instance, his gender to be either male or female. These initial values create a very distinct population. Over time, the best ones will survive this ecosystem.

The color assignment is random It doesn't change the behavior since this quality only defines the final graphical output. On the other hand, sociability and mobility affects not only the individual but the general dynamic of the system. Both these qualities generate higher interaction between the members of the population (sociability) and their ability to move around (mobility). Mobility in a very important characteristic since an individual can find others members to interact with only if he's mobile. Sociability only matters if there are other individuals to enable the interaction between them. Sociability also allows procreation. Procreation requires more detailed investigation since there are other factors that affect successful procreation.

The food efficiency, energy and the maximum food storage have a very important role in the survival of each entity and enables the growth of the population. While at a first glance, they seem only associated with the survival of the population since the absence of energy is associated with its death, we also need to relate the proportion of resources with reproduction. The energy of an individual grows when he acquires resources.

With such characteristics, the individuals of the population find a balance in which they grow (until a certain limit since the maximum resources of the world is limited) and can shrink, saving the ones with the most ability to live through the hard times and procreating when possible. The individual may die of old age or starvation

There are other important aspects of the system,related with procreation and its movement all over the world, which shall be described in the following topics.

### Reproduction

In this a-life system, we identified the need to implement a type of reproduction that depended on satisfying three characteristics, two of which were associated with the individual and the third related to the world. This decision was motivated by our objective of humanizing our entities and giving them characteristics that were not only parameters but also attributed some significance to their behavior. Even though these individuals' qualities are very important to promote mating, we also required a factor that reflected the ecosystem characteristics, making it more or less likely to happen.

We associated the sociability of the individual to make him more or less likely to interact with his neighbors. The higher his probability to interact, higher is the chance for him to mate .The sociability of the individual must be greater than a random value attributed to what we call reproduction chance.

```
if(reproductionChance < individual->sociability && individual->energy > 10){
    for(auto mate: *(_grid[individual->gridCellIndex].localPopulation)){
        if(mate->gender != individual->gender && reproductionChance < individual->sociability * mate->sociability *
            increasedSociablityFactor && individual->timeFromReproduction > 100*timeToReproduceFactor && mate->
            timeFromReproduction > 100*timeToReproduceFactor && individual->energy > 15.0f&& _grid[individual->
            gridCellIndex].food > 50){
            _population.push_back(reproduce(*individual, *mate));
            individual->energy -= 15.0f;
            individual->timeFromReproduction = 0;
            mate->timeFromReproduction = 0;
            numReprs ++;
        }
```

Figure 27 Sociability and energy required to procreate. If those characteristics allow the individual to mate, will be tested if the mate is from a different gender, the amount of resources in the cell, time from reproduction and factor.

Other important characteristics of an individual to even start looking for a mate is his amount of available resources. The quantum of an individual's energy depends on the amount of available resources at that moment, but also his capacity of storage and the resources available in the previous cycles. This ability to store and transform food into energy is associated with the maximum amount of energy and his food efficiency enabling the ones with a larger capacity to save energy and hence making them more capable to procreate. The individual energy must be greater than fifteen to even have a chance at reproduction.

Although some individuals are very capable of storing a lot of energy, over population may exhaust the available resources thus making it impossible to generate more individuals. Thus, we implemented a rule that restricts the ability to mate if the number of available resources in that cell is less than required. On the other hand, the chances of mating will increase if there is an excess of resources in that cell (Figure 28). It is required that the cell has least 50 units of resources available.

```
}
auto reproductionChance = CCRANDOM_0_1();
auto cellFood = _grid[individual->gridCellIndex].food;
auto excessFood = MAX((0.8f*maxFood - cellFood)/maxFood,0); // if there is lots of food in the cell that the
    individual is, makes it easier to reproduce
reproductionChance = reproductionChance + excessFood;
```

Figure 28 Excess of resources in the cell will increase the change matting

Besides the fact that reproduction is creating more individuals and therefore increasing the overall consumption of resources, the individual will lose 15 units of energy after reproduction, causing a risk to the living one to procreate in times of recession.

A variable is responsible to calculate the time between reproductions of each individual. The higher this time interval, better is the potential for the individual to achieve conditions favorable for procreation. This rule exists to ensure that there isn't a super individual that is always reproducing and transforming the whole ecosystem into copies of himself.

If the neighbor is of the opposite gender and all the previously described characteristics are achieved, the reproduction is a success. The result is the creation of an individual that is almost a complete replica of the individual that original searched for the reproduction. The new individual will be exactly like his parent only receiving a new random color. In this manner, the good qualities of the one that have higher reproduction rate are propagated.

### Movement

In the previous section, we saw how the energy and the available resources are not only essential to the survival of the population but also for successful reproduction. We also understand that the resources are distributed along the ecosystem and the relationship of the individual with the resource is associated with the cell he is at presently.

Although we have been treating the individual as in a static mode, it isn't what actually happens here. The individual is moving and this movement is generating new dynamics in the system but is also allowing it to search and store resources.

Mobility is a tendency of each individual to move. Some are more likely to move more while others don't. The other element that defines the movement it is its energy.

Without sufficient energy, the individual won't have the ability to move. The energy necessary to move is relative to a random number given by a variable called moveQuantity. This variable gives us the distance to be traversed and therefore the amount of energy that is going to be required to do so.

The "will to move" of each individual is a characteristic that is equal during the whole life. Individuals that tend to move more also tend to find more resources while also spending more of the stored energy. The equilibrium of this "will to move" is very important to the survival and propagation of his characteristics to the future generations.

As a result, the movement depends on a variety of random directions (angle). However, the individual never leaves the screen, changing his direction back to the ecosystem delimitations.

```
int numReprs = 0;
for(auto individual: _population){
    // makes an individual eat if there is enough food
    if(_grid[individual->gridCellIndex].food > 1 && individual->energy + individual->foodEfficiency < individual->
        maxEnergy){
        _grid[individual->gridCellIndex].food -= 1;
        individual->energy += individual->foodEfficiency;
    }
    auto chanceOfMovement = CCRANDOM_0_1();
    auto moveQuantity = CCRANDOM_0_1();
    // if the individual has enough energy and enough "will to move", makes him move on a random direction
    if(individual->energy > moveQuantity && chanceOfMovement < individual->mobility){
        individual->energy -= moveQuantity;
        auto radius = moveQuantity*gridSize/10*movementRange;//movementRange increases via the movement area of the
            interface
        auto angle = CCRANDOM_0_1()*2*M_PI;
        individual->position.x += radius*sinf(angle);
        individual->position.y += radius*cosf(angle);

        individual->position.x  = MIN(individual->position.x, xMax - 0.1f);
        individual->position.y  = MIN(individual->position.y, yMax - 0.1f);

        individual->position.x  = MAX(individual->position.x, 0);
        individual->position.y  = MAX(individual->position.y, 0);

        individual->gridCellIndex = findGridIndex(individual->position);
        individual->particles->setPosition(individual->position);

    }
    auto reproductionChance = CCRANDOM_0_1();
    auto cellFood = _grid[individual->gridCellIndex].food;
    auto excessFood = MAX((0.8f*maxFood - cellFood)/maxFood,0); // if there is lots of food in the cell that the
        individual is, makes it easier to reproduce
    reproductionChance = reproductionChance + excessFood;
```

Figure 29 Movement of each individual

Due to the movement and the sociability described in the previous sections, a behavior is created that modifies the dynamic of the a-life system. The movement associated with a population that is genetically more sociable, creates a dynamic where the population is more organized in clans. Reduced movement and the low sociability generate a completely opposite dynamic where the population is more distributed across the area of the world.

These dynamics are not only important to the interconnections of the system and its successful equilibrium but also for the final visualization. In the next section, we will study how these dynamics completely change the aesthetics of the graphical composition.

### 5.2.2 Graphical representation of the System

Defining the a-life provided us important information about the representation we chose to adopt in the first version of the app. The rules established the dynamics and behaviors while the possible combinations of colors and combination of the graphical elements emerged from the choices we made based on the available variables of the system.

Our goal with the aesthetics was to ensure its beauty as well as conjugation with all the elements that coexisted on the same surface. We conceptualized the graphical outcome separately from the interface. However, their union was important since both were seen together by the performance, while the audience was only receiving the final graphics.

The aesthetic we chose to represent the individuals from the a-life into the projections didn't differ much from the previous ones. We searched for fluidity, a concept we have also explored in the preliminary experiments. During these experiments, we were able to define our notions of aesthetics. In some cases, the graphical result seemed more like a gas and at other times more like a thick liquid which is constantly navigating from the inside of the digital (the darkness of the screen) to the outside (actual world). Although in the initial experiments, this transgression was always happening in a very dark way, in *Fantasia sobre Fantasia* we were able to successfully add color without losing this dichotomy of the movement between two worlds. In ALIVEART, we tried to modify some elements but the color of the elements was now assigned by sound analysis (we will dive into it more deeply in the next section).

While in Fantasia and 2+n, we worked with a particle system that was most of the time more like a cloud that had more or less smoky feeling or like a liquid that had a mix of colors. Instead of the mass approach we used on the other experiments, here we decided to play with a particle system, in which each individual would be more clearly identified.

We wanted to retain the liquid aspect but instead of creating puddles, we wanted to explore something more like drops where each individual was more represented, not just the sum of all members.

To achieve this, we used a particle system that gave a smoky look on the borders and gave it a movement consistent with smaller puddles that move across the screen.

This change completely modified the final outcome of the graphical output due to the change in the dynamics of the relationships between the entities. This affected the organization and composition of the space, therefore modifying completely the general aspect of the piece.

Without any interaction, we felt the results were not completely satisfactory. However, it gains strength with the right performative choices, user engagement and intervention although at first glance the system may seem very simple and uninteresting.

The graphical outcome depends not only on the actual system and the choices made by the performer but also have much to do with the sound characteristics being received. These characteristics will be described ahead.

### 5.2.1 Sound

Although sound is an element external to the system, it is responsible for many changes in its behavior and in the graphical representation of the a-life. In the last few chapters, we have described the importance of sound in our app and the manner in which we chose to represent its changes and the paradigms behind it.

We decided that sound needs to change the graphics in a manner the viewer can relate the type of sound based on its actual representation. We searched for ways that different types of music could have different graphical outputs.

This task was more difficult than we previously anticipated. To achieve the desired results, we would have to implement a Music Information Retrieval (MIR) algorithm, which is a multi-disciplinary field where music is automatically analyzed and retrieved. Relative to other music elements, this analysis is more complex as it requires computer intelligence that can identify patterns, characteristics of the music and classify it according to its genre and style (Tzanetakis, 2014).

This kind of approach would allow us to create customized reactions based on the genre of music being played. Due to the complex nature of the system and time constraints for this research, we decided against this effort at this time.

Instead, for the first version of the app, we identified that the number of harmonics present in the music could help us identify many attributes about the sound being played. At least, we could emphasize differences between the two most relevant types of music we normally use in this type of performance. These harmonics allow the system to express itself differently when we dealing with laptop artists versus a full orchestra (conclusions driven from the preliminary experiments).

In our approach to music, we realized that the musicians working with us that used laptops made extensive use of pure sinusoidal waves or noise while instrumentalists produced more complex sounds. Of course, sinusoidal waves and complex sounds can be easily differentiated based on harmonics. The noise can be differentiated since it is a conjunction of chaotic frequencies.

By using the Fast Fourier Transform, we were able to understand the number of peaks at each moment of the music and therefore understand the type of music being played.

With this strategy, we were able to differentiate the two types of music and use it in the development of the graphics. We decided to search for metaphors that clearly connected the type of sound and graphics mainly because we felt that we need to create some impact on the user to demonstrate this relationship. We attempted to avoid making the graphics too literal while being aware that at some point, we would have to engage the viewer. We believe that engagement had to be achieved by a more direct behavior of the elements in the exhibition and the graphics.

We decided, it was interesting to relate the saturation of the individuals to the type of sound. Many times through the process of clarifying the metaphors behind the preliminary experiments, we related digital life to the binary organization and we normally associated with opposite colors such black and white. We decided to maintain this metaphor where the music defined if the artificial system is more digital or more in the actual world.

The saturation of the color gives its percentage of presence of the pigment. By lowering the amount of pigmentation/saturation, we are making the world to go greyer. The entities became white in a grey ecosystem, making it very digital. This saturation may grow a bit but the system continues to be more digital than actual. When the saturation is high, the graphics become more colorful. The increase of the saturation in directly related to the number peaks over time (Figure 34).

It results in more vibrant representation of the a-life and produces a completely different outcome from the sounds described before. We relate the variety of color to the actual world multiplicity. The system can change between both situations if the music requires so, creating a very flexible representation of both situations in the same performance.

In Figure 30 and Figure 31, we can see the difference between the system graphical representation while listening to Ryoji Ikeda's album Matrix and Fluvio Salamanca's compilation. The colors saturation is very different in both scenarios and it is consistent with the metaphors we were hoping to establish between different sound inputs. The reactions to the sound will be further analyzed in the next chapter when we take in consideration the results of an experiment conducted with a group of experts.

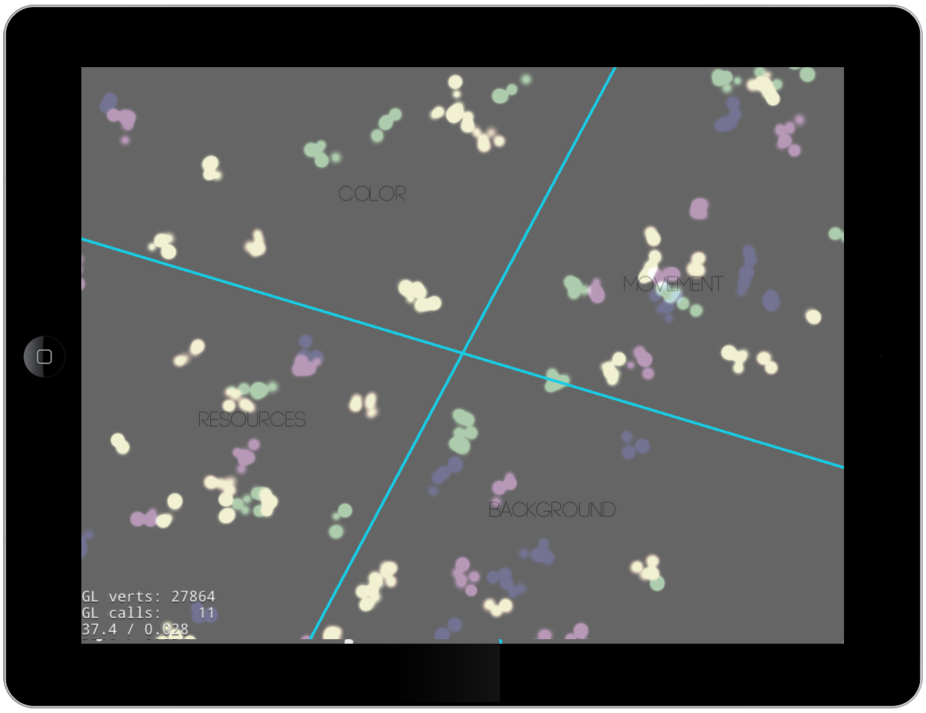



Figure 30: result of the graphics during experimentations with Ryoji Ikeda's album Matrix (99-00) Disc 2

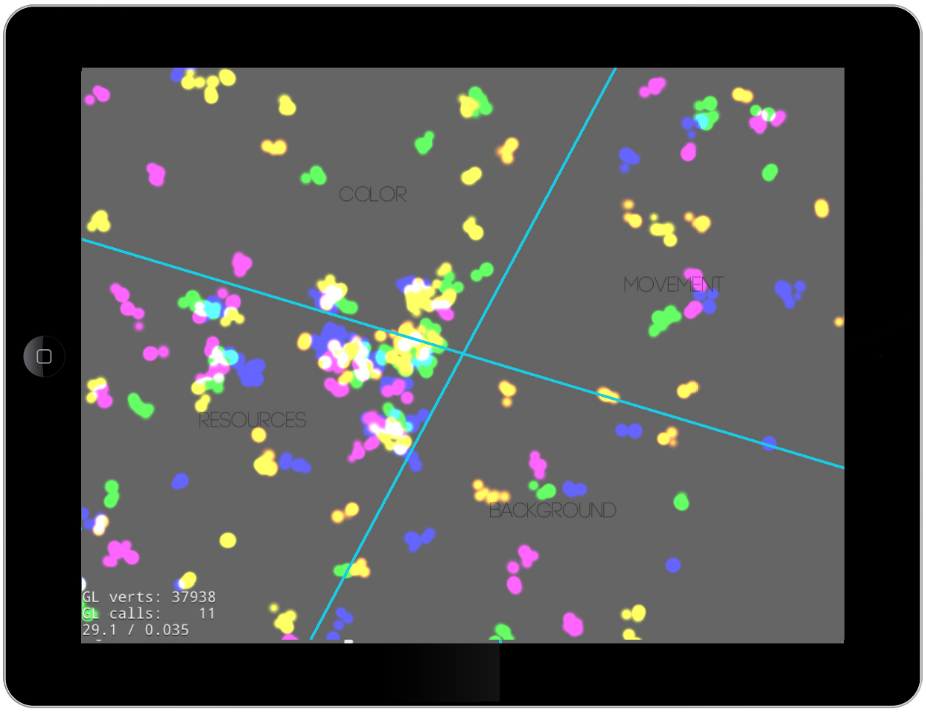



Figure 31 result of the graphics during experimentations with Fluvio Salamaca's songs (Adiós, corazón (1957), Yo tengo un pecado nuevo (1958) and Quereme corazón)

If there isn't any sound being received by the system, the population will continue to exist but the individuals will be white since there aren't any frequencies to attribute them colors. In Figure 32, we can see the result of the representation of the world without any sound input.

In addition to defining the amount of the system representation saturation, the sound also allows the user to zoom in and zoom out according to the sound amplitude. Like we have being seeing throughout the analysis of our systems, we believe that is important to establish previously incorporated metaphors into the design of the system to reinforce our relationship with it. The colors of the system tell us if the individuals of the a-life are more in the digital or actual world. The amplitude of sound brings us closer or away from the world.

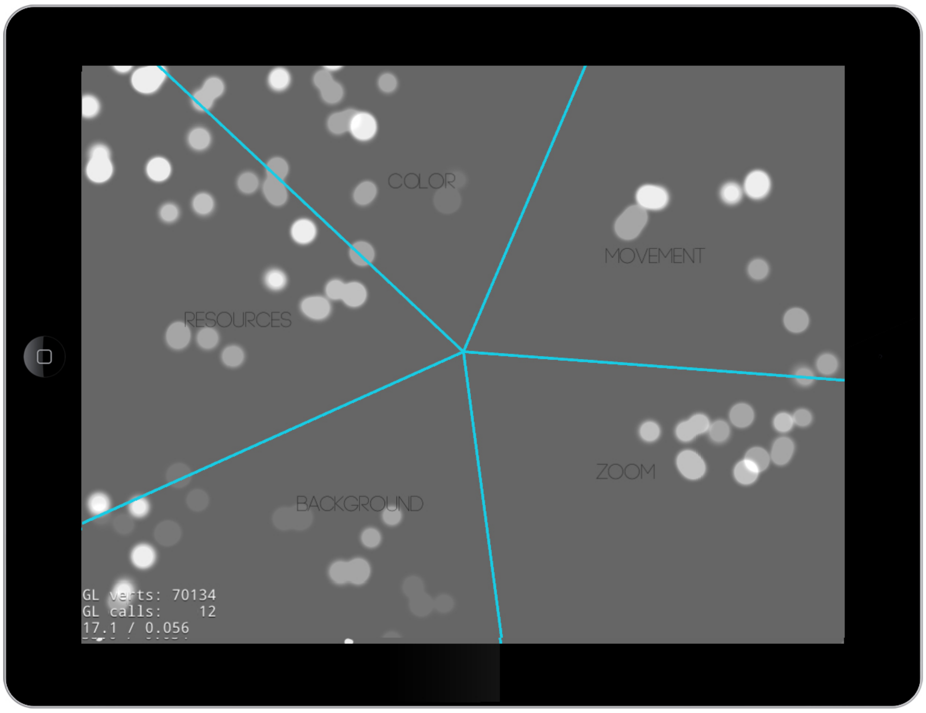



Figure 32 No Sound input but the system will continue to generate graphics. Maximum Zoom In (controlled by the interface)

Another element in which the sound provides the user the possibility to have a closer look into the ecosystem is related with the volume of the sound being produced. Its clear that sound is always louder if we are closer to the source. It is also important that a group of entities that are louder is automatically noticed more and hence attracting more attention to themselves. The opposite is also true. If we are low with volume, we normally don't want to disrupt or draw attention to ourselves. Lower volumes mean the sound is normally more distant from the source. From these relations, we observed the possibility to allow the user to get a closer view of the a-life when the sound is louder and vice-versa.

By creating this relationship where music is a key element to our proximity to the artificial life system, we are establishing that the relationship with system can be more or less profound depending to its elements and the sound being received by the system. Although the system is not producing the sound in this case, it is important to guarantee this link as being essential to both sound and a-life/graphics. We think of them as a unit instead of looking at them as separate things. By allowing the user to perceive that the sound is a voice from the a-life, we are reinforcing their oneness.

Like we mentioned, we can see the entire world whenever zoom out is complete making it possible for us to see all the elements of this a-life system from a completely distant position. The change in the volume modifies our view over the world by approximating us from it and allowing us to see the most interesting dynamics of the system at each moment. For this to happen, it is important to have a law in which we can define where we should zoom in.

Whenever the system makes a zoom out (farthest view) the system searches for the area where higher number of individuals are concentrated and defines the next spot on which it will zoom in the next time the volume gets louder (Figure 33). By implementing this strategy, we are able to zoom in into the area with more activity and therefore with more interest.

```
// when the simulation is zoomed out, find the cell with the biggest population and center there on the next zoom in
    if(nextLevel <= 1.1f){
        auto maxSize = 0;
        auto px = gridSize/2 + CCRANDOM_0_1()*(World::xMax - gridSize);
        auto py = gridSize/2 + CCRANDOM_0_1()*(World::yMax - gridSize);

        for(auto cell: world->_grid){
            if(cell.localPopulation->size() > maxSize){
                px = cell.cell.origin.x + cell.cell.size.width/2;
                py = cell.cell.origin.y+ cell.cell.size.height/2;
            }
        }
        _zoomPosition = cocos2d::Point(px,py);
        cocos2d::Point anchor = cocos2d::Point(px/worldLayer->getContentSize().width,py/worldLayer->getContentSize().height);
        worldLayer->setAnchorPoint(anchor);
    }
    _nextZoomLevel = nextLevel;

}
```

Figure 33 Making the decision in which direction is made the next zoom in

To make this experience smooth, we need to ensure that zoom in and out doesn't happen in response to every variation of the system. Instead, we need to find a balanced way to respond to the variations in the amplitude of the sound so as to make it comfortable to the viewer. To solve this problem, we defined that we would vary the average from the last few frames, ensuring that we the zoom happened in smooth changes but without loosing much energy in the moments that the sound required it. From the code excerpt, we can see how we implement such a rule in Figure 34.

```
// finding the amplitude of the sound and calculating the average from last few frames
// this determines the zoom level, but the changes aren't abrupt
historicAmplitude[ampBufIndex] = MAX(max - min,baseLevel);
float amplitude = 0;
for(int i = 0; i < ampBufSize; i++){
    amplitude += historicAmplitude[i]/ampBufSize;
}

ampBufIndex =  (ampBufIndex + 1)%ampBufSize;
if(amplitude > baseLevel + 4.0f){
    interfaceLayer->hideZoomInterface();
    interfaceZoom = 0.0f;
}
else{
    interfaceLayer->showZoomInterface();

}
amplitude += interfaceZoom;
zoomIn((maxZoom - 1)*(amplitude - baseLevel)/50 + 1);

//set how colorful the game is based on the number of peaks found on the fft data
world->setNumColors((int)peaks.size()/2);
```

Figure 34 Excerpt of the code where is defined the average of the sound amplitude from the FFT. The number of peaks is used to determine the color of the individuals

### 5.2.3 The Parameters

We chose to allow the user to interfere with the system via five parameters. Each parameter interferes with the system in a different way. Some parameters create more complex changes and others more direct ones.

To begin to understand the importance of these parameters for this first version of the app, we will take the information we just exposed about the system and understand that the chosen parameters are actually key elements of the system, creating a intense relationship between system and interface and therefore interface and user.

The information we choose to represent on the interface needs to be important to the system and representative of the system as well. At first glance, although this description appears to be oriented on the side of the interface, we believe it can be only truly understood according to the system paradigms.

The most relevant elements of the system are the relationship between resources (food) and entities, the movement of each individual and the movement of the entire system. In addition to the general aspects of any living system, this system was also configures by sound input making important changes in the graphical representation of the system.

From this data collection, we concluded that the most relevant characteristics of the system to be represented on the interface would be: 1) Resources; 2) Movement; 3) Zoom; 4) Color of the particles and 5) Background.

Resources:

Like we saw in the description of the system, the food is very important to the organization of the system. It dictates how the individuals relate to each other (acting more like a clan or more individually), their position on the screen, the number of individuals in the world.

The resources are created, as we saw previously, in random areas of the screen and the amount of food allows or disallows the individuals to procreate. In other words, the number of resources available can cause death, stagnation or growth of the population. When the resources are too low, the population will get minimum amount of food and begin to die. Hopefully, the death of some will allow that the others get the minimum required food to find a equilibrium between number of individuals and available resources. When the number of resources gets bigger, the individuals begin to procreate because the conditions allow more living beings in that area.

But the food/resources also determines the position on the screen, defining where and how the population organizes itself. Thus, both positioning and the number of elements drawn are graphical elements that are very closely related with the amount of resources. Although this parameter is given by the system, we considered it important to allow the parameter to be influenced by the performer/user.

As described, the interaction only proposes a new direction to the a-life, not actually changing the status of the world. By adding resources to the system, it won't necessarily grow the population or even distribute the habitat in a different way. With more resources, the system will grow according to its own rules creating its own new choices.

The opportunity to increment the resources is only available to the system when the amount of resources is so low that the population is dying or if the resources are just enough to keep the existing ones alive.

By proposing the growth of the resources into the a-life, the user can expect the following outcomes:

1) The population grows and groups around the places where the resources are available since the number of individuals are not very big.

2) The population grows dispersed since there are many individuals. The population tries to spread as much as possible.
3) The population doesn't grow but it changes its dynamics and how the population is organized in space. New spot with resources allow them to create new setups.
4) There isn't any change.

Given these possible outcomes, it is obvious that there are millions of differences that emerge in each one them. These are possible global outcomes, not considering small but relevant possibilities inherent to any emergent system.

This changes applied in the graphics can generate variations regarding the number of elements on the screen and their organization. Some elements may be spread; others grouped in small spaces or both. It results in new graphical compositions and in different balances in the image. The number of elements produces more or less graphical weight and impact.

#### Movement

The movement of each individual of the population is given by a random function of a chance to move plus the amount energy available. This movement is, therefore, not only a personal quality but also an environmental condition. Of course, each individual is capable of storing more or less resources but also depends on the previous levels of resources being produced in each area.

When we decided to introduce this characteristic to be mutable by the user, we didn't want individuals to just move more. We wanted to make sure that the individuals were able to explore different areas, and maybe move to areas where there were more resources.

By permitting the user to control this parameter, we not only allowed the graphical movement to be incremented but we also endorsed the system to develop different dynamics searching for conditions that better suit the population.

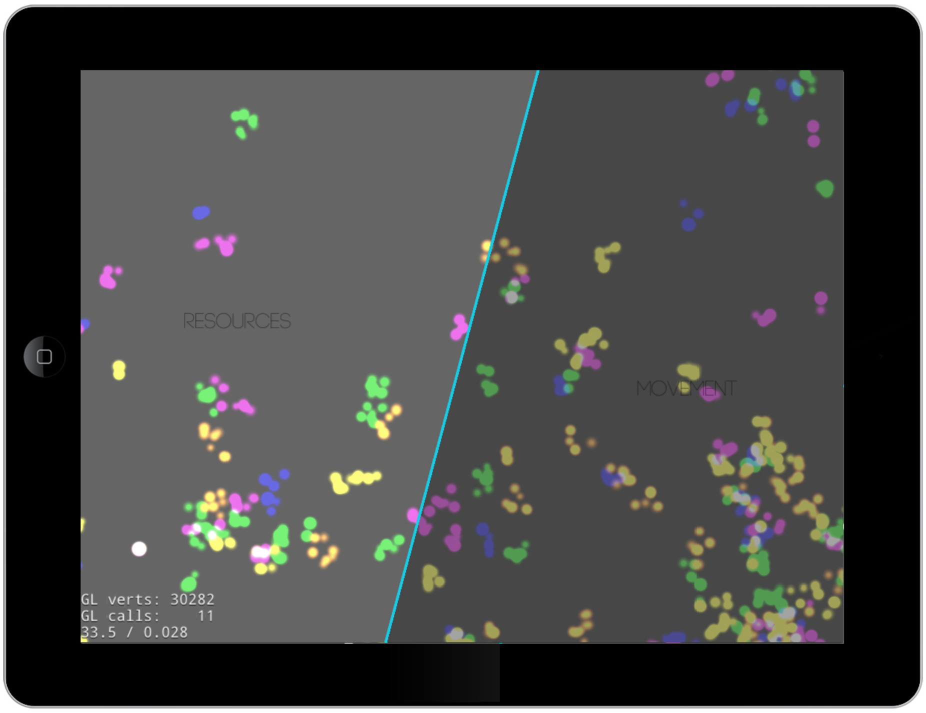



Figure 35: Here's an example of the selection of the parameter movement. The area of the parameter selected is darker.

In the description of the parameter "Resources", we also talked about how it influenced the organization of the population on the screen. What we need to clarify here is that there is an important difference between the two ways in which the user can propose new organizations. While by pressing the area of the screen identified as resources the population can organize itself in a more controlled space, by pressing the movement option the user explores wider variations. What we mean is that although both can change the type of relationship between the members of the population by proposing greater or lesser formation of clans, what differs between both strategies is the amplitude of those changes. The resources allow these changes in a smaller range while the movement allows the population to explore different areas of the screen.

Such difference may seem irrelevant but actually changes the population behavior in a larger way. Of course, these changes are very visible graphically because the change of movement normally also changes the velocity of the movement and direction of the particles, but also opens new possibilities to the population, putting these entities in a new position that may be on the other side of the screen. Without this interference, the population could not arrive at a certain area of the screen for a great number of cycles. This way, it is possible to promote new interactions in a wider range.

This parameter becomes available for the user to modify as the population is not moving. If the movement of the population is high, the system will not allow increase in the mobility.

These possible changes over the A-life may or may not happen. All depends on how the world responds to this stimulus according to the world options at that given moments.

#### Zoom

Another important parameter available on the interface is Zoom. Like we already reviewed previously, the zoom in and out are associated with the sound amplitude.

This analogy between the low and high volume of the sound is translated graphically. The viewer gets a chance to change his point of view. When the sound gets louder, he gets closer to the world. This means that if the volume of the sound is low, we can see the population as something far away, being able to see everything as a whole. If the sound gets louder, the user gets a chance to go closer and enter the world.

This relationship between distance and sound is obvious. being always louder the sound the is produced closer to us than the ones far away is complemented by the relation between the sound and the size of the representation of each individual. When a sound is louder, we tend to relate it with something big and making more impact, while if we hear something quieter, we normally associate it with something more delicate and fragile.

By allowing the user/performer to interfere in the zoom, we are allowing the performer to change the distance between them and the world, and therefore changing the relationship between the sound and the image.

Even though this proposal allows influencing the distance between the actual and virtual worlds, we are not disrupting the actual effect of the sound over the system. The rhythm is maintained.

The user can only get closer to the a-life and the zoom, as in the natural zoom, is directed to the area where most living systems are concentrated. As with all the other parameters, the user can keep the option pressed, making the zoom in to move exponentially. By releasing the zoom area and pressing again, the region in which the zoom in is going to be directed can change, according to the dynamics of the system. If the area is pressed continuously, the zoom will focus on the area decided at the starting moment of the touch. It doesn’t change its trajectory while zooming in.

The zoom is only available to the user according to the variation of the sound amplitude. This means that like all the other parameters of the system, it is not always possible to interfere with it. For this parameter, we decided that the zoom could be done when the zoom defined by the sound analysis of the previous frames was not changing much. In other words, the system allows more changes to the zoom if the sound is not producing as many variations as expected.

#### Color of the Particles

Another aspect that is related with sound and that interferes with the a-life and, therefore with the graphical representation, is the parameter related with the color of the particles. From what we understood about the description of the system one of the characteristics, which defines each individual, is his color. Although it may seem that the color of the individual may change through his lifetime, what actually changes is the saturation. The color is the same during his entire life.

The variation of the saturation is related with the variety of frequencies available. This means that the saturation of the population will vary depending on the sound composition and the number of different frequencies at each moment.

Therefore, the colorfulness of the population will depend on the type of the music the system is listening to. Sounds from orchestras tend to be more colorful than a concert from minimal laptop users. This way, the music affects the system, making a clear difference between sound styles and reflecting them in the graphical representation.

The user can interfere with the general saturation of the population by selecting the parameter “color”. This parameter is available every time the saturation is low and allows the user to achieve a higher saturation even when the sound produces grayish outcome.

This change made by the user can't be incorporated by the system when the system has more influence. As soon the user stops to press the area designated for color, the system will go back to its original saturation.

Every time the music stops, the system is still able to survive but it losses all saturation retaining only grey and white since no frequencies are received by the system.

Background

The last parameter in which the user can interfere with the system is the background. It is a parameter that that defers the most from all others given that it doesn't change any of the system's mutational characteristics.

From all we saw until now, the user is always interfering with structures of the system and the sound. They have the power to change graphical and functional characteristics of the system. This case is different. The user can change the background color (it is always the same) by making it darker every time the general aspect of the graphics is not varying much.

Like we just saw, different songs have different characteristics that are analyzed through FFT. This analysis gives us information regarding the sound suggesting if it is more or less complex and even the variety of frequencies at each moment.

We decided to give the user/ performer an option every time the system is too predictable or too colorless by allowing him to modify the background and by that, change the graphical outcome.

The result is a parameter that isn't available to the user most of the time but when it is available, it introduces some novelty that won't depend on the system, and there fore can be modified , as the user wants. The user can also create variations and rhythms with the variation of the background (Figure 36).

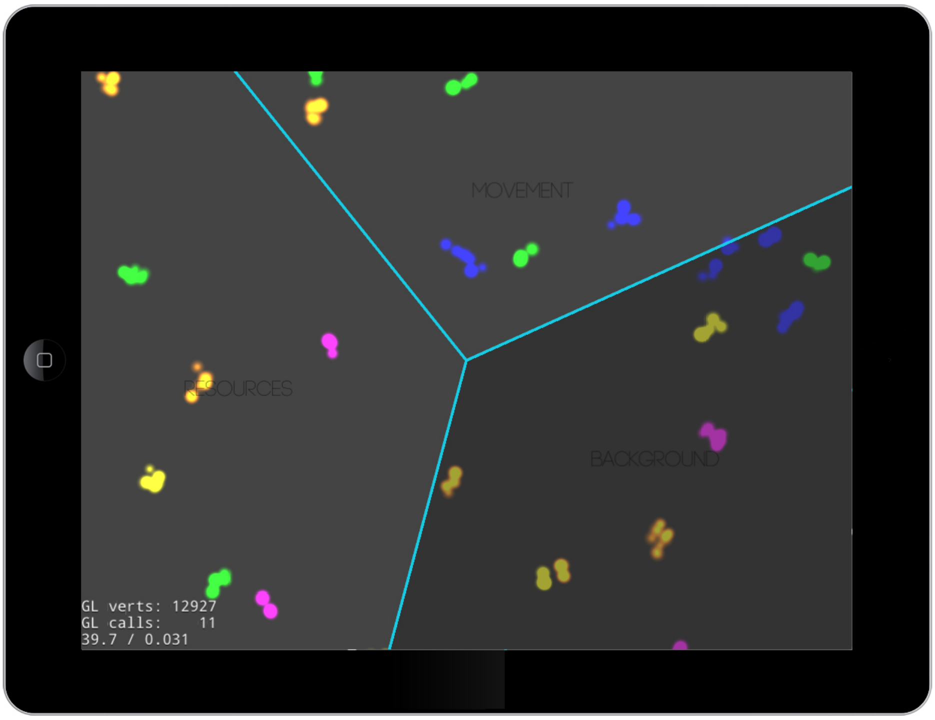



Figure 36: The user can choose to make the back ground darker. By doing that the selected area gets even darker.

## 5. 3 Conclusions about ALIVEART

Throughout this chapter we exposed the features about the ALIVEART mobile app. This detailed explanation of the most important aspects of our research, such as the interface, the a-life and the sound input, allowed us comprehend the conceptual and technical aspects that structured the development of the app. During this process of describing the app, we were able to understand several important metaphors and the innovative aspects we were able to achieve through this research.

In our description about the interface designed for this piece, we explained key points that regarded the interaction metaphors such as the process of stimulating the system instead of modifying the values of a given parameter and the communication between both system and user, where both effect the interface during the whole interaction. We also defined how we chose to communicate graphically, where the interaction space was divided equally according to the number of parameters available for the user at each moment and the overlap of the graphics and the interface with the goal of setting both on the same plane. This facilitated a better integration of the virtual and real world making it possible that the system and the user explore more naturally the idea of contribution.

We also described the a-life system and all its most important elements such as the attributes of the population and the individuals, the graphical output and the interference of each parameter (that the user has access via the interface) in the functioning of the a-life. In this process, we were able to understand the conceptual aspects developed to sustain the technical developments and how all of it gained form in the screen of the iPad and iPhone.  It is very important to us, once again, to demonstrate that this conceptual aspect of the piece sustain the app because they are responsible for creating the right metaphors and therefore allowing us to achieve the right connections between user and system. In this process, we were also able to understand the implementation of the system by exemplifying the most important parts with actual code.

Finally, we dedicated ourselves to understanding the sound and how it affected the graphical representation. This was an extremely important part of the research since we decided that sound was going to be the element that was going to make the graphics a bit more responsive than other elements. Until this point we more focused on the autonomy of the system but we also needed the place to connect with the people and to create engagement with the audience. Establishing relationships between sound qualities and the graphics gave a sense of presence to the graphics, i.e. the sound allowed the graphics to create a more clear connection between all three elements since it was capable of exposing relations between actions and reactions of the system.

Hopefully, with this description, we were able to demonstrate the process of designing and producing the app thus, allowing us to develop a comprehensive understanding of all three elements.

# 6 Proof of Concept Prototype: Analyses and Results

As a proof of concept, we proposed an adaptive user interface for live generative graphics. Here, we report the results, presenting the conclusions derived from experimentation and the completion of a survey from a set of expert users.

To establish clarity of the process, we first describe the testers and the process of creation of the questionnaire that was given to the testers to obtain their feedback. Our selection of the audience and the questionnaire play an important role in the evaluation of our interface targeted at obtained expert opinion regarding the three most important areas of our research. We believe that designers, performers and user interaction experts cover all the topics related to this research.

Prior to analysis of the results, we will describe the instructions provided and specific requests made to the testers to ensure their understanding of all the aspects.

## 6.1 Choosing the testers

An important objective of this research was to develop a system where experts and non-experts could easily use the system for production of graphical compositions assisted only by a generative system and sound input. Finding common ground to achieve ease of use by both experts and novices is not easy. Characteristics that engage experts normally are very different than the ones that engage users who have little or no knowledge about the subject. To make common people aware of generative strategies in artistic process, we have to address the topic in a much different way so as to introduce the purpose and educate regarding its use. A favorable characteristic of mobile apps is that it is available for a great number of people at very low cost.

Although, we seek to expand generative practices by making it more understandable to a greater number of people, what we were really searching for was a way to facilitate the artistic expression by creating an interface that is more aware of the user and the system thus enabling it to be customized for a specific situation.

We felt the feedback on ALIVEART would be more comprehensive if we had inputs from three multi-disciplinary groups.

Thus, we looked for people with relevant work in any one of these three areas. Some classified themselves as experts in two or three of the areas, making them the perfect group of testers for such a multi-disciplinary system.

Only eleven of the twenty testers completed the whole process. The whole process consisted of registration of the device, testing the application according to instructions and responding to a survey at the end.

## 6.2 Design of the Survey[7]

[7] Full survey can be found in Appendix A

This survey is divided into four parts: 1) Personal Information; 2) Technical Aspects; 3) Knowledge related to Generative Live Graphics and 4) About the application.

In surveys such as this one, it is very important to get to know the user and his background. The brief personal questions helped us to understand our tester in terms of his experience, type of expertise, age and background.

The technological aspects allowed us to comprehend the type of use made by the tester. We also inquired about the specific device being used for the testing to help us to understand differences between iPad and iPhone users.

In the third section of the questionnaire, we were able to understand the tester's knowledge of terms relevant to generative practices and more specifically with generative life performance. We also inquired about his interest in the type of concerts and spectacles.

The last section was about the mobile app ALIVEART. Here the focus was on understanding the interaction, final graphical output, tester's take away from the experience and his general feeling regarding the whole experience.

### 6.2.1 Characterization of the User

Four of the five questions regarding the user and his background were mandatory. We attempted to understand cultural aspects of the user by knowing his place of birth, decade of birth, age and other aspects.

These three elements helped us construct a profile of the user by understanding his most general experiences and his cultural context. We also classified the user based on his fit into one of the three categories.

The five questions asked regarding users:

1) Tester name;
2) Gender;
3) Age;
4) Nationality;
5) Area of work.

### 6.2.2 Technological Aspects

Since our three groups of testers constituted designers, user interface experts and performers, we had to identify their use of technology and more specifically about mobile technology.

The user answered four questions in which they described their normal use of mobile devices, if he usually buy apps and if he ever bought any dedicated to art expression.

From responses to these questions, we were able to understand their use of the device along with their experience experimenting on non-traditional apps. We also recorded data on the device to understand impact of the size and the configuration of the device on the experience.

The four questions were:

1) On which device did you try the app?
2) How frequently do you buy apps for the device?
3) Have you ever tried other apps dedicated to art expression?

4) If your answer to the previous question is positive, please describe.

### 6.2.3 Generative Live Graphics

The objective of this section is to understand the user's awareness about concepts related to generative art and generative live graphics..

Throughout this experiment, we wanted to determine the impact of the knowledge of the basic concepts of generative art on the user's understanding of the app and related experience. In other words, we wanted to assess if the responses of the tester changed depending of their understanding of key concepts of generative art. It was important to determine if prior knowledge of concepts of generative art would influence the user experience and hence have an impact on the experience being more or less fulfilling.

We also included questions to assess the kind of concerts normally attended by the tester to measure his awareness of this type of artistic language. Our goal is to confirm if previous experience influenced the user ability to engage with the app.

This section contained the following five questions:

1) Do you know about Generative Graphics?
2) Do you know the meaning of A-Life?
3) Which live performances have you attended?
4) Have you ever developed any type of live graphics for concerts?
5) If your answer to the previous question was positive, please describe.

### 6.2.4 ALIVEART: the app

In this section of the survey, the user answered specific questions about his experience with the app. Here, we evaluated the main characteristics of the app such the interaction, the aesthetics, the engagement and the user capacity to understand the main goals of the app.

The following sixteen questions were asked:

1) How long (more or less) was your first interaction with the app?
2) How easy was it to use the app?
3) Did you understand the main goal of the app?
4) Did you understand how the interface works?
5) Did you understand how your interaction was affecting the system?
6) Could you notice the a-life system while using the app?
7) Did you feel you could express yourself through the graphics being created?
8) Could you achieve interesting graphics while exploring the app?
9) I think the graphics are…
10) How easy was to read the information displayed on the screen?
11) The mixture on the same screen, of the system and the interface was...
12) While using the app, did you experience any problem?
13) If you had any problem while using the app, please describe it:
14) Do you plan to continue using the app?
15) What is your general evaluation of the app?
16) Which of these aspects were you able to recognize in the system?

## 6.3 Instructions Given to the Users

After selecting the group of testers and formulating the survey, we considered it important to provide the testers with some instructions. Our goal was to facilitate their work during the time they spent using the app.

The first step consisted of instructions to enable the user to access the app. Since the app wasn't available for everyone on the apple store, we needed to allow each one of the users to download it on to their device. Each user was instructed to fill a form in which they were able to register an account and their device.

A small description of the app and its goals was also provided along with installation instructions. It was more important for us to explain the degree of autonomy of the system, the influence of sound and the interaction paradigm over technological or conceptual ideas. These three elements are very specific to this app and had to be noticed even by those users that did not have enough background information on the subject.

This description provided the user with the purpose of the app and the need for creating an adaptive interface for live generative graphics in which the graphics are stimulated by sound and changes according to different sound characteristics, such as frequencies and amplitudes.

We also created a brief explanation about the behavior of the interface, and its changes according to the a-life system characteristic with time. It also described that in this version, we allowed only 5 elements to appear on the interface (Resources, Color, Movement, Zoom and Background). Another fact about the interface we found important to explain was how the interaction actually happens. Since this interface is not defined by knobs or sliders, we decided it was important that the user understand that its control happened by selecting the area of each parameter and that the time he kept his finger on the selected area caused the parameters stimulus to increase exponentially. The approach of stimulating the parameter and not modifying it had to be clear from the start else the user could feel less engaged. We also clarified that the user could select any number of parameters at once (as we can see on the Figure 37) where two parameters are activated at the same time.

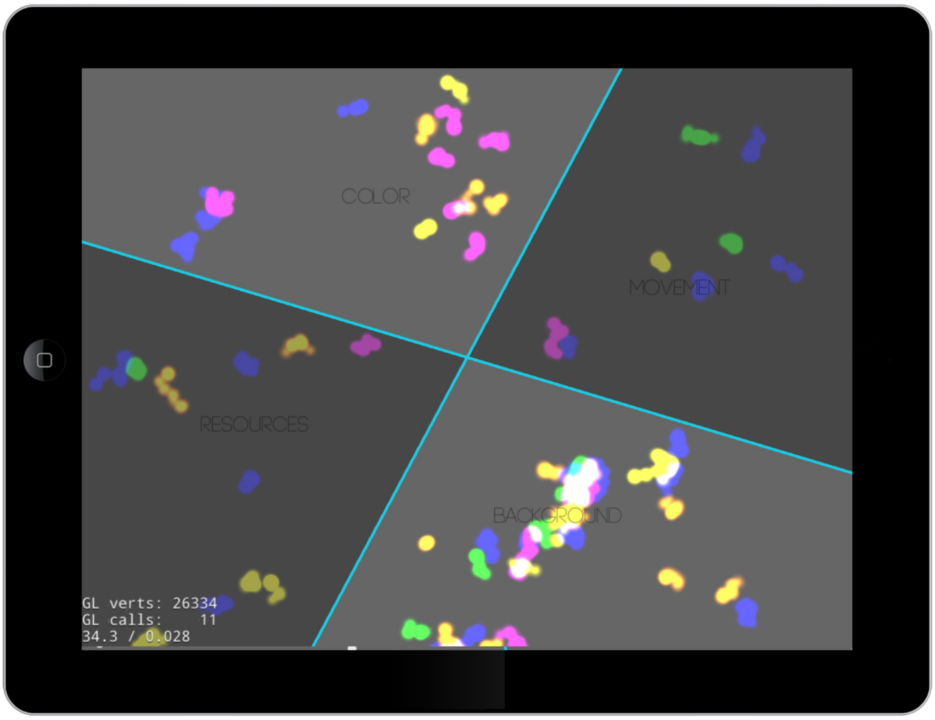



Figure 37: ALIVEART when the interface is presenting four parameters (color, resources, background and movement). Users can select more than one parameter at a time. All the selected areas get darker.

After the app was downloaded, installed and explained to the tester, we found it important to select two collections of music that represented opposite situations of music concerts. As identified in chapter five, one of the elements we decided was important to stress upon in the app was the fact that the system can't represent equally an orchestra and a minimal laptop user. Although we could have explained the same to the user, it would be a challenge for the user to find such different types of music. Thus, the tester woud not be aware of the differences and hence unable to complete the test.

The compilations of songs were each from different artists. The first one was the full version album of the artist Ryoji Ikeda (available at https://www.youtube.com/watch?v=yTrh_QiMbd4). The album is entitled Matrix (disc 2) and was released in 2000 (Ikeda, n.d.). It is 32 minutes long collection where are reveled ten different songs filled with pure sine waves and white noise that makes the sound very digital and minimal. Ryoji is an artist that is always rethinking the sound and experimenting with sound installations and different sources of data to create his music. His work is very relevant for today's art practices. We suggested to the users, to hear with this compilation with the ALIVEART app because it introduced very distinct elements for the sound analysis.

The second compilation was made of four songs from Fluvio Salamanca, an Argentinian tango musician and composer. The songs were recorded between 1957 and 1958 (available at https://www.youtube.com/watch?v=PIn9MWaWE5I). These four tangos are very different from the songs created by Ikeda allowing the user to perceive the differences between both effects of the sound over the generation of the graphics described in the previous chapter.

After the instructions were completed, the tester was able to experiment the app and complete the online survey.

## 6.4 Survey Evaluation

In this section, we will analyze the users and evaluate their responses. The information derived from this data will allow us to formulate conclusions that are important to allow us to understand the impact this research has on the development of interfaces for generative graphics, performance and mobile design applications.

### 6.4.1 Testers Information and Background

The group of 11 testers constituted both male and female, in almost equal numbers (**Error! Reference source not found.**). Most of them were between the ages of twenty-five and thirty-five (Table 2). Ten of them were Portuguese and one was American.

Table 3 Representation of the proportion of both genders in the group of testers

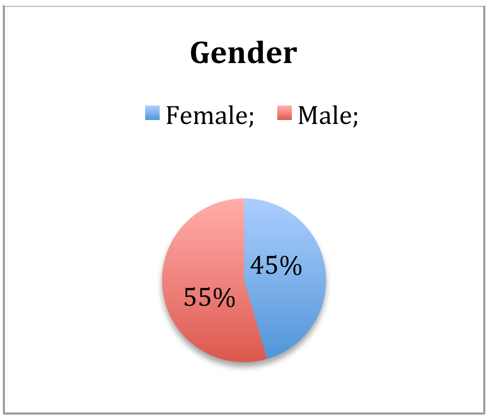
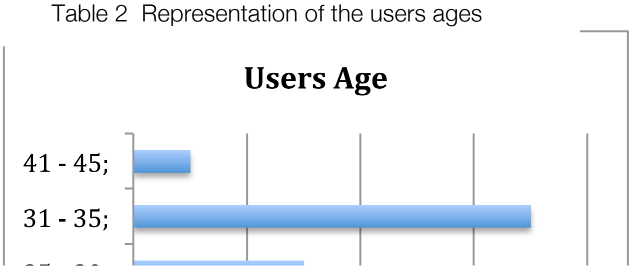
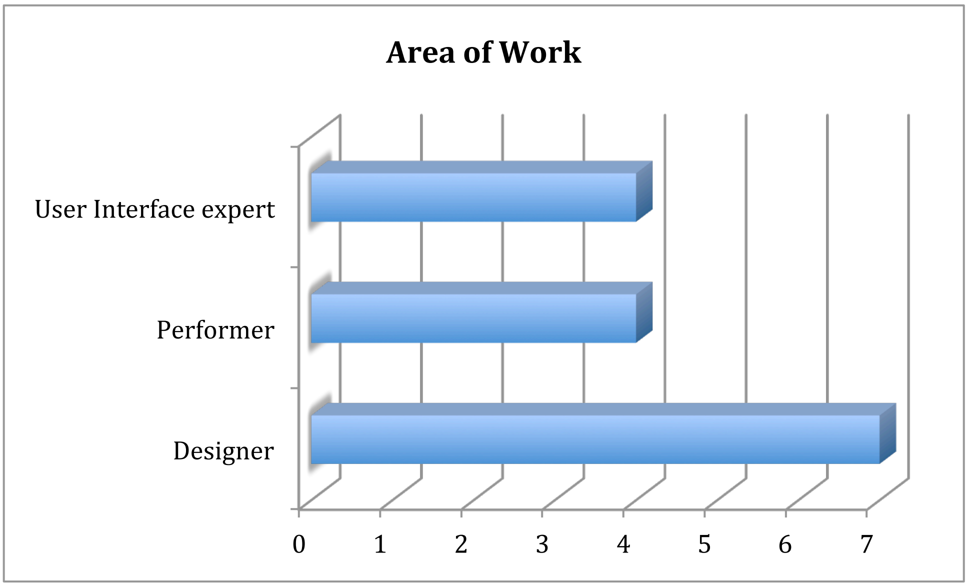



Table 2 Representation of the users ages



It is our observation that most users are young experts in the areas of design, performance and user interfaces. Some of them had expertise in more than one area. This group is representative of most artists that work in such multi-disciplinary areas and are contemporary artists that are dedicated to the creation of interactive digital art.

Table 4 Areas of expertise of testers



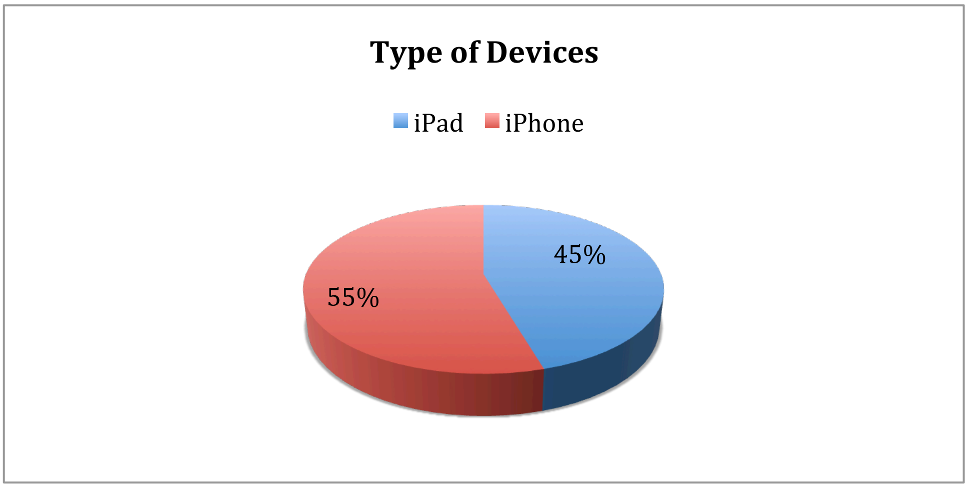

As described previously, it was more important to have feedback through these surveys from the three most important areas of work that are combined in ALIVEART.  Although, we could find testers in with experience in specific areas, we chose to work with multi-disciplinary testers becauses it meant that we would get higher-level information and detailed information about specifics rather than more.higher number of responses from a less specific group of testers We decided to take this approach because this app was not developed with the goal of actually entertaining but to serve the needs of a more specific group of artists and performers.

Our goal was to focus on the people that could best explore and provide us with good feedback since they covered the three most relevant areas of work implemented in this app.

### 6.4.2 Technological and Specific Generative Knowledge

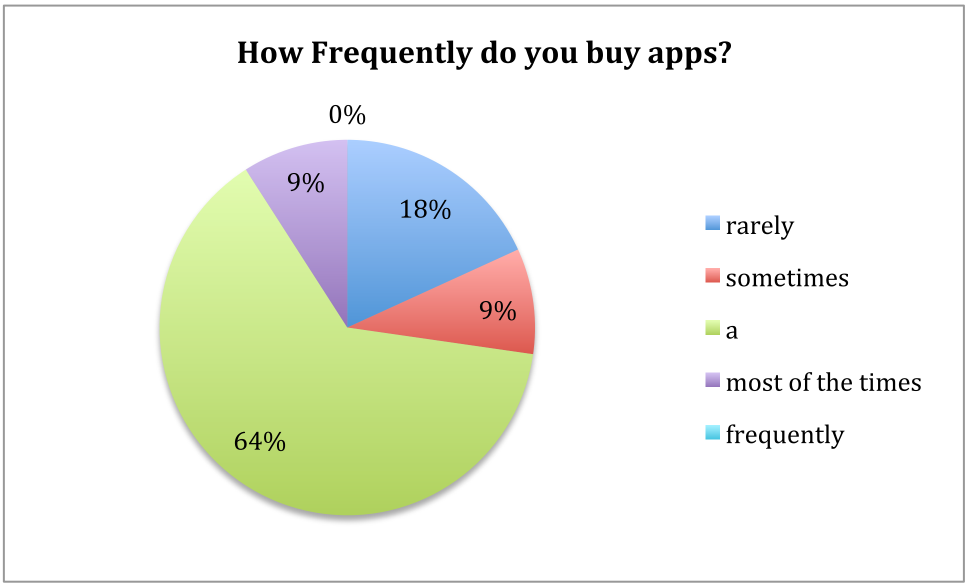
This section of the survey was intended to collect important information about the testers habits and about the devices they typically use. Unfortunately, we didn't receive any responses from a user that used both the iPhone and the iPad. Hence, we were unable to compare if the experience of a user actually changed depending on the device. Although we unable to compare the use of the app by the same user on different devices, we were able to receive a balanced response regarding each one of the devices (Table 5). This allowed us to make some correlations that are further described at the results section.

Table 5 Percentages of testers that use iPhones and iPads



Regards user's purchasing apps and their use of common versus apps built for specific purposes, we were surprised to note that only nine percent of the testers buy apps regularly. None of them buy frequently. Majority of the testers (64%) replied that they buy apps from time to time and 18% only buy it rarely. This data caught our attention because we would expect that people that work in such areas would have a more active relationship in the acquisition of such applications.

Table 6  Percentage relating to users and their habits of consumption apps

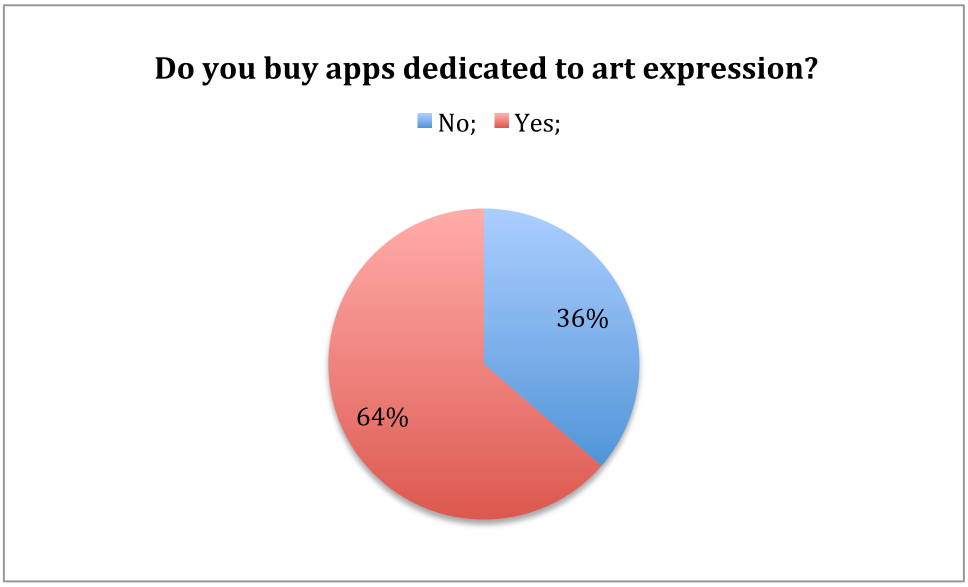



Further, only 64% of them have ever bought an app dedicated to art expression (Table 7), meaning that about 40% of them have never purchased apps to create or explore their artistic expression.

Most of the testers that purchased apps mentioned apps dedicated to sound and not images. Synthesizers and sampler, beat boxes and loop machines were the apps that appeared more recurrently in the list of purchases. The only reference other than sound related apps were not very specific, mentioning only the purpose of image processing.

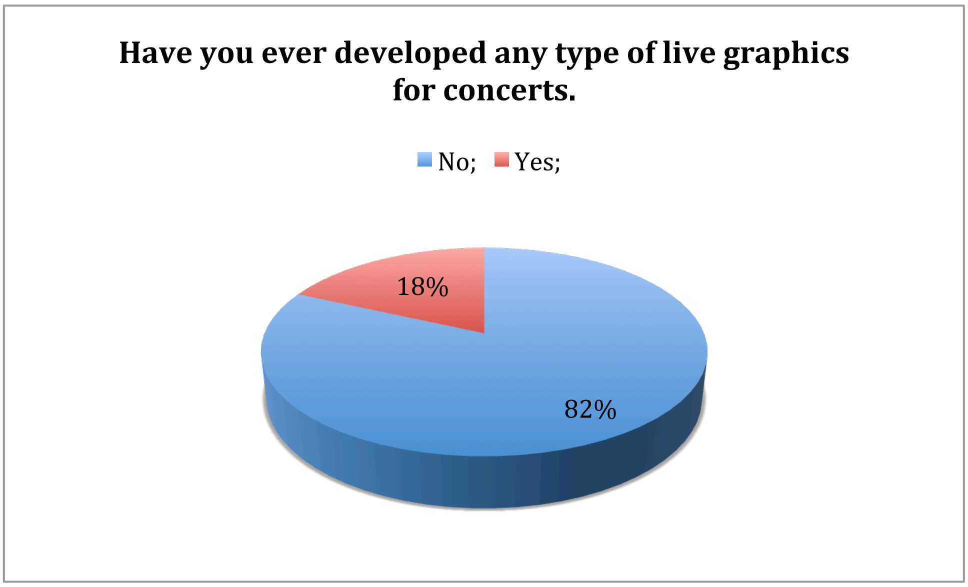
These findings implied that most mobile apps being used professionally or casually in the creative process normally relate to the sound production and not to images. Also strike our attention that while people that are using sound mobile apps are being more specific about what kind of apps they have explored, the few that mentioned image weren't very prolific about its caracteristics, saying only image processing without making further references of what type of processes. It was clear from these findings that many users are making use of such apps to create music while not many graphical artists are doing so to create new graphic expressions.

Table 7 Percentage of users that have ever bought apps dedicated to art expression



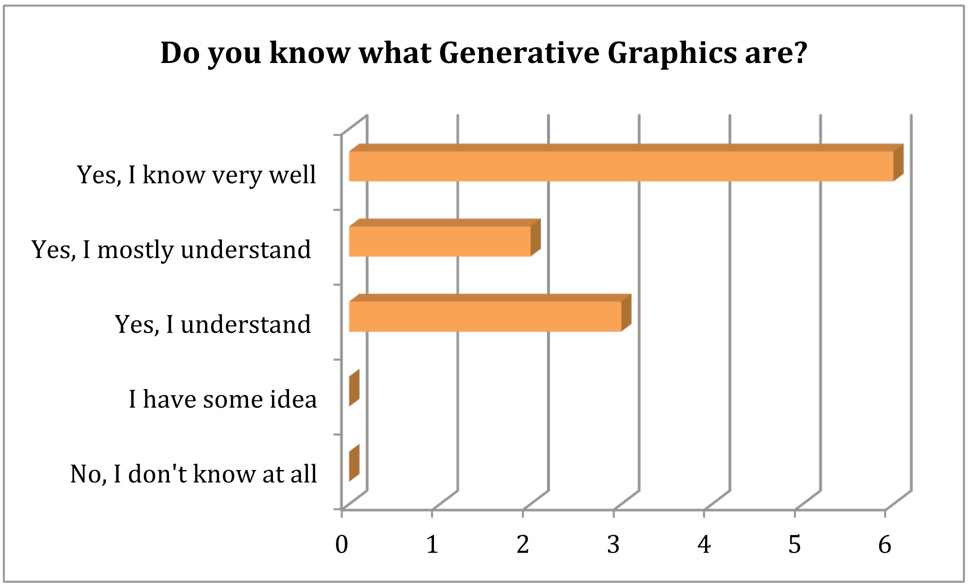

Although most of our testers were more from an image background rather than a sound background, only 18% had ever developed live graphics for concerts (Table 8). These users, in spite of being multidisciplinary, have not adopted mobile apps into their art practices, probably explaining the lack of experimentation of such apps.

Table 8 Experience with life graphics for concert setups




Regards the understanding of generative practices, a-life and knowledge of semi autonomy of the system amongst our testers, we observed that all testers responded positively to their understanding of generative graphics (Table 9). Generative graphics is studied and applied in very different areas of work and hence is a more commonplace concept, explaining the higher understanding of the subject amongst the testers.

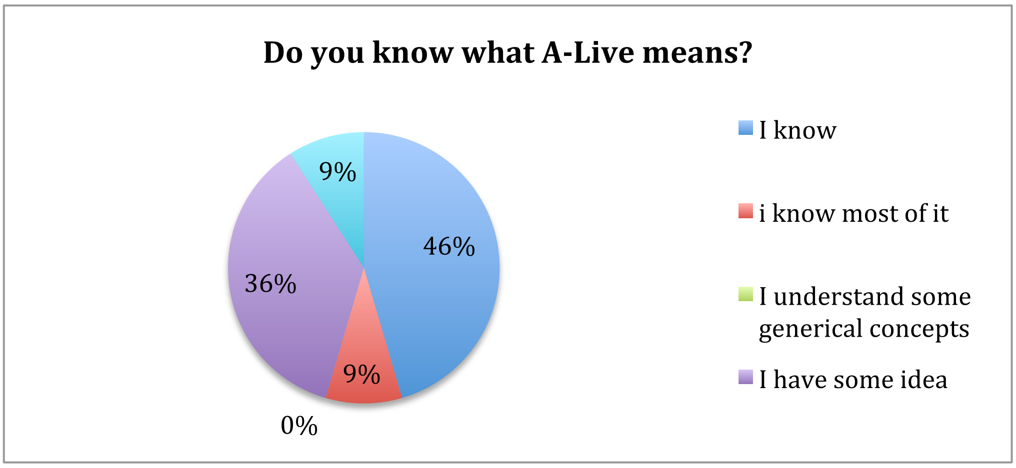
Table 9 How well do the testers understand the meaning of generative graphics




Only 46 % responded positively about their understanding of the subject. 9% had no clue and 36% had some idea.

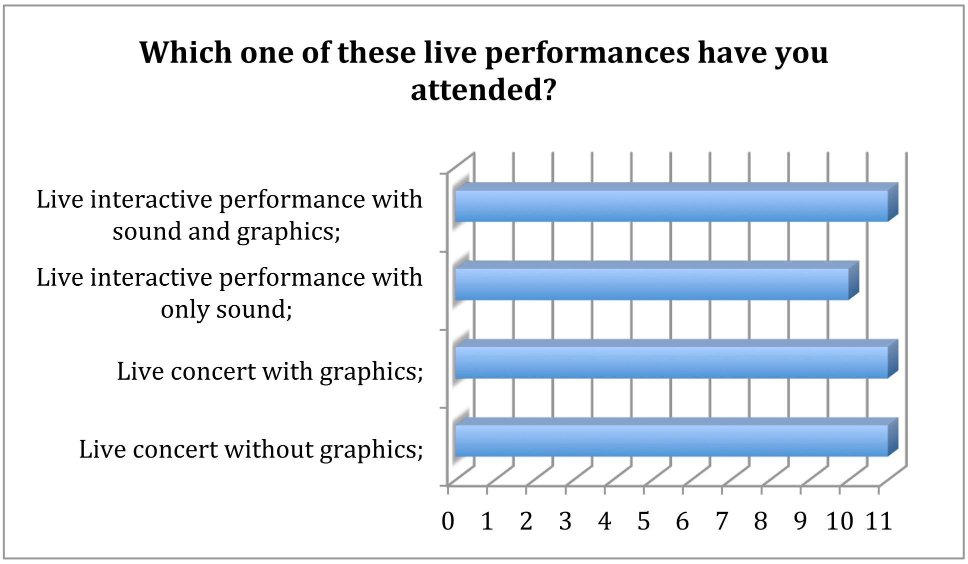
This led us to understand that our testers had a very good understanding of the ideas related with generative graphics while they struggled with more profound concepts and subliminal strategies. This information is very important and will be further explored when we analyze these results along with the evaluation of the app.

Table 10 Percentages of how well the testers understand the meaning of what A-Life



As evident in (Table 11), majority of the testers (all except one) had experienced all types of concerts. This was important to define the level of knowledge our users had about interactive concerts and possible concert setups.

Table 11 Experience of testers in different concert setups




These criteria are important to enable our understanding of the user and aspects of the app, making the experience more or less satisfying.

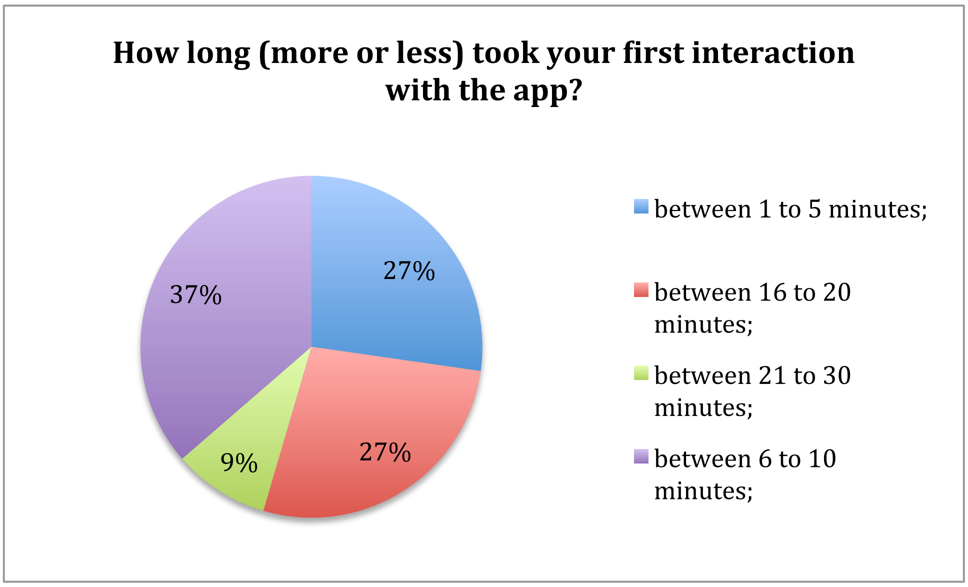
### 6.4.2 ALVEART Evaluation

Per data in Table 12, we tried to understand how long it took the tester to gain experience with the app. Our goal was to understand the level of user engagement and the correlation between his experience and his understanding and perception of the piece. As in evident in Table 12, we were unable to find any patterns. It appears that experiencing the app didn't have anything to do with his area of expertise or background.

Given that our collections were for longer than one hour, we found it surprising that a few testers spent only between 1-5 minutes. While we were not expecting users to engage for extended periods, we did estimate longer than the usage reported.

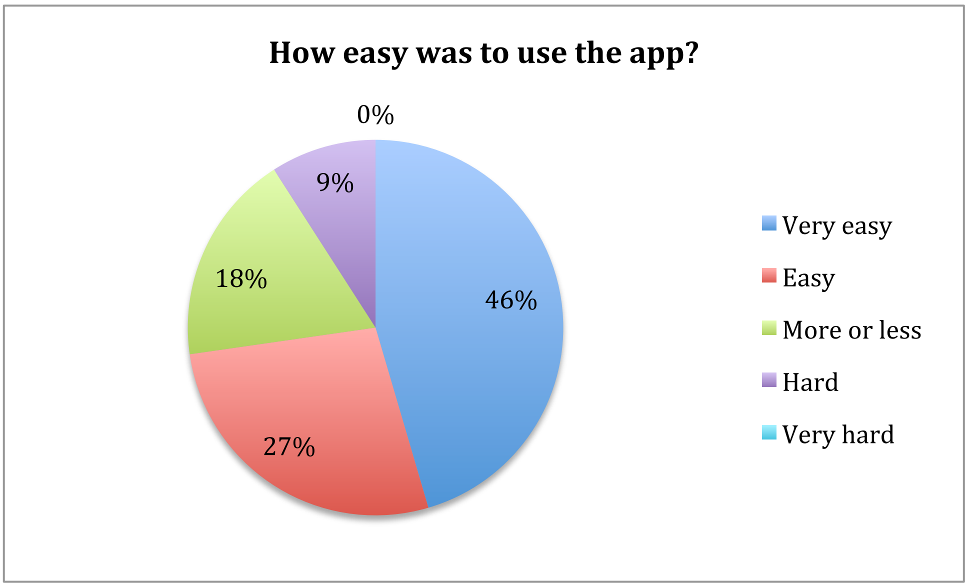
Since we weren't able to identify why testers spent more or less time trying the app, we concluded that interest of the specific individual played a vital role in understanding the apps characteristics.

Table 12 the percentage of individuals based on the time they spent in his first approach to the app.



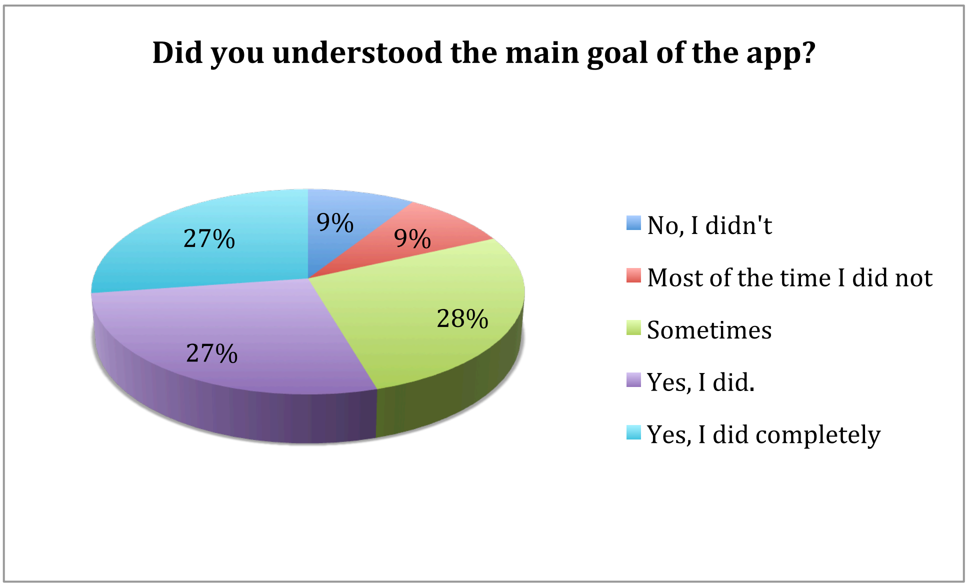

The next set of questions tried to define the interaction of the tester with the app and hence identify the most complicated and difficult points of this interaction. To achieve this objective, we asked both low-level and high-level questions. Table 13 is about a more general evaluation of difficulty in using the app. Table 14 is about the understanding of the goal of the app. Table 15 about the usability of the interface and Table 16 about and the perception of the tester's effect on the system.

Table 13 percentage of users about ease of use of the app




46% of the users found the app very easy to use and 27% easy to use. Although a large number of user found the app very easy to use, testers also confirmed having distress in understanding how the interface worked. Over 45% of the users reported that they barely understood how the interfaced worked.

Table 14 Users understanding of the goal of the app



We found it difficult to comprehend how several testers felt distress in understanding the functionality of the most important mechanism of interaction but at the same time seemed to understand the goal of the app and also understood the effect of their acts on the system.

We are aware that the interface is very different from those most people are familiar with. While previous knowledge and the time they took to experience the app could have affected their understanding, we couldn't find anything in the data to prove such a relationship.

Our conclusion about this result is that the testers had a more intuitive understanding of his actions over the interface being able to completely formulate what was happening. For us it doesn't mean they didn't understood what was happening, it just means that the question may implied a more profound understanding that the group of testers wasn't able to fully elaborate on .

Table 15 The user's understanding of the interface

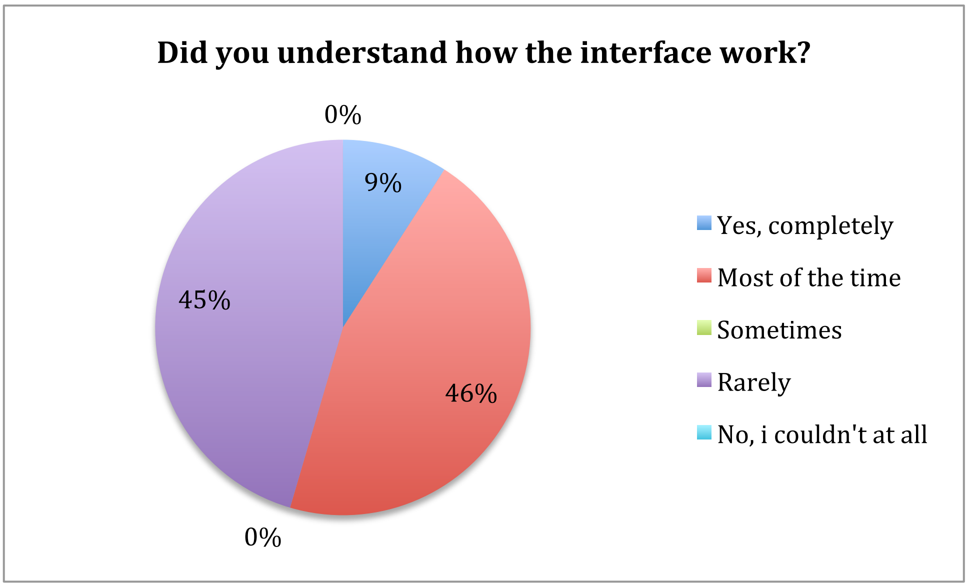
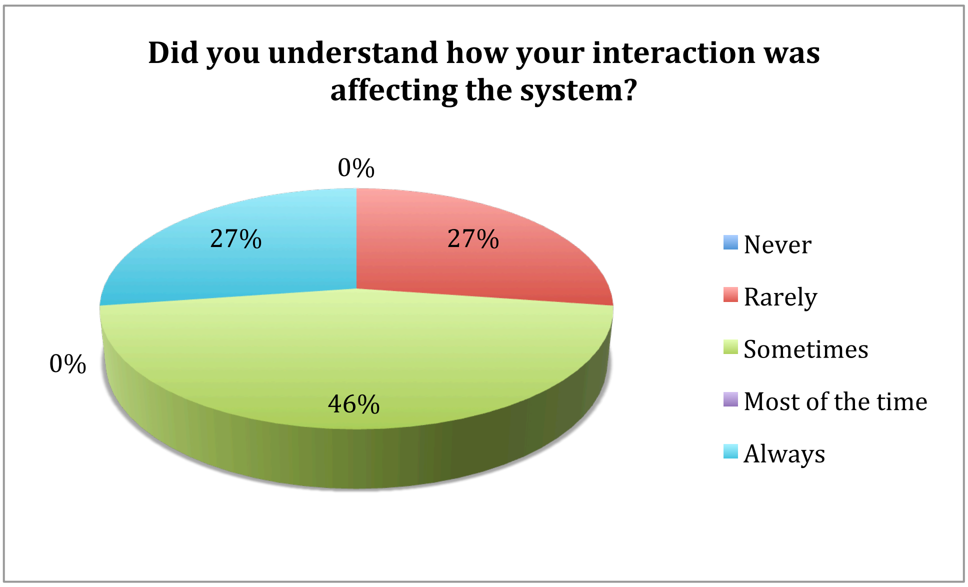
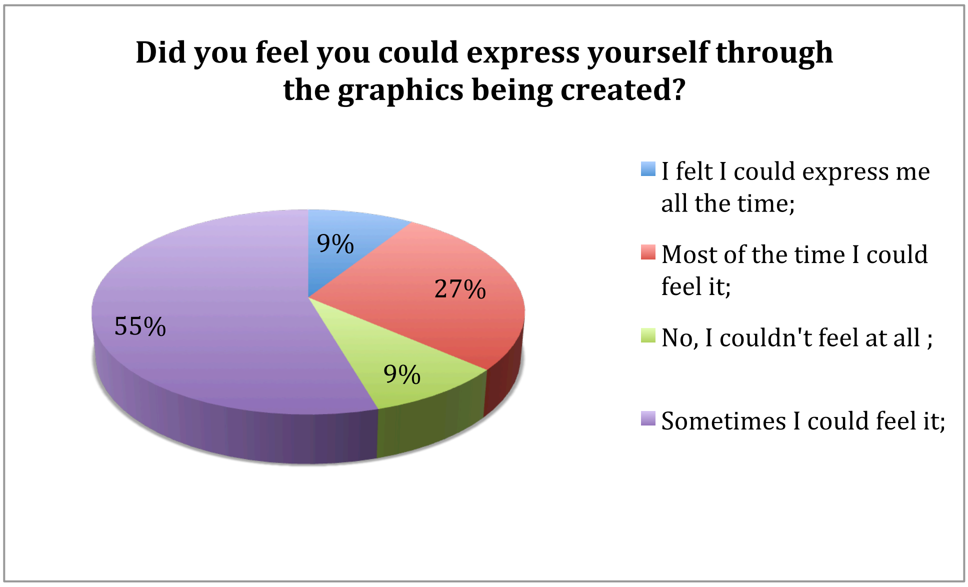


Table 16 percentage of how well the testers understood his effect over the system




Considering that we are dealing with generative systems, it was reassuring to know that 73% of the testers felt that they were affecting the system, thus feeling engaged. Since many of the interactions generated complex reactions, it was important to note that the testers were able to engage and observe their actions impact and system responses.

Table 17 percentage of users that felt the graphics developed were expressive.



People also felt they were able to express themselves through the graphics. Even though the response was not very positive, we think the poor response has more to do with the aesthetical choices than the actual interaction with the system given the data we can extract from Table 19. How each one decides to express himself differs very much. Since we didn't select the testers according to their graphical taste, we assume that the aesthetic doesn't fit all users and therefore does not suit their goal while using the app. We will propose an alternative for this problem in the chapter dedicated to future work.

Table 18 How the user felt about the graphics

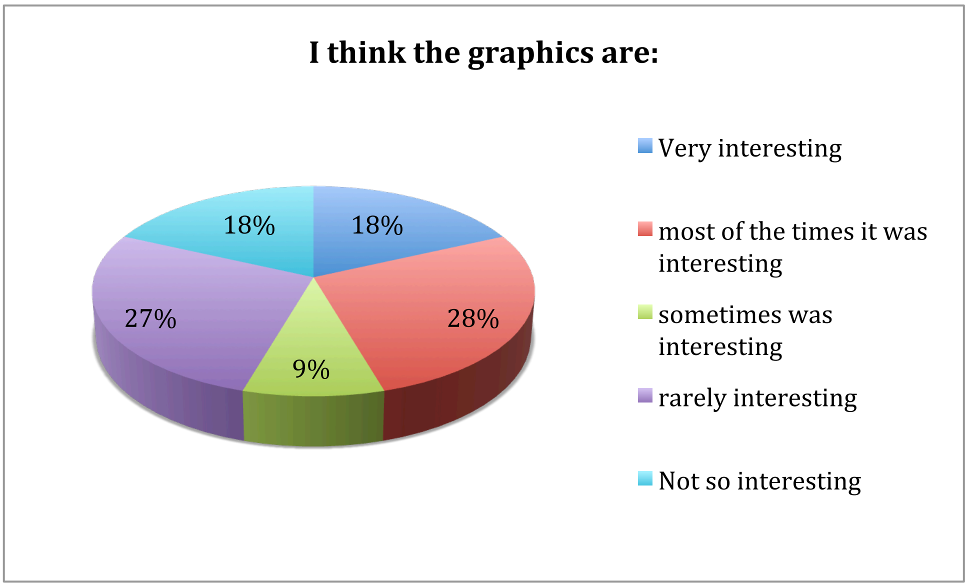
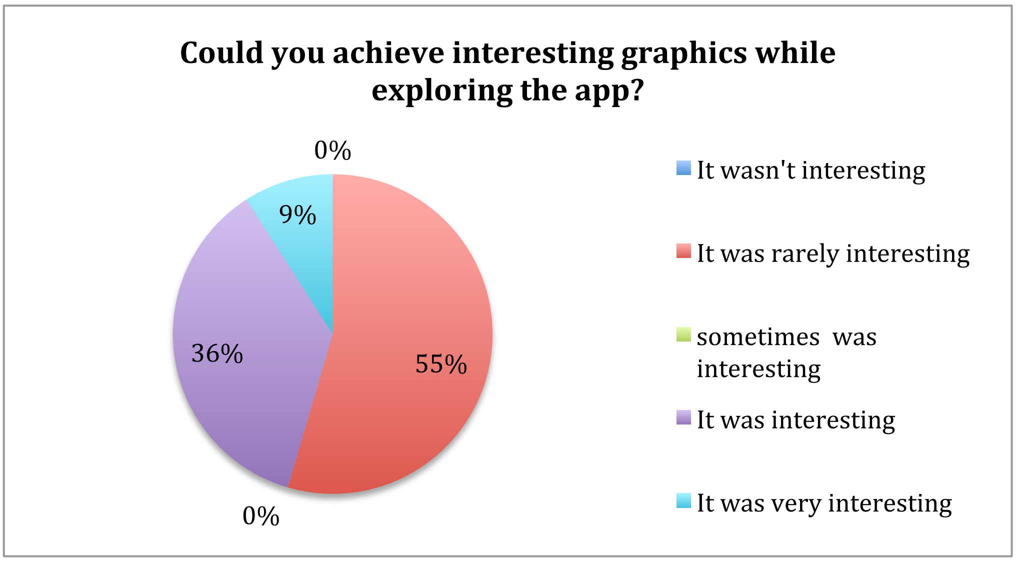


Table 19 Percentage of users that were able to achieve interesting graphics during the time he/she was exploring the app

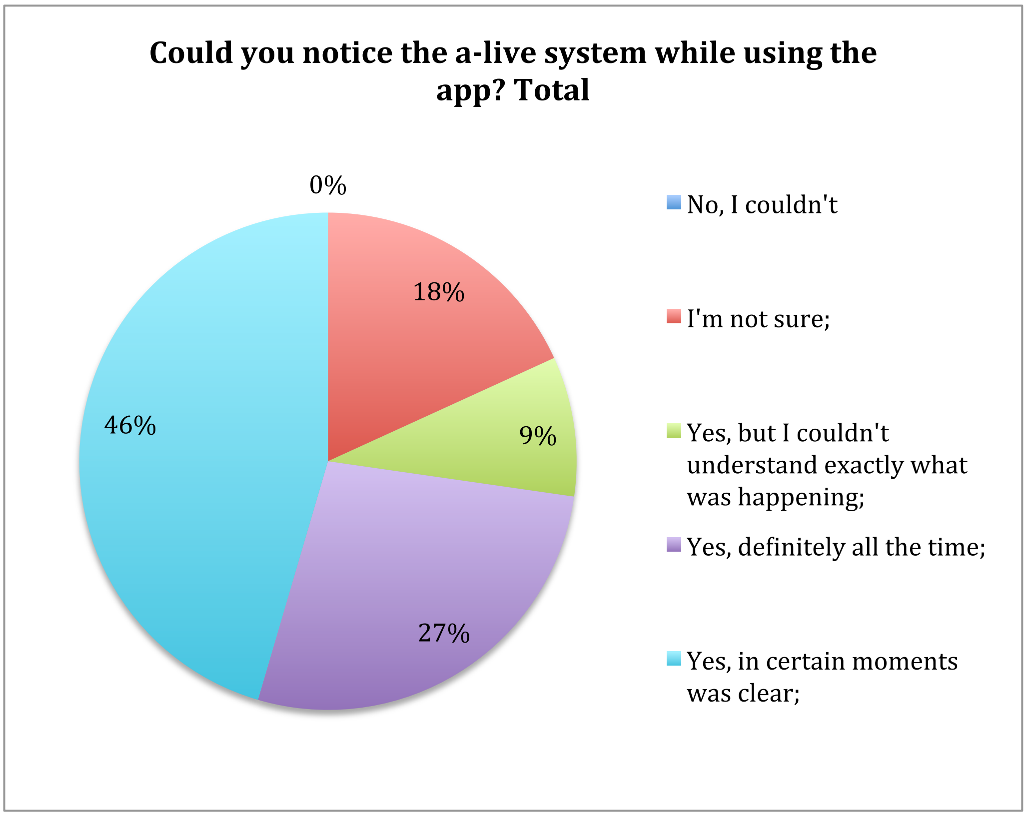



Since the a-life has a great impact on the development of the artistic act for this piece, we need to understand not only the superficial characteristics (such aesthetics) but also the interference of the A-life in the tester's acts. Most users reported they could notice the a-life presence (Table 20).

Taking into consideration that most of the testers didn't understand enough about a-life systems, we believe that they were able to recognize dynamics and semi autonomous behaviors that were consistent with generative systems.

This finding allowed us to conclude that the connection of the three elements (interface, A-life and user) were working correctly by stimulating a collaborative relationship between all elements.

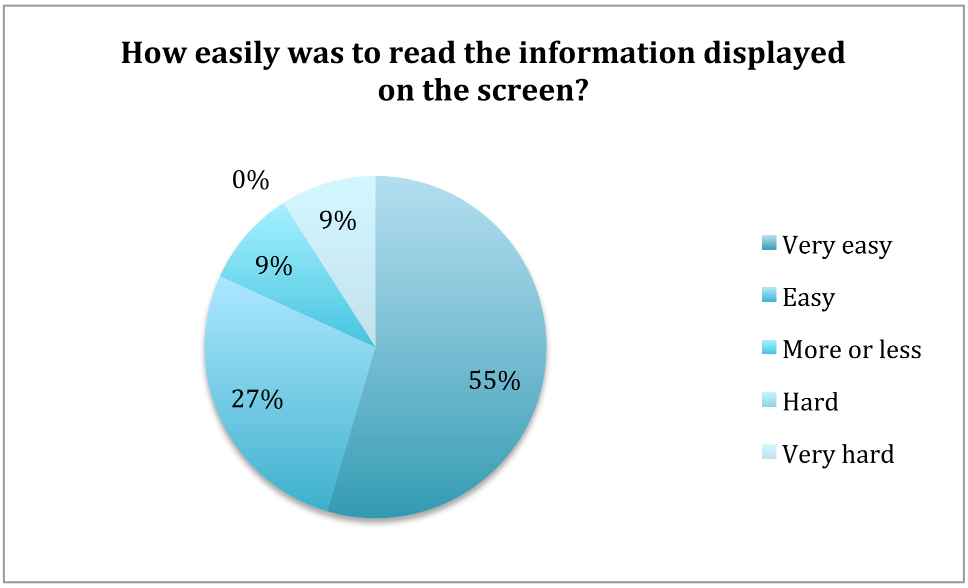
Table 20 the users ability to perceive the action of the a-life system




One of the elements that reinforced this collaboration (besides the interface itself) was the way we chose to overlap the information from the graphical output and the actual interface. The connection between the three parts of ALIVEART had to be done in a careful manner to ensure that the excess information did not cause difficulty to the user in reading the information clearly and fast.

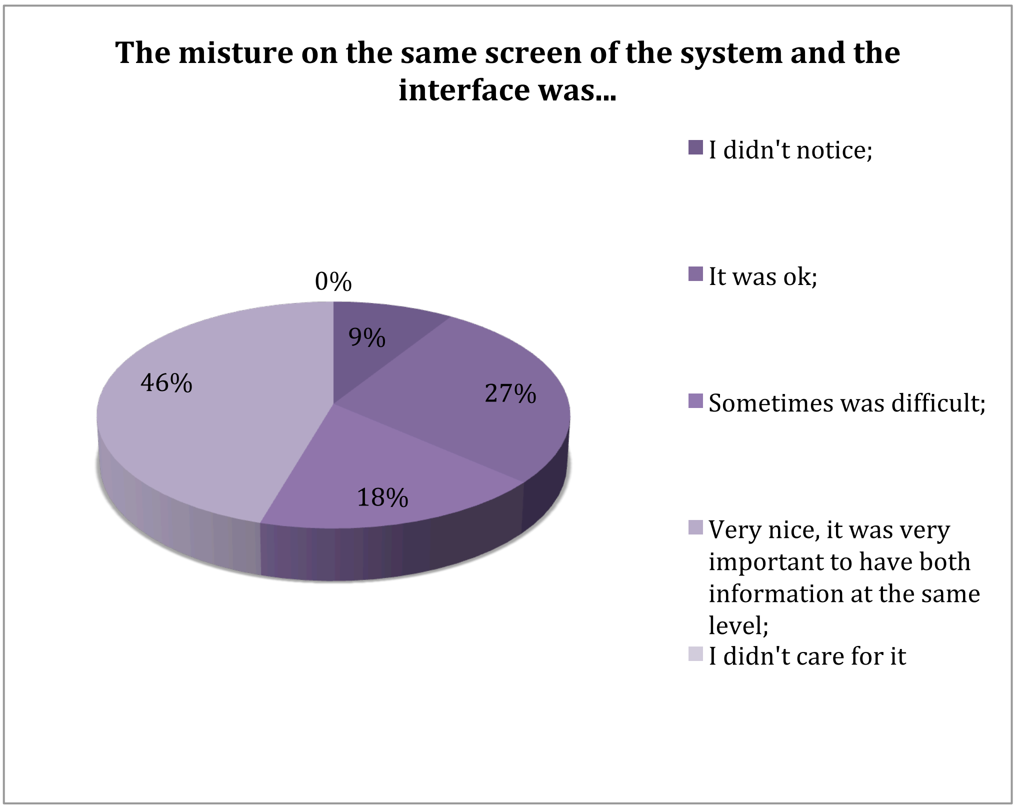
To ensure that the overlap was the best possible, we applied substantial effort in its development. From the tester's responses, it is evident that they found it easy to read the information displayed on the screen (Table 21). More importantly, they found it very important to have both pieces of information on the same level (Table 22).

Table 21 Percentage of testers that found it easy to read information displayed on the screen




In Table 22, we see the user's response to the superposition of interface and the graphical output. Talking with the testers after the survey made us realize that this connection between user and system was not so abstract and could be felt by the user. They agreed that having the interface and the graphics at the same level played a major role in amplifying this feeling.

Table 22 – the importance of overlapping the information on the screen




To determine more accurately what the user was able to understand, we elaborated a group of questions in which the user confirmed what he/she was able to identify in the system. These six questions covered all parts of the app - graphics, sound and interface. The results are demonstrated in Table 23 - Table 27.

The most positive responses were for questions about the color change of the graphics according to sounds, the amplitude modifying the graphics zoom, the changing parameters on the interface, the selection of areas of the screen and the modifications according to the time the area was selected. The reflection of the a-life into the parameters of the interface was barely noticed by most of the testers.

It is clear that the relationship between the A-life and the parameters is abstract and difficult information to be retained in the system. This recognition is difficult specifically because users are not aware of the functioning of such systems and how these parameters influence the whole system.

Table 23 Percentage of users that was able to identify that color change depending on the sound

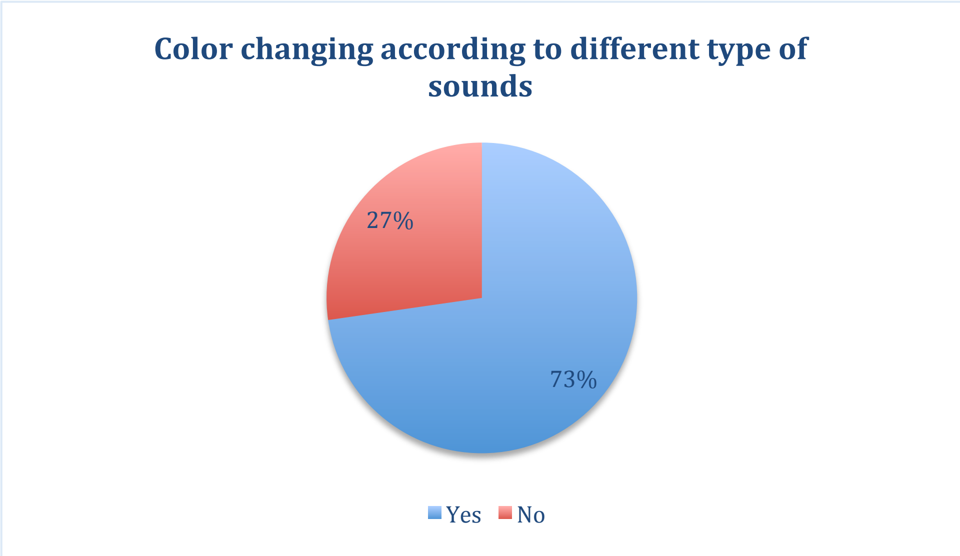
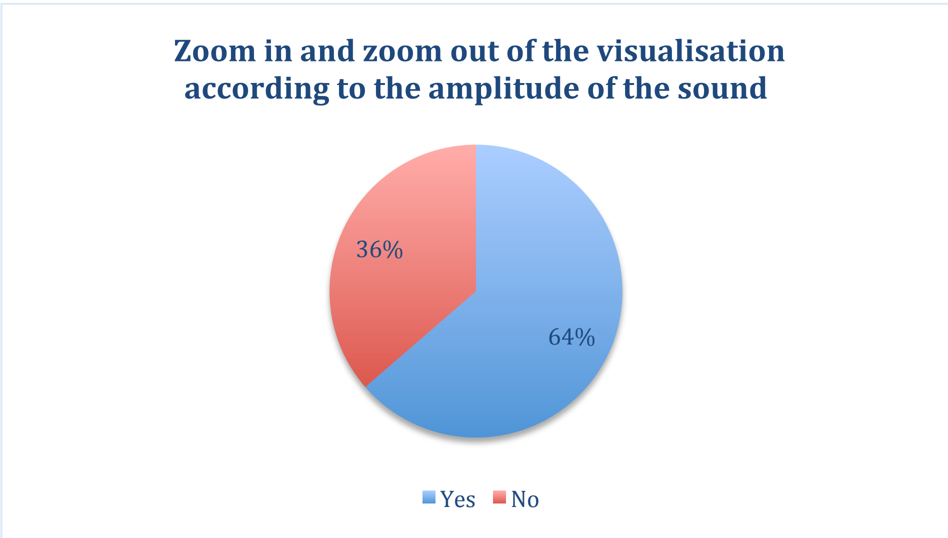



Table 24 Percentage of users that was able to identify that zoom difference depending on the amplitude of the sound




The influence of sound on the system is the most direct. The responses in Table 23 and Table 24 confirm this. We can see that 73% and 64% of the users respectively were able to identify the relationship between color and zoom with aspects of the sound input.

Table 25 Percentage of users that was able to identify that interface was changing according to the parameters

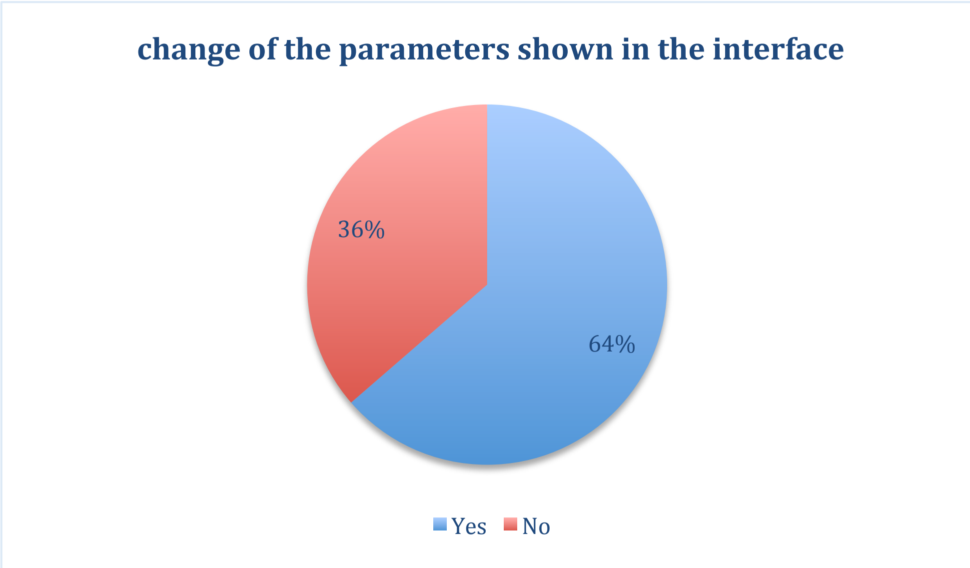
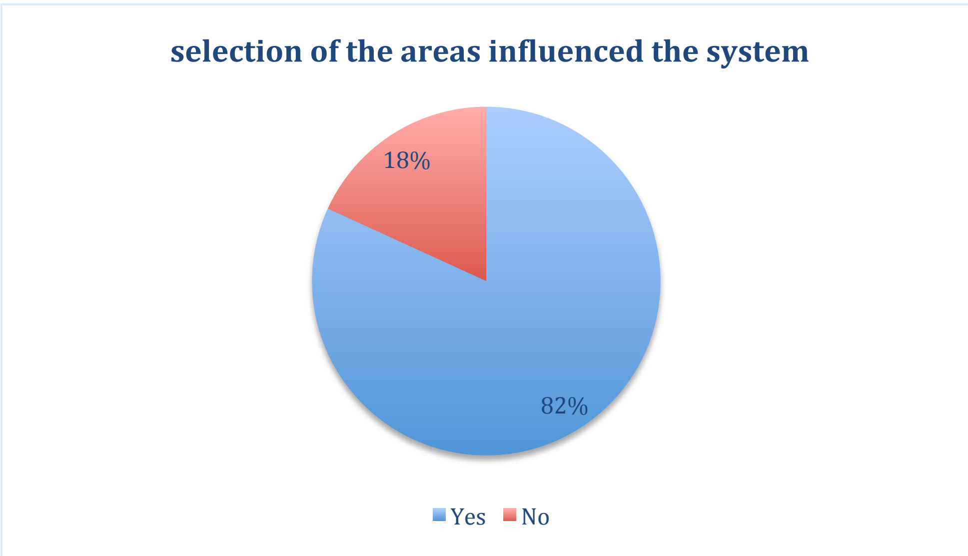
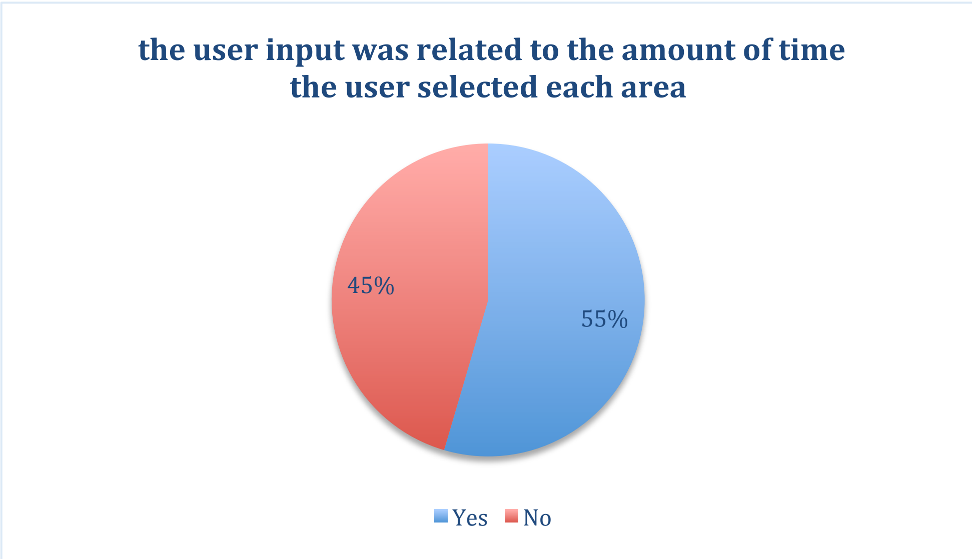



Table 26 Percentage of users that was able to understand that selecting areas was influencing the system



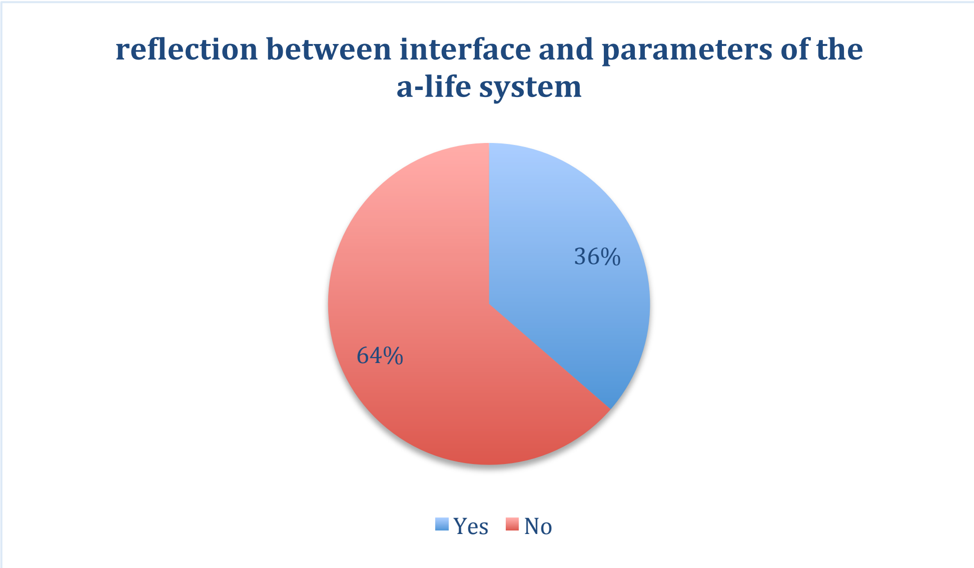

When the testers were asked about the interface in Table 25, Table 26 and Table 27, it is evident that most of the users were able to understand how to interact with the system. They also understood that the influence over the system changes according to the duration of the selection and not merely by pressing on the area. Thus, a relatively good number of users were able to achieve the goal of the interaction by being able to understand the changing interface and the technique to change the parameters.

Table 27 Percentage of users that felt that the amount of time they selected an area of the interface changes the input information to the system




The main problem was with the relationship between the interface and the A-life system. Majority of the testers did not feel the reflection between the a-life parameters and the interface (Table 28).

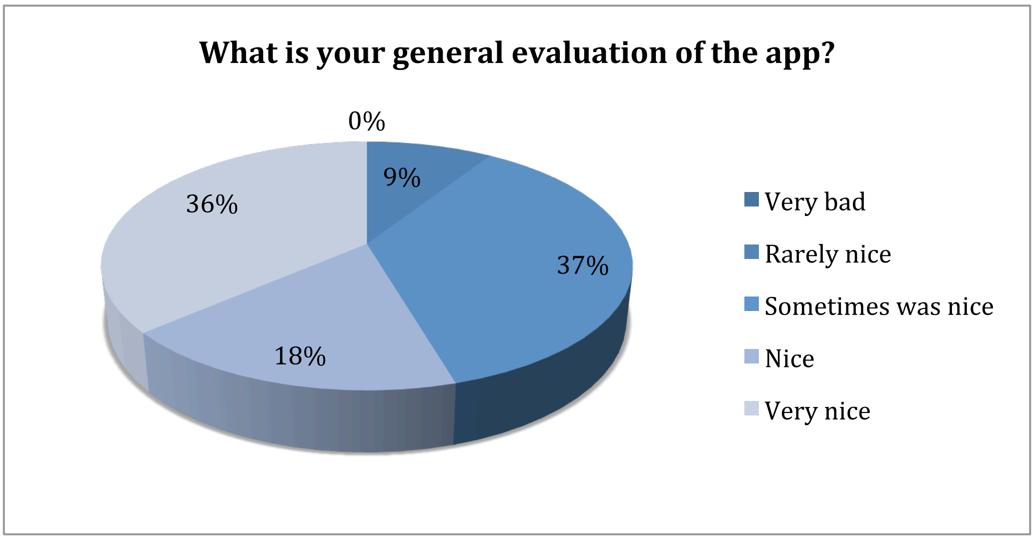
Table 28 Percentage of users that could feel the a-life reflection on the parameters shown in the interface




To conclude our survey, we asked the testers an overall evaluation of the mobile app ALIVEART. We also asked if they thought they would use the app again the context in which they would use it (Table 31).

As can be seen in Table 29, we were not able to identify a clear tendency since the responses were distributed between the 4 ranges “very nice” (36%) to “rarely nice” (9%). We were intrigued by the results and did some searching for a potentail explanation.

Table 29 General evaluation by the testers of the mobile app ALIVEART

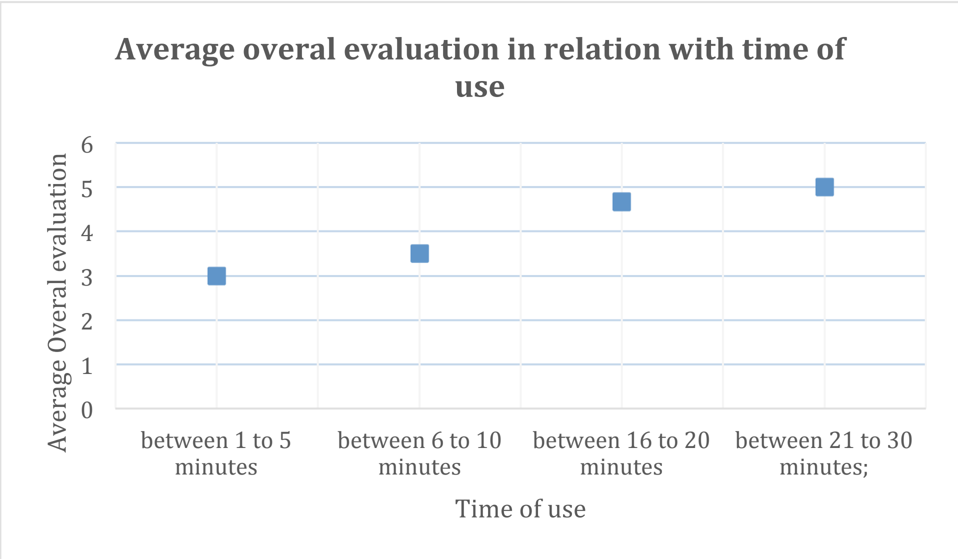



We found an interesting correlation between the time spent experimenting with the app and the final evaluation that can be seen in Table 30. When we computed the average evaluation according to the amount of time the users spent using the app, we found that there is a tendency for a better evaluation of the app. This is possibly because the user tends to spend more time experimenting thus achieving the maximum grade (5 points) when users used the app between 21 and 30 minutes.

This led us to establish that a minimum amount of time is necessary for the users to take more advantage of the app, thus making them more aware of the functioning of the interface and the a-life system that sustains the whole app.

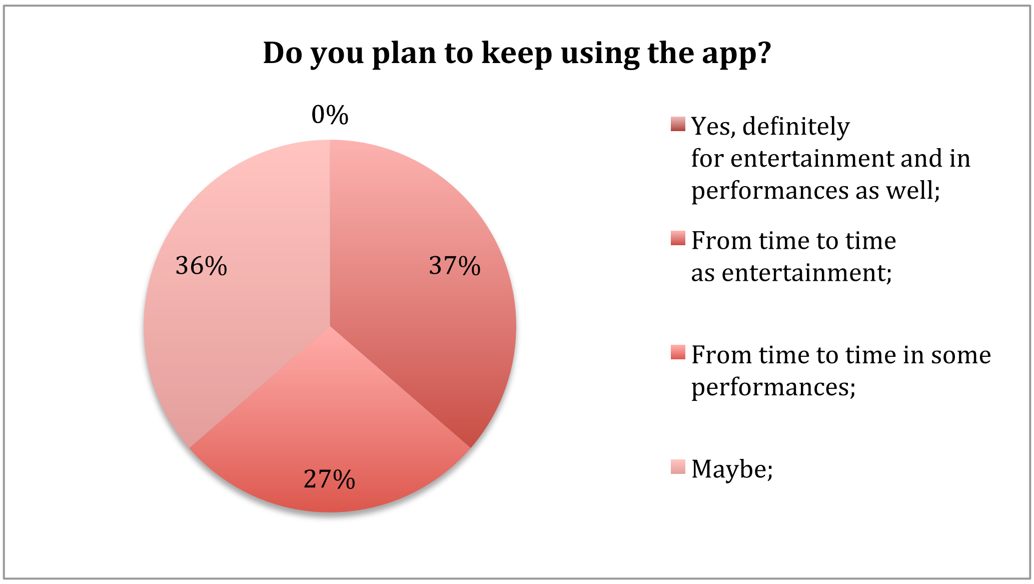
Since we are dealing with an a-life, we can also assume that after a certain time, the system finds its balance creating reactions that are a bit more stable. In the early stages of creating a-life, it is safe to assume that the system is still configuring itself by creating new dynamics since the initial state of the ecosystem is normally more random due to the definition of the initial population. We recommend that the user spend at least 10 minutes exploring the app to have a more fulfilling and engaging experience.

Table 30 Relation between the average of the overall evaluation of the app and the time spent by users experimenting the app




In spite of discrepancy in results related to the overall evaluation of the app, we observed that majority of the testers felt like using the app again in different contexts (Table 31), including for professional uses and entrainment.

Table 31 Context in which users plan to user the app again




## 6.4 Conclusions from the Survey Results

By choosing a group of testers that represented the three areas of expertise related to the mobile app ALIVEART, we were able to formulate a group of users that could provide important inputs in all areas of the research. This helped us understand the level of clarity of the information being presented.

We established that the time of experimentation of the app is very important to understand the main behaviors of the a-life and the interface. It appears that the experimentation needs to be a minimum of 10 minutes and doesn't need to exceed 30 minutes.

This represents the time for a user to understand how the interface is remodeling itself and the manner in which the five parameters affect the a-life. We also believe that the a-life system needs some time to achieve interesting relationships that normally don't happen before those 10 minutes.

From our users reply we also detected the graphical output didn't fulfilled of all users measures, specially to the ones that didn't interacted during a minimum amout of time. We believe that the A-life is not by itself an interesting graphical representation, only becoming interesting after a few interactions.

In spite of the fact that we are dealing with an interface that is changing over time, users felt engaged and were able to understand its functioning. We also realized that the users who established a communication with the system were the ones that understood the relationships between the system and interface.

These series of tests confirm our belief that the interface and the graphical outcome should be presented on the same level so that the user can understand the modifications to the interface while the interaction is happening. We also received confirmation that the stimulus of a given parameter based on the time an area was selected worked, thus promoting a more collaborative relationship between the user and the system.

.

# 7 Conclusions and Future Work

This research project is the result of extensive literature review, experiments and evaluation. From this process we were able to draw important conclusions about generative graphics for live performance with sound and adaptive interfaces for a more collaborative approach to the generative systems.

Upon review of the conclusions, we shall propose possible interesting paths to follow for research in the future.

## 7.1 Final Conclusions

The artist embraced the unexpected and adopted processes that could go beyond the human mind by allowing generative practices in the creation of artwork. With such introduction, paradigms changed and artwork that until them was focused on the artifact became concerned about the process. This process is constantly being modified by the changes to the system.

In this process of finding new ways to create artworks, artists also manage to transgress the traditional notions of creativity and art. Computers start to demonstrate creative behaviors in which the artist decides to develop his work. New complex artworks are developed, resulting in immersive experimentations where humans search to better understand living beings and their own relationships by the use of artificial life simulations.

In this process, we realized that interactivity in the arts has in itself the quality of delegating part of the creative process, from the artist to the user and also changing its dynamic. Both, generative practices and interactivity have a special impact on the creation of Art and in its relationships. In conjuncture, interactivity and generative process became a space of genuine innovative creative practices for art. By uniting both ways to engage in new forms of creative, the artwork can extrapolate this idea of the machine as an extension of the human.

We propose that more than generative ideas, we look into a process in which these systems are able to express themselves in the construction of the experience. More than using generative practices to produce content, we hope to incorporate this process in the interaction, allowing the computer to propose new relations and establishing new paradigms that are not present in the human domain. Is our goal to express generative process not as a static creative process, but instead an iterative communication between system and interface and interface and user. This collaboration between system, user and artist will gain its higher expression through the creation of an interface that is capable of synthesizing all these expressions.

During the time we have been developing the four pieces analyzed in this thesis dissertation, we came to realize that some elements are essential to take into consideration when developing a live performance of generative graphics. Using different setups and working with different groups of musicians, allowed us to play with different types of generative system, different sound sources, different data sharing and especially different interactions with the system in order to propose an innovative way to interact with generative graphics.

Our proposal consisted of developing an adaptive interface that reacted to the user and the A-life system, changing its parameters and displaying information as the system changed, allowing the ecosystem to create a dynamic communication with the user. Since we believe generative systems allows a relationship of collaboration with the user, we demonstrated that static interfaces rupture this potential existent in the connection between user and system since it forces a delimited and rigid navigation. This rigidity emerging from static and pre-established parameters wouldn't take into account the changes in the system. A system that is moving and changing but where the interface is predefined is incapable of receiving any new input.

As a proof of concept, we developed a generative mobile app called ALIVEART. It is an a-life system that triggers generative graphics from a musical input. Depending on the features of the music, the graphics develop algorithmically through an artificial life system that can be also modified through an interface that introduces another level of performance (beyond the musical performance) controlled by the visual artist. However, this interface also adapts to the musical features and the development of the a-life system. This adaptive interface presents the visual performer with the elements that can be controlled excluding the ones that are irrelevant at that moment, allowing more focus on the performative act.

Experts in three areas conducted the evaluation of this proof-of-concept (designers, performers and user interface experts). The responses provided us useful information about these three areas. The responses were important for us to able to formulate the two most important conclusions we draw from this work.

From our experiments, we confirmed that such a type of adaptive interface was successful in promoting more collaboration and engagement with generative systems thus promoting a more dynamic and fluid interaction with a system that is by definition semi-autonomous. Like we learnt from the literature review, both generative practices and interactivity are very important in the process of creativity. In the development of the ALIVEART interface, we noticed that adaptive interfaces actually change the process of creativity by allowing the user to define inputs external to his abilities that promote creativity.

By creating better interaction metaphors for establishing the relationship with generative systems, we are not only changing the interaction but the whole understanding of the artwork. Sliders or knobs don't enhance or provide the right information about the system. This type of interaction doesn't suit a system that is maintaining some characteristics but is receiving input from a user. These interactions dictate that the interaction happens in a very authoritarian way where the user changes the parameters he/she wishes. We believe that in a system that is alive, the user is not supposed to change the information about the system but to improve and worsen certain qualities of the system.

The work developed here opens possibilities for new experimentations and new conclusions about generative graphics and interface design. It allowed us to understand the large range of techniques and strategies that can be developed in order to promote greater collaboration between the digital and actual world.

## 7.2 Future Work

In spite of the many accomplishments in ALIVEART, there is potential for further research.

We identify three areas of further work that could arise from the work developed here. They are all derived from the main areas we focused in this research and they are all very relevant in today's art practices. They are the interface, the sound and the generative system.

It is clear to us that generative systems in association with interactivity is the path in which the artist can embrace new collaborations and create creative process by engaging with the computer in a much more profound way. Until now, we have been seeing generative strategies that are trapped by interfaces that don't comprehend the system plasticity.

In this work, we presented an option that can make the system more present by interacting with the interface in real time. For this research, in order to better categorize and evaluate the proposed objectives, we had to limit ourselves by allowing only 5 parameters to be modified during the interaction. However, to achieve a fully dynamic collaborative process, we need to allow the system to propose its own elements without limiting the parameters that should be available, thus embracing an even more open relationship between all parts involved. The number of parameters must be balanced with the capacity of the user to learn and adapt to such interface allowing him to engage. Other wise, the interaction becomes uninteresting to him/her.

Regarding the sound input, it would be very interesting for visual live performances to adopt Music Information Retrieval techniques to obtain more information from the sound being received and allowing the system to assume new behaviors as different styles of music are being played. We found that better-optimized choices can be generated by the system if it understands the information being received.

Another important element that can be even further developed is the graphics. Although we developed our own graphical language, it is important to review the ways in which a system like this can be malleable to different user tastes and choices without overloading the performative act. An interesting possible solution is by allowing the user to have presets that can be changed prior to the performance. In other words, a user could develop their own shaders, that would be uploaded to the system thus creating new versions of the same a-life system. This method allows a more personalized approach to graphics while maintaining consistency in the general functions and system behavior.

We believe that through the implementation of these proposed elements, we will certainly develop areas of knowledge associated with live graphic performance in concert situations, generative art and interactive art allowing further understanding of the relationship between user and machine and engaging in new paradigms of  digital creativity.

# 8 References

Alberro, A., & Stimson, B. (1999). *Conceptual Art: A Critical Anthology*. MIT Press.

Artport, W. (n.d.). Structures (2004). Retrieved October 10, 2014, from http://artport.whitney.org/commissions/softwarestructures/

Aurenhammer, F. (1991). Voronoi diagrams---a survey of a fundamental geometric data structure. *ACM Computing Surveys*, *23*(3), 345–405. doi:10.1145/116873.116880

Bedau, M., & Humphreys, P. (2008). *Emergence Contemporary Readings in Philosophy and Science*. Retrieved from http://psycnet.apa.org/psycinfo/2007-14527-000

Benjamin, W. (1970). The Work of Art in the Age of Mechanical Reproduction.

Boden, M. A. (2004). *The Creative Mind: Myths and Mechanisms, Second Edition*. Routledge.

Burraston, D. (2007). FUNDAMENTAL INSIGHTS ON COMPLEX SYSTEMS ARISING FROM GENERATIVE ARTS PRACTICE. *Leonardo Music*, 362–374.

Caramiaux, B., Montecchio, N., Tanaka, A., & Bevilacqua, F. (2014). Adaptive Gesture Recognition with Variation Estimation for Interactive Systems. *ACM Transactions on Interactive Intelligent Systems (ACM TiiS)*, *V*(212), 1–34. Retrieved from http://research.gold.ac.uk/10541/

Carvalhais, J. (2010). Towards a Model for Artificial Aesthetics Contributions to the study of creative practices.

Dawkins, R. (2006). *The Selfish Gene*. Oxford University Press. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+Selfish+Gene#1

Dixon, S. (2007). *Digital performance: a history of new media in theater, dance, performance art, and installation*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Digital+performance+A+History+of+New+Media+in+Theater,+Dance,+Performance+Art,+and+Installation#0

Eco, U. (1989). *The open work*. HARVARD UNIVERSITY PRESS. Retrieved from http://philpapers.org/rec/ECOTOW

Flake, G. W. (1998). *The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos*. MIT Press.

Fry, B., & Reas, C. (n.d.). Processing.org. Retrieved from www.processing.org

Gajos, K. Z., Czerwinski, M., Tan, D. S., Weld, D. S., & Way, O. M. (2006). Exploring the Design Space for Adaptive Graphical User Interfaces.

Galanter, P. (2003). What is Generative Art? Complexity theory as a context for art theory. In *In GA2003–6th Generative Art Conference*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.90.2634

Gomes, J. F. (2009). HOME: a look inside an algorithmic world. In *AMBERconference*.

Gouyon, F., Barbosa, Á., & Serra, X. (2009). 6th Sound and Music Computing Conference. In *Proceedings of the 6th Sound and Music Computing Conference*.

Heller, E. (2012). *A Psicologia das Cores*. (G. Gili, Ed.) (p. 311).

Holland, J. H. (1992). *Adaptation in natural and artificial systems* (p. 211). MIT Press.

Ikeda, R. (n.d.). Ryoji Ikeda. Retrieved November 11, 2014, from http://www.ryojiikeda.com/

Jameson, A. (2007). Adaptive Interfaces and Agents. In A. Sears & J. A. Jacko (Eds.), *Human-computer interaction: design issues, solutions, and applications* (pp. 105–130). Taylor & Francis Group.

Jordà, S., Geiger, G., Kaltenbrunner, M., & Alonso, M. (2007). The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In *Tangible and Embedded Interaction*. Retrieved from http://dl.acm.org/citation.cfm?id=1226998

Kaltenbrunner, M. (2009). Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces (p. 240). Banff, Alberta, Canada: ACM.

Kaltenbrunner, M., & Bencina, R. (2007). reacTIVision: a computer-vision framework for table-based tangible interaction. *… on Tangible and Embedded Interaction*. Retrieved from http://dl.acm.org/citation.cfm?id=1226983

Kidao, M. (2010). *Emergent Symbiotic Creativity within Artificial Societies: An investigation in the use of collective creativity towards socially adaptive environments*. University of London.

Krueger, M. W., Gionfriddo, T., & Hinrichsen, K. (1985). VIDEOPLACE - an Artificial Reality. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 35–40). New York, NY, USA: ACM. doi:10.1145/317456.317463

Kwon, M. (2002). *One place after another: site-specifc art and locational identity* (p. 231).

LaBelle, B. (2006). *Background Noise: Perspectives on Sound Art*.

Langley, P., & Simon, H. (1995). Applications of machine learning and rule induction. *Communications of the ACM*. Retrieved from http://dl.acm.org/citation.cfm?id=219768

Levin, G. (n.d.). Messa di Voce. Retrieved October 09, 2014, from http://www.flong.com/projects/messa/

Lieberman, Z., Watson, T., & Castro, A. (n.d.). Open Framenworks. Retrieved October 09, 2014, from http://www.openframeworks.cc

McCormack, J., Bown, O., Dorin, A., McCabe, J., Monro, G., & Whitelaw, M. (2014). Ten Questions Concerning Generative Computer Art. *Leonardo*, *47*(2), 135–141. doi:10.1162/LEON_a_00533

McLuhan, M. (1994). Understanding Media The extensions of man. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Understanding+Media+The+extensions+of+man#0

Minim. (n.d.). Retrieved October 12, 2014, from http://code.compartmental.net/tools/minim/

Nasoz, F., Lisetti, C. L., & Vasilakos, A. V. (2010). Affectively intelligent and adaptive car interfaces. *Information Sciences*, *180*(20), 3817–3836. doi:10.1016/j.ins.2010.06.034

Pearson, M. (2011). *generative*.

Penny, S. (2009). Art and artificial life–a primer. *Digital Arts and Culture 2009*. Retrieved from http://escholarship.org/uc/item/1z07j77x.pdf

Reeves, W. T. (2009). Particle Systems A Technique for Modeling a Class of Fuzzy Objects, *2*(2), 359–375.

Ridgway, N. (2004). In excess of the already constituted: Interaction as performance. *Conference for New Media and Technological Cultures: …*. Retrieved from http://www.persons.org.uk/ci/mm/nmtc/nmtc2/Ridgway Paper.pdf

Rodrigues, M., Wanderley, M., & Ferreira-Lopes, P. (2013). Intonaspacio: a site-specific digital musical instrument. In *CIRMMT Students Symposium 2013*.

Rokeby, D. (1996). Transforming Mirrors : Subjectivity and Control in Interactive Media. In S. Penny (Ed.), *Critical Issues in Interactive Media*. SUNY press.

Ross, E. (2000). Intelligent User Interfaces : Survey and Research Directions, (March), 0–17.

Sá, C. (2012). *O que é um Interface? Da entificação à identificação do interface enquanto complexo mediator*.

Sims, K. (n.d.). Galapagos. Retrieved October 22, 2014, from http://www.karlsims.com/galapagos/index.html

Smith, H., & Dean, R. (1997). *Improvisation Hypermedia and the Arts Since 1945*. Routledge.

Snibbe, S. (n.d.). Boundary Functions. Retrieved October 14, 2014, from http://www.snibbe.com/projects/interactive/boundaryfunctions/

Sommerer, C. ;, Jain, L. C., & Mignonneau, L. (Eds.). (2008). *The Art and Science of Interface and Interaction Design (Vol. 1)* (Vol. 1). Springer.

Sommerer, C. ;, & Mignonneau, L. (1998). *ART @ SCIENCE*. New York, New York, USA: Verlag.

Sommerer, C. ;, & Mignonneau, L. (1999a). ACM SIGGRAPH 99 Conference abstracts and applications (p. 286). Los Angeles, California, USA: ACM.

Sommerer, C., & Mignonneau, L. (1999b). Art as a Living System: Interactive Computer Artworks. *Leonardo*, *32*(3), 165–173. doi:10.1162/002409499553190

Steichen, B., Carenini, G., & Conati, C. (2013). User-adaptive information visualization: using eye gaze data to infer visualization tasks and user cognitive abilities. *Proceedings of* *the 2013 International Conference on Intelligent User Interfaces*. Retrieved from http://dl.acm.org/citation.cfm?id=2449439

Stelarc. (2007). *Stelarc: The Monograph* (p. 272). MIT Press.

Stern, N. (2011). The Implicit Body as Performance: Analyzing Interactive Art, 233–238.

Todd, S., & Latham, W. (1994). *Evolutionary Art and Computers* (p. 224). Academic Press, Inc.

Tzanetakis, G. (2014). *Music Information Retrieval*. *Annual review of information science and …*. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/aris.1440370108/full

Ullmer, B., & Ishii, H. (2000). Emerging frameworks for tangible user interfaces. *IBM Systems Journal*, *39*(3), 1–15. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5387042

Watz, M. (n.d.-a). Drawing Machines 1-12. Retrieved October 09, 2014, from http://www.unlekker.net/dm1-12/index_e.php?rule=8&day=24&ismacro=1

Watz, M. (n.d.-b). Marius Watz. Retrieved October 09, 2014, from http://mariuswatz.com

Weibel, P. (1996). The World as Interface: Towards the Construction of Context-Controlled Event Worlds (pp. 338 – 343).

Wexelblat, A. (Ed.). (1993). *Virtual reality: applications and explorations*. Morgan Kaufmann Pub. Retrieved from http://ftp.hitl.washington.edu/scivw/scivw-ftp/postings/1993/Apr_93/93-04-22.01

Whitelaw, M. (2004). *Metacreation: art and artificial life. Computing Reviews*. MIT Press. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Metacreation+Art+and+Artificial+Life#0

Wright, M. (2005). Open Sound Control: an enabling technology for musical networking. *Organised Sound*, *10*(03), 193. doi:10.1017/S1355771805000932

# 9 Appendix A

## 9.1 Survey

ALIVEART

### ALIVEART - Adaptive Interface for Generative Live Graphics

ALIVEART is an app for mobile devices developed during a Doctoral program in Science and Technology of the Arts (Interactive Art) at the Portuguese Catholic University.

This survey aims to understand the impact of the use of the application by performers, user interface experts and designers.  We hope to have important feedback from users in order to understand the effectiveness of this interface.

No personal information will be published. We require this information to best determine the user background, allowing us to reach better conclusions.

* Required

#### Personal Information

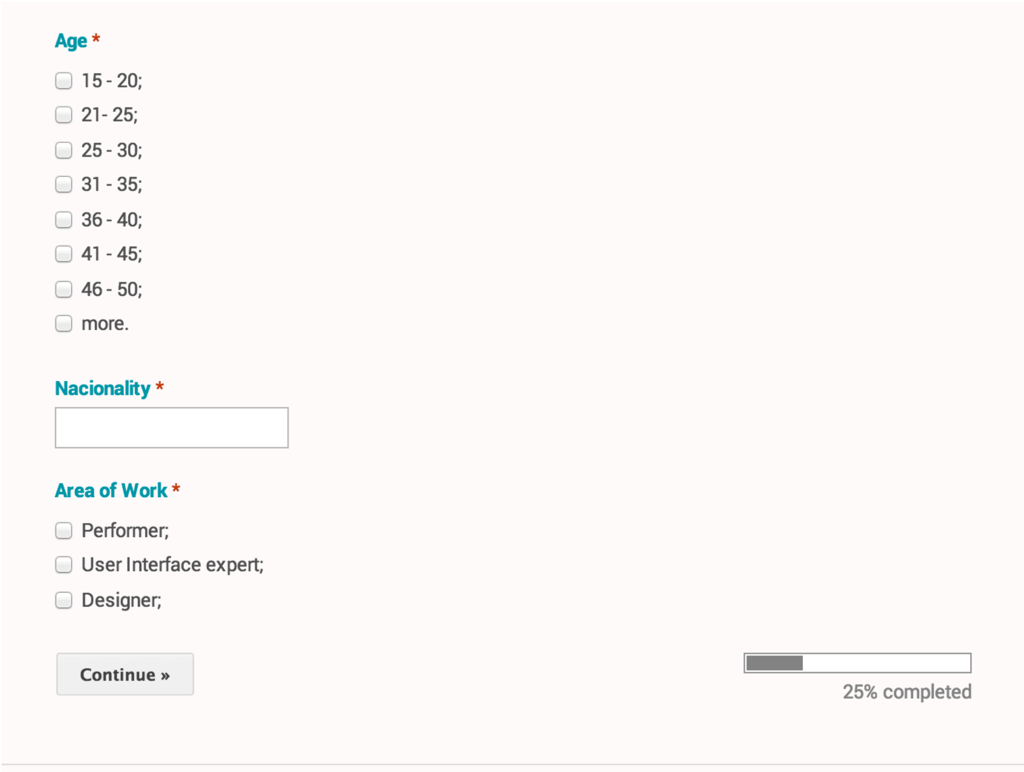
Some questions in order to characterize the User

**Name**

**Gender ***

- Female;
- Male;

**Age ***



**Age** *

- [ ] 15 - 20;
- [ ] 21- 25;
- [ ] 25 - 30;
- [ ] 31 - 35;
- [ ] 36 - 40;
- [ ] 41 - 45;
- [ ] 46 - 50;
- [ ] more.

**Nacionality** *

**Area of Work** *

- [ ] Performer;
- [ ] User Interface expert;
- [ ] Designer;

Continue »

25% completed

# Generative Live Graphics

**Do you know what Generative Graphics are? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| No, I don't know at all | ○ | ○ | ○ | ○ | ○ | Yes, I know very well |

**Do you know what A-Live means? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| I know | ○ | ○ | ○ | ○ | ○ | I don't know |

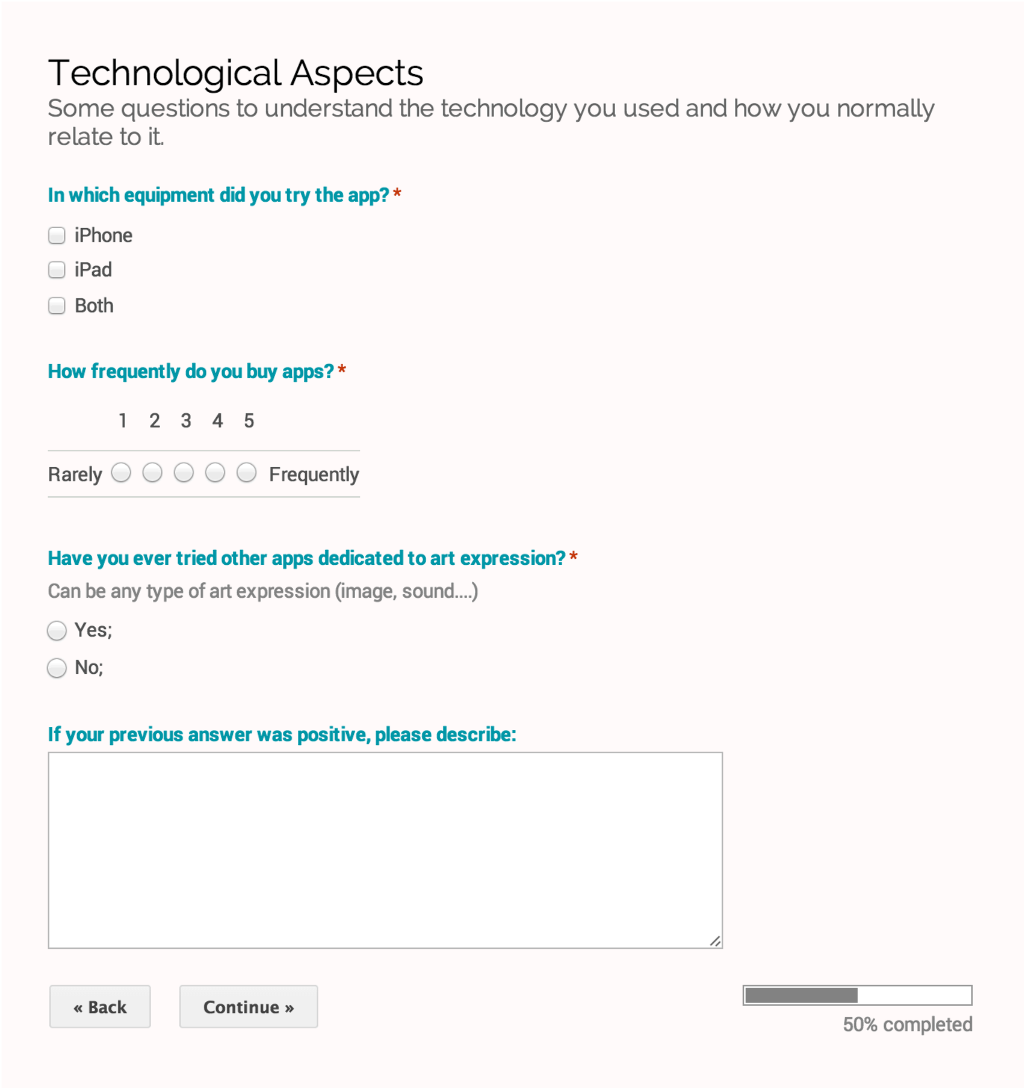
**Which one of these live performances have you attended? ***

- ☐ Live concert without graphics;
- ☐ Live concert with graphics;
- ☐ Live interactive performance with only sound;
- ☐ Live interactive performance with sound and graphics;
- ☐ Neither;
- ☐ Other: ______

**Have you ever developed any type of live graphics for concerts. ***

- ○ Yes;
- ○ No;
- ○ Other: ______

**If your previous answer was positive, please describe:**



## Technological Aspects

Some questions to understand the technology you used and how you normally relate to it.

**In which equipment did you try the app?** *

- [ ] iPhone
- [ ] iPad
- [ ] Both

**How frequently do you buy apps?** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Rarely | ○ | ○ | ○ | ○ | ○ | Frequently |

**Have you ever tried other apps dedicated to art expression?** *

Can be any type of art expression (image, sound....)

○ Yes;

○ No;

**If your previous answer was positive, please describe:**

« Back    Continue »

50% completed

# ALIVEART

Some questions relate to the app itself.

**How long (more or less) took your first interaction with the app? ***

- ◯ I closed it right away;
- ◯ between 1 to 5 minutes;
- ◯ between 6 to 10 minutes;
- ◯ between 11 to 15 minutes;
- ◯ between 16 to 20 minutes;
- ◯ between 21 to 30 minutes;
- ◯ More than 30 minutes;

**How easy was to use the app? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Very easy | ◯ | ◯ | ◯ | ◯ | ◯ | Very hard |

**Did you understood the main goal of the app? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| No, I didn't | ◯ | ◯ | ◯ | ◯ | ◯ | Yes, I did completely |

**Did you understand how the interface work? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Yes, completely | ◯ | ◯ | ◯ | ◯ | ◯ | No, i couldn't at all |

**Did you understand how your interaction was affecting the system? ***

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Never | ◯ | ◯ | ◯ | ◯ | ◯ | Always |

**Which of this aspects you were able to recognise in the system?** *

- ☐ Color changing according to different type of sounds
- ☐ Zoom in and zoom out of the visualisation according to the amplitude of the sound
- ☐ change of the parameters shown in the interface
- ☐ selection of the areas influenced the system
- ☐ reflection between interface and parameters of the a-life system
- ☐ the user input was related to the amount of time the user selected each area

**Could you notice the a-live system while using the app?** *

- ○ Yes, definitely all the time;
- ○ Yes, in certain moments was clear;
- ○ Yes, but I couldn't understand exactly what was happening;
- ○ I'm not sure;
- ○ No, I couldn't ;
- ○ Other: ______

**Did you feel you could express yourself through the graphics being created?** *

- ○ No, I couldn't feel at all ;
- ○ Sometimes I could feel it;
- ○ Most of the time I could feel it;
- ○ I felt I could express me all the time;
- ○ Other: ______

**Could you achieve interesting graphics while exploring the app?** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| It wasn't interesting | ○ | ○ | ○ | ○ | ○ | It was very interesting |

**I think the graphics are:** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Very interesting | ◯ | ◯ | ◯ | ◯ | ◯ | Not so interesting |

**How easily was to read the information displayed on the screen?** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Very easy | ◯ | ◯ | ◯ | ◯ | ◯ | Very hard |

**The misture on the same screen of the system and the interface was...** *

- ◯ Very nice, it was very important to have both information at the same level;
- ◯ It was ok;
- ◯ I didn't notice;
- ◯ Sometimes was difficult;
- ◯ I didn't care for it;
- ◯ Other: ____________

**While using the app, did you experience any problem?** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Never | ◯ | ◯ | ◯ | ◯ | ◯ | Always |

**If you had any problem while using the app, please describe it:**

**Do you plan to keep using the app?** *

- ◯ Yes, definitely for entertainment and in performances as well;
- ◯ From time to time in some performances;
- ◯ From time to time as entertainment;
- ◯ Maybe;
- ◯ Definitely won't be using it again;
- ◯ Other: ________

**What is your general evaluation of the app?** *

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Very bad | ◯ | ◯ | ◯ | ◯ | ◯ | Very nice |

« Back | Submit

*Never submit passwords through Google Forms.*

100%: You made it.