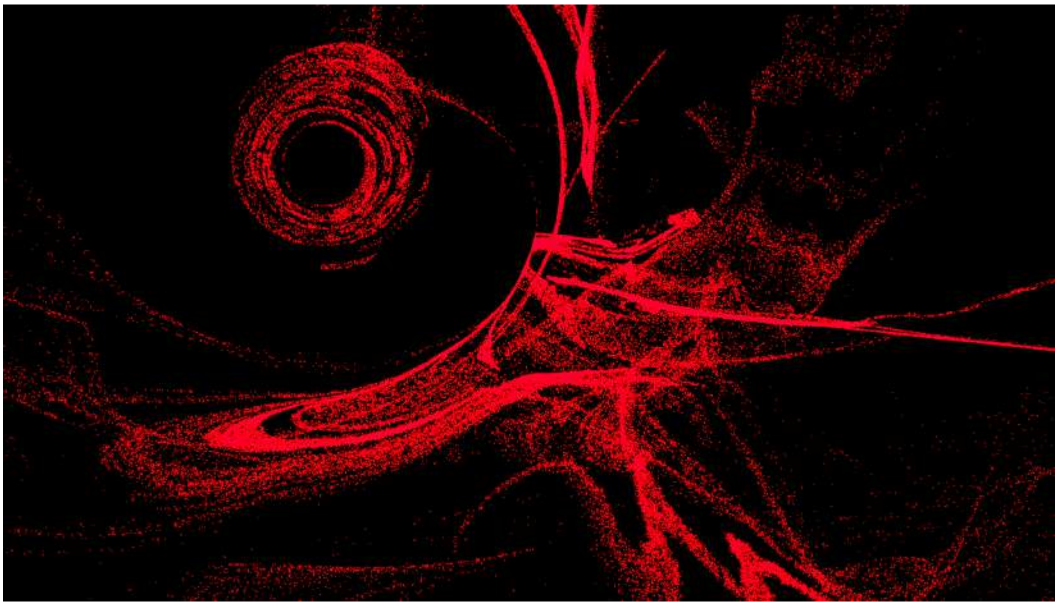
Master conjoint Franco-hellénique

Université Paris 8 - Spécialité : *Arts et Technologies de l'Image Virtuelle*

Ecole des Beaux-Arts d'Athènes - *Arts et Réalité Virtuelle Multi-utilisateurs*

Virtual Reality in the Use of Real Time Interactive Dancing Performances And Theater



Vasiliki Bismpiki

EUROPEAN
GREEK / FRENCH
MASTER

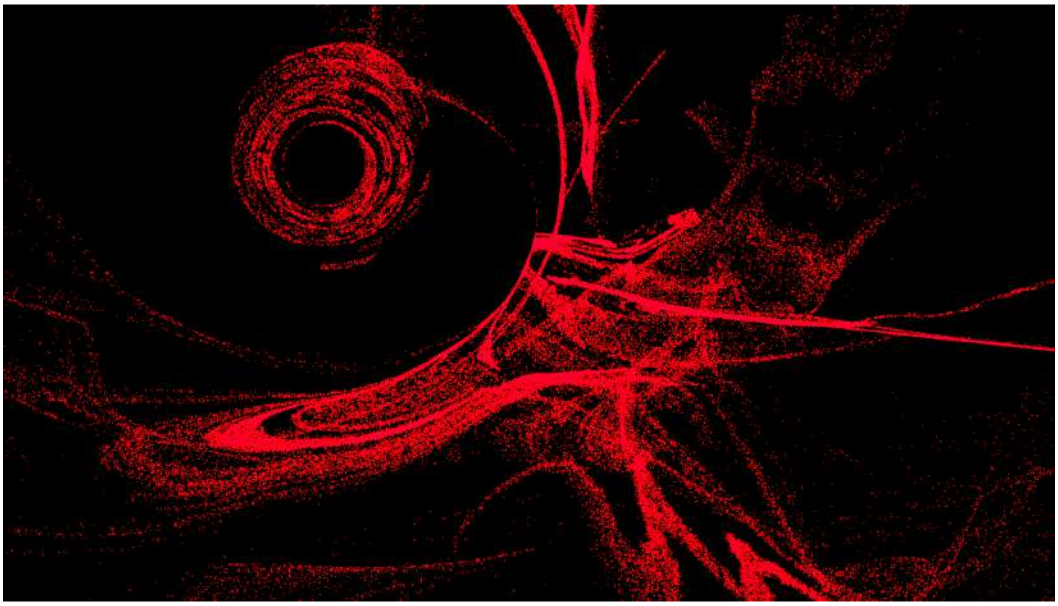
Mémoire de Master 2, 2013- 2014

French-Greek Master

University of Paris 8 - Specialty: *Arts and Technology of Virtual Image*

School of Fine Arts Athens - *Art and Multi-User Virtual Reality*

Virtual Reality in the Use of Real Time Interactive Dancing Performances And Theater



Vasiliki Bismpiki

EUROPEAN GREEK / FRENCH MASTER

Master 2 Thessis, 2013- 2014

ABSTRACT

Virtual Art, with its sub-genres of interactive art and generative art, consider to be the most advance form of new media art. (Grau, 2002). The field of Interactive Dancing Performance and theater is being to absorb interactive audiovisual elements to a new unity of expression. Virtual reality development tools relies mostly on behavioral, kinematics and physical implementation of the real world. In an expressive dynamic system could concept of physics define the non linear narrative through abstract visual forms and sonic elements? Could we develop an expressive dialogue between interactive dynamic systems and human movements? This thesis argues on those questions in order to explore the unique environment and elements of the Interactive Dancing and Theater area.

RESUME

L'Art Virtuel, avec ses subdivisions – l'art interactif et l'art génératif – est considéré comme la forme la plus avancée du nouveau media art (Grau, 2002). La vocation de la Performance de Danse Interactive et du Théâtre est d'intégrer des éléments audiovisuels interactifs dans une nouvelle unité d'expression. Les instruments du développement de la réalité virtuelle sont basés principalement sur une réalisation comportementale, cinématique et physique du monde réel. Dans un système dynamique expressif, le concept de la physique pourrait-il définir une narration non-linéaire à travers des formes visuelles abstraites et des éléments sonores? Pourrons-nous développer un dialogue expressif entre les systèmes dynamiques interactifs et les mouvements humains? Ce questionnement s'interroge sur ces questions afin d'explorer l'environnement unique et les éléments du domaine de la Danse Interactive et du Théâtre.

INDEX

Introduction 7

Virtual Realities in the field of Interactive dancing performances and theater 9

I.A. Exploring virtual and real space - Researches and Historical background 9

I.B. Immersive Audiovisual Elements in Interactive Performances 14

I.B.1. The action of digital media actor in non linear narratives 14

I.B.2. Autonomous behaviors and Generative Art 15

I.B.3. Laban movement analysis approach in the field of interactive art 17

I.B.4. Autonomous media actors 19

I.C. Concepts of Physics In Interactive Art 20

I.C.1. Approaching Interactive Art through the Science of Physics 20

I.C.2. Forces and physical movement in the use of creation 21

I.C.3. Implementing Physical Laws in Virtual Reality Development Tools 23

Synthesis of Evolutive AudioVisual Virtual Space 25

II.A. Construction of real time moving visual elements 25

II.B. Real time Interactive Soundscapes 26

Connection and Interconnectivity of Digital Image and Sound in Real Time 28

III.A. Techniques for interactive Audiovisual communication 28

III.A.1. OSC protocol 28

III.A.2. MIDI protocol 31

Motion Capture Technologies 33

IV.A. Mocap System for motion tracking technic 33

IV.B. Kinect technology for real time motion capture technic 35

Description of Experiments **37**

V.A. Project December 38

V.B. Project CREATIC 40

V.C. Project Lust 43

Conclusion **52**

Bibliography **53**

“Space is not just where you go to, but where you walk through”
Oddey 2006

Introduction

Over the recent decades the new media achievements has rise up as never before. The variety of the technological tools expands every day which gives the opportunity to discover new ways of expressive environments and processes of creation. Virtual Reality Art involves the design of artificial worlds that offer new experiences to spectators and is mostly approached as a tool for representing the real wold. In all the field of convictive science, the new technological achievements, with which virtual reality has find its new definition, has effected and show new paths to follow. In the field of creativity, where the results are not so clear to declare, the new paths has also increased more questions and different processes of creativity. Through the years, artists and researcher share one same source of inspiration: Nature. Physical phenomenon has given to both fields new points of view to discover . Concepts of physics, such as gravity, attraction, velocity, speed, balance and unbalanced system, motivate the artist and the researcher to approach interactive art through its roots: the concept of act.

This thesis approaches Interactive dancing performances as a synthesis of Virtual and Interactive art in order to explore its unique environment and elements. In this exploration we begin with the research in defining where concepts of physics and artistic creation has found one the other over the years. Also we describe the direction that the pioneers of creating immersive virtual spaces draw for us. Theorists, researchers and artists define the cognitive model in order to approach immersive audiovisual elements in Virtual Reality area.

In the first chapter this thesis continues to extract the key points of a cognitive model, such as autonomous behaviors of the virtual elements, kinematics and physical forces. Those are elements that contribute in the non linear narrative of an interactive performance. Laban movement analysis and autonomous media actors also help us to understand qualities of movements that rise the elements of the virtual space from non living objects to life-like digital actors. In the first chapter we continue with the historical background of artists that was inspired by physical phenomenons which goes beyond the mathematical simulations of representation. Which forces and physical properties could evolve an artwork through aspects of action and energy? Finally the first chapter ends with the report of the development tools with which we can implement physical laws in a Virtual Reality digital framework.

In the second chapter the algorithmic design of dynamic audiovisual systems is discussed. The synthesis of interactive audiovisual projects evolve in real time in such a way that makes the performer or the 'user' of the dynamic system, a participant of it. This leads us in developing our own tools through programming language that would serve the needs of our every immersive virtual environment. The third chapter follows in which interconnectivity of the digital image and sound is approached. We are introduced from synesthesia, the "joined sensation" of image and sound, to networking protocols in order to communicate sonic elements with elements of the virtual space and the other way around. The methodology of this research lead us in discussing to the next chapter the motion capture technologies such as Optitrack Mo-cap system and kinect technology. Those tools are used in order to develop effective interaction and movement generation in the virtual world, from real actor movement in the real space. In the last chapter the experiments 'Dialogues', 'The CREATIC project' and the project 'Lust' are described. Through those experiments three ways of interaction are defined. Those are 'trigger', 'follow' and 'reaction' with which we approach physical forces that are applied in the virtual space. The interaction between the performer and the projects are: In the first experiment through the keyboard and the cursor. In the CREATIC project through the Mocap system movement capture technology. In the ‘Lust’ project the performer interact with the abstract audiovisual synthesis through kinect technology. All the experiments aims to express the questions that this project approaches.

I. Virtual Realities in the field of Interactive dancing performances and theater

Exploring the potentials of new media in the expressive process, virtual reality come across the field of space, motion, and by its origin, theater. The theater by its definition is connected and inspirited by virtual reality far before the new technological achievement. The poetic synthesis of traditional theatrical scenes was created in order to be immersive, expressive and some time to provoke illusions of the theme that was evolved. The there is no need to explore the connecting points of virtual reality and theater but in the contrary there is a need to define the points that they distinct. The frame is quite similar so which are the limits of new media performances and theatrical play that make this new approach on this field necessary? Is it a new field where the technological tools define its existence or it is an evolve form of the traditional performance art? In addition traditional performances media artists are being now also to innovative forms of interaction and interface design, thus contributing to the development of the medium in key areas, both as artists and as scientists.

I.A. Exploring virtual and real space - Researches and Historical background

Alison Oddey, a Professor of Contemporary Performance & Theatre Studies at Loughborough University who is also a performer, writer, broadcaster and teacher, argues that theatre is a place where fiction and reality come together to promote each other, “What is presented in performance is always both real and not real, and there is constantly interplay between the two potentialities, neither of which is ever completely realized. The tension between the two is always present, and, indeed, it can be argued that it is precisely the dual presence of the real and not real, that is a constitutive of theatre.”(Oddey et al. 2006). The explorations of performing art with the new technologies, often referred as theater technology, involves the definition of this radical aspect of new technology in theater and performing art. Mathew Causey in his work Theatre and performance in Digital Culture, explores the philosophy of the digital age and its relation to modern performance and techno-culture. Causey's work makes great roads into understanding the affect that digital culture has had upon performance, how it has changed notions of the body in space, performance and in itself. For him, the question is becoming one of bio - virtuality for modern practitioners rather than of liveness; technology and theatre performance are the technē which reveals the digital culture (Arrey, 2011). Technē refers to the origin of the world technology in research of treating theatre technology merely as a theatrical technē -- a tool or craft of the art.

As Christine A. White suggests there is a need for the provision of technologies within the rehearsal spaces as a prerequisite for making performance in the twenty-first century. The ability of scenery and space to change has been one of the cornerstones of Scenography. However, often the process of producing theatre forces the designer to consider the design as a static space, or at best one that changes only sporadically at key and necessary moments in performance. Ironically, of course a director may be working in a rehearsal room dealing very specifically with time and performers in time, but not necessarily with space.(White, 2006)
In working on a project the following may be of concern to the designer:

- The changing setting, either in detail or in whole

- The changing atmosphere and lighting environment
- The rhythm and pace of movement and change
- The development of theme/metaphor over time
- The balance between motion and stillness
- Different groupings and dynamics, developing a scenography of the actor in space
- The fact that nothing changes
- The compression or expansion of time.

From anther point of view the real time synthesis of the audiovisual elements could provide the ability of improvisation which may be thought as a contrary aspect of rehearsal need. The real time generative scenography would evolve with a fixed space in which the performance would occur and this comes in addition to the improvisation of the acting actors, either we refer to the real actor interactivity or to the media actor which would be the actions of the virtual world. Could the live acting occur in harmony with the fixed objects of the scene? The live acting would occur both from the real actor and the media actor so the fixed space is deformed and reformed in a level where nothing could or should be fixed.

Project in VR

The pioneer Charlotte Davies and his work is an example of the Virtual Reality potentials using not only the concept of an imaginary world but also the hardware which would immerse the audience to a different yet virtual world. Although Charlotte Davies's virtual environment Osmose (1995) has been exhibited only six times in North America and Europe, it has received more attention in the international discussion of media art than perhaps any other contemporary work. Only a few thousand visitors have actually experienced the installation, but many times that number of art aficionados have avidly followed the debate on aesthetics, phenomenology, and reception of virtual art that has homed in on this particular work. Moreover, Osmose cultivates the user-interface—a central parameter of virtual art—at a level that is still unequaled; an independent treatise could be written on this aspect alone. Osmose is a technically advanced and visually impressive simulation of a series of widely branching natural and textual spaces: a mineral/vegetable, intangible sphere. (Grau, 2002) In the project web-description this project and the hardware it uses are placed as one way to define the project: The attempted standstill in data space is nevertheless laborious, since the breathing interface continually collects data that causes a change of position. This constant need for repositioning within the dimensions of time and space creates an aesthetic experience that irritates the ideas of time and space as experienced in reality. In the data worlds of Char Davies, light and speed are the only parameters used for drawing references – so our practiced sense of orientation, normally used to lead us along a wall or through a door, no longer applies here.

Figure 1: Charlotte Davies, Osmose

Figure 2: Charlotte Davies, Osmose

In research of this new form of performing art mixed with virtual art we need to define also the context in which virtual art exist. Besides the hardware and software Osorio introduce a hierarchy of models used to create virtual wolds depending on Cognitive Science which emphasize the importance of the physics, behavioral and cognitive models simulation, in order to implement simulations and VR product design. This model consist of those four elements to achieve cognitive modeling: Behavioral, Physical, Kinematic, Geometric. (Osorio, 2006)

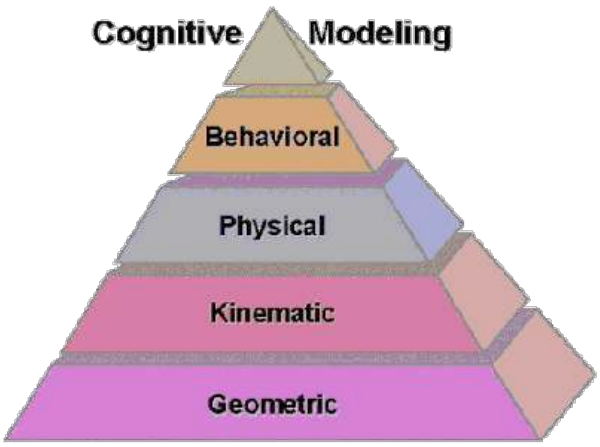


Figure 3: Hierarchy of models used to create virtual worlds

According to this model those elements-concepts are needed to represent real world in Virtual Realities application. This final thesis would approach the Geometric visualization of abstract expressive concept, Physical approach for expressive action in the virtual wold, kinematic aspects in new forms of capturing human movement and applying the data to the virtual world and autonomous behaviors for generative movements of the virtual elements. The fundamental difference of this final thesis approach to virtual words and the Convictive Model which was described, is that this project dose not aim to represent real wold as it is but uses real world constructive concepts develop virtual wolds of abstract elements in which the engagement and the immersion comes through the action of the mixing realities and not from the actual represented objects and their characteristics.

According to the cognitive model that was described, the second step to achieve immersive Virtual Realities worlds is kinematic. Motion Capture technology is one of the fundamental technological tools for the Virtual Art to exist. Artist and science are getting more and more involved with this breaking through concept of capturing real movement from real life and translated it to a movement in the virtual world, either in real time of recorded. The work of *Merce Cunningham* is one of the characteristic innovations in the field of performance technology. He is an innovator in dance and technology. His collaboration with *Paul Kaiser, Shelley Eshkar*, and *Unreal Pictures*, called *Hand-drawn Spaces*, is a milestone in motion- capture for dance performance. It was featured in the 1998 *SIGGRAPH Conference's Animation Theatre*, and later installed in the *Wexner Center for the Arts*, as well as traveling to Spain, Italy, Austria, and England. In the fall of 2002, the team began to explore motion-capture, with a student dancer in a motion-capture suit driving a rudimentary bipedal virtual character.

Figure 4: Hand-drawn Spaces :by Merce Cunninghama

Figure 5: Hand-drawn Spaces :by Merce Cunninghama

After learning the true limitations of the suit, the first live performance was featured in a student-produced dance showcase in November 2002. Like *Troika Ranch's The Plane*, this performance had only one dancer wearing the suit, choreographed to interact with her live virtual counterpart. The team achieved interaction by using camera moves that changed the scale of the virtual character compared to the real dancer, reversing the direction of the virtual character. Though the virtual character made the same moves as the real dancer, it took on its own personality through camera changes and by changing its shape.(Meador et al. 2004)

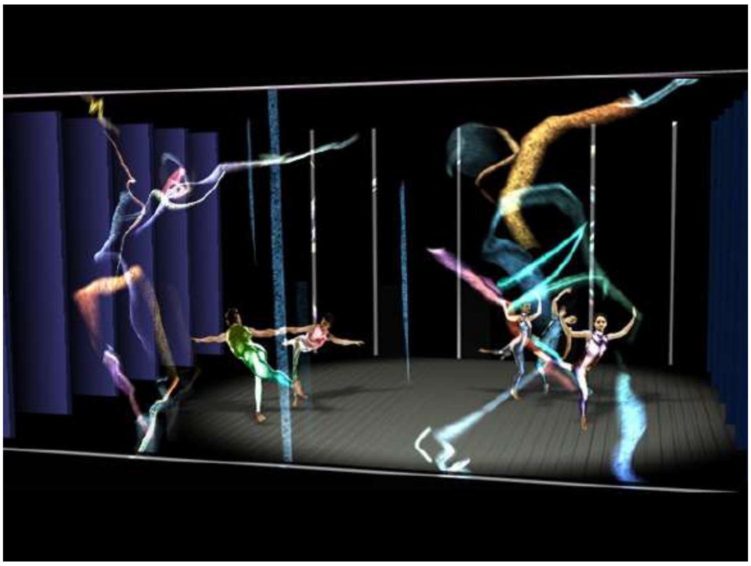


Figure 6: Hand-drawn Spaces : virtual dance installation by Merce Cunninghama

More recent works in interactive dancing theater take advantage of the basic characteristics to achieve Virtual and immersive environments. '*Apparition*' the project of *Kaus Obremaier*, is an interactive dance and media performance in which computational processes that model and simulate real-world physics create a kinetic space where the beauty and dynamics of the human body and its movement quality are extended and transferred into the virtual world.

Figure 7: Apparition interactive dancing performance by Kaus Obremaier

The questions that this project argues about are:

- What choreography emerges when software is your partner?
- When virtual and actual image space share the same physics?

- Where everything that moves on the stage is both interactive and independent?

- And any form, dancing or still, can be transformed into a kinetic projection surface?

In this project the artist's goal was to create an interactive system that is much more than simply an extension of the performer, but is a potential performing partner. Sophisticated interactive technologies release the performer from the determination of set choreography and generate the visual content in real-time.

I.B. Immersive Audiovisual Elements in Interactive Performances

I.B.1. The action of digital media actor in non linear narratives

As Nicolas Szilas claims there is no clear juncture between linear and non-linear forms of narrative. While it is often claimed as fact, it is simply untrue that linearity dominates traditional narrative forms. Many narratives break the linearity of time or viewpoint. He arguers that one must distinguish narrative form from the specificity of its medium. Linearity and non-linearity are both familiar fictional forms regardless of media. Non- or multi-linearity is not by itself the defining criteria of interactive forms. (Rieser, 1997) In his study *'IDtension: a narrative engine for Interactive Drama'* he distinguishes four constrains according to which the narrative is not considered as a succession of events, but as general non-temporal principles: a discursive approach, a narrative grammar, emotion and perceptive criteria.(Szilas, 2003)Those four constrains are:

- The user intervenes in the story very often

- His or her actions have dramatic consequence on the story (significance of interactivity)

- The user has many choices (range of interactivity)

- The overall experience is narrative

The wold drama comes from the Greek world "*δράω- ῶ*" which means the generation of an action. The dramatic principles aim to the concept of engagement: flow. Flow is defined as a state in which a subject becomes totally absorbed in an activity. This state is also characterized by decreased self-consciousness and time awareness.(El- Nars, 2007) Magy Seif El- Nars argues that while adapting the narrative to accommodate interaction is important, creating an experience that exhibit the type of engagement requires representation of dramatic principles including conflict pacing and temporal dramatic progression. Early approaches to interactive drama emphasized the development of autonomous believable agents. For a convincing stage presentation and interaction with users, the work that has been done in the context of embodied conversational agents, as described by Justine Cassell is also of high interest.(Spierling et al. 2002). Interactive drama in Virtual Art takes advantage of all theoretical research in interactive narrative to achieve the state of flow.

I.B.2. Autonomous behaviors and Generative Art

The term of autonomous characters is widely used in the field of Virtual Reality, computer animation and interactive media. This terms refers to represent a character in the story or game that have some ability to improvise his actions. Autonomy is defined as the self-governing of one's actions and acting independent of someone's control. Behavior refers to the actions or reactions of an object or organism, usually in relation to the environment and is mostly used to describe the improvisational and life-like actions of an autonomous character. An autonomous character could evolve the story or could support the actions of the virtual environment. Concerning motion behavior for autonomous characters, Craig W. Reynolds suggests three divisions of the possible behaviors. The first is the Action Selection the second the Steering and the third is the Locomotion.

Steering behaviors is used for movement adaptation in order the character, vehicle, object or elements of the virtual environment to obey in physical, life-like actions. "Autonomous Steering Behaviors", as first defined by Craig Reynolds in his presentation at the 1999 Game Developer's Conference, are a simple yet effective method of creating realistic movement in computer-controlled characters. The summarized patterns that steering behaviors implement first to determine the desired target location, to calculate the desired velocity vector (the direction of the target and the speed that the character would move towards to that direction), to compare the desired velocity to the current velocity and calculate the acceleration that is required as the difference between them and to apply the steering force in the direction of the desired acceleration.

According to Reynolds, Steering behaviors for autonomous agents are categorized in the following behavioral types:

- Seek & Flee
- Pursue & Evade
- Arrival
- Wander
- Obstacle Avoidance & Containment
- Collision Avoidance & Unaligned collision avoidance
- Wall Following
- Path Following
- Leader Following
- Flow Field Following

Those behavioral types could evolve through time in pairs of tow or more, according to the force and the priority that is given to each of them. For example a moving element in the virtual environment could obey in the wander behavior but also with a less force could obey in the path following. According to the which priority is given the same element would wander around a path that is following. If the force of the path following is higher the element would have a slightly wander. In the contrary if the element has a higher wander force and a slightly path following force then the wander behavior would effect the movement more. Each of these behaviors defines only a specific reaction on the simulated environment of the autonomous system. The results are simple building parts for complex systems. Depending on the combination of behaviors the character or object that obeys in steering behaviors can be configured to handle different complex situation. Steering behaviors in autonomous character design are often considered an important part of "Game A.I.", despite the fact that they do not really have any relation to traditional A.I. techniques. The behaviors grouped under the name 'Steering Behaviors' are only the lowest level for an autonomous system. Besides game development such movements and forces could be applied in order to develop meaningful 'dialogue' between virtual elements in any computer generative art. A step further is consider when those behaviors involve human interaction trough an interface. The movement of the elements is construct through physical and natural kind of actions thus the immersion of the viewer, the user or performer is deeper and more effective.

The theoretic framework of generative art is deeply rooted in artificial intelligence and cybernetics - both in practice and theory. In robotics and artificial intelligence, the term "autonomy" con-scribes a set of technical conditions for a given robotic system: Capable of interpretation of directives, such a system needs to be environment aware, self-controlling and able to anticipate outcomes of its own actions. Interactive art is often understood as a sub-genre of installation art – yet performative actions, live audience participation and real time engagement are its integral components. Interactive art has its roots in performance arts, happenings and the explorations of Fluxus. In between sculpture and installation, performance and participation, interactive art is considered an independent platform.
According to Robert Spahr, one approach on the question *'what is generative art'* could be the following: *Any art practice that incorporates instruction- based, mechanical, organic, computer-controlled, and/or other external, random, or semi-random processes and/or apparatuses directly into the creative process, which is then set to motion with some degree of autonomy contributing to or resulting in a work of art.*
Another one could be: *Any art practice that incorporates random processes set to motion with some degree of autonomy resulting in a work of art.*

Through the historical examples of generative art the term is finding its meaning. Artists and researchers such as Marcel Duchamp 1913, John Cage 1946, George Brecht 1959, Steve Reich 1968, Sol Lewitt 1970 gave meaning to a concept which is still to be explored.

The Oxford Dictionary defines interactive as allowing a two-way flow of information between a computer and a computer-user, i.e. as responding to a user's input. A computer is defined not only as an electronic device, but secondly as a person who performs calculations, especially with a calculating machine. In the strict sense of the term, interactive art is linked to the history of computers as an electronic device which is capable of receiving information (data) in a particular form and of performing a sequence of operations in accordance with a set of procedural instructions (program) to produce a result in the form of information or signals. The artist Nathaniel Stern states that in interactive art "installations are not objects to be perceived but relations to be performed".
Virtual Art in the field of performing Art consist generative and interaction by its definition. The immersive virtual words what are being to engage the viewer and the participant. The levels of such a wold consist not only a consciousness communication with the

environment and its elements but also an unconsciousness meaningful participation of the fictional world.

I.B.3. Laban movement analysis approach in the field of interactive art

Laban Movement Analysis (LMA) is a method and language for describing, visualizing, interpreting and documenting all varieties of human movement. In addition many derived practices have developed with great emphasis on LMA methods. Also known as Laban/Bartenieff Movement Analysis, it uses a multidisciplinary approach, incorporating contributions from anatomy, kinesiology, psychology, Labanotation and many other fields. It is used as a tool by dancers, actors, musicians, athletes, physical and occupational therapists, psychotherapy, peace studies, anthropology, business consulting, leadership development, health & wellness and is one of the most widely used systems of human movement analysis today. Rudolf Laban was born in Bratislava, Hungary in 1879. He was an architect and painter and became fascinated with rituals, folklore, mythology, dancing, art and mathematics. He saw life as a dynamic movement experience. He founded several dance/movement schools in Germany and in 1930 became Director of Movement at the State Theaters in Berlin. Eventually, however, the Nazis banned his notation and books. Laban fled to Paris and later travelled to England where he turned his energies to education and improving the efficiency and harmony of the industrial workforce. He died in 1958. Laban looked upon movement as a two way language process through which the body could communicate by giving and receiving messages. He believed that movement stems from the inter-dependence of body, mind and spirit and he understood that our inner life relates to the outer world. Laban created a theoretical language in order to help the observer understand and record movement objectively. This is still widely used in many fields of the movement/dance and therapy worlds.

Laban's work will not lend itself to turning emotional expressions into a table with one-to-one mappings of movements to emotions – but his theories of movement can be used to understand the underlying dimensions of affective body behaviors. Theater practitioners use Laban Movement Analysis to create and describe character movement, to explore how objectives can be physicalized in action and to experiment with disparate movement in an effort to pair movement with character personality. Several researches in software development and human machine interface and interaction has turned to Laban Movement Analysis in order to design effective communication between the virtual and the real space. Such project approach the emotional reaction of the human body for pre-consider a potential movement of the user and in order to find affective gestures that can express emotion. By addressing human emotions explicitly in the design of interactive applications, the hope is to achieve both better and more pleasurable and expressive systems. (Fagerberg, 2003) What is noticeable in LMA approach for interactive performances is that LMA is not based in a personal opinion or form but in objective lows of kinematics.
Three aspects of Laban Movement Analysis are noticeable in implications for Virtual environment design approach of this final thesis:

- Effort Actions: the ways people perform actions and their intentions, based on weight, time, space, and flow
- Body: the structure and physical characteristics of the body in motion and how they interact

- Shape: the ways in which the body changes shape during movement, in relationship to the environment in which motion takes place

Effort and Effort Actions:

One way Laban categorizes movement is by elements of Effort or Dynamics, which take into account the way a person performs an action and his or her intention in doing so. These two aspects are important because an action counts the degree of control over the movement, the timing of the movement. These dynamic qualities of movement help us to understand how movement reveals the actor's attitude, which may not be conscious.

Effort has four factors, each having two polarities:

- space: indirect, direct
- time: sustained,sudden
- weight: light, strong
- flow: free, bound

Laban's theories of Flow, Space, Time and Weight are incredibly useful and come with a plethora of exercises actors can take part in. The Four Movement Factors are further broken down into the Eight Basic Effort Actions:

- Pressing movements
- Wringing movements
- Gliding movements
- Floating movements
- Thrusting movements
- Slashing movements
- Dabbing movements and
- Flicking movements

Laban notions are based on the belief that by observing and analyzing movements, both conscious and unconscious, it is possible to recognize the objectives of the mover and to become aware of an inner attitude that precedes an action. Laban provokes to create momentary moods and long-standing personality characteristic through movement and action which is one of the main aspects in Interactive Art. For the purpose of this final thesis the Laban Movement Analysis is taken into consideration in order to develop expressive actions and apply them to the virtual elements. The non human virtual forms are defined by their movement in relationship to the user. Every action in time an space needs to follow the principle of Laban Movement Analysis on order to be meaningful to the viewer and communicational with the improvisational acting of the performer.Exploring and applying Laban dance theories to a virtual character increased awareness of the motion-capture system's capacity, and, in creating the piece, helped to focus on the strengths of motion-capture. Although this project do not get into the mathematical translation of LMA into algorithm it takes the structural and forming aspects of this theory to apply them in an expressive Virtual World.

I.B.4. Autonomous media actors

In the field of Computer Graphics, animation and interactive art a great progress has been made in the creation of life-like characters and autonomous agents. These characters are driven by 'desire', goals and 'needs'. They can sense the environment through real or virtual sensors, and respond to the user's input or to environmental changes by modifying their behavior according to their goals. Since the character exist in the virtual world is a virtual element of it. In interactive audiovisual performance such character would evolve the non linear storytelling not only according to the user's or the performer inputs but also to their own behavioral and kinematic potentials. In the field of theater technology a virtual element which is design to act and to react and gives a unique continuity to the concept of the play and the narrative could be called a 'media actor' . The term 'media actor' was first introduced by the researcher Flavia Sparacino whose work is based on interactive performance featuring people interacting with behavior-based "Media Creatures." She is a visual storyteller who combines transformational images and expressive typography for physical, virtual, and web-based environments. Flavia Sparacino argues that such media actors are able to engage the public in an encounter with virtual characters that express themselves through one or more of these agents. They are an example of intentional architectures of media modeling for interactive environments.(Sparacino, 2000).

A step further is consider then the media actor has a degree of autonomy, meaning that it was design with a AI (Artificial Intelligent) techniques and through a 'brain' could make decisions according to a given situation. Sparacino distinct interactive systems in five categories*: scripted, responsive, behavioral, learning, and intentional.* In scripted system is described by a central program which present the audiovisual material to the audience. The interaction modality is often restricted to clicking on a static interface in order to trigger new material to be shown. The design of such systems needs to be very careful due to the high complexity when drawing content from a large database. In responsive systems the approach is addressed in sensor-based real-time interactive art applications. In such architectures one-to-one mappings is used deleting the memory of pasted interactions between the system and the user. The responsive systems is clear in terms of that the performer of user controls and has a higher level of immersion achievement. In behavioral systems the internal state is essentially a set of weights on the goals and motivations of the behavioral agent. The values of these weights determine the actual behavior of the agent. Behavioral systems provide a one-to-many type of mapping between the public's input and the response of the system. Behavioral agents are also called life-like creatures. In learning systems program the have the potential to learn new behaviors or to modify the existing ones by changing dynamically the parameters of the original behaviors.

The behavioral approach of a dynamic system through scripted, responsive and learning architecture design system, is developed in this final thesis in order to create a media actor that would be generated, act and react to the inputs of the performer with a degree of autonomy. In multimedia, performance, and the electronic arts, the designer of the experience and the public are often involved in more complex forms of interactions and communication which require a revision of the current behavior-based model.The non human media actor could not be specified only by its audiovisual aspects but also by the sensors and its way of interactivity between the dynamic system and the human gestures/actions.

I.C. Concepts of Physics In Interactive Art

Art and Physics exist in the same frame as much as they both defers from it. For sure, the progress of physics affected art and imagination had inspired many evolutions in the science of physics. F. Wagner describes the exceptional and unbelievably creative time when Planck, Bohr and many others tore down the old world concepts and replaced them by a new one and that more-or-less at the same time Manet, Cezanne, Picasso and many others taught the world new ways to look at it and thereby expanding our minds and sensations. Unfortunately, when Einstein and Picasso once met, both share the fame of having destructed the existing and well-contained systems in their fields, replacing them with more general one or one where limits are overcome allowing a deeper and better understanding of the world, they did not have a lot to say to each other. Both fields, physics and art, deal with a better understanding of the world.

I.C.1. Approaching Interactive Art through the Science of Physics

According to Leonard Shlain those tow area separate in the methodologies but have a lot in common in their fundamental principles. He argues that despite what appears to be irreconcilable differences, there is one fundamental feature that solidly connects those disciplines. Revolutionary art and visionary physics are both investigating into the nature of reality. While their methods differ radically, artist and physicists share the desire to investigate the ways the interlocking piece of reality fit together.(Shlain, 1991)
Regarding the field of Interactive Art and as a more wide aerie, the Virtual Art, physical laws consist a very important , almost undoubtable principle. One of the keys to an effective virtual world is for the user to be able to “suspend disbelief”.That is, the user must be able to imagine that the world portrayed is real, without being jarred out of this belief by the world's behavior.

Traditionally, computer graphics techniques attempt to “capture” the real world in the computer, and then to reproduce it visually. What Virtual Reality attempts is to reproduce the real physical laws in order to create a fictional environment. In interactive art though the tools and the methodology is almost the same, sometimes the artist/researcher do not aim to a real representation of the world, but is seeking for expressing his or a teams point of view of reality. Grau argues that reality, as stated by quantum physics, is always a product of perception. Distance and closeness will coincide through a technical set up in real time and create the paradox of I am where I am not and I experience sensory certainty against my better judgment. To accomplish this task it is a need to approach the physical concepts in the use of creating interactive art and virtual environments in order to be able to break those laws and reconstruct our personal view of reality.

Virtuality allows it to evolve software while suspending the laws of physics and chemistry, and the procedure of self-replication guarantees that certain characteristics of the artificial life forms are left to the computer’s programs.

I.C.2. Forces and physical movement in the use of creation

The impact of physics in Art and the opposite has its root far before the digital area we live into. New scientific discoveries inspires artist and artist inspires new discoveries to happen. When it comes to forces and phenomenon of physics that influenced artistic creation, *Starry Night*, by *Vincent van Gogh* is a cross section of this belief. The painting is from 1889, a year before his death, and displayed in the *Museum of Modern Art*. At the time of painting the first photos of spiral galaxies were reported by the media. *Van Gogh* had contacts with astronomers and he was informed about the scientific progress in this field. The painting may show the Milky Way and a galaxy.

Figure 8: Starry Night, by Vincent van Gogh

Another example is the spatial analysis of *Jackson Pollocks* painting. In this case experiments in physics is influence by an artistic approach of creation.

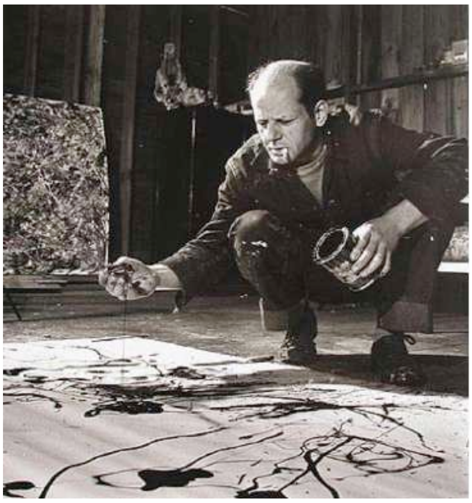


Figure 9: Jackson Pollocks

Figure 10: Painting, Jackson Pollocks

In an experimental study, Pollock's technique of painting was mimicked first with a mechanical system which carried out harmonic oscillations and second with one where the paint pot was attached to a chaotic pendulum.

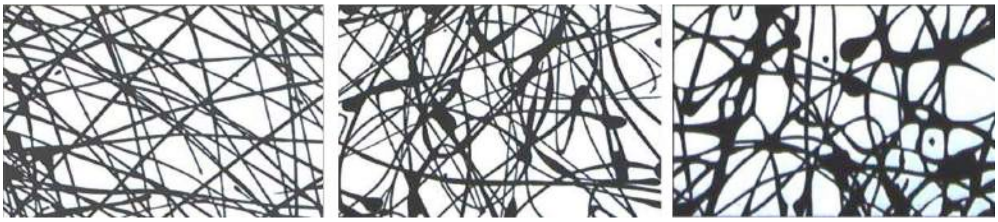


Figure 11: results of harmonic and chaotic pendulum

Regarding the approach of interactive art/virtual art through concepts of physics several questions come across this research. How can we implement concepts of physics in abstract visual forms and sonic sound? Can an interactive audiovisual system act like a media actor in an interactive performance? Could interactive dancing performances be defined as a new form of cinema or we need to explore and evolve/develop its unique field and elements that defines it? Interactive Art and Virtual Art come across physical forces through the theory of relativity. From the roots of creating a virtual art project we explore the most important equivalence, the one of mass and energy: E=mc2. This simple formula tells us where energy comes from, it comes from mass but it can also be transformed back into mass. This equation explains where the sun and the stars get there inexhaustible energy from.

Through physical phenomenons that every human being is close to is possible to approach the characteristics of a virtual media actor. The non human creatures that consist the virtual environment have the potentials to act like life-like actors in a mixed reality dialogue.

Forces of Physics in VR:

As Fernando S. Osorio claims virtual reality systems should apply forces and simulate object kinematics, detect and react - since two concrete objects cannot occupy the same space at the same time and they must respect the laws of conservation of energy - simulate articulations and object deformations - changing the object shape or even breaking it into smaller pieces - . The implementation of all those physical behaviors must be done in order to increase the virtual worlds realism. In this way, the objects and elements of the virtual world start to behave as the concrete elements of our real world (Osorio, 2006). In the hierarchy of concepts used to create virtual worlds that Osorio introduces for creating Virtual Environments, physical approach consist one of the five step.

A basic level to virtual environments, is what is called the “VR physical” - simulation of motion based on physics. When we begin to consider the world composed by concrete objects - virtual elements are not just polygons in the 3D space -, and we begin to associate behaviors to these objects, according to the physics laws, then we will have a “VR physical” environment. (Osorio, 2006) The physical concept is formed by objects that possess physical properties, such as:

- Balance and un balance systems

- Position and orientation in the 3D space

- Movement and acceleration/deceleration with application of forces and torques

- Attraction and repulsion (e.g. gravity, magnetic charges)

- Laws of conservation of energy and mass

Regarding this approach of concepts the visual elements could form a narrative that do not rely on the simulation of the real wold but is consider as an abstract form of a world of actions. The actions of every element reveals the narrative. The performer is participating in a dialogue with the virtual space through the action, reaction and the interaction.

I.C.3. Implementing Physical Laws in Virtual Reality Development Tools

Development tools to implement physical simulations could be approach in tow categories. The first refers to the real-time rendering platforms, such as Xcode, Visual Studio or Code Blocks, which provide interfaces for developers to write scripts to define the behaviors of the virtual objects in VR scenes. The second category uses the development of the game engine technology, especially the physics engine technology, for game engines to perform physical simulations. Physics engine provides a set of basic functions for physical simulation and the developers need to implement those functions or develop their own. Software packages such as OpenSteer library, ODE (Open Dynamics Engine) and AGEIA PhysX (Integrated Hardware and Software solution) are also some development tools for implementing physics in virtual reality applications.

Frameworks and physical simulation tools include models - or have the potential to develop such models - that can implement:

- Kinematics Simulation

- Articulated Rigid Bodies Simulation

- Dynamic Simulation of Deformable Objects

- Fluid simulation and Particle Systems

The kinematic simulation allow to apply forces on object that can simulate motion by the lows of energy conservation such as generate motion and trajectories, acceleration, deceleration, gravity, friction, collisions, reaction to collisions and simple steering models. The articulated rigid bodies simulation allows to represent skeletons or robotic arm. With dynamic simulation of deformable object one could simulate elastic and coupled mass-spring systems and finally with fluid simulation and particle systems it is possible to simulate the interaction of complex elements, like fire, smoke, clouds and liquids.

<u>Physics in Unity 3d</u>

Unity contains the 3D physics engine NVIDIA® PhysX® Physics in order to create immersive and visceral scenes with clothes, hair, tires that screech and burn, walls that crumble and glass that shatters.
In Unity 3d the hierarchy of the physics engine follows the diagram (Wenfeng Hu, 2012):

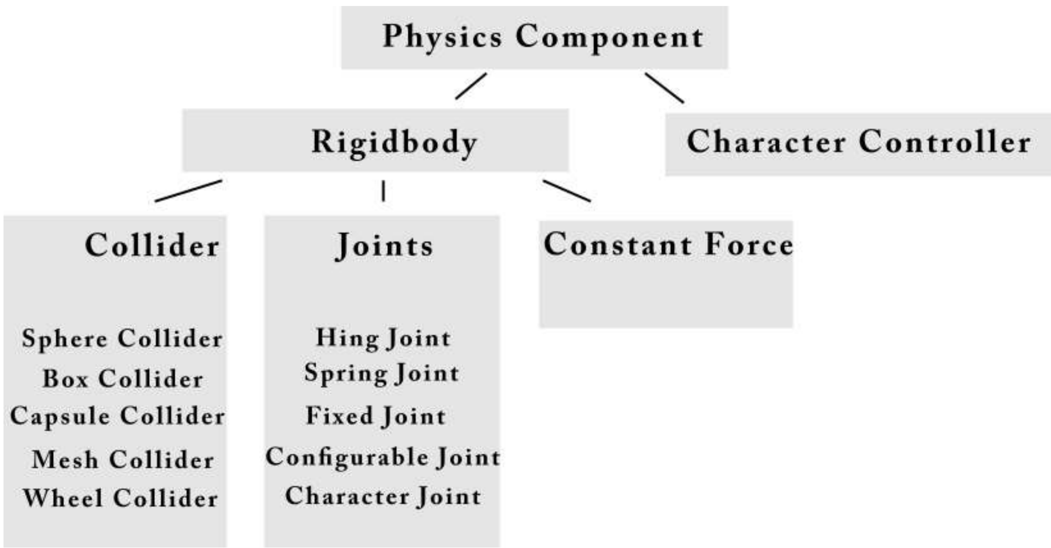


Figure 12: Diagram physics in Unity

- Rigid body: This component is the foundation of other components. It enables the game object to be under the control of physics. It can receive forces and torques to make the objects move in a realistic way.
- Collider: Whereas the rigid body component allows objects to be controlled by physics, collider allows objects to collide with each other. This component enables the object to receive the collision signals.
- Constant Force: It can be used to add constant forces to an object. When an object is influenced by external forces, it is necessary to add this component to it to simulate the situation.
- Joint: This is a component that can simulate the conjunction relation between adjacent parts of the models. Due to difference in types of the connection, it can be divided into fixed joint, hinge joint, spring joint, configurable joint and character joint.

OpenSteer for Unity 3d, a C++ library to help construct steering behaviors for autonomous characters in games, animations and virtual environments - also provide physical steering behaviors.

II. Synthesis of Evolutive AudioVisual Virtual Space

From the very beginning of live performances, researches and artists associated the creation of virtual space with the development of applications that could act and react in real time. The benefits of video art and video installation, could modify, redefine and give a completely other dimension in the creation of virtual wolds but besides the hardware that are used they luck in one fundamental principle. That is the randomness and the unexpected evolution that could occur in a virtual reality space. The audience in no longer viewer of that is happening but is a part of it. A single move or action could lead to a completely different virtual act. And this is the approach of the real world. Not in a represented way of reality, as it is the most common in the most project, but in way of constructing immersive and dynamic evolutive virtual spaces. The algorithmic synthesis of live visual and sound give the potentials of improvisation and a freedom in creation process that no existing application could offer, simply because the needs of every project and artist are not fixed and could not be predefined by other developments. With this frame the virtual worlds, the sound, the moving visual elements and the interaction between human action and the virtual wold, was designed, constructed and developed regarding this research project.

II.A. Construction of real time moving visual elements

Algorithm is the most highly qualified methodology. The word comes from *algorism*, which means to calculate with Arabic numerals. According to Donald Knuth (1973) algorithm is a broader concept, covering any set of rules or sequence of operations for accomplishing a task or solving a problem so long as it demonstrates each of the following five characteristics:

- Finiteness: The method must not take forever.
- Definiteness: Each step must have a significance that is commonly understood.
- Input: The method must have valid materials or information upon which to operate.
- Output: The method must produce at least one result, generated by applying the method to the inputs.
- Effectiveness: The method must always produce the same output from the same input; the result must not depend upon unknowns (e.g., a miracle, a coin toss, or the phase of the moon); and there can be no ambiguous outcomes (e.g., dividing by zero is not allowed because the result is undefined).

A method that meets all these requirements is called algorithmic.(Loy, 2006)
Beginning with a traditional storyboard to express the desired non linear narrative of the abstract 3d visuals, the process lead to C++ programming in Openframeworks. OpenFrameworks is an open source toolkit that is designed for expressive algorithmic synthesis of 3d and 2d moving visuals. It was developed from *Zachary Lieberman*, *Theo Watson, Arturo Castro and Chris O' Shea* - also with the contribution of institutes *'Parsons School of Design'* , *'MediaLabMadrit'* and *'Hangar Center for the Arts'* to make the programming language C++ more accessible and user friendly. (O' Reilly, 2009)

Game engines provide also algorithmic development work-field for creating virtual spaces with the potentials of programming languages. They provide easy ways of interactivity and also importing, using, modifying and constructing 3d objects and scenes.The aesthetic approach is also promising since the researcher/artist can make his own textures and 3d models in the game engine or even create them in other software and them apply it to the desired object. For this research the creation of the first experiment was developed in the game engine Unity 3d and SuperCollider and for the second in the toolkit Openframeworks and SuperCollider.

Autonomy behaviors are developed - for the purpose of this final thesis - with the library Steering behaviors for Unity 3d, initially based on the open source library OpenSteer. The ideas behind these behaviors is proposed by Craig W. Reynolds. They are not based on complex strategies involving path planning or global calculations, but instead use local information, such as neighbors' forces. OpenSteer is a C++ library to help construct steering behaviors for autonomous characters in games, animations and virtual environments and provides a toolkit of steering behaviors, defined in terms of an abstract mobile agent called a "vehicle." (Osorio, 2006) Steering is an important aspect of behavioral animation that allows autonomous agents to navigate through an environment, and this topic has generated a large amount of research in the field of robotics, graphics, artificial intelligence, and even sociology and psychology. (Singh, 2009) Each entity's motion is simplified to a single force vector. The calculation of the force vector is a result of simple vector additions of desired behaviors. The standard set of steering behaviors that have been provided as part of the OpenSteer libraries are: Seek, Pursuit, Obstacle Avoidance, Wander and Path Following.

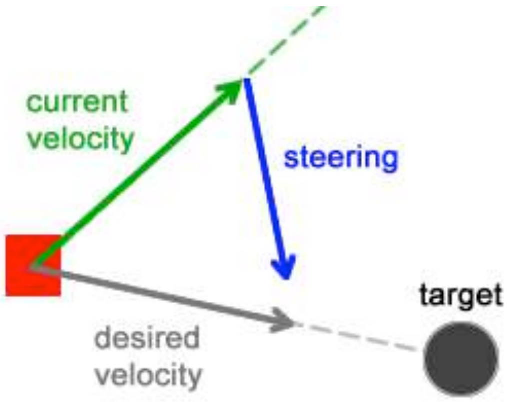


Figure 13: steering behavior

II.B. Real time Interactive Soundscapes

Although the research and application on interactive virtual environment systems are of great interests from the acoustic point of view, most systems are 'silent', or only have simple sound effects. The computational complexity in simulating realistic sound environment is exorbitant. In order to allow real-time, interactive environments to be built, many current virtual reality systems do not include any acoustic modeling. Those that include reverberation often use very simple effects, for example, by accurately simulating only a small number of discrete echoes, and generating uncorrelated decay to simulate later-arriving reverberation tail. (Meng, 2005) To produce an immersive virtual acoustic environment, acoustic modeling needs to be used and, therefore, the requirements of simplifying simulation algorithms to reduce computation time becomes the key issue. The representation of the three-dimensional audio sound is also a main aspect.Three-Dimensional Audio refers to the arbitrary positioning of sounds around a listener, which is located into an open or closed space. This method creates a so-called virtual auditory scene or virtual auditory environment. 3D Audio systems are intended to work with two-channel reproduction systems, i.e. headphones and stereo loudspeakers.

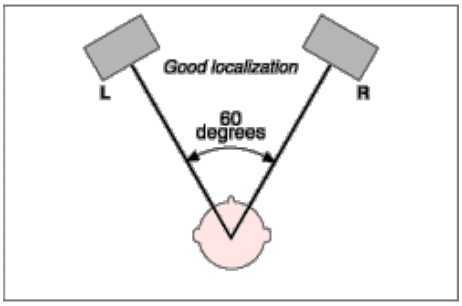


Figure 14: position of the speakers

Regarding the quality of the audio sound generated in real time interactive acoustic artwork, the synthesis of sonic environments needs to be constructed both as a hole soundscape electroacoustic performance, and also as an evolutive and changeable live coding synthesis.

The live coding synthesis refers to real time generative sounds which could be modified during the performance either by the designer or by the position and the quality of the performers movement.

We are introduced from the prerecorded samples and fixed sound synthesis to algorithmic sounds generators and live generative synthesis. For the needs of this research the sound design for all the experiments was developed in SuperCollider. SuperCollider is one of the most important domain-specific audio programming languages, with potential applications that include real-time interaction, installations, electroacoustic pieces, generative music, and audiovisuals. SuperCollider, first developed by James McCartney, is an accessible blend of Smalltalk, C, and further ideas from a number of programming languages. It is an open-source, cross-platform, and with a diverse and supportive developer community, it is often the first programming language sound artists and computer musicians learn.

III.Connection and Interconnectivity of Digital Image and Sound in Real Time

The connectivity of different or abstract elements to an unity has been taken into account far before the networking protocols where developed. In Neuropsychology is explained with in the context of synesthesia. Synesthesia (Greek, syn = together + aisthesis = perception) is the involuntary physical experience of a cross-modal association. That is, the stimulation of one sensory modality reliably causes a perception in one or more different senses.(Cytowic, 1989) The word synesthesia, meaning "joined sensation", shares a root with anesthesia, meaning "no sensation." It denotes the rare capacity to hear colors, taste shapes, or experience other equally startling sensory blending whose quality seems difficult for most of us to imagine.

In AudioVisual live performances the moving image is developed not only to correspond in the exact sound - on what it sounds - but also goes one step further, to communicate and supplement the quality of the general ambient. For this project experiments of different protocols of connectivity were developed to achieve communication between sound and moving image, human gesture and sound, and human gesture with the moving image. Since both sound and moving image were constructed with algorithms the potentials of connectivity are unlimited. So, the task was not only to make the data of one element to correspond to the data of the other element but also to define which processes where going to be evaluated in real time. Two main protocols of communication are described, OpenSoundControl (OSC) protocol and MIDI protocol.

III.A. Techniques for interactive Audiovisual communication

III.A.1. OSC protocol

In 1997 developers Matt Wright and Adrian Freed unveiled the OpenSound Control protocol, better known simply as OSC. OSC is a modern network data transport control system. Such a system defines the types of data it carries and manages streams of those data types. Like other transport protocols OSC enables communication between computers and other media devices, and of course OSC also allows communication between programs running on the same machine. OSC has been designed for musical purposes, but it is certainly capable of serving in other capacities.

Data Types:

- int32
- float32
- OSC-string
- blobs
- int64
- Time Tag

- float64
- symbol
- ASCII
- RGBA
- MIDI
- true
- false
- nil

OSC Packets

The unit of transmission of OSC is an OSC Packet. Any application that sends OSC Packets is an OSC Client; any application that receives OSC Packets is an OSC Server.
An OSC packet consists of its contents, a contiguous block of binary data, and its size, the number of 8-bit bytes that comprise the contents. The size of an OSC packet is always a multiple of 4.
The underlying network that delivers an OSC packet is responsible for delivering both the contents and the size to the OSC application. An OSC packet can be naturally represented by a datagram by a network protocol such as UDP. In a stream-based protocol such as TCP, the stream should begin with an int32 giving the size of the first packet, followed by the contents of the first packet, followed by the size of the second packet, etc.

The contents of an OSC packet must be either an OSC Message or an OSC Bundle. The first byte of the packet's contents unambiguously distinguishes between these two alternatives.

OSC Messages
An OSC message consists of an OSC Address Pattern followed by an OSC Type Tag String followed by zero or more OSC Arguments.

OSC Address Patterns
An OSC Address Pattern is an OSC-string beginning with the character '/' (forward slash).

OSC Type Tag String

An OSC Type Tag String is an OSC-string beginning with the character ',' (comma) followed by a sequence of characters corresponding exactly to the sequence of OSC Arguments in the given message. Each character after the comma is called an OSC Type Tag and represents the type of the corresponding OSC Argument.

For the three projects/experiments that are described in this final thesis, was achieved OSC communication between Unity 3d and SuperCollider and between Openframeworks and Supercollider, thus between human gesture and sound control and human gesture and visual control.

Each message contains a sequence of zero or more arguments. The official OSC data types are ASCII strings, 32-bit floating point and integer numbers, and “blobs,” chunks of arbitrary binary data. OSC’s type mechanism allows for many other types, including 64-bit numbers, RGBA color, “True,” and “False.” Only a few implementations support these other types, but they all represent them in a standard way. (Matt Wright, 2002)

<u>Unity 3d and SuperCollider:</u>

In the first experiment (see Char. V) the position of the evolutive moving elements is received and controls basic parameters of the sound such as frequencies, pitch up and pitch down, randomness, arrays of frequencies and others. In details, an algorithm C# in Unity 3d describes that the position and the velocity of every joint is translated to OSC message and send to a defined client with the name ‘SuperCollider’. Apart from the *address* pattern the *port* and the *host* of the software to which the message is send the id which defines the kind of data is needed. Messages from external clients that should be processed by OSCresponders must be sent to the language port, 57120 by default. We could use NetAddr.langPort to confirm which port the SuperCollider language is listening on.
The *host* refers to the network so if it is on the same computer the number of the host is the same.

As we execute the application of Unity 3d the messages are being send. In the SuperCollider, in order to receive those messages, again a host, port, and address is defined:

```
// evaluate the responder
(
u = OSCresponderNode(nil, '/test/gravity01/', { |t, r, msg|
	msg.postln;
	}).add;
)

// and then remove the responder
u.remove;
```

The argument nil describes that the responder will receive osc messages from any application on the same computer. The /test/gravity01/ describes the address in which the responder is waiting the messages. At this point the data that are received are posted in the Post Window. Working back in C# in Unity 3d we define which messages are going to be send. For the first experiment the position of the moving visual elements was send and every trigged action, such as ‘begin an autonomous movement’ and ‘change the scene’.

The SynthDef what are constructed in SuperCollider takes the value of the data and translate it to values of the sound. For example in the last scene of the first experiment the position of the visual element changes the pith of the sound. In the second experiment (CREATIC) the position of the foot of the human in real space controls the frequencies of the generated sound and the velocity of the hands controls the volume of the sound. If there is no movement in the hands the sound would fade out. This was made through the Mocap Tracking System, that every joint of the avatar was wireless connected to the joints of the human/dancer. Every movement of the human in space was translated to the movement of the avatar through Unity 3d.

Openframeworks and Supercollider:

Openframeworks and SuperCollider are both open source developer tools that are build up on the fundamentally libraries of the computer. The communication between them could provide connectivity between algorithmic moving image and algorithmic sound and also connectivity with kinect technology. Motion Capture through kinect was achieved for the purpose of this final thesis, and more specifically in the Dancing Performance experiment (Char. V), through Openframeworks. Due to the OSC communication between Openframeworks and SuperCollider kinect technology was also connected to the sound generators so the movement of the dancer would control qualities of the ambiance sound. The position of the human/dancer in the x, y, z axis is mapped in values that the sound generators produce.

In OF (stands for Openframeworks) a port also is needed to be defined, a type of the message and a address where the message will be send. The data were received in SC (stands for SuperCollider) with a responder Node and would change the sound. The inverted communication, thus from SC to OF was developed in order to control the time of every scene, the total time of the application and to trigger the autonomous movement. In OF a second port is defined on which the application is waiting for osc messages.

```
osc_sender.setup( HOST, SCPORT );
cout << "listening for osc messages on port " << OFPORT << "\n";
osc_receiver.setup( OFPORT );
```

III.A.2. MIDI protocol

The original Musical Instrument Digital Interface (MIDI) specification defined a physical connector and message format for connecting devices and controlling them in "real time". A few years later Standard MIDI Files were developed as a storage format so performance information could be recalled at a later date. The three parts of MIDI are often just referred to as "MIDI ", even though they are distinctly different parts with different characteristics.The MIDI Message specification (or "MIDI Protocol") is probably the most important part of MIDI.Though originally intended just for use over MIDI Cables to connect two keyboards, MIDI messages are now used inside computers and cell phones to generate music, and transported over any number of professional and consumer interfaces (USB, FireWire, etc.) to a wide variety of MIDI-equipped devices.

MIDI is a music description language in digital (binary) form. It was designed for use with keyboard-based musical instruments, so the message structure is oriented to performance events, such as picking a note and then striking it, or setting typical parameters available on electronic keyboards. For example, to sound a note in MIDI you send a "Note On" message, and then assign that note a "velocity", which determines how loud it plays relative to other notes. You can also adjust the overall loudness of all the notes with a Channel Volume" message. Other MIDI messages include selecting which instrument sounds to use, stereo panning, and more.

The first specification (1983) did not define every possible "word" that can be spoken in MIDI , nor did it define every musical instruction that might be desired in an electronic performance. So over the past 20 or more years, companies have enhanced the original MIDI specification by defining additional performance control messages, and creating companion specifications which include:

- MIDI Machine Control
- MIDI Show Control
- MIDI Time Code
- General MIDI
- Downloadable Sounds
- Scalable Polyphony MIDI

For the purpose of this research there is no need to go further on the MIDI communication .

IV.Motion Capture Technologies

Human movement in space provides a unique approach in representing digital characters movement and natural animation of digital environments. In traditional animation technics the observation of everyday life and the natural phenomenon provide to the creator a magnificent source of inspiration for his virtual world contraction. Motion capture is the process of recording a live motion event and translating it into actionable data that allows for a 3d recreation of the performance. In other words, transforming a live performance into a digital performance. Seizing human motion as data, motion capture provides a record of individual movement characteristics that can then be manipulated, embodied, and projected into a live performance.(Oddey, 2006) Motion capture is a standard in Film making such as in Final Fantasy, The Spirits Within and The Lord of the Rings trilogy is proved that characters created by human motion are accepted as substitutes for living actors: for example, in the creation of Golem for The Lord of the Rings. In a new age of mediated bodies and avatars, the potentials of motion capture in performance suggest a new method of character creation as well as new possibilities for recording and re-using human motion.
In this chapter tow basic techniques is presented, motion capture with the Mocap system technology and with kinect technology.

IV.A. Mocap System for motion tracking technic

The potentials of motion capture with Mo-Cap System has been accessed by theater artists for real time performances. In 2000 at the University of Georgia, David Saltz presented a version of *William Shakespeare's The Tempest*, which used motion capture in live performance. (Wittenberg, 2013)

Optical motion capture systems tend to utilize proprietary video cameras to track the motion of reflective markers (or pulsed LED's) attached to particular locations of the actor's body. Single or dual camera systems are suitable for facial capture, while 8 to 16 (or more) camera systems are necessary for full-body capture. Reflective optical motion capture systems use Infra-red (IR) LED's mounted around the camera lens, along with IR pass filters placed over the camera lens. Optical motion capture systems based on Pulsed-LED's measure the Infra-red light emitted by the LED's rather than light reflected from markers. The PhaseSpace system is an Active LED motion capture system. It achieves phenomenal accuracy via 12 Megapixel cameras at rates of up to 480 frames per second.

Figure 15: dual camera system

Figure 16: reflective markers - pulsed LED's

The centers of the marker images are matched from the various camera views using triangulation to compute their frame-to-frame positions in 3D space. The use of multiple cameras in the set-up not only allow for near complete coverage of the subject, but are what help determine the location of the markers in space when the frames are processed. Most systems use a skeleton which is driven by the tracked marker positions as they are captured. The captured skeleton moves around the character's skeleton, which moves the mesh that makes up the skin of the character. This results in animation of the character.

Figure 17: attaching the markers to the performer

Figure 18: virtual and real actor precise communication in real time

The process needs to be operated in a rather dark room with no additional light sources for the tracking not to 'see' any un-existing markers. The actor wears the uniform in which the markers will be attached. Every key position of the bones needs to have a marker so the computer could calculate the triangles of the digital skeleton. Once the markers are on the space in which the cameras 'see' the actor needs to be calibrated. This is achieved with a single point market. The software is in mode of calibrating so all cameras provide that they 'see'. Then the calibration begins the single point-market scans the hole aerie. The point cloud that is formed after the calibration shows as in the virtual scene which is the captured aerie.

Besides the captured aerie the human body with the markers on it needs also to be matched to the virtual avatar. The P position (hands up in the level of the shoulders), after the hight and the weight is defined, will match the avatar with the human. Now the human would move in the real space and the avatar would have the exact same movement in the virtual space.

Motion capture through Mo-Cap System is mostly used for the movement to be recorded and then passed to a digital character or creature. In the group project i participated, in the CREATIC project, where the data of the human movement where first passed as a animation to a 3d model, to the elements of the digital scene and also to real time movement in a virtual scene. The dancer would interact with the autonomous digital characters, with the avatar of her own and with the sound, all in real time.

IV.B. Kinect technology for real time motion capture technic

The release of Kinect in 2010 made a break through in the technology of motion capture not only for the low price accessibility that could offer but also for the various open source implementations that were developed. In the very beginning this technology was used for video gaming in which the players are able to navigate by telling where they want to go, waving their hands over the desired selection and other features. In the research aeries, kinect was seen as a new human input device that could create 3d moving objects and characters with the ability of depth values.

Figure 19: kinect camera infra-red

Kinect camera is able to track human values due to the combination of color camera, infra-red emitter and infra-red receiver. Together, the infrared emitter and receiver are used to create depth values which can be associated with the color image received from the camera(Wittenberg, 2013). Although the human figure is captured and translated to data values for the computer to manipulate, when it comes to skeleton tracking there is still work to be done. Even when working with the SDK of Microsoft the aeries of the perceptions that the camera do not 'see' could cause some strange effect. This is because the camera could record only one side of the 3d real space, and could be solved by using multiplies cameras around the space. However for small scale performances, using the open source library Open NI the skeleton tracking could be very efficient.

For the purpose of this final thesis an application was developed that would track the human movement and translated it to data values in the computer and then use those values to move the dynamic visual elements on the projector and also to change the sonic ambience. The library that was used to achieve a this real time dancing performance was ofxKinect and ofxOpenCV.

Through Openframeworks, in which all the libraries and all the algorithms are compiled, the human figure in the real space appears as a blob (with OpenCV configuration) or as a point cloud. Working with blobs make it possible to define how many humans we are going to capture. For the 'Lust' performance only one figure was defined to be tracked. The figure of the dancer. Once the dancer is in the captured field the data of his position are translated to the virtual space in the axis x, y, z. The field that camera kinect can capture in the ground (in the x, z) is about 4x3 m. The blob detection provides as with the space that the human body covers. With the algorithm that calculate the center of the blob the values of the position of the hole body are translated to x, y, z in the virtual space. Since the position of the body is capture, it is possible to calculate the velocity and the acceleration of the movement. The 3d object in the Lust project are moving according to the position and the velocity of the dancer. (see char. V) The position and the velocity of the body which is captured in space are translated to data and modified to control the 3d elements. The same values with a different modification are send to the sound generators in the SuperCollider through OSC. The generators of the sound which are constructed through algorithms, would also be modified by the position and the velocity of the dancer in real time.

The potentials of the motion capture with the kinect technology are still to be explored. The skeleton tracking or the point cloud modifications are areas that could evolute the theatrical space and actor to new dimensions. Comparing to other media what kinect technology offers is the real time modification and synthesis of the sound and moving image. This would give to the actor or the dancer the potential to improvise in his own will according to a basic narrative. It is the non fixed results that every time will come to surface according to different movement approach that contributes to the non linear narrative of a play or story. The same performance if it was to be presented two or more times, it would never be exactly the same due to the different movement of the dancer. For example if the human/performer chooses not to move at all the audiovisual elements would be evolved in a completely different way - or not be evolved at all.

V. Description of Experiments

The visual elements were developed to evolute their movement with autonomous behavior and also by the interaction with the movement of the performer. Concerning the three different kinds of human interaction tow basic experiments was accomplished. The three different approaches of interactions refers in approaching different ways of possible interactivity and then use each of those in the non linear narrative according to the action which is needed. Those interactions are:

- trigger
- follow
- reaction

The first approach is the trigger action which describes - as the wold refers - when a movement, a sound, or an action in the virtual wold is triggered. This would occur by the human interaction with the system either through an interface or from a capture devise. The second approach refers to the continued data values which 'connects' an action which happens in real space to an action that occurs in the virtual space. The characteristic of this sub-interactivity is the continues data value which makes the virtual form to follow as the times evolves the real movement of the performer in real time. In every scene a concept of physical action is approached to the visual elements such as dragging, magnetic field, cloths behavior and flowing movement in order to create expressive action.

In all the experiments the sounds are real time generative and communicate with the values of the moving images and the values of the motion capture of the performer through OSC protocol. Functions and generators such as sines, noise mix, feedback envelopes and others are developed and modified to achieve the interactive acoustic virtual world.

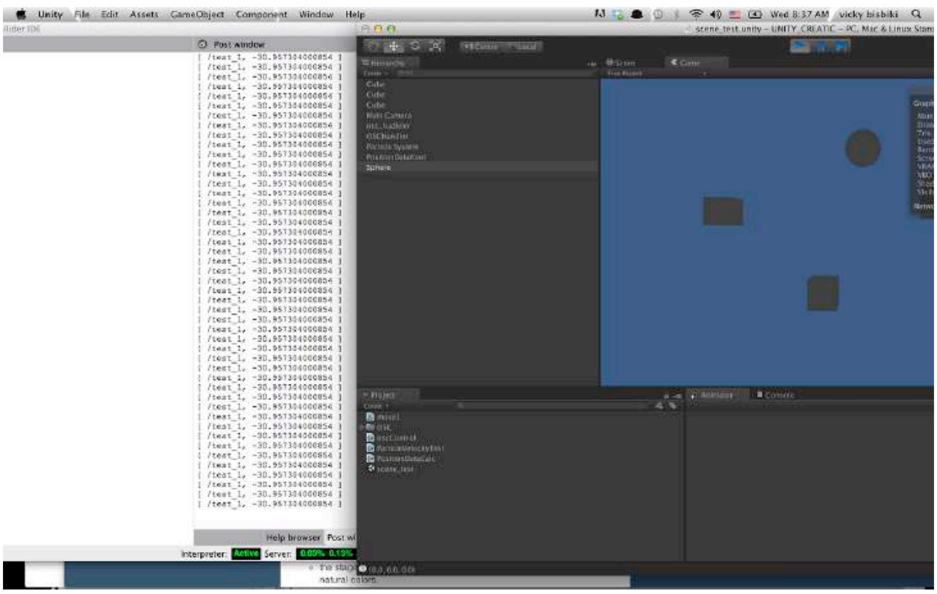


Figure 20: unity 3d and SuperCollider - OSC communication in real time

V.A. Project December

Technical description of the visuals in project Dialogues:

In the first scene two big cubes define the space and the limits of the virtual space and smaller cubes are placed in an order inside them. When the application begins the elements has no movement unless the keyboard is used by the user/performer. Every specified key will trigger the action of a small cube which will be attracted to the center of the scene. The movement of every cube has an autonomous movement of flowing around the attraction field. With the definition of how much value the flowing would be, how fast of slow the cube would arrive in the magnetic field and when the hole movement will occur the performer gives the ambience of evolutive space but not the exact evolution itself since this is defined in the autonomy behavior of the agents.

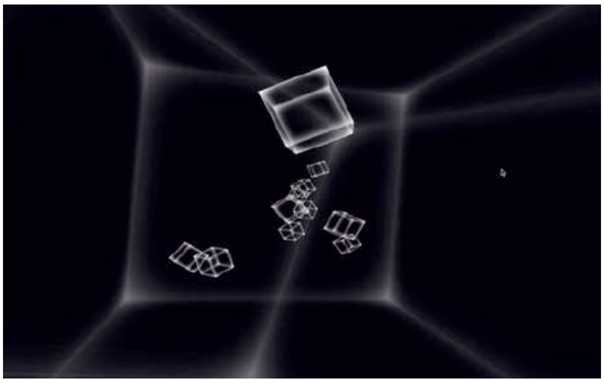


Figure 21: Dialogues - scene 01

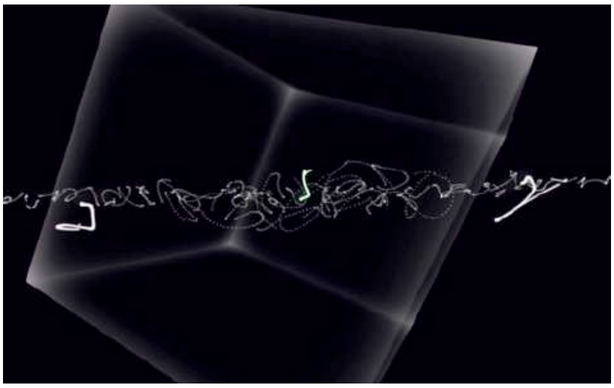


Figure 22: Dialogues - scene 02

In the second scene the movement of the light is additive (constructed by particles and source lights). The autonomous movement of a light line is attracted by the center of the source light and when the action of each light line is trigged the attraction field changes to the center. This changes the path of the light line, and not the light source. The line follows the path to the center and then goes back to its light source.
In the third scene the single light source is generating a light line which is evolved in three different pairs of states. The first pair refers to the distance of the particles that consist the light, the second to the attraction field that the line light would wander, and the third to an interaction of dragging the line light or continue its autonomous movement.

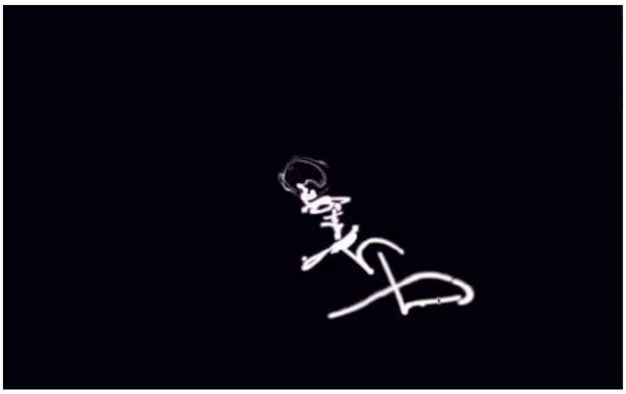


Figure 23: Dialogues - scene 03

Figure 24: Dialogues - scene 04

The fourth scene approaches the physical behavior of cloths and gravity. Also the interactivity ‘follow’ occurs with the movement of the object in the x, y, z axis by the performer. According to the performer choice of movement the visual element is navigated in the scene as a form of a creature that is moving in a cave.

<u>Technical description of the sound in project Dialogues:</u>

In this experiment five sounds synthesis methods were developed in order to create the sonic environment of the four different scenes. Each sound was first design with the approach of synesthesia (see Char. III) and then deformed regarding the three different interactive approaches. The method consist first of al the synthesis of each sound in a SynthDef definition which will load the construction of the sound that will be generated. All SynthDef needs to be ‘added’ in a Synth which will be ‘called’

In the fist scene the initial sound is generative by oscillators with envelopes that deform the sound trough time. As the project evolves the cubes which forms the visual virtual space send values of their movement, position in x, y, z axis. According to which cube is triggered to be moved the frequency of the sound changes so that it would describe and accompanies the evolutive visual acting. Regarding the quality of the sound the small cubes would change the frequency of the ambience sound while the big cubes which describes the limit of the actions that occurs, would be associated with another generative sound.

In the second scene the sound quality could be described like a wind sound. In the initialization of the scene the sound would describe mostly the big cube which is moving forward in the z axis. Then the movement of the light-lines is triggered the sounds takes describes the positions of the edge of the line which is moving towards the center of the big cube. A band pass filter is used to achieve the wind flow sound synthesis and a function which describes the frequencies that will be cut of is defined - all multiplied by an envelope which will effect the hole sound synthesis.

In the third scene the sound is driven both by the autonomous movement of the light and by the interaction through the cursor. In details the x, y, z position of the line light and the changes of the position in time would be send through OSC protocol from Unity 3d to SuperCollider. The signal is described by a decayed PinkNoise generator which is multiplied by a Saw generator. The function of the hole signal would be Comb delayed in line with linear interpolation by the filter CombL. In this interactive sound synthesis the sound is corresponding to the x, y, z axis of the virtual world either by the autonomous movement or by the human/performer interactivity through the cursor.

In the fourth and last scene of the first experiment the sound describes the physical movement of the virtual creature. The algorithm for this soundscape contains a Lang filter, a Mix function, an array of frequencies between 130 to 589, a resonant low pass filter, a Normalizer of the hole signal and a Panning effect. The initialized sound generator which is the base for this sound design is a Noise sound generator. All the signal would again be multiplied by an envelope. The interactive position of the virtual creature in the virtual space is send through OSC communication to the sound synthesis and controls defined values of the sound. When the performer has no interaction the last value that was send is used.
For each of the scenes it was developed an OSC responder for the sounds structure to be modified in real time by the performer in three main ways - trigger, follow and reaction.

V.B. Project CREATIC

Technical description of the visuals in project-laboratory CREATIC:

In the group workshop-laboratory of CREATIC, Du geste capté au geste d'interactivité numérique we developed a Virtual environment in which the dancer would have a dialogue with it. With the Optical Mo-Cap System it was possible to capture the movement of every bone of the real dancer and to translate it in data-values for the computer in real time. Through the library AkeNe the data of the points would move the virtual actor in Unity 3d and would control the sound in SuperCollider.
The visual of this project were developed in Unity 3d. The goal was organized in three levels:

- to build an non human, abstract visual environment that would be controlled by the dancer

- to create realistic 3d characters from the scanned faces of the people of the team and then apply to them animated movement from the real dancer

- to develop a dialogue between the virtual and real character through FSM (Finite State Machine)

A finite-state machine, or FSM for short, is a model of computation based on a hypothetical machine made of one or more states. Only a single state can be active at the same time, so the machine must transition from one state to another in order to perform different actions. FSMs are commonly used to organize and represent an execution flow, which is useful to implement AI in games. The "brain" of an enemy, for instance, can be implemented using a FSM: every state represents an action, such as attack.

For the purpose of the first step, a virtual environment was developed with lighting bolds. The lighting bold formed an abstract structure of the virtual space and where attached to the hands and foods of the virtual character. Every bone of the avatar was translated in space and in time by the real dancer in space whom the movement detection was made by the Optical Mo-Cap System.. For the experiments on this step the movement of the real dancer was recorded in .fbx file and then applied to the avatar. The 3d model was created with the software Makehuman. Makehuman is an open source 3D computer graphics application designed for the prototyping of photo realistic humanoid to be used in 3D computer graphics. It is developed by a community of programmers, artists, academics interested in 3D modeling of characters. Starting from a standard (unique) androgynous human base mesh, it can be transformed into a great variety of characters (male and female), mixing them with linear interpolation. For example, given the four main morphing targets (baby, teen, young, old) it's possible to obtain all the intermediate shapes. The humanoid character was imported in Unity 3d where the .fbx animation was applied. We developed algorithms that made possible to connect the lighting bolds movement to the movement of the hands and the foods and also to every bone of the captured dancer.

As a second step to this first approach the real dancer would take the place of the animated character to control the movement of the environment. The position of the captured person in space was corresponding to the ending of the lighting bolds and the velocity of her movement was connected to the scale of the distance of the particles. When the velocity of the hands and foods was increased the lighting bolds would spread even more and when the velocity was decreased until zero the particles would also diminished to zero and form a line.

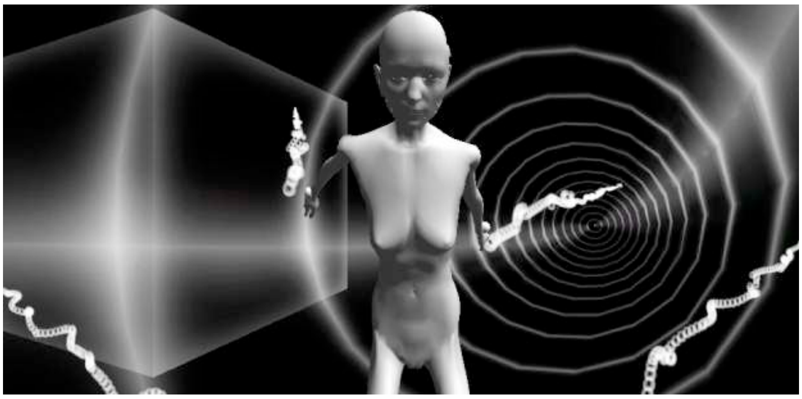


Figure 25: CREATIC project - experiment 01

Figure 26: CREATIC project - experiment 02

Figure 27: CREATIC project - experiment 03

The movement of the real dancer corresponds and controls also the algorithmic sound synthesis on real time as it will be explained in the next sub-chapter.

For the implementation of the second goal all persons of the team were scanned with the 3d scanner ARTEC. The technical possibilities of this technology are:

- Scanning in real-time
- Portable Handheld Scanner
- No Markers Needed
- Able to Scan Moving Objects
- Specialized Scanner Software
- Export Data in popular formats

The scanned faces were then modified on the software Blender, and MakeHuman in order to attach the 3d scanned faces to realistic 3d humanoid models.

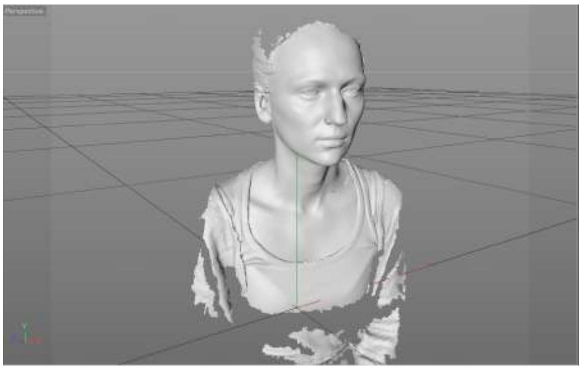


Figure 28: CREATIC - scanned me

Figure 29: CREATIC - scanned face attaching to 3d model

In the final step we develop a dialogue between the virtual avatars and the real dancer through motion capture and FSM method. With AkeNe library we developed algorithms to define and describe three different states and the transition from to other. The autonomous agents would react according to the state that is was triggered. Every state contains an action that would go on until another state is triggered.The first state describes the action that the real person is dancing in the main aria and the virtual dancers would around her avatar. The second state is describes the one of the virtual characters dance in the main aria and the avatar is moving with the other characters around it. The third state describes the virtual dancer that goes out of the main aria. The transition from one state to another is given-trigger by the movement of the real dancer and her avatar.

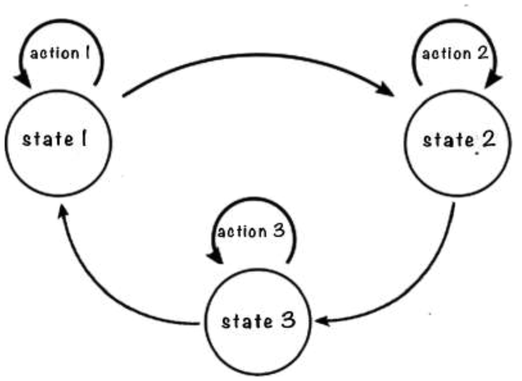


Figure 30: Finite State Machine diagram: Tree states

Figure 31: CREATIC - final synthesis

The captured movement of the real dancer in space is controlling also the generative sound in SuperCollider. For example when the dancer moves her feet she changes the pitch of the sound and with the velocity of her movement of her hands she controls the volume of the sound. The communication between the motion capture data and the sound in SuperCollider is described in chapter III.

V.C. Project Lust

For the purpose of this final thesis a basic linear narrative was written in order to be deformed and formed again through the interactivity between the media actor which is the virtual space and the real dancer. In the project Lust the media actor is non humanoid visual elements that were formed according to the story. Four scenes describes the basic narrative in which the dancer chooses the kind of his actions.

The Story:

Lust

Man as a being is inextricably connected to the physical wold, since he is a part of it. He is affected by it. Human instincts are characterizing our being through the centuries despite our effort to rationalize and control them. The Lust, one of the seven deadly sins, describes the feeling of intense desire and the entirely surrendering to that feeling.
This project attempts to describes a dialogue between human's lustful desire and Technological Perfection. The character of the human being is performed by the performer (dancer) and the character of Technological Perfection is performed by the moving visual image and sound.

The four basic parts:

• The Man surrenders to his lustful desire and he is almost unwilling to act differently while Technological Perfection (form) seems tough. inapproachable and impersonal.

• The virtual forms (being modeled by the human mind) surrender to the lust of the human being. Together they experience moments of ecstasy. almost a kind of unprecedented beastly nature.

• The virtual forms now have acquired physical properties but seems to be closed in a context where the boundaries are not distinct. The spiritual tensions between Man and Technological Perfection are declining to a harmony. The Man now stands in front of his nature and he observes it (he looks at his characteristics). He has assimilated strictly features. Features like those that initially was characterizing the form of Technological Perfection.

• The dim contexts of the virtual world which hods the technological structure, is vibrating without rhythm and start to expand. When Man is getting closer to the virtual world, only then the cold structures that reflect it are transforming into natural forms. Its only then that the context that surrounds the Technological Perfection form decay. And the Man stays still with the glimpse of the intense bounding with the Technological Perfection. To get closer (the Man) to the Technological Perfection so he is assimilated from the virtual world and the Technological Perfection is assimilated to him?

Regarding the story of this interactive performance four scenes were contracted in a potential storyboard. According to the action that the dancer would have the storyboard would evolve in a different way. The elements that are fixed are the changing of the scene and the time that they last. In those scene the dancer improvise according to his acting.

STORYBOARD

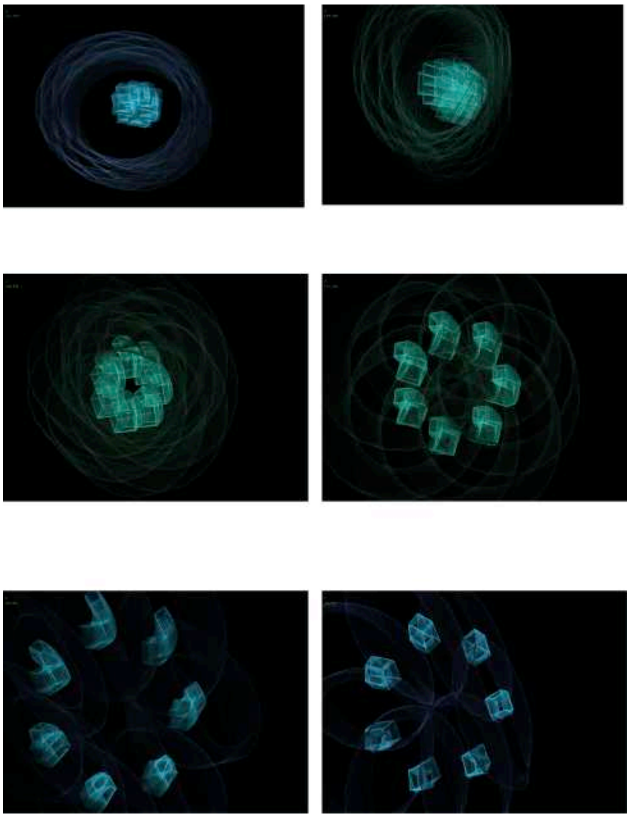


Figure 32: ‘Lust’ project first scene

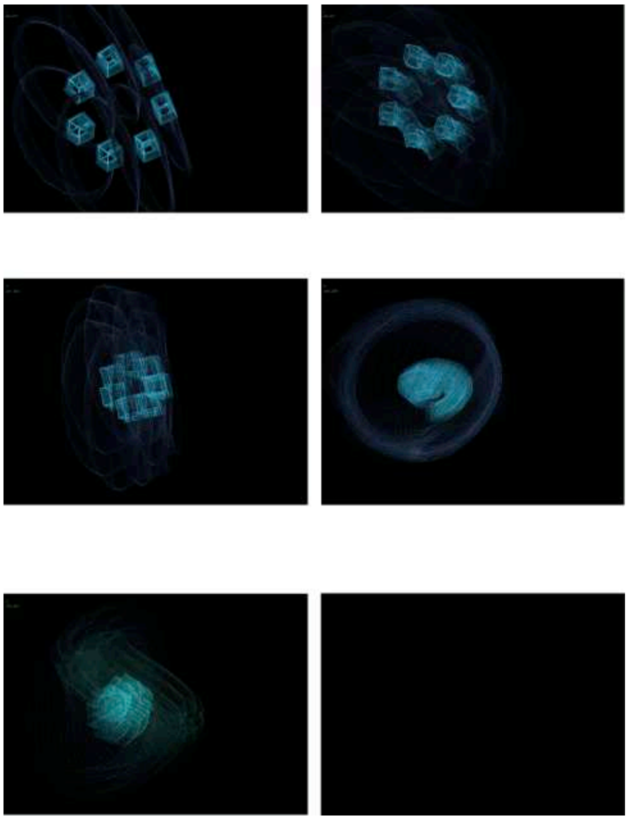


Figure 33: ‘Lust’ project first scene

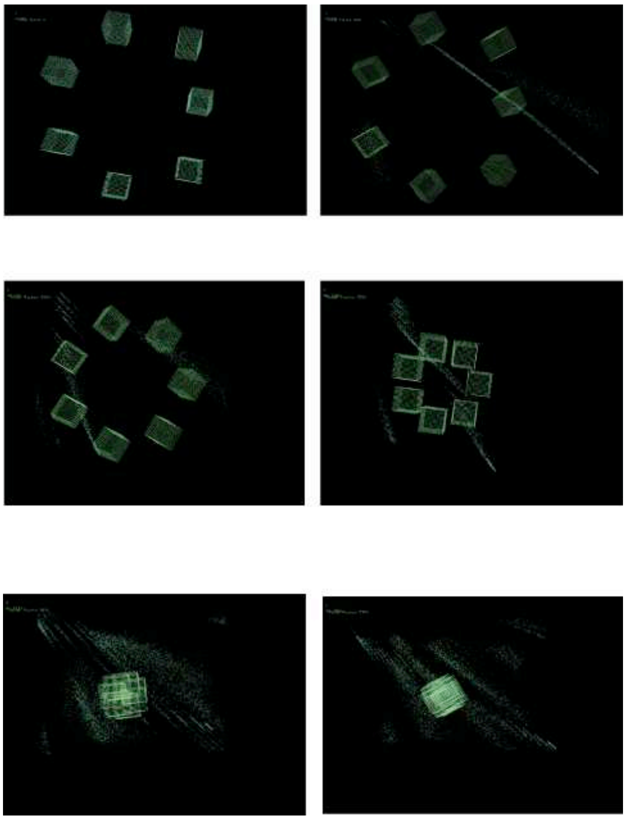


Figure 34: ‘Lust’ project second scene

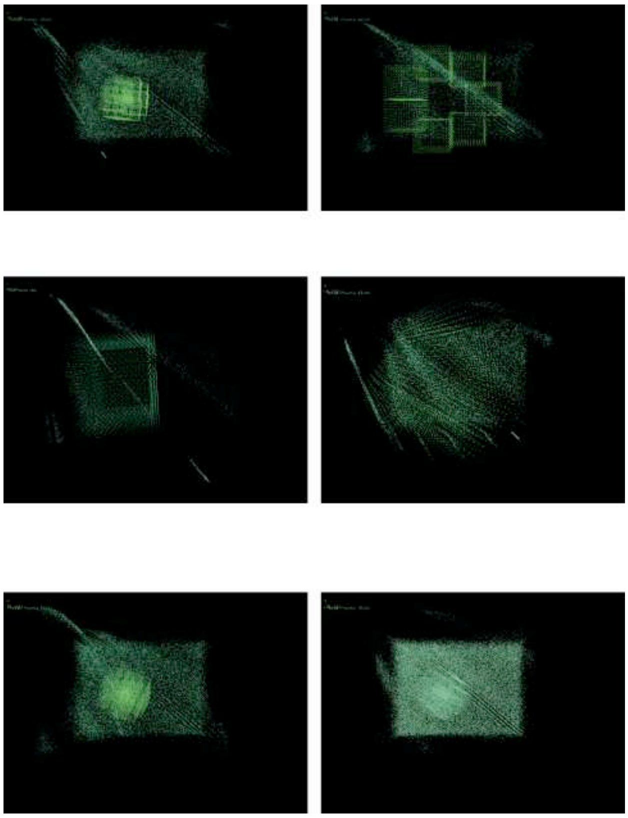


Figure 35: ‘Lust’ project second scene

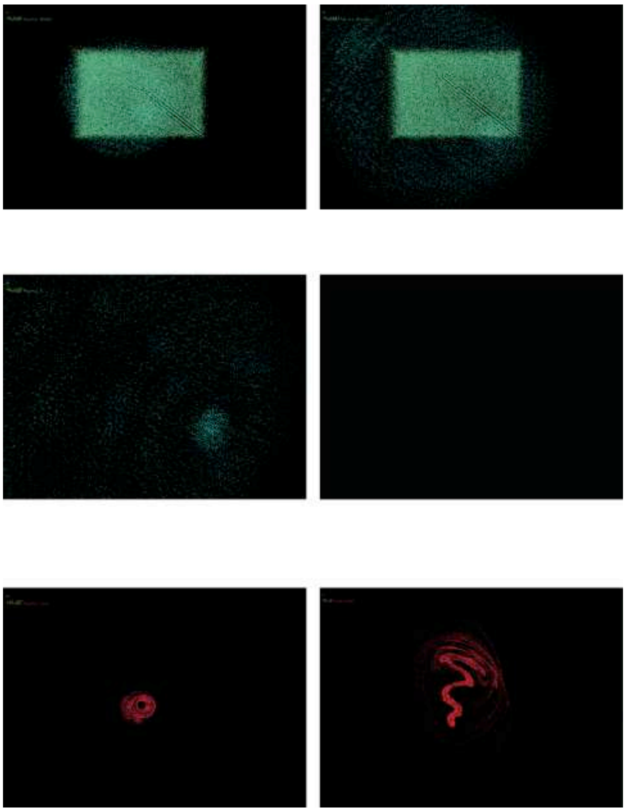


Figure 36: ‘Lust’ project second to third scene

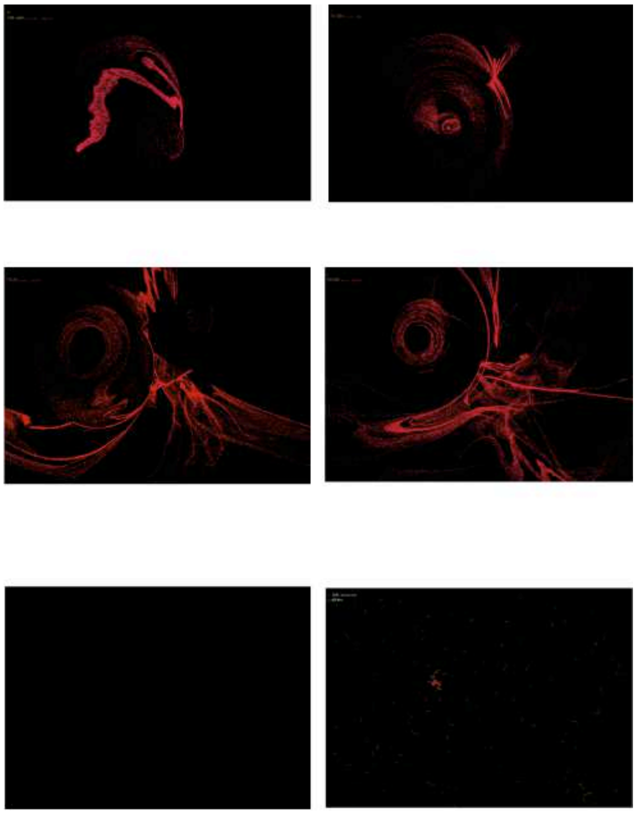


Figure 37: ‘Lust’ project third scene

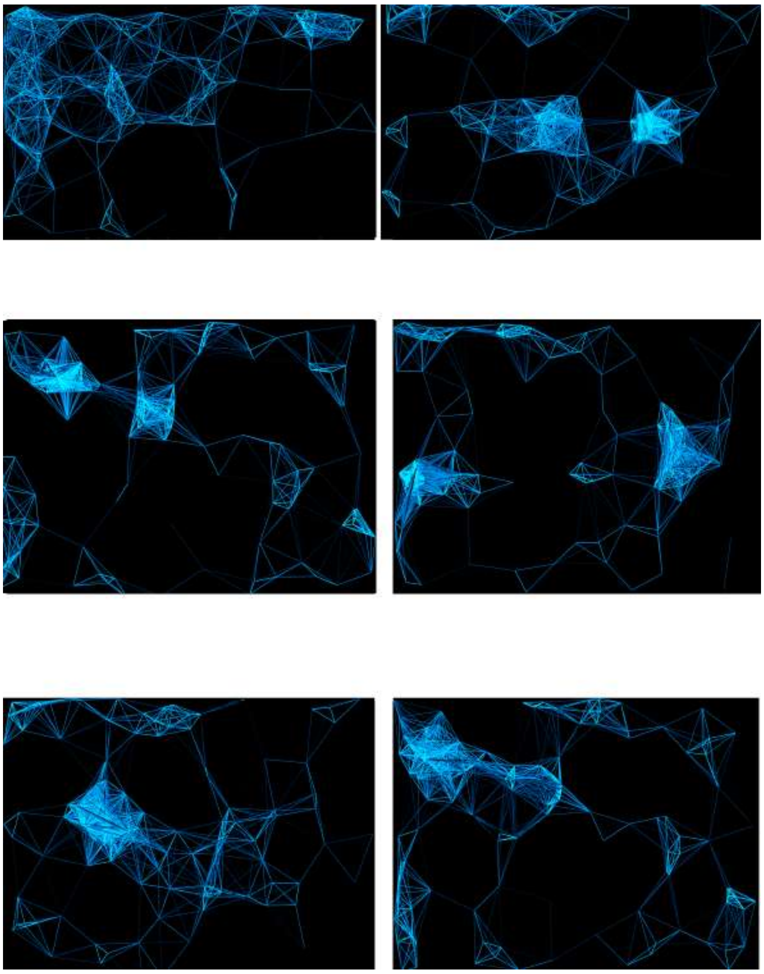
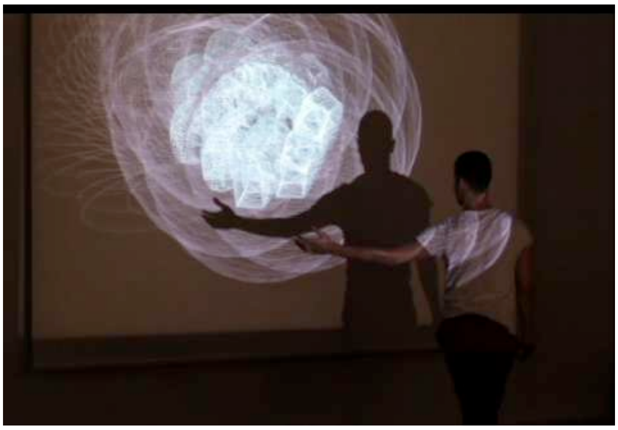


Figure 38: ‘Lust’ project fourth scene

<u>Technical description of the visuals in project Lust:</u>

In the second and complete personal experiment the four scenes are created to express an interactive narrative about 'Lust'. For the purpose of this work the algorithms were developed in C++ programming language using the compiler Xcode and the toolkit OpenFramework. Regarding the three different levels of interaction and morphing the visual element regarding selected forces of physics, the first experiment is to be a continuity and a completion of this research.

In the first scene the concept of balance is taken into account since the visual elements are contractive in an order that is not to be broken by the movement of the performer. Every line of cubes has a fixed movement according his global position and an interactive movement according to its form construction. With the movement of the performer in the x axis the ‘cloud’ of each element is growing or reduced. In a specific time given the global position of the cubes would change in real time through OSC communication. In order to develop the cloud movement of the cubes was developed an algorithm that generates Perlin Noise movement with a multiplication of a float. Perlin noise is a computer-generated visual effect developed by Ken Perlin, who won an Academy Award for Technical Achievement for inventing it. It can be used to simulate elements from nature, and is especially useful in circumstances where computer memory is limited.



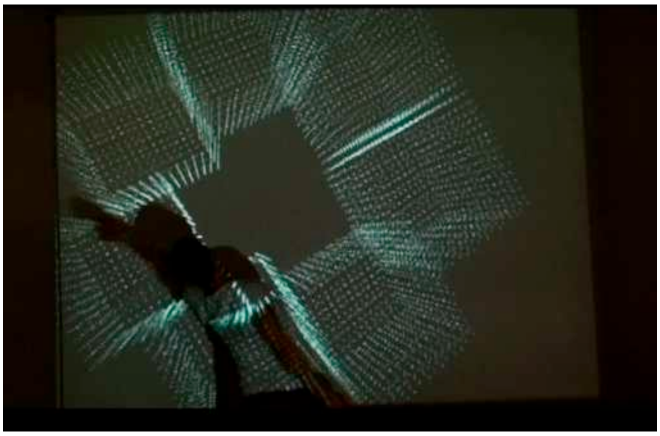
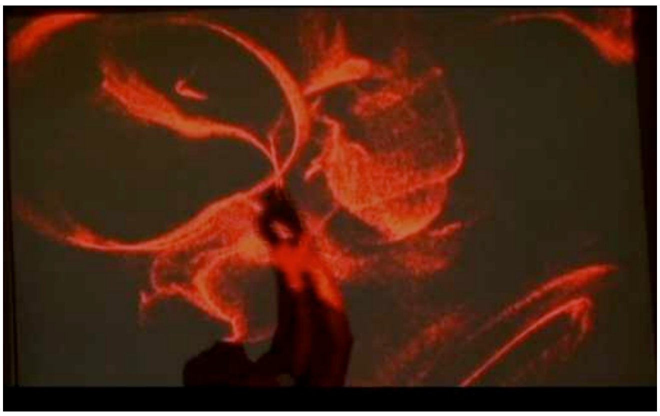


Figure 39: ‘Lust’ interactive performance scene 1

Figure 40: ‘Lust’ interactive performance scene 2

In the second scene the 3d object was first modeled in the software Maya 3d and exported in VRML format in order to have access in the position of each points of the geometry. The model is ‘reconstruct’ by points in Openframework and taken in account as particle that has a position a velocity a center attraction point and a grabbing force - in the very end of the scene. When the grabbing force occurred the points are no longer points of the cubes model but became to a second model which is a sphere. The transformation of the cubes to spheres consist also a pulling force a velocity of movement and an acceleration. A second visual element in this scene is a noisy field that is generated in real time according to the position of the performer. The noise field has a movement to the center and in -z axis which is controlled in real time through OSC messages.

In the third scene the performer generates particles around the virtual space which have a slightly 3d movement in x, y, z axis. The position of the performer is also a repulsing force to the particles with a given radius of 200 pixels. The particles that are generated are 70 per frame-rate. As the performer moves in the space the repulsing force is moving along with his position so ineffective particle would now be repulsed by this force.



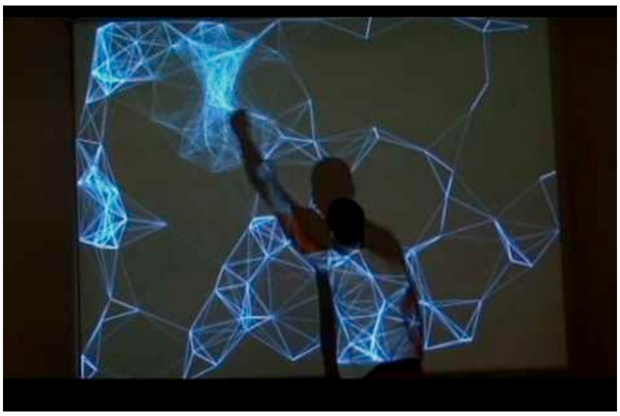


Figure 41: ‘Lust’ interactive performance scene 3

Figure 42: ‘Lust’ interactive performance scene 4

In the fourth and last scene the particles and the lines between them covers the virtual space and are generated according to each particle position. Each one of the particles behaves like an autonomous agent who is looking upon his ‘neighbors’. Specifically, in the beginning is given a random amount of particles that would make connective lines with the particles that are closer to a given distance. As each of the particle has a movement of its own the radius is changing so the lines are disconnected if the distance is bigger than the given distance that they are suppose to make connection. This makes the lines between the particles to be generated and then faded and then again generated along each particle through time changing. Upon all there is one more force that acts on a given radius to all the particles. An attraction force of the particles that is given by the position of the performer with a fixed radius. This force would attracted like a magnet the particles - also the lines between them - that are in the range of the given radius. When the potion of the particles is not in the magnetic field they would move on their own initial kind of movement. As the performer 'scans' the captured space he changes the position of the magnetic field in the virtual space and the generated particles with the generated lines lines are either getting attracted or continue their autonomous movement.

Technical description of the sound in project Lust:

The sounds design of the project lust was accomplished regarding the narrative of each scene and the transition from one to the other, the physical concept approach of the visual elements, the three different ways of interaction (trigger, follow, reaction) and the desirable sonic ambience of the performance as a unity. Sound properties, such as pith, volume, density, intensity and others provide a wide variety of sound deformation qualities . Those deformations are evaluated in time and evolve according both to a simple predefined composition of the general structure and also according to the movement of the performer in space. Due to the algorithmic nature of the sounds every element of it could be deformed. This provoke the creator to define the qualities and the elements which are going to characterize each sound and would not be changeable in by any interaction and the sound elements that would evolve in time either trough human interaction or machine interaction.

In the first scene the Ugen which uses the input data in real time for the sound to be modified is the GVerd which is a two-channel reverb. What is modified in this unity generator in real time by the movement of the performer is the room-size in squared meters. The arguments of this filter are the followings:

Arguments:

in: mono input.

roomsize: in squared meters.

revtime: in seconds.

damping: 0 to 1, high frequency rolloff, 0 damps the reverb signal completely, 1 not at all.

inputbw: 0 to 1, same as damping control, but on the input signal.

spread: a control on the stereo spread and diffusion of the reverb signal.

drylevel: amount of dry signal.

earlyreflevel: amount of early reflection level.

taillevel: amount of tail level.

maxroomsize: to set the size of the delay lines. Defaults to roomsize + 1.

mul

add

The initial size is 10. With the OSC responder the values of the movement of the performer in x axis - in real space and the reference in the virtual space - are being used to the sound elements. In the Openframeworks, where the motion capture is done the data values of the movement in x axis are mapped to a variable int from 0 to 200. In SuperCollider the data are mapped once more to fit with the room-size argument. This argument would describe the effect of the movement in the sound. The result of the second mapping would be an int from 10 min to 150 max.

In the second scene the final sound is formed by a random array of given frequencies and then modified in a FreqShift. FreqShift implements single sideband amplitude modulation, also known as frequency shifting, but is not a pitch shifting. Frequency shifting moves all the components of a signal by a fixed amount but does not preserve the original harmonic relationships. The amount of shift in cycles per second is controlled by a XLine which generates an exponential curve from the start value to the end value. Both the start and end values must be non-zero and have the same sign. The values of this sound evolving would be from int 110 to int 0 - which describes the frequencies - in 15 second. The hole output sound signal is multiplied by an envelope.
The second sound of this scene is a beat which in a range of randomness is impulsing. The hole algorithmic sound signal in filtered with the linear filter Ringz. This is the same as Resonz , except that instead of a resonance parameter, the bandwidth is specified in a 60dB ring decay time. One Ringz is equivalent to one component of the Klank UGen. The argument of this filter are:

Arguments:

in:	The input signal.
freq:	Resonant frequency in Hertz.
decaytime:	The 60 dB decay time of the filter.
mul:	Output will be multiplied by this value.
add:	This value will be added to the output.

The input signal is a CoinGate.When CoinGate receives a trigger, it tosses a coin and either passes the trigger or doesn't. The trigger input is formed by an Impulse modified by a T2A which converts control rate trigger into audio rate trigger (maximally one per control period). The final sound signal is send to both channels left and right and is multiplied by an envelope. The performer in this scene approaches the third kind of interaction, according to which he reacts on the sound beat and improvises with his movement on that he hears.

In the third scene the algorithmic consist of five envelopes, a phasor, a feedback, a transporter an activated sound synthesis and a reverb. The activated sound is a modified WhiteNoise generator. Before the second scene is finished the sound of the third scene is triggered for the transition of the actions to be smoother. The qualities of this sounds are referring to the physical concept of repulsion with a slightly energy/force. In more details the trail of the activated sound elements refers to the repulsion force and the activation itself to the generating particles of the visual world. Again the final signal is send to both channels and multiplied by a basic envelope.

In the last scene of this project the forces of attraction are implemented and in balanced and unbalanced system of particles. The sound of this scene is designed to correspond to the autonomous movement of the particles and also to the action of attraction. In the Mix function the oscillator SinOsc forms its frequency values with the argument given by the movement of the performer. The signal is panning to the left and right channel with a frequency given by a Dust control generator. The final signal is formed in a Comb delay. Comb delay is a line delay with no interpolation. CombLwhich uses linear interpolation, and CombC uses cubic interpolation. Cubic interpolation is more computationally expensive than linear, but more accurate. The delay Comp is structured by the following arguments:

Arguments:

in:	The input signal.
maxdelaytime:	The maximum delay time in seconds. Used to initialize the delay buffer size.
delaytime:	Delay time in seconds.
decaytime:	Time for the echoes to decay by 60 decibels. If this time is negative then the feedback coefficient will be negative, thus emphasizing only odd harmonics at an octave lower.
mul:	Output will be multiplied by this value.
add:	This value will be added to the output.

The performer moves in a vector which is described as (x, z) vector and represents the data values of the movement in the ground field. From this vector the distance which is covered is calculated so it would used in the sound element. The element of the sound which uses the movement vector distance is the bace frequency of the Sine oscillator multiplied by an argument a = 1 + a. Finally the hole sound synthesis is send to both channels left and right and is multiplied by a basic envelope. The same sound with a fixed frequency of the oscillator is evaluated in this scene for the sonic ambience to be more intense.

<u>Performance Requirement</u>

In order to implement the interactive performance ‘Lust’ different aspects had to be combined. First of all it was a need to find a dancer who would improvise with his dancing movement and interact with the project in real time. Carlos Ferreira Da Silva who is a professional dancer participated in this project. The one rehearsal that was made took place in the ‘Salle du Video’ of the ATI department in Paris 8 University. After a briefly explanation of the basic story we discussed about the meaning of of every scene and the energy of every part. It was also explained to Carlos the technological tools of the performance and he tested the interaction between his movement and the audiovisual set. Most of all he was free to contribute in the performance with his improvisation dancing movement on every scene. That was the element that upgraded the performance to a new level of perception. The sound and the moving visual became one with his dance and he would flow into the narrative which made the audience to become one as well

For the requirements of the stage and the hardware, i was given tow speakers and a console as well as a project and a big room for the kinect camera and the speakers to be at the right position according to the audience and to the performer.

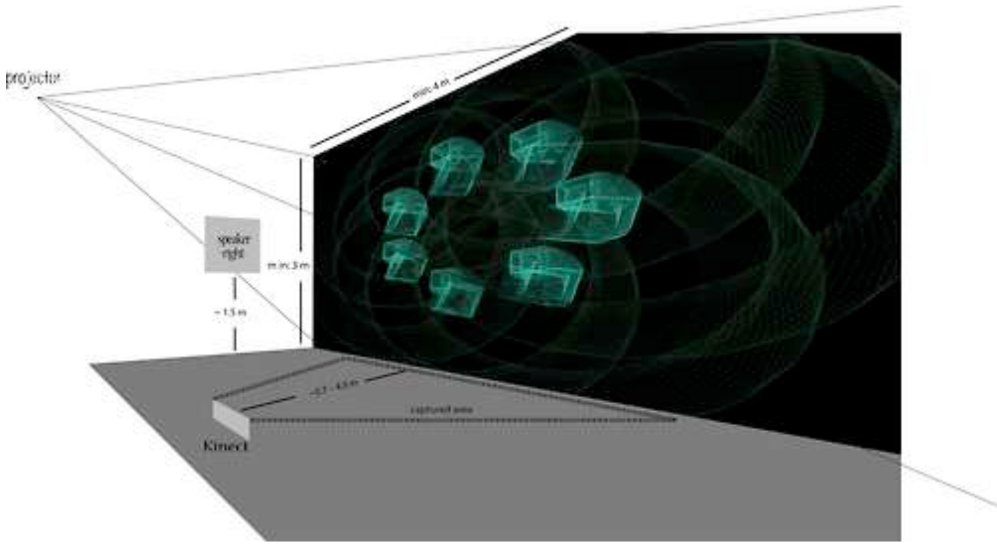


Figure 43: ‘Lust’ Stage information 1

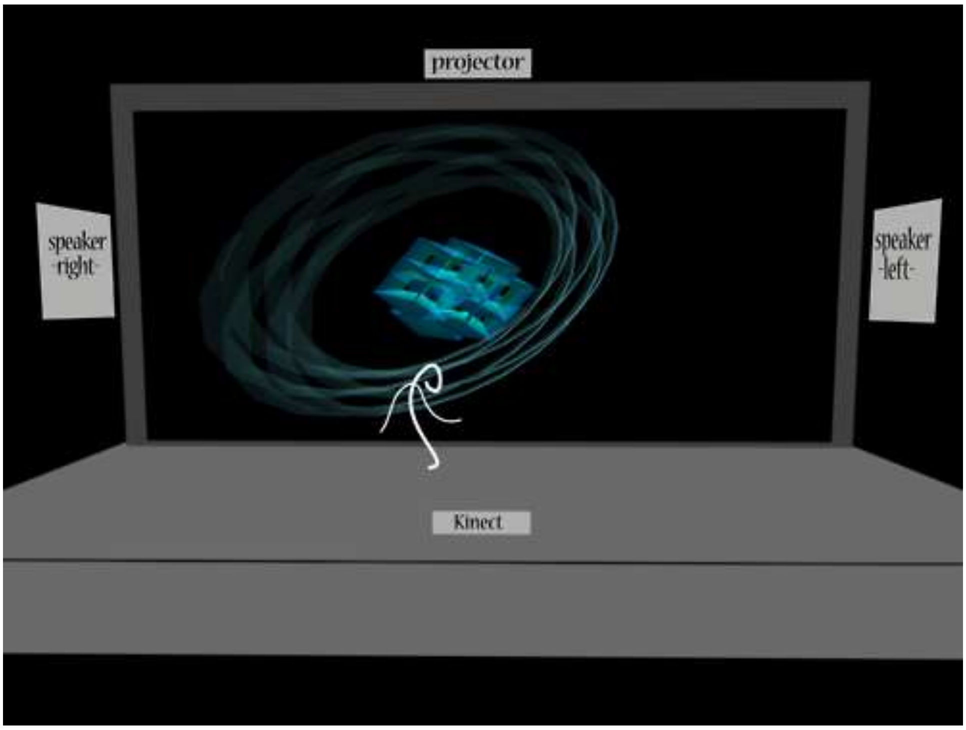


Figure 44: ‘Lust’ Stage information 2

Conclusion

Virtual Art is defining and redefining its definition day by day by the technological and the conceptual experiments that are made in the field of Virtual Reality. In this thesis different aspects were disgusted, such as physical movements and forces, behavioral characteristics to virtual elements, avatars and creatures guided by human movement in the real space, motion capture technologies in real time sound synthesis and algorithmic visual synthesis, in order to explore the multidimensional field of Virtual Art. The experiments that were developed in this research and the theoretical approach on those subjects showed as key points of approaching Interactive Performances. Applying physical, behavioral, kinematical and conceptual characteristics to virtual creatures could provide us not only with the life-like representation of the world we live in, but with the potential of forming our point of view for the real world. Physical forces such as attraction, repulsion, dragging and physical phenomenon such as balanced and unbalanced systems, flowing and steering behaviors could be developed and evolve in a dynamic system. In order to express abstract concepts and non linear narratives, those dynamic systems evolve in interactive mixed realities.

Interactive performances and Virtual Art could exist in the same frame since the performer is guiding the virtual world and the sound in it. Algorithmic approach in developing audiovisual dynamic systems give us the freedom to develop the virtual images and sound from scratch. This would mean that in every abstract form could be applied energy and action according to what it serves in the virtual world. Motion capture technologies in combination with abstract moving visual and sound provide a wide open field for real time performances. Laban movement analysis in combination with the movement structure of the visual elements and sound is an approach to be researched deeper in the future. Since expressive movement could be applied to both the virtual world and to the real actor or performer. Another point of interest to be developed is the ambisonic synthesis and structure of the sound in a abstract virtual art project. Combining physical movement in the virtual image and applying ambisonic synthesis of the sound could evolve expressive virtual environments and provide to both participant and viewer with an immersive non linear narrative.

Reality after all is an aspect of perception, either as an artist or a researcher, or both. Virtual Art in the field of Interactive Performances could present, represent, construct or reconstruct life-like words, in whatever - expressive way - life-like means to every each of us.

Bibliography

Books:

• Corris, Michael. *Conceptual Art: Theory, Myth, and Practice*. Cambridge University Press, 2004.

• Wakefield, Graham, and Wesley Smith. *Cosm: A Toolkit for Composing Immersive Audio-Visual Worlds of Agency and Autonomy*. Ann Arbor, MI: MPublishing, University of Michigan Library, 2011.

• Shlain, Leonard. *Art & Physics*. Quill; Morrow, 1991.

• Loy, Gareth. *Musimathics: The Mathematical Foundations of Music*. Vol. 1. MIT Press, 2011.

• Ryan, Marie-Laure. *Narrative as Virtual Reality*. Johns Hopkins University Press Baltimore, 2001.

• Hosale, Mark-David, and Marcos Adviser-Novak. *Nonlinear Media as Interactive Narrative*. University of California at Santa Barbara, 2008.

• Manovich, Lev. *The Language of New Media*. MIT press, 2001.

• Oddey, Alison, and Christine A. White. *The Potentials of Spaces: The Theory and Practice of Scenography & Performance*. Intellect Books, 2006.

• Sherman, William R., and Alan B. Craig. *Understanding Virtual Reality: Interface, Application, and Design*. Elsevier, 2002.

• Grau, Oliver. *Virtual Art: From Illusion to Immersion*. Mit Press, 2003.

Conference Paper:

• O'Dwyer, Mark F., Guillaume Potard, and Ian S. Burnett. "A 16-Speaker 3D Audio-Visual Display Interface and Control System." In *ICAD*, 2004.

• Wulfhorst, Rodolfo Daniel, Luciano Vargas Flores, Lauro Nakayama, Cecília Dias Flores, Luis Otávio Campos Alvares, and R. M. Viccari. "An Open Architecture for a Musical Multi-Agent System." In *Proceedings of Brazilian Symposium on Computer Music*, 2001.

• Osório, Fernando S., SORAIA RAUPP Musse, Renata Vieira, Milton R. Heinen, and Daniel C. Paiva. "Increasing Reality in Virtual Reality Applications through Physical and Behavioural Simulation." In *Proceedings of the Virtual Concept Conference*, 1:1–45, 2006.

• Szilas, Nicolas. "Interactive Drama on Computer: Beyond Linear Narrative." In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, 150–56, 1999.

• Müller, Pascal, Simon Schubiger-Banz, Stefan Müller Arisona, and Matthias Specht. "Interactive Media and Design Editing for Live Visuals Applications." In *GRAPP*, 232–42. Citeseer, 2006.

• Wright, Matthew, Adrian Freed, Ahm Lee, Tim Madden, and Ali Momeni. "Managing Complexity with Explicit Mapping of Gestures to Sound Control with Osc." In *International Computer Music Conference*, 314–17. Citeseer, 2001.

• Wright, Matthew, Adrian Freed, and Ali Momeni. "Opensound Control: State of the Art 2003." In *Proceedings of the 2003 Conference on New Interfaces for Musical Expression*, 153–60. National University of Singapore, 2003.

• Vissers, Chris A., and Luigi Logrippo. "The Importance of the Service Concept in the Design of Data Communications Protocols." In *PSTV*, 3–17, 1985.

• Galanter, Philip. "What Is Generative Art? Complexity Theory as a Context for Art Theory." In *In GA2003–6th Generative Art Conference*. Citeseer, 2003.

• Wolff, Kristen, and Peter Nordin. "Evolutionary Learning from First Principles of Biped Walking on a Simulated Humanoid Robot." In *Proceedings of the Business and Industry Symposium of the Simulation Technologies Conference ASTC'03*, 31–36, 2003.

Journal Article:

• Chion, Michel. "9 Audio-Vision and Sound." *Sound* 11 (2007): 201.

• Luck, Michael, and Ruth Aylett. "Applying Artificial Intelligence to Virtual Reality: Intelligent Virtual Environments." *Applied Artificial Intelligence* 14, no. 1 (2000): 3–32.

• Shanken, Edward A. "Art in the Information Age: Technology and Conceptual Art." *Leonardo* 35, no. 4 (2002): 433–38.

• Hartman, Christopher, and Bedrich Benes. "Autonomous Boids." *Computer Animation and Virtual Worlds* 17, no. 3–4 (2006): 199–206.

• Fagerberg, Petra, Anna St\a ahl, and Kristina Höök. "Designing Gestures for Affective Input: An Analysis of Shape, Effort and Valence," 2003.

• Ryan, Marie-Laure. "Immersion vs. Interactivity: Virtual Reality and Literary Theory." *SubStance* 28, no. 2 (1999): 110–37.

• Aylett, Ruth, and Marc Cavazza. "Intelligent Virtual Environments-A State-of-the-Art Report." *Proceedings of Eurographics 2001 STARs* 3 (2001).

• Sparacino, Flavia, Glorianna Davenport, and Alex Pentland. "Media in Performance: Interactive Spaces for Dance, Theater, Circus, and Museum Exhibits." *IBM Systems Journal* 39, no. 3.4 (2000): 479–510.

• Meador, W. Scott, Timothy J. Rogers, Kevin O'Neal, Eric Kurt, and Carol Cunningham. "Mixing Dance Realities: Collaborative Development of Live-Motion Capture in a Performing Arts Environment." *Computers in Entertainment (CIE)* 2, no. 2 (2004): 12–12.

• Loy, Gareth, and J. Chowning. "Musimathics: The Mathematical Foundations of Music (Volume 2)." *AMC* 10 (2007): 12.

• Wright, Matthew. "Open Sound Control: An Enabling Technology for Musical Networking." *Organised Sound* 10, no. 3 (2005): 193.

• Herczyński, Andrzej, Claude Cernuschi, and L. Mahadevan. "Painting with Drops, Jets, and Sheets." *Physics Today, Iunie*, 2011, 31–36.

• Cytowic, Richard E. “Synesthesia: Phenomenology and Neuropsychology.” *Psyche* 2, no. 10 (1995): 2–10.

• Morris, Carrie. “The Creation of Narrative Worlds in Physical Space: A Theoretical and Personal Examination of the Artistic Work Temporal Understandings of Impermanent Places (hold Still),” 2007.

• Camurri, Antonio, Giovanni De Poli, Anders Friberg, Marc Leman, and Gualtiero Volpe. “The MEGA Project: Analysis and Synthesis of Multisensory Expressive Gesture in Performing Art Applications.” *Journal of New Music Research* 34, no. 1 (2005): 5–21.

• Chion, Michel. “The Three Listening Modes.” *Audio-Vision: Sound on Screen*, 1994, 25–34.

• D’Arcy, Geraint. “Towards an Aesthetics of Theatre Technology,” 2013.

• Bates, Joseph. “Virtual Reality, Art and Entertainment.” *Presence* 1, no. 1 (1992): 133–38.

Thesis:

• Wittenberg, Ian. “Performance and Motion Capture Using Multiple Xbox Kinects.” Rochester Institute of Technology, 2013.

Book Section:

• Singh, Shawn, Mubbasir Kapadia, Petros Faloutsos, and Glenn Reinman. “An Open Framework for Developing, Evaluating, and Sharing Steering Algorithms.” In *Motion in Games*, 158–69. Springer, 2009.