Responsive Environments for Performance, Including Voice, Speech and Whole Body Interaction Techniques

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complies with the regulations of this University and meets the accepted standards with respect to originality and quality.

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Abstract

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Nikolaos Chandolias

For my Master of Arts in the Individualised Program, my practice-based research investigates a design and development framework within an artistic context of responsive environments for performance, including voice, speech and movement interaction techniques. To poetically address issues regarding the way people perform and experience a space, responsive environments, as ambient intelligence systems, should be able to coevolve and auto-adapt to its inhabitants and to the environment.

Although relevant work and research has taken place in the fields of interactive art and installations, they primarily concern body tracking, while the potential for voice, spoken or written language, and sound has been left floundering. Positioned at the intersection of design, computation arts, performance and physical spaces, I introduce the role of natural language processing as a tool that aims to non-hierarchically co-construct, augment and mediate human experience, interaction and perception in live events.

Furthermore, by adopting different interaction design paradigms and collaborating with artists and performers, I am afforded the opportunity to reproducibly and rigorously investigate the potentialities of such systems under the demands of live improvised situations. In addition, these collaborations with non-digital artists and practitioners allowed me to better reflect on the effectiveness of such systems and re-evaluate the way I am developing them.

The understanding of interactivity as a quality that exists between different systems and their ability to converse with and respond to any sensorial input correspondingly impacts the aesthetic and affective experience of the participants (performers and spectators). This allows for redefining the role of the participant from a spectator to a co-creator, as well as the role of the space itself.

My practical explorations emerged as two complementary trajectories: the development of a responsive audio-visual *Storytelling Space*, and a technologically augmented - sound and movement improvisation - performance, *Orbital Resonance*.

Acknowledgements

Foremost, I would like to express my deepest gratitude to my parents, whose unconditional love and sacrifices made it possible for me to chase my dreams. This work is dedicated to them and all those who supported my efforts over the years.

I am indebted to my supervisors Sha Xin Wei, MJ Thompson and Jason Lewis for their assistance, guidance and support throughout my studies, and especially for their confidence in me. Their encouragement, immense knowledge, astute experience and extreme candidness were key motivations throughout my Masters. The pioneering work done by many thinkers (among them Sha Xin Wei, Jason Lewis, Christopher Salter, Garthe Paine, Vangelis Lympouridis, Johnston W. D. (Jhave) and many, many others) has seeped into my mind, however I have tried wherever possible to cite all sources.

Furthermore, I would like to express my gratitude to all the colleagues, artists and researchers that participated in the collaborative performances and workshops: Omar Alfaleh, Julian Stein, Navid Navab, Doug Van Nort, Anne Goldenberg, Jerome DeLapierre, Evan Montpelier, Jen Spiegel, Patricia Duquette, Elena Frantova, Liza Solomonova, Nina Bouchard, Katie Jung, Lauren Osmond, Adrian Freed and all the members of the Topological Media Lab. Special thanks to Prof. Michael Montanaro, Chair of Contemporary Dance, who provided me with useful insight and advice. I am entirely thankful to my collaborator Margaret Westby for proofreading and making suggestions throughout the writing of this thesis with patience and extensive care.

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1. Introduction

During the past decades, the numerous collaborations between different disciplinary roles, such as choreographers, musicians, engineers, performers and creative technologists, have worked as an incubator for the explorations of digital technologies in the context of live performance. Some of the early examples of these collaborations, as examined later, might seem to lack interesting interactive design methodologies, restraining the potential and expressivity of the performance, or adding unnecessary technicalities. However, as the technology evolves, and by introducing the notion of digital interactivity into the performance, we are able to extend the fields of *traditional* performance making and explore new forms of expression.

Technology surrounds us and forms part of our everyday life and habits; it is capable of shifting social interactions and how we experience the space we are in. This is evident starting from the industrial revolution, where the streets were lighted for the first time, thereby alienating the darkness of the night [1], to today's online social media that are reshaping human interactions and relationships.

Figure 1: Caricature engraved, after a drawing by Woodward, about the first attempts to light the streets of Pall Mall in 1809 [Rowlandson 1809][2]

My work stems from the belief that we can deploy these technologies in a more inviting, meaningful and engaging way. Instead of creating works and interactive systems that react to presence in a monologue way, inviting the user to contemplate the results of the reactions allows us to deploy and enable technology to augment and mediate human experience in converse with the actions that take place in the space as well as with the environment itself. This genre of work is known as *Responsive Environments*.

In my thesis, I will examine responsive environments as ambient intelligence systems that are able to coevolve and auto-adapt to the environment and its inhabitants. Responsive environments that do not follow a deterministic logic help us to poetically address issues regarding the way people perform in a space and perceive it.

> "A critical look at the differences between interactive and pre-composed media, and their influences on the aesthetic and affective experience of participants, allows for redefining the role of the participant from a spectator to a co-author, and for redefining the space from "where the event takes place" to becoming the event itself." [Alfaleh, Chandolias 2014] [3]

The purpose of the systems that I am proposing is not to duplicate the experience of spaces but to supplement them. The proposed research explores responsive spaces that begin from the person to expand and interpolate with the environment. Furthermore, it aims to provide additional conceptual and technical resources for advanced knowledge in relation to digital technologies and interactive media. Expanding on a media art focus, the vision of the research is to provide a diverse environment for collaborative explorations of responsive media projects, applications and environments.

These investigations take place as a fusion of computer science, design and digital media critical studies. Practically, I am conducting a set of experiments in collaboration with Topological Media Lab and other fellow researchers, concerning the study of human behaviour when a user interacts with such multimodal systems. Deepening the work in the direction of performance and engaging in projects with artists, actors and dancers allows for the opportunity to investigate the potentialities of responsive environments when used by trained users in these contexts. The findings of this research is a pallet of exploratory research creation work which exhibits a high degree of innovative expression, conceptual clarity and technological skill, while providing a new framework that allows speech and voice analysis.

My insights are influenced by my seemingly contradictory but very intertwined background in engineering studies and dance. During my studies as an Electrical and Computer Engineer, I developed strong skills and knowledge in programming and designing software systems. This

knowledge alone was not completely fulfilling my longing for creativity and social interaction. Hence, simultaneously with my studies, I started expressing those clamant needs for artistic creation through my dance in different styles. During my studies in the State School of Dance, I enjoyed comprehensive training on various contemporary disciplines involved in the development of artistic projects. Through my personal training, I have started to understand the potentials of the human body and how it can improvise meaningful motions collectively or individually in an artistic and conceptual context.

As Steve Paxton stated,

> "I think that one of the reasons I got involved in dance is to finish my movement development. Because I have a hunger to find, and to finish, and to explore, to do essentially what babies do when they begin to move. A hunger to find out more of what movement is or can be. I think it provides a service to keep the search alive in a culture, which has engineered an environment which requires physical and sensorial suppression to exist in. Most of the people who study dance aren't ambitious to be dancers, in fact. Or aren't serious about that ambition. I think they're trying to complete physicality that gets messed up by sitting for 12 years in school, or longer." [4]

For the completion of the research and experiments, the following methods and techniques were crucial in order to examine and deploy new methods for developing responsive performative environments. The technological design, always being informed by and for the body, voice and speech, follows threads of adaptive, processual programming (software, movement analysis, voice-speech analysis) in combination with visual and modular programming techniques and hands-free systems. In my design, I aim for solutions that combine these concepts of dynamic morphology and object-oriented software development. This combination has the potential to provide a particularly strong and customisable framework for the realisation of multimodal systems that can expand over time, even beyond the scope of their original design, providing a diverse range of effects that can reflect the input dynamics.

One of the branches of this research is to provide a continuous ontology and explore the potentials of syntactic and semantic analysis in the field of interactive art and multimodal applications in combination with whole body movement. By using constant data streams, this research permits the provision of ongoing qualitative data referencing momentary changes in behaviour, movement, speech and voice patterns.

The process and methodologies undertaken for the research creation projects under discussion are quite complex due to the fact that my involvement in the projects is not only that of a creative

engineer, interactive media developer and technologist but also that of an active participant and performer. It is necessary to implement different design strategies when constructing this responsive improvisational environment. As stated above, the traditional predetermined action -> reaction model yields limited set of results for the participants, and turns the responsive space into a structured game-like environment with little space for expressivity, intentionality, and nuanced control. Therefore, the design processes followed “must be flexible and organic enough in order to permit participant to have a wider array of possibilities and create a common language between the stakeholders to allow better communication of needs and obstacles.” [Alfaleh, Chandolias et al. 2014] [5]

Supplementary research into digital poetry and typography as well as interactive storytelling and emergent narration, is essential, in parallel with research into movement creation that are based upon somatic practices and my own background in dance. This combination of kinaesthetic methodologies aims to inform my explorations and help me integrate both human and non-human materials. In addition, experimental music practices and improvisational techniques by Topological Media Lab in both sound and movement informed my process and creative content. The materials in play were language, bodies, movement, gestures, sound, lights, cameras, computers, sensors and various other technological apparatuses. It is noteworthy that an attuned focus on maintaining a horizontal collaborative spirit was key at all time. This involved continuous discussions around language, methods, learning and teaching, patience with different practices, and an understanding of knowing and accepting constraints, whether with the technology or within me.

2. Performance and Technology

"Technology", as Barbara Kirshenblatt-Gimblett writes, "is integral to the history of performance" [6].

My practice and research blends theatre, dance, performance, digital arts, digital performance, design, interactive art, spoken words, story-telling, sound art, typography, installation art and software development. Ultimately, it is the inherent quality of the liveness of an event, the collaborative and participatory aspects of it, that situates my practice within the overarching field of performance. As Reaves suggests,

> "In the digital world you cannot distinguish different disciplines by the physical nature of the media or by which work is created…. Theatre has always been an integrative, collaborative art which potentially (and sometimes actually) includes all art: music, dance, painting, sculpture etc. Why not be aggressive in the tumultuous context of the Digital Revolution? Why not claim all interactive art in the name of theatre?" [7]

2.1 From Performance…

Performance is defined as the act of staging or presenting a play, concert, or other form of entertainment, or the action or process of carrying out or accomplishing an action, task, or function. In the performing arts, a performance generally is comprised of a set-up of a space, a performer/s, and a set amount of time in front of an audience. [OED Third Edition 2010][8]

Sometimes the dividing line between the performer and the audience may become blurred, and the audience gets invited to engage in an active way with the performers, thereby becoming part of the whole production. The *participatory theatre* approach could be achieved by using different methods and techniques, from innovative and non-traditional staging techniques to more technological approaches with the use of digital media and the internet. Examples of this kind of work could be found in Richard Schechner's early works, like a production of Bertolt's Brecht's *Mother Courage and Her Children (February to April 1976),* where the audience was scattered around the performing area [9]; as well as in more recent ones, such as Punchdrunk's *Sleep no more,* where

the audience is invited to an old building and the performance takes place on every floor. The spectator chooses how to move in the space and thus forms his/her own narration and experience.

Generally, performance can be encountered on many different occasions, which sometimes overlap each other. It can be found in everyday life, in actions like cooking, cleaning, communicating, or in other everyday actions. Of course, the term is directly associated with the arts, with the sports and other forms of entertainment, as well as with business and technology. Rituals and play also have a performative aspect. However, this list does not exhaust the possibilities of other kinds of performance that can be manifested. [10]

One could argue that performance (art) could happen at any time, in any space with two or more people. It could use different elements such as time, space, bodies, movement and the relationships amongst them, and it could be expressed in different forms and techniques such as dance, theatre and circus. For the purpose of my current work, I am approaching performance as a hybrid form of art that combines different mediums such as notions of movement and sound composition, as well as different techniques like improvisation, physical theatre and dance.

The performing arts could be considered as a unique and revolutionary experience involving performers and audience in a real-time event. For instance, theatrical plays could be based on human stories involving relationships, conflicts, passions, desires, loves, thereby showcasing cultural, historical and quotidian facts, ideas and ideals. However, “theatrical performance has to do with everything that’s beyond the text, the practices and ideologies of directing and design, or acting and dance, of architecture and economics, the unscripted materiality of stage production” [Worthe 2005][11]. Although staging issues might seem trivial, they are encountered everywhere in social life. The way we dress and express ourselves in front of others and all those social protocols derive from this everyday life staging.

In addition to the spatial-staging component, the temporal aspect of performing arts is quite unique. As Peggy Phelan states in her book, *Unmarked: The politics of performance*, “performance’s only life is in the present. Performance cannot be saved, recorded, documented, or otherwise participate in the circulation of representations of representations: once it does so it becomes something other than performance.” Performance becomes itself through disappearance[12], argues Phelan, and whether we agree or not to this essentialist vision of performance, we could at least agree that it becomes another possible iteration of the performance. Each performance, no matter how many times it is performed, is never, and can never be, exactly the same. An attempt to understand the performance’s absence of longevity is the notion of flux, as it was introduced by the Greek philosopher Heraclitus of Ephesus [c. 535 - 475 BCE]. *Flux* is the idea that all things pass and nothing stays, change is constant and is always happening, allegorically it is almost like a river flow; “No one can step twice into the same river, nor

touch mortal substance twice in the same condition.", because the flow of the river ensures that new water continually constitutes the old [Schechner 2002] [13]. In a sense, that is how we define performance; everything is constantly moving, thus there is a continuous action. As Peter Brook asserted for theatre, "it is always on the move" [14].

This ephemerality of the performance is consistent with the notion of theatre as described by Robin Nelson, as involving "the collective witness in a given space at a given time of a more or less intentionally constructed sequence of things happening through time" [15]. Thus, a performance can be defined as

> "all the activity of a given participant on a given occasion which serves to influence in any way any of the other participants. Taking a particular participant and his performance as a basic point of reference, we may refer to those who contribute the other performances as the audience, observers, or co-participants" [Goffman 1959][16].

In a performance event, a body has its determined place. It moves and expresses, it is present. However, it also becomes something else, perhaps greater than the self, whereby "the performer actually disappears and represents something else — dance, movement, sound, character, art" [Phelan 1993][17]. The word performance in Greek (as the stage-art) is παράσταση (parastasis), which means to display something in front of someone else. The word derives from the Greek medieval word παράστασις (parastasis), which in turn derives from the ancient Greek word παρίστημι (paristimi), a combination of the words παρά + ίστημι (para + istimi). Παρά indicates alternation and ίστημι means to be real, or to have presence, and thus alternate presence. However, not only the performers are present; the spectators form part of this constant transformation and re-configuration of the self. By trying to interpret, understand and at times, participate in the performance, the spectators allow their own desires to take place in the performance. This presence is "the effect not simply of perception but of the desire to see" [Lehman 2006][18].

These notions of the collective shared experience and co-presence are key, even when the audience consists of only a single person, as in Brook's example where both performer and spectator are simultaneously present. It is, I believe, this constant dialogue between spectator and performer that allows the performance space to be a place of creativity and spontaneity, a feeling that proceeds from natural, momentary impulses without constraint. It is this spontaneity and pleasure in the witnessing and participation, by both performers and audience[19], that creates this sense of liveness in the performance space. And it is the same type of liveness that makes the

performance spectacle a rich environment to explore the possibilities of digital technologies and media.

2.2 Digital Technologies and the Performance Arts

Since the 1970's, the evolution of the digital technologies and the Internet, as well as the use of personal computers, have been the centre of discussion and have led to the extensive use of the notion of interactivity in the arts [McLuhan 1964]. At first this notion was introduced not as a technological exchange of information and action but as a way of experiencing the art[20]. This is reflected in the performance-making as well during the past decades, with the works of Merce Cunningham, Johannes Birrringer and other choreographers, performers and technologists. It is in this context that Dixon reminds us that theatre not only has the capacity to re-appropriate new technologies, but can also provide us with a template so that *'new forms*' such as film, television, and digital performance can be understood as theatre that has appropriated and incorporated digital technologies [21].

Prior notions of technology, as a way of communicating information, a staging prop or commentary, were used in the performance world way before the birth of the Internet. Examples include Erwin Piscator (from 1924, among others[22]), a pioneer of hybrid cinema-theatre spectacle, who is considered to be the father of projection design. Through his collaboration with Berlot Brecht, one of the most influential theatre directors of the 20th century, they created the epic theatre. This is an early example where technical craftsmanship collaborated with writing and directing genius.

2.2.1 Interactivity in Performance

The notion of interactivity emerged at about the same time (1920s), and for the performing arts world this consists of two essential phenomena: on the one hand it is the spatial, architectural concept of a performance event, and on the other hand it is the notion of collaborative,

participatory, co-creative spectating. This is all manifested in tandem with the performers, the spectators, the space and the existing technology [23] [24] [25].

As Birringer noted, introducing the spatial, architectural aspect into the performance in combination with the notion of interactivity allows us to create a space that constantly responds to movement. Such environments shift the focus of the performer away from the creation of step combinations and alter the performers' '*internal bodily awareness*' to his/her environment[26]. This extension of the physical body to the surrounding space and the creation of relational associations is strongly evident in how Laban perceived and wrote about the space, prior to any technological interventions:

> "The conventional idea of space as a phenomenon which can be separated from time and force and from expression is erroneous… Movement is the life of space. Dead space does not exist for there is neither space without movement nor movement without space" [27].

Thus, for Laban, the space is not an empty container but a dynamic form [28], an environment that is constantly shifting according to each individual's input nuances. In order to complement that, we have to move away from '*technologies of representations*', or technologies designed to create media that do not vary according to what is happening in the surrounding environment, to "technologies of performance"[29] or "performance systems"[30] that vary in the spatiotemporal scale, in the context of digital performances. It is noteworthy that this shift is not reflected just by the development and use of new technological apparatuses, but mostly in how we apply these technologies (representational vs. performative mode) [31].

The term digital performances has been known and used for decades by scholars in the field of media art and technology sciences. It is a cross-disciplinary, sometimes controversial territory that a lot of scholars have written about (such as Salter, 2010; Dixon, 2007; Causey, 2006; Giannachi, 2004, to name but a few). It refers to any type of performance where computer technologies play a key collaborative role in the content and aesthetics of the performance. These computer technologies include any type of technological apparatuses (such as a camera, body sensors, etc.) that will input data, analyse the information and map out the means to control, activate or modulate the media in the environment. These media could be the lighting, projected images, sound, robotics or other types. Digital performances include but are not limited to interactive dance and theatre performances, telepresence and the internet, video games and virtual reality.

Another key aspect, as I mentioned above, is the participatory aspect of the performance. The active spectator, with the use of technology, has been a popular concept since the early times of the digital performance world (1960s - 1970s). A pioneer in telematic and cybernetics art, Roy

Ascott (1966), stated the importance of the art is to be responsive rather than a static object. Specifically, he proposed that we should enable artworks so that "the spectator is involved and that the artwork in some way behaves" [32], which is in a sense what the composer John Cage proposed with his *4'33"* piece (1952) [33].

The early examples of the use of technology in the performance world demonstrated its capacity to form a fundamental part of the performance-making. Dixon approaches the term *digital* as an instrumental or technological concept that could be used as a tool to broaden the possibilities of the performance. He proposes to use technologies as "a huge and constantly expanding toolbox of theatrical effects that each has their own intelligence, sensitivity and subjectivity, that in a sense become characters on stage" [34], meaning technologies that can manifest "*agency"*. Here, the concept of "*agency"* essentially explains where the action takes place and/or where control exists between human beings and nonhuman entities; where the action occur in an interactive environment, in a non-predetermined or pre-designed way, in the process of making knowledge and creating bilateral interactions. In that sense, technology in the context of performance, although it is being vastly referred as a tool in the existing bibliography, actually becomes a co-performer.

Following this notion of digital technologies and interactivity in performance as it has come to be at the intersection of design, computation and performance arts, music and electrical engineering, one can identify Robert Rauschenberg and Billy Klüver as among the first to explore the potentialities of digital technologies and electronics in the context of performance [35]. In 1965, with the help of Bell Laboratories and 10 artists including choreographers Lucinda Childs and Deborah Hay, and performers John Cage, Öyvind Fahlström, Alex Hay, Steve Paxton, Yvonne Rainer, Robert Rauschenberg, David Tudor and Robert Whitman, created an interdisciplinary project blending avant-garde theatre, dance and new technologies. The artists were joined with the engineers, who helped produce the technical components used on stage by the participants (dancers, actors, musicians) creating performances that were presented in the context of the *9 Evenings: Theatre and Engineering* events [36].

The key concepts of 9 Evenings were: "fluidity, spontaneity, liveliness, transparency, immersion and intimacy between artist and audience" [37]. Although the technological apparatuses that were used in the performance event might seem obsolete today (analogue vs. digital), the techniques, which include sound amplifications, simple mappings of sound to light, wireless communication and the use of sensors to transpose inaudible or invisible effects and data into the range of human perception, are still widely used.

This work has been criticised, examined and re-examined for its success and/ or failure. The technology in place has been categorically characterised as mere stage crafting at the expense of artistic context and as unsuccessful, in terms of the collaboration between the artists and the engineers [38]. However, I believe that the problem was neither of these. A new form of art was being presented and as anything new, time needed to be invested in order to realise how can we absorb and experience such performances and collaborations. As Jack Burnham wrote, in the professional theatre the use of technology, such as the lighting console system, is successful because its relationship with the performance remains linear, efficient and not noticeable by the audience. In the *9 Evenings* event, the technology was brought forth.

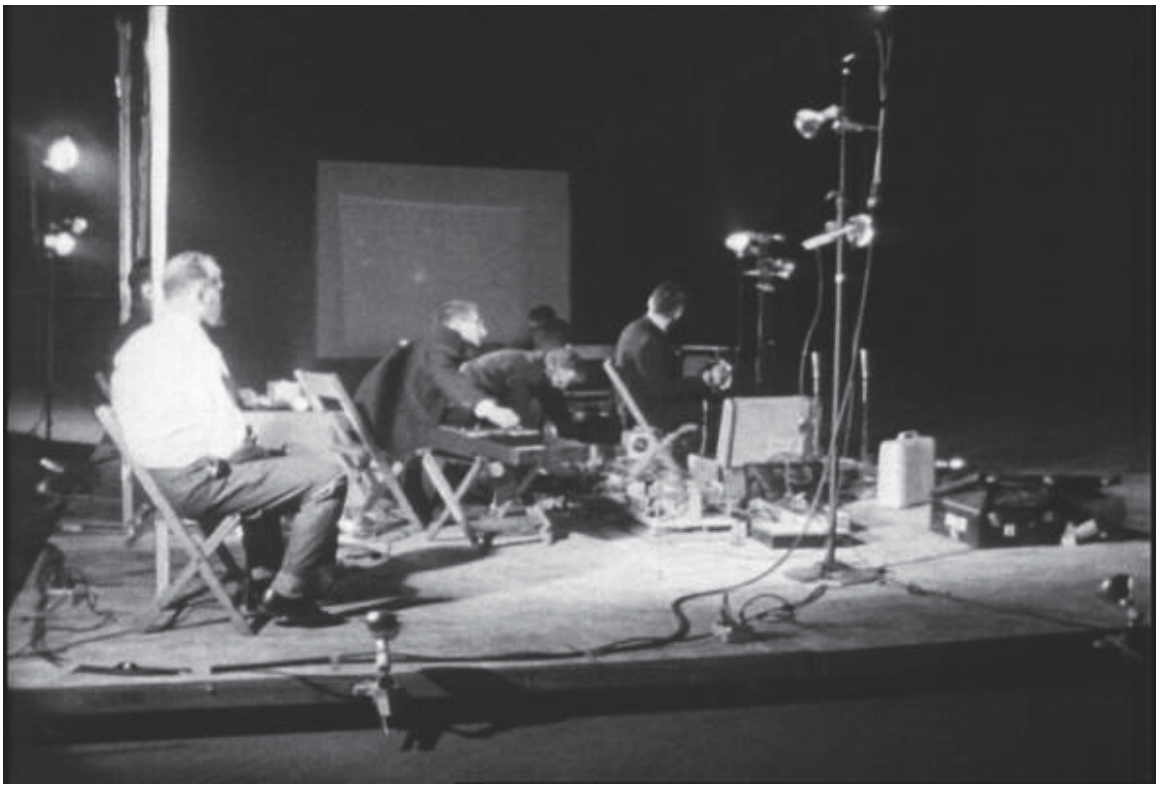

Figure 2: Frame capture, 9 Evenings: Theatre & Engineering, 1966, “Bandoneon ! (a combine)”, camera: Alfons Schilling and Bell Labs Engineers, produced by Billy Klüver, 16mm black-and-white film. Courtesy of Experiments in Art and Technology [E.A.T. 1966][39].

> *“*The new artists want to magnify, to isolate for its own sake, this relationship between performer and system. Lucinda Childs's air-supported vehicle, John Cage's sound mixer, Deborah Hay's radio controlled platforms, Yvonne Ranier's "theatre electronic environment modular system," and the audio amplifiers of Alex Hay were all constructed as physical extensions of the human performer's abilities” [40].

Nonetheless, we have to bear in mind that for everything mediated, there is inevitably a simultaneous loss and gain of meaning, as a new piece is being created as a collaboration. 9 Evenings was an innovative work that formally planted the seed for the collaboration between artists and engineers that followed and still flourishes.

After this collaboration, Robert Rauschenberg, Billy Klüver, Fred Waldhauer and Robert Whitman launched the *Experiments in Art and Technology* platform that was used as an organization to establish collaborations between artists and engineers. During the same period (1965), another collaboration flourished as well between Billy Klüver, Merce Cunningham and John Cage (among others) which resulted in the performance, *Variation V*. For this performance Klüver built a system with photoelectric sensors aimed at the stage lights, so that the dancers triggered sounds as they cut the light beams with their movements. The second system consisted of an array of microphones that detected sounds and a series of antennae. When a dancer came within four feet of an antenna, a sound would result. Thus, in that way movement was translated into sound, creating a reactive soundscape that could be used as a score from the performers.

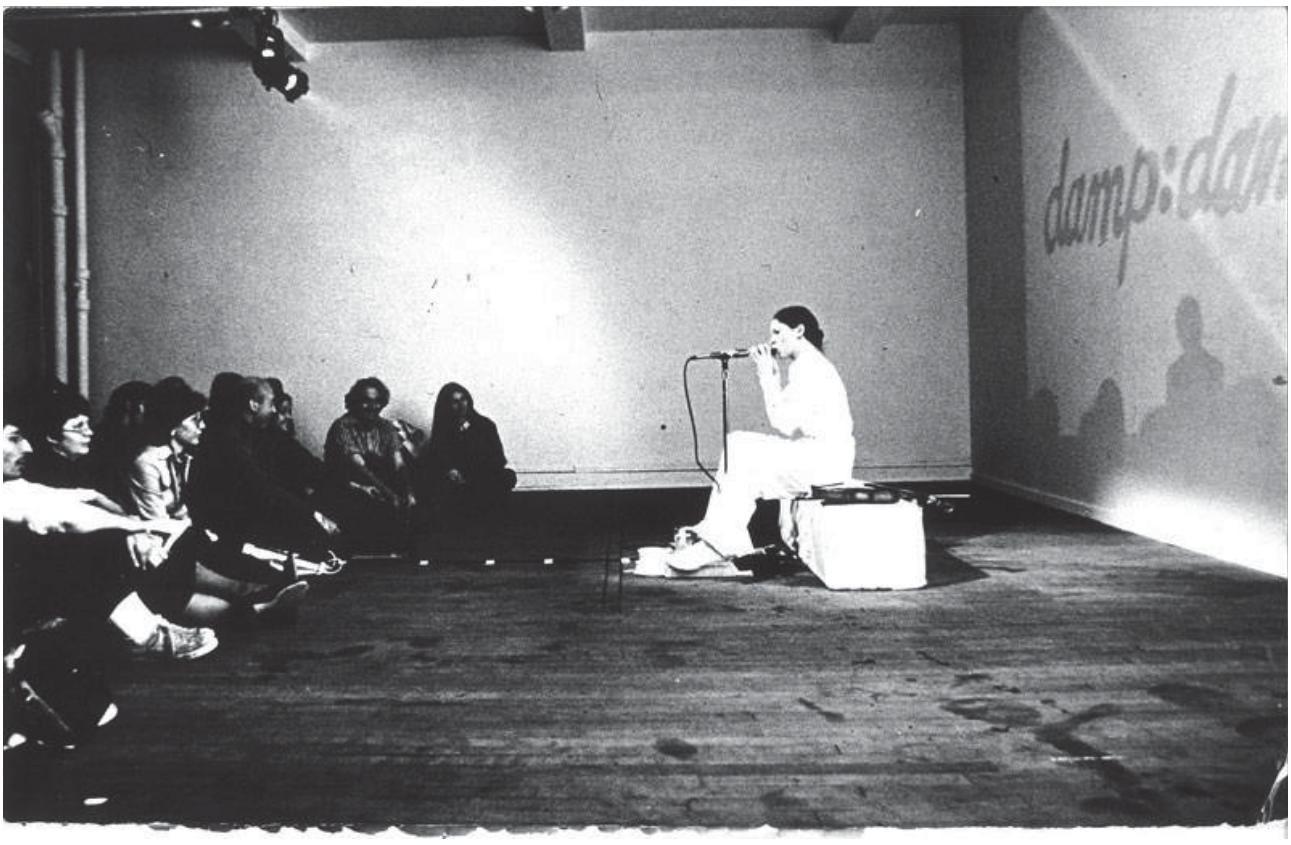

Figure 3: Performance As:If - by Laurie Anderson, April 25, 1974 [41]

Another pioneer, or 'the doyenne of digital performance' as characterised by Dixon, is Laurie Anderson, an experimental performance artist, composer and musician. Starting with her early

work (in the 70's), she arguably impacted the popularisation of the use of projected media [42], while her primary concern was how to use this state of the art (at that time) technology in order to communicate her stories. Although she is best known as a multimedia performance and recording artist, she was also a storyteller. Anderson's fascination lies in the words, as Dixon writes [43]. She sometimes uses the written language as a navigation tool for her narratives (As : If, 1974) and other times she moves away from the semantic content and explores the sounds and patterns of spoken language (Engli - SH, 1976).

2.2.2 Performance-based Approaches of Interaction

Examining the preceding works, among others, Dixon "defines four categories in order to classify interactive art installations in relation to the openness of the system and the consequent level and depth of user interaction. These categories include: Navigation, Participation, Conversation and Collaboration." as adequately noted by Vangelis Lympouridis [44]. *Navigation* is defined as the interaction scenario where the users are following a simple narrative. *Participation* is the most often used type of interaction, where the user activates the environment with his actions. *Conversation* occurs through a dialectic engagement with the system and the user, and *Collaboration* "emerges where actions are created collectively or significantly alter the artwork or interactive space itself" [45].

Interactivity and the use of digital technologies in the performance space allow us to redefine notions of space and time as well as oneself. In order to enhance the spaces and create intelligent ambiences, we have to arm the spaces with the ability to perceive presence and respond to that accordingly. This is also illustrated in Povall's (1999) idea of the existing duality between the interactive space and the performances that occur inside it. He suggested that the spaces needed to be "physically and emotionally intelligent" [46]. I will argue that technology has the ability to enhance the consciousness of one's self, and to mediate change in the environment. This can alter the perception of presence and embodiment, while simultaneously creating an interesting playground. However, that does not mean that technology interferes with the practice of performance - it just opens new, exciting ways of experimenting and experiencing these phenomena by creating a more dynamic space for the performance to occur. This notion of the dynamic space is candidly connected with the notion of the resonating environment and the '*technologies of improvisation*' that Birringer brings into his work [47] [48].

Most of the interactive installations, or so-called interactive-design systems, are placing the person (spectator and/or performer) in the role of the end-user, which could rapidly grow stagnant in the performance world. For interactive systems to be conducive to and beneficial for the performer, they need to be able to culminate '*conversation*' and treat the performer with virtuosity in order to acquiesce in the co-creation.

An example of a *Conversation* and *Collaboration* system, as Dixon describes it, that allows these '*conversations*' to flourish is the *TGarden*. As Sha Xin Wei elaborates, the *TGarden* installations were developed in such a way that goes beyond a '*dyadic turn-taking "communication"'* model and allows the density and richness of a live performance event to flourish [49]. In that way, *TGarden* intends to blur the lines between performer and spectator [50] while the actions of the latter concurrently shape the surrounding environment and vice versa. In a *TGarden* space, visitors wearing enhanced clothing create and modulate video and sound based on their gesture and movement. One of the main questions posed for the project was, "how people make sense of and navigate in rich and dynamically evolving media spaces?" [51] There are two major aspects of the *TGarden* installations that added the important aspect of theatre (performativity) to the form of play. First, there was the design of the different garments that visitors were asked to wear, with the embedded sensors that affected the environment [52] and second, there was the staging and setup of the event and its dynamic-formative relationship with the architectural space. [53]

Figure 4: TGarden, Sponge & FoAm, 2001 [54]

Another example that has been extremely influential for my work, not necessarily because similar methodologies or aesthetics were followed, but because of the collaborative nature and the intentions of the approach, is Merce Cunningham's work. Cunningham is one of the first choreographers who sought the use of technology in the context of performance in order to extend and alter the performance space and the body's movement [55] by using the computer as "'both a memory device and a creative tool'" [56]. Looking through his work, one could argue that Cunningham had a genuine interest in extending the self and investigating the digital self. His intentions towards that are depicted even in his early work (1950's) since his sketches are analogous to computer functions where he used chance procedures for his movement processes [57].

Trackers (1991) was one of the first of Cunningham's computer-aided live dance work. For the development of this work, he used the software *Life Form*. Other works following *Trackers* were *Loosestrife* (1991), *Beach Birds for Camera* (1992), *Enter* (1992), *CRWDSPCR* (1993) and *Ocean* (1994), which were among the early works. Later on, one of his first works that utilised motion capture was the *Hand-drawn Spaces* (1998) in collaboration with Paul Kaiser, Shelly Eshkar, Mark Downie of the Open Ended Group. For this performance the motion capture was used to capture the body movement and drive hand-drawn digital characters, and the performance itself was exhibited as a screen-based installation [58]. However, undoubtedly, one of the most conspicuous live digital dance performances of the last twenty decades is his work *BIPED* (1999), which can be conceived as a progression of *Hand-drawn Spaces* [59]. In *BIPED*, the virtual hand-drawn figures were projected on a transparent scrim that was placed in front of the stage. The hand-drawn figures were appearing, disappearing and dancing on the screen while the *real* dancers were performing and creating a dialogue between the actual and the virtual dancers. "*In a performance where even the creators were unsure of how the combined media would fare together onstage, there were incredible moments where dance and technology seemed to speak the same language*" [60].

The ideas portrayed in Cunningham's work as mentioned above were further extended with *Ghostcatching* (1999) [61]. The project blends together the practices of dance, drawing and computer composition. The collaborators, Bill T. Jones, Paul Kaiser and Shelley Eshkar, created a digital choreography that uses motion capture, dance and vocal phrases. The software used created multiple virtual performers with the hand-drawn aesthetics that together with Jones constituted an

astounding performance. Bearing in mind the technological advances, *After-Ghostcatching* (2010) is a re-envision of the previous piece.

Figure 5: Ghostcatching, by Bill T. Jones, Paul Kaiser, and Shelley Eshkar, (openendedgroup), 1999 [62]

As a continuation of this work and in collaboration with Cambridge and MIT, Downie introduced elements of artificial intelligence (A.I.) to his work, in order to advance the simple animations that were previously introduced by software such as Life Forms. With the use of A.I. programming, Downie was able to create digital *agents* that couldcreate more nuanced digital environments for the performance to flourish. This led to two more pieces, *22* in collaboration with Billy T. Jones and *how long does the subject linger on the edge of the volume…* with Trisha Brown*,* that used similar techniques. More advanced was his work, *Biped*, where real time motion capture projected images of digital stages and motion traces were combined with the real dancers in the space.

Although this work is powerful and demonstrates the potentials of the combination of digital technologies and live performance, the interactions suggested are minimal or, in some cases, especially in the earlier works, almost non-existent. Additionally, the process varied according to the collaborators' intentions for the work. As noted by many in the existing bibliography, although Cunningham was interested in using technology to further extend his views of the body and its potentialities, maybe he was not so interested in *collaborating* with the technology or the technologists to co-create the pieces. As commented by Vangelis Lympouridis, in Cunningham's works, "the choreography dictates the process, and the responsive system responds to the actions of the dancers, but the dance does not seem able to alter or be altered based on the responses of the system" [63] [64].

Dawn Stoppiello and Mark Coniglio are two more pioneers in the field of Dance and Technology. In 1994, they co-founded Troika Ranch, which is a collective of artists, dancers and engineers. Their

work could be used as another early paradigm for sensor based systems, where sensors were placed on the performer's body to create data of his/her movement, mapped to different sound manipulations. Here the notion of *gestural sound* is introduced; a notion that is still an on-going investigation (Vangelis Lympouridis 2012; Navid Navab 2008 - currently; and the author of this thesis in collaboration with performer Margaret J. Westby in *Orbital Resonance*, which is described later) between the relationship of the gestures and the sound, where gestures are used as an instrument that creates soundscapes based on the performers' movements. As Lympouridis cites from Coniglio (2004), this technology could be used as "an attempt to release the performer from the synchronisation to external musical structures and define the whole composition as driven by rhythmical and internal movement structures"[65]. This is in agreement with Birringer's comments on interactivity, where he proposes responsive systems that could shift the focus of the performer away from the creation of step combinations and towards the performer's '*internal bodily awareness*' of his/her environment (as noted earlier on this chapter). Among the systems that Coniglio has developed, the *MidiDancer* sends midi signals through flex sensors that are attached to the dancer's body. Also, another tool that is widely known in the dance world is the software *Isadora*. *Isadora* was introduced as an object-oriented motion analysis system, that can provide interactive control over elements and data that derive from the movement, but very soon its users shifted their attention and emphasis was given to real-time manipulation of digital video.

One of Troika Ranch's first works that used the MidiDancer in combination with visuals was the performance, *In Plane* (1994). The performance was a duet for a dancer and her video image representation. Using the MidiDancer system, the performer was able "to control the generation of music, the recall of video images, the theatrical lighting and the movements of a robotically controlled video projector" [66]. *16 [R]evolutions* is a more recent work (2006), where we see how they move from experimental sonic dance performances to more complete works. At this performance, live video tracking was used to capture the performers' actions and generate vivid abstract images that depicted aspects of their actions. It is noteworthy that Troika Ranch placed their media systems in the realm of musical instruments, where movement was the bow and the sensor system the violin; "thus just as violin responds to the gestures of its player and transforms them into sound" [67] through physics. This is the same way their sensor-based system translates movement into sound, in tandem with how Sha Xin Wei describes the T-Garden Space, and the use of *computationally augmented physics* [68] to augment the performers' movements.

The dancer Robert Wechsler, in collaboration with Frieder Weiss and *Palindrome* (founded by Wechsler), created several performances together after 1995. Their interests are similar to that of Troika Ranch since they used motion capture to create interactive environments that will augment the performance. The difference is that first group was interested in the interactions that were happening in digitally mapped areas, allowing the performers to explore the space, whereas the

latter group was more interested in the dynamics of the movement. Another interesting factor is that Palindrome used bio-sensors to capture and externalise the internal, intimate body functions of the performer to manipulate the visual and sonic environment. With this kind of technology in place (bio-sensors), a more physical interaction can occur, where energy that is being accumulated through time is being manifested in the surrounding environments. However, having explored biological sensors during the course of my ongoing research, I could argue that the data received from sensors as such are quite noisy, since they don't really measure the heart rate or muscle movements but instead reduce these complicated notions into simple voltage differences that could also occur from a simple cable misplacement. More on this matter will be discussed later in the thesis, where the relevant project is discussed.

Figure 6: Einstein's Dream, Particles and Lights, Topological Media Lab, 2013 [69]

A more contemporary work from my personal explorations is the *Einstein's Dreams* [70], a time-conditioning installation at Concordia's Hexagram-Blackbox, by Topological Media Lab. For four weeks, the Hexagram Blackbox was transformed into a sandbox for altering senses of time [71]. As Omar AL Faleh and I wrote in *Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces* for the 5th Annual International Conference on Visual and Performing Arts [72], "designing computational media to enhance and activate spaces gives the

spectators the capacity to re-conceptualise, re-contextualise and question the existence and perception of space and time". Einstein's Dreams is an environment in which visitors encounter performers in responsive fields of video, light, and spatialized sound, presented and conceptualised as a set of tableaus. Each tableau is inspired by a vignette from Alan Lightman's novel, Einstein's Dreams [73], which is set in Berne Switzerland in 1904, the year that Albert Einstein received the Nobel Prize. Or rather, a set of parallel 1904's, each of which is a different kind of time: in one, time slows to a halt as you approach a particular place; in another there is no future; in the third, time sticks and slips; in a fourth, age reverses and what is rotten becomes fresh as time passes.

> "In one concept, a large theatrical space (24 x 20 x 8m) will contain multiple tableaux, each with room for 6-12 people in its own pool of light and sound. Visitors and perhaps performers can move from tableaux to tableaux. The performers' actions will evolve in concert with the dynamics of lighting, sound, and visitors' expectations in order to create different kinds of time, inspired by the novel's vignettes. Sometimes a performer will walk from a location, dragging the pool of conditioning light and sound. The pool mutates or merges into another pool with a different type of time" [74].

As the authors note, the concept of flux, as Heraclitus introduced it, is at the core of this installation's design, "for it allows us to envision a continuously changing space-time that responds to the constant movements of the performers/spectators in space, which in turn, triggers a continuous change of the media stream in the environment. Once again, the line between spectator and performer is blurred".[75]

> "Inevitably, in an immersive space such as Einstein's Dream, the media effectiveness and its impact on the performer's decisions and experience might be suggestive or dictative. This issue was addressed by moving away from representational imagery and sound, and by staying away from linear and sequential media. The explorations and discoveries of the potentials of the environment, as well as the potentials of the change that is at the possession of the participant, are key elements in the co-creation of an event-experience that naturally arose from such activated space. Playing with the sand, which was furnished in the play area, was not only a symbolic reference to the concept of time and the passage of time, but also a play on the physical manifestation that contrasts and complements the projected media -herein the projected graphical particles-, and a medium that enabled the media to have a physical manifestation beyond flat projections, and a tangible materiality, as participants could walk into the sand and

> throw the sand to capture and/ or alter the media in the space.This integration of the performer and the environment happened by embodying and/or engendering broader intentions by way of personal and interpersonal (inter- subjective) engagement." [Alfaleh, Chandolias 2014][76]

I remember the first time that I entered the Einstein's Dreams installation as a performer (not as a technologist [77]) with Jen Spiegel and Patricia Duquette. We began primarily with emphasis upon bodily '*listening*', and an embodied character expressiveness, while exploring and discovering our relationship to/with the (technologically) active and responsive environment. Starting the warm up sessions, just us, barefoot in the space, sensing the environment, sinking our feet to the sand, immediately this sense of summer and beach came almost simultaneously to our mind. One could say that it was an ingenious disruption where the 'time' theme was concerned. The environment started slowly shifting around us, and we had already defined a set of exercises in order to familiarise ourselves to the environment, the media and each other. Those exercises, led by Patricia Duquette, included principles of some very specific theatrical schools like: *Commedia, Rasa, Grotowskian Active Culture, and any Chekhovian (Archetypal) Actioning* – however, it's noteworthy that we were not aiming to reproduce these genres/traditions. Instead, we used these genres as techniques to support, mediate and delimit our initial explorations. Very soon, when the mediated environment came to a climax in conversation with our movement, we unconsciously (as we noted later) moved away from the exercises we had in our mind and started playing with each other and the space in a dramaturgical way, using quotidian movement and notions of catching and falling [78].

We could argue "that the genre of performance work could just as well be considered conceptually abstract, as it could resemble naturalism, and everyday life gestures, where in environments as such become charged aesthetic gestures" [Alfaleh, Chandolias 2014][79]. Thus, the environment is not there to serve the performance or the performers to serve the mediated environment.

> "By developing and experimenting in environments as such, we have the opportunity to support participant/co-performer engagement (with the performers or with the space in general) and give them also the chance to alternate and sometimes coincide, and evoke action among themselves and the media around them. In that way, everything is becoming a generative part of the broader aesthetic. It is from within this vein of inquiry that a more appropriate or situational dramaturgical methodology might arise" [80].

In a paper for the ACM (Association for Computing Machinery) conference on Designing Interactive Systems [81], the author of this thesis, et al. stated that

> "by developing systems that support the creation of non pre-determined experiences, and that adapt to each individual's input nuances in an idiomatic and fulfilling manner, and by capturing and analysing continuous data streams, we allow the performers to embody and manifest their broader intentions by way of personae and interpersonal (inter-subjective) engagement with the systems and each other" [82].

Thus, for instance in Einstein's Dreams,

> "the performers' computational inverse shadows are endowed with agency. While performers move and explore the space, improvise, and play with the space and each other, their inverse shadows intuitively decide to detach from them and remain still in a specific space for a while and continue following them after arbitrary period of detachment, or even disappear" [Alfaleh, Chandolias 2014][83].

In a way, as noted earlier, "… each' shadow 'has their own intelligence, sensitivity and subjectivity, that in a sense becomes character on the stage" [Dixon 2007][84].

> "This is a kind of non-linear agency that eventually leads to a media-rich environment that moves away from technologies of representation and simultaneously culminates the co-creation between the performer and the space. System and performers become a generative part of the broader aesthetics, and they evolve, manifest, and co-create at tandem as they progress in creating a common language" [Alfaleh, Chandolias 2014][85].

2.3 Introducing Voice and Speech in Performance and Interactive Art

There have been some recent examples of performances (especially dance) where the use of vocalisation, language and movement are occurring simultaneously, without one dictating the other, in a non-hierarchical way. *iSA* (2008) from dance company *T.r.a.s.h.* [86] and the *Same Difference* (2008) by Paul Lightfoot and Sol Leon (*NDT*: Netherland's Dance Theatre) [87], are two examples. In both performances, although they are not narratively structured, the use of linguistic elements and poetic language allows for multi-layered interpretations, while demonstrating the importance of the musicality and materiality of the uttered vocalisations and language [88].

One of the first performances that explored the potential of body movements in combination with the use of technologies similar to the aforementioned, as well as the use of transcribed, recorded, live voice and (poetic) language, is half/angel's (dancer/writer Jools Gilson-Ellis and composer Richard Povall) *The Secret Project* (1999). The technology in play is motion-sensing, sound/MIDI software, text/vocalisations and video. A very interesting comment on the performance was made by the *v2* [89] group from Netherlands, where they stated that it is a "performance of corporeal confusions," that "wishes to uncover and discover secrets of desire and technology... Performed by three dancers, Richard Povall, Jools Gilson Ellis and technology, the secrecy of technology is probed". So, by moving away from technologies of representation that used virtual interpretation of the space to create the interactions, and towards technologies that "look inside the body, inside the intention of a movement - to work with emotional rather than purely physical space", the interactive system is allowed to function as a third performer-collaborator, creating more nuanced relationships between the system and '*performative content*' [Povall 2003][90]. As Birringer describes, Gilson-Ellis (and Povall) invited the audience to

> "experience movement as live musical composition and vocalisation of the poetry she had written. She literally danced with her arms and voice as extended musical instruments that can layer and caress the textscapes / soundscapes (programmed by Povall) she triggered in space through her interaction with the camera-sensor. The Secret Project was subtle and moving in its astonishing distribution of the voices and her recorded or amplified breathing in the interactive live dance" [91].

The ensemble of ideas presented in this work is of high interest for my research and work, because it constitutes one of the first examples where dance-performance and technology do not take into account only movement and physiological data, but also vocal data for the interactions to occur.

Indubitably, my research field is intertwined with the realm of digital poetry and performative writing since I am dealing with live speech, transcribed voice and projected words. Additionally, movement exercises and improvisations are based on conceptual frameworks created with the help of automatic writing techniques. The concept of language, voice, vocal representations and communication in the context of interactivity, digital performance and installations are further examined in the following section.

From the world of computational installations I am investigating and questioning methods and installations like the work of Golan Levin and Zachary Lieberman. In their work *RE:MARK* [92] (2002), the sounds uttered into a pair of microphones are analysed and classified by a phoneme recognition system. When a phoneme is recognised, it's being transcribed (for example, oh, ee,

ah, etc.) and projected on the installation's display. If the user's sound is not recognised with sufficient confidence by the system's classifier, then an abstract shape is generated instead, according to parameters derived from the *timbral* (spectral and formant) characteristics of the vocalisation. Among other mappings, a sound with high frequency spectral centroids are represented with pointier, more irregular forms. This work does not deal with transcribed text directly and mostly focuses on non-utilitarian speech representation and voice patterns.

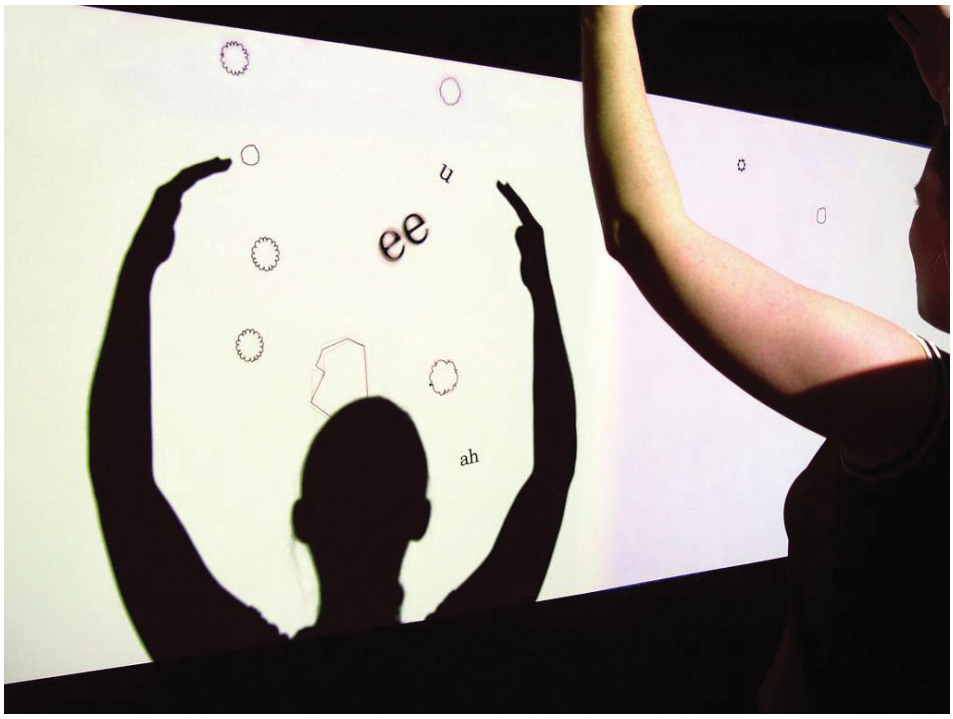

Figure 7: Re:MARK by Golan Levin and Zachary Lieberman, with production support from the Ars Electronica Futurelab, 2002 [93]

Figure 8: The Hidden Worlds of Noise and Voice, by Golan Levin and Zachary Lieberman with production support from the Ars Electronica Futurelab, 2002 [94]

In their other work, named *Hidden World of Noise and Voice* [95] (2002), the spoken utterances are segmented, analysed and then represented graphically as abstract *'sound-gestures'*. The creation of the shapes of the sound-gestures is controlled by mapping the duration of the sound to the length of the abstract shape and the volume of the uttered sound to the diameter of the shape. When the shape is created, it initially appears to be emerging from the location of its speaker's mouth; thereafter, however, it gradually submits to the influence of a flocking simulation, making it appear as if it swims around the visitors' heads. Here also, Levin et al. are using the spectral information to manipulate and form the shape of the representative shape. Once again, in this example, the representation of the voice is non-textual and non-utilitarian. Using abstract representations as such adds a playful and artistic character to the installation, but in a performance context the relationship between the visuals and the voice could become quite static. In addition, it encases the user in equipment. Furthermore, *Messa di Voce* [96] (Ital., "placing the voice", 2003) is an audiovisual performance in collaboration with Jaap Blonk and Joan La Barbara, in which the vocalisations produced by these two abstract vocalists are augmented in real time by being translated into abstract visual shapes that are dependent on the qualities of the voice. The performance's intention is to refer to themes of abstract communication, synaesthetic relationships, cartoon language, and writing and scoring systems, as the creators suggest, always within the context of a playful, and virtuosic audiovisual narrative. [97]

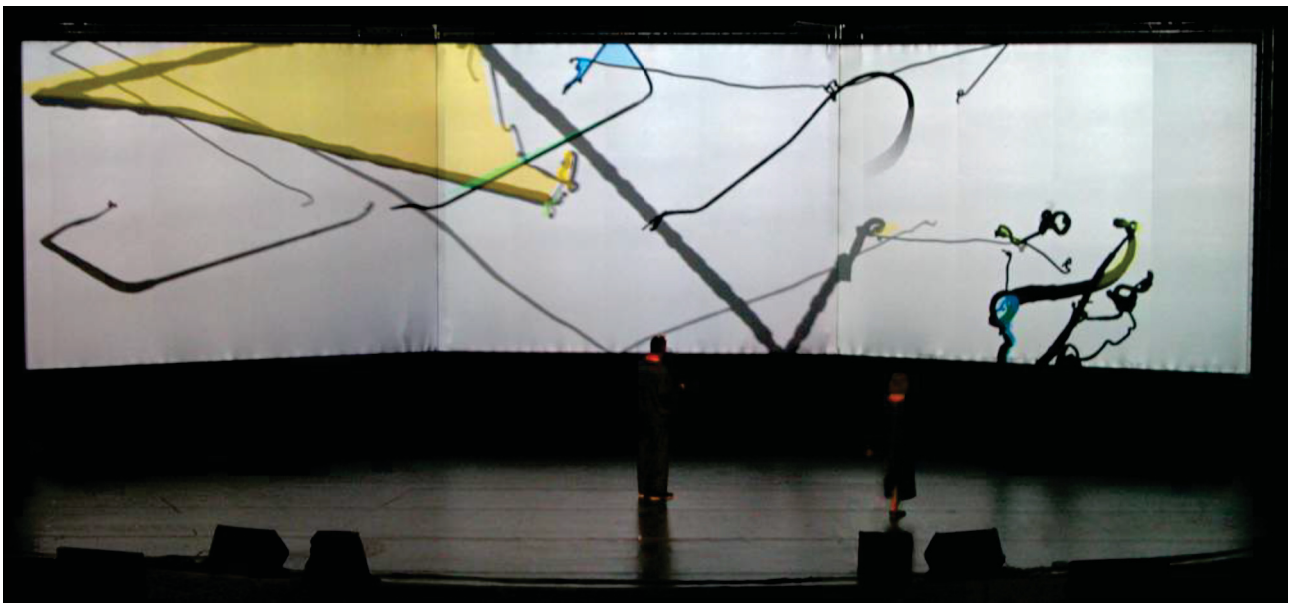

Figure 9: Messa di Voce by Golan Levin, Zachary Lieberman, Jaap Blonk, and Joan La Barbara, photo taken by Tmema/Blonk/La Barbara, 2003-2004 [98]

Golan Levin and Zach Lieberman [99] have created multiple performances and installations (some of which are mentioned earlier in the paper) that do not deal with text directly and focus on non-

utilitarian speech representation and voice patterns. However, although their work has a playful and aesthetic character and it might visually be very pleasurable, I believe they fail to address questions of meaning and it is merely another abstract layer of voice and speech representation. They point out that speech visualisation has generally been treated as a scientific problem, but artists have begun to use these techniques in installation and performance. Practitioners in those fields have developed or refined a range of widely adopted and useful visualisation techniques, including waveform graphs, spectral and formant plots etc., which help solve the problems those practitioners encounter. The *Storytelling Platform* (presented at chapter4) adjoins semantic and prosodic patterns from continuous speech and voice input, in order to provide nuance and gesturality derived from vocal performance and storytelling, in the context of live performance, including unencumbered whole body movement.

Another example that comes from the installation world and uses semantic databases is *The Giver of Names.* It is a computer system and installation developed by David Rokeby (1997) that assigns names to objects and to combinations of objects. As Rokeby describes in the installation's website, this project is intended as a comment on the process of *semiosis* [100] and is a challenge for the viewers to try and disassociate the object from its name and explore other parallel meanings based on the computers interpretation of it. Thus, contrary to Levin's (et al.) work, Rokeby's approach successfully enables an enactment of a critical reflection about nominalism, semiosis and notions of meaning.

Figure 10: David Rokeby, The Giver of Names, 1991, Photography | © David Rokeby

> “The installation includes an empty pedestal, a video camera, a computer system and a small video projection. The camera observes the top of the pedestal. The installation space is full of objects of many sorts. The results of the analytical processes are then 'radiated' through a metaphorically linked associative database of known objects, ideas, sensations, etc. The words and ideas stimulated by the object(s) appear in the background of the computer screen, showing what could very loosely be described as a 'state of mind'. The phrase is, of course, not a literal description of the object. At the same time, it is definitely not a randomly generated phrase. Everything that the computer says in some way reflects its experience of the objects. However its experience is in many ways quite ‘alien’” [101].

The previously mentioned works that deal with voice, vocalisations and interactivity have been developed as installations. As previously discussed, interactive installations often tend to assume the spectator/user as an end-user, whereas in the context of interactive performances and responsive environments, the performer/spectator is being thought of as a virtuoso and is invited to co-create and co-perform with the system.

Two examples of performances that are tackling the semiotic and semantic process, but have no technological augmentation, are *iSA* by T.r.a.s.h. (2008) and *Same Difference* by Lightfoot León (2011). A basic element in both performances is the live spoken words and vocalisations that occur through the temporal and spatial performance event, without imposing any hierarchical relationship between the sounds and the movements. *Same Difference* **[102]** seems to be concerned with language as a communication tool and the impossibilities this tool creates. On the other hand, *iSA* is looking for a counter colour to its dynamic dance and the omen of violent motional language, for silence opposed to chaos.

Eggers (2009), in a case study she wrote about the two performances, noted that throughout both *iSA* [103] and *Same Difference* the “body movements produce language and the live spoken language produces movement”; the dance movements both follow and initiate the language and vice versa. This does not mean that both dance and language lose their autonomy towards each other or that they lose their independent perspectives; it rather means that in the performances a linguistic body is created, as a new dancer [104]. In my thesis, it is this linguistic body that I am trying to understand and *choreograph* (enable), in collaboration with the physical body, using technology and developing systems inspired by the *media choreography* [105] approach of the topological media lab. Thus, I am talking about non-deterministic systems that are not governed by simple causality laws. Such systems do not assume or expect actions to react, and every given condition might not yield the same result through time. Thus, they are able to evolve through time and co-perform with the people in the space.

As Lehmann [106] puts it, the words can become “a dance of language gestures”. Those “*gestures*”"do not only carry their semantic components but are also characterised by the musicality, materiality and physicality of the language. Here is where the prosody (quality) of the voice can enter the game. The amplitude, noisiness and other values of the human voice are as important as the linguistic/semantic values of the speech but are less associated with its representative or communicative characteristics.

Another case of dance performance that uses spoken words and vocalisations as an element for the performance comes from the choreographer and performer Maria Kefirova. Her work explores notions of embodiment/disembodiment and appears to be in a constant quest for the different changes of presence and perception, as well as the deconstruction of our pre-conceived and teleological semiotic processes. She uses live speech and vocalisations in an almost doctrinal sense [107]. Two of her performances that I have personally witnessed will be discussed, *End.Lessend* [108] and different iterations of it (which is a work in progress that we are also collaborating on) and *CORPS.RELATIONS* (2010) [109]. In both works, she performs using live spoken speech and different vocalisations while the performance unfolds, allowing the audience to access multiple layers of signification and presence, either with the content of the speech in tandem with the movement or with the seemingly abstract vocalisations and silences that not only contribute to the dramaturgy of the piece but form an essential part of the totality of the work.

In spite of the fact that the examples above are not dealing with the use of interactive/responsive technology, I consider them both valuable for their aesthetic and conceptual significance in an artistic and performative content. When dealing with speech and immersive environments, most often one will wait for something to happen immediately, assuming that interactive entities will immediately exist or appear in the space. Dealing with speech, the most obvious entity (product) that you can have is the transcribed text produced from the spoken utterance. Speech to text technologies is not something new; from the early stages of speech analysis and recognition technologies, the speech to text (STT) function was embedded in such systems. However, in the context of live performance, having text projected in the space could be easily criticised for redundantly representing what is already there, which is the spoken words from the performer. New media technologies, digital typography and other live manipulations allow us to create interesting parallel levels of meaning that are not just an interpretation or representation of the spoken words.

Émile Benveniste emphasises that in the process of ascribing meaning to language, two separate faculties of the mind are involved: “the ability to perceive a correspondence between what is there and what has been there before” (the recognition of the sign) “and the ability to perceive the

meaning of a new enunciation" (the understanding of the discourse) [Eggers 2009][110]. Thus, the linguistic body of the performer's spoken words has a temporal and spatial value.

A more recent, digitally augmented performance that tackles the ideas of digital poetry, responsive environments, digital imagery and gesturality in relation to the performer's movement is *.txt* (2009). This is about an interactive digital performance that is using multiple sensorial techniques, such as camera tracking and motion capture, and investigating different ways of interactive scenarios that can occur in the performance space. As a result, during the performance the audience finds itself exploring multiple layers of interactive soundscapes, visual compositions, and *real-time choreography*, combined to bring forth the dramaturgical intentions of the work. Watching the performance one can identify multiple bodies in the space, although there is only one human performer; images and body are joined together and interact in a way that the imagery helps to bring forth the movement, and the movement in its turn is vital to the creation of the imagery. The grammatical, syntactic, semantic and semiologic connotations of the words are no longer there, and one could argue that they could be perceived as bodies in the space that constitute an important part of the emotional and dramaturgic creation in the performance space.

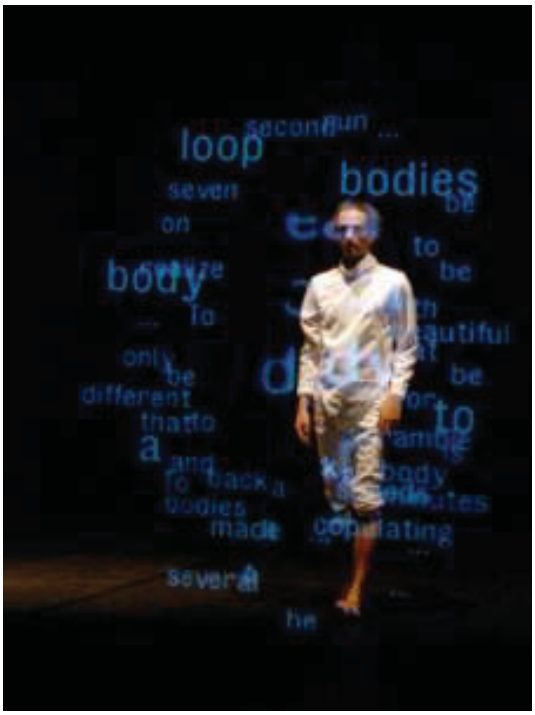

Figure 11: Excerpt from '.txt' performance, by Fernando Galrito, Fernando Nabais, Stephan Jürgens, 2010 [111]

It is noteworthy that the creators of the work, Fernando Galrito, Fernando Nabais, Stephan Jürgens, expressed the necessity of a non-intrusive system that perceives the performer as

another element in the space — the idea of a technological system as an ecosystem, a *living-like* environment that will allow the interactivity, spontaneity and liveness of the performative event to bloom, is present in the work [112]. In addition, an interesting factor for this performance is the use of social media, such as Twitter, in order to create a participatory experience for the spectator. In *.txt* the audience was encouraged to participate in the performance by using this platform in order to alter it, manipulating some of the media in the space.

Generally, as noted by Jacques Rancière, the spectator in events as such is able to observe, select, compare and interpret what is being unfolded in front of her.

> "She links what she sees to a host of other things that she has seen on other stages, in other kinds of place. She composes her own poem with the elements of the poem before her. She participates in the performance by refashioning it in her own way- by drawing back for example, for the vital energy that she is supposed to transmit in order to make it a pure image and associate this image with a story that she has read or dreamed, experienced or invented. They are thus both distant spectators and active interpreters of the spectacled offered to them" [113].

In this work (*.txt*), the creators wanted to enable the spectator by including him as another element in the equation of the responsive stage. In this case however, I consider the way the interaction scenario works, to be very weak because I believe it is kind of obsolete and distracting for the audience to use phones, tablets and social media for a performance event.

The scenic space is constructed with a similar aesthetic to BIPED, where a transparent scrim is placed in front of the stage, used not only as a canvas for the imagery and movement to occur but also as an interface, thereby extending the possibility for interactions. Techniques such as particle systems and digital typography are part of the interactive system, while keeping autonomous emergent behaviour, according to the creators. What is at stake here though is not just the performance itself, but also the use of language and the performance of the words, which also include the interaction of the user with the words. There has been already a lot written in the bibliography on how we ascribe meaning to language or dance, but what happens when language and movement occur simultaneously in a non-hierarchical way? Thus, in performances where language is not used as a communicative factor, or in order to explicate something that is equivalent to the movement vocabulary, leaving the spectator to oscillate between grasping and interpreting the experience present before him/her in his/her own individual way. Maybe what is happening in performative events as such, is that the meaning is not owned or dictated by anyone, neither the spectator, the performer, the choreographer, the language or any other element of the event itself. Instead, the meaning subsists somewhere in between all those factors, therefore excluding from the equation any notion of hierarchy and causality relationships [114].

The work of Chris Ziegler [115] at Arizona State University with the live voice manipulation through the use of networked iPods [116] is a complement to this genre of work, and maybe is a more relevant example, meaning a closer ensemble of methodologies and work, to the goal I have set for *Storytelling Space*. The performer is placed on the stage with wearable sensors, iPods, and a wireless microphone. As he/she starts improvising with his/her voice and body gestures, the one feeds to another creating an interesting looping-feedback without any set ordering. The body movements manipulate the live voice feed and the movement is being informed by the sonic environment created by realtime manipulations.

It is true that ascribing meaning to dance and movement and the potential of sign-recognition is more vague than the communicative language. A movement could have endless meaning possibilities, depending on factors of personal experiences, memory, training, intentions, necessities, sensations and perceptions, whereas a single word that belongs to a specific language with specific grammatical, syntactical and semantical structure has perhaps a more straightforward meaning ascribed to it. This is central to my research, but in the case of the *.txt* performance event, it is a little bit easier than the explorations that I am proposing because the words are just transcribed and not uttered by the performer. However, if the words are also uttered, then the semantic layer of the word is already (temporarily) present and the visual display of the utterance might easily become trivial. Thus, what are the implications of the use of live spoken language in combination with movement? This question fuels my investigation and is examined in the context of my project, *Storytelling Space*, in the corresponding chapter.

2.4 Epilogue

It is of particular interest how the collaboration between performance and interactive systems evolve through time, starting with a more reactive type of interaction scenarios that later transforms into a more integrative process where the technological apparatuses and the digital interactive components are perceived as co-performers. Many have written and talked about the combination of technology and performance, and how the system's manifestations sometimes could have been just simple presets for the effect, where the performance would have been as effective for the audience. This logic is not false, because sometimes the performance might be more refined through the multiple rehearsal iterations that it goes through, and other times the technology and the interactions are vague or unclear, resulting in an *invisible* technology. However, I am interested in technologies and performative events with a more improvisatory character, where technology is

not treated as a staging prop but as another performer-collaborator, where performer, technology and the architectural space are equally part of the same equation. In that way, the performer is not just the end-user, as is what typically happens on all things that claim to be interactive, but he/she is invited to co-create with an *instrument* (being technology) as a musician does with his violin. I believe that in this context, the use of technology makes the performance space more interesting for the performer and invites them to explore and expand their body and movements with audible and/or visible manifestations as a result. It is then that the performance liveness and spontaneity with the use of technology can be brought forth.

Informed by the above mentioned works and by previous applications exploiting speech to text representation and signal analysis of features of the voice (from TML and Obx labs at Concordia University, Appendix I), I advance this genre of work by fusing natural language processing (NLP) techniques and semantic networks together with real-time signal analysis adapted from music and sound processing, in order to further explore the potentialities of live speech in the context of digitally augmented performances (*Storytelling Space*).

3. Interaction Design and Responsive Systems

In this chapter, I introduce the ideas and theories behind the development and my use of interactive systems. In the most basic sense, by interactive systems I am referring to systems that are able to digitally enhance different spaces, by responding to any sensorial input accordingly. These technological apparatuses exist at the intersection of design, computational arts and engineering, and they implement theories of communication, cognitive science, psychology, sociology and philosophy[117]. I am examining different forms of interaction design and interactive/ responsive systems within the framework of performance spaces and performativity.

3.1 Interactive Methodologies for Performance

It is noteworthy to mention again that interactive performances are not necessarily always mechanical or electronic in nature. The idea of focusing beyond the technical capabilities and technological limitations, and targeting the conceptual and theoretical processes and methodologies in designing and creating these systems, is a key aspect for developing a successfully interactive system. To go beyond a mere technical demonstration of digital proficiency is to facilitate a collaborative aspect between the performers and the ambient environment. When digital technology was introduced into the arts almost half a century ago, it was necessary to re-think concepts of space, performance and the body. These interdisciplinary studies created a rich theoretical and practical base from which we can draw, to produce new artistic interactive systems that go beyond the traditional action-reaction software approach.

As Al Faleh and I wrote, these ideas of interaction stem from

> "the ancient eastern forms of public story telling, in which a narrator recounts tales and myths to a live audience [and] can be thought of as an early form of performance that allow audience interaction in a narrative and theatrical context. The Narrator would sometime resort to engaging his audience, when reaching a climax in his tale, by asking them for a verdict on the fate of character. When the audience votes whether the character should live or to die, the narrator would

improvise an alternative storyline based on the audience's interaction, making this a very early form of a participatory performance where the spectator is endowed with agency and authorship".

"These local storytelling traditions were later followed by other forms of non-technological interactive performances in the work of many artists and directors in the 20th century. This includes Yoko Ono's Cut Piece where the audience is invited to cut pieces of Ono's dress while she sits passively on stage [118], and Marina Abramović's Rhythm 0 where the artist sat in a gallery space on a table that has several objects on it (knife, whip, chain, a bullet, a gun, etc.) and invited the audience to use the objects on [119] her while she sat and observed passively. Such works do not only allow the audience to create unique performances, but also turns the spectators into temporary performers whose contribution to the event flow can be as critical as the artist's role himself." [Alfaleh, Chandolias 2014][120]

This ensemble of the aforementioned works are some of the many leading projects and research that explored the tendency to blur the line between the spectator and the performer, including themselves in the creation process, which brings forth again the spatio-temporality of the performance space [121]. Arguably, a major influence to this genre of work, more specifically to staging techniques, can be shown by examples such as the stage designs of the Bauhaus along with the work of Mohly-Nagy and Schlemmer. This work and research helped remove the boundaries between spectator and performer and led to the creation of the *total theatre,* where stage, viewer, performer, media and exposed mechanical apparatuses are fused into unity, forming a whole that creates total sensory experiences, and transforms the static-traditional performance spaces into spaces with a more dynamic morphology [122] through technical means. In more recent times, in consonance with Garth Paine, Sha Xin Wei and other pioneers in the field of responsive space and intelligent ambiences, I will argue that in order for the systems to be able to evoke this dynamic interactive engagement, they must be able to co-evolve and adapt autonomously to the environment, the objects and the people that are inhabiting it, while considering all the spatial and temporal parameters.

"In order for the system to represent an interaction, it must be capable of changing and evolving. The process of evolution must promise continually new outcomes that are based upon the nature of a response-response relationship where the responses alter in a manner that reflects the cumulative experience of inter-relationship" [Paine 2002][123].

These concepts are fundamentally embedded in the core of my research but also in recent works, realised by many performance and dance companies and research laboratories all over the world, with some examples like Dumb Type, Big Art Group, LAb[au], F0am, Topological Media Lab and many others.

3.2 Responsive Systems

"A responsive media environment is a physical space in which people's activity and time-based media (video, sound, active materials) influence each other and evolve in concert to create an event" [Sha 2013][124]. That brings up the question: how do people perceive and move in such spaces? The interactivity I am writing about refers to these complicated relationships and embodied interactions that occur between the participants in space, and also between the participants and their environment, including the media and the technical apparatuses. It is this comprehensive and corporeal nature of these interactions that affirms the role of *the body* as an active element and an agent of change in creating the experience. This eventually leads to a media-rich environment that moves away from technologies of representation and simultaneously culminates the co-creation between the bodies (performer/audience/other elements in the space) and the space. Thus, everything becomes a generative part of the broader aesthetics, as all bodies evolve, manifest, and co-create in tandem as they progress in creating a common language. For example, a shadow that moves away from one's body (as in Einstein's Dreams), or lights that follow bodies in the space and then suddenly move away, manifest characters of their own (as intended in *Orbital Resonance*).

The above described "correlation between body and space, and the duality of the physical space and the mediated and interactive space, is a major research interest and a main consideration during the process of designing" [Alfaleh, Chandolias 2014][125] the systems presented in this thesis. "Corporeal interaction mediates changes in the responsive environments, but it can also become elements of the space that receive and perceive the change that is influenced by the actions of other bodies. According to Lefebvre [126], the active body creates its own spaces with the energies at its disposal, yet is still governed and influenced by the laws of space" [ibid.][127], which is true in any context, and not only in interactive environments. However, the term "'laws of space' that Lefebvre talks about in here can be examined beyond the traditional physical delineation of walls and ceilings and material properties" [ibid.][128]. By capturing and analysing continuous data streams, I

propose the extraction of ongoing qualitative data referencing the momentary changes in "*behaviour"*, movement patterns and voice in order not to barricade the experience but to fortify it in an idiomatic and fulfilling way based on each individual's input nuances. That way, the *laws of space* can be expanded to include the computational media and the relationships that are created between the other bodies in space and their motion in space.

In the 1920's, a pioneer of modern movement and dance Rudolph Laban treated the movement of the body by labelling not body parts, but rather sequences of trajectories of movements, which can be candidly connected to what Sha Xin Wei states in his book, *Poiesis and Enchantment in Topological Matter*: "the world contains not only things but also relations of things" [129]. For the design of responsive environments, I am proposing to follow a similar logic for the '*gestures'* of voice and/or body movements, but at the finest temporal scale. That is to say, it is necessary to enforce the interactive systems with the ability to dynamically observe relational patterns that occur from all the sensory features (voice, speech, or movement). Also necessary are adapted machine perception and signal analysis methods, in order to generate meaningful interactions on the temporal and spatial scale.

This is congruent with what Flavia Sparacino writes,

> "[…] in order to turn computers into articulated storytellers that respond to people's natural gestures and voice, we cannot simply model interaction as a list of coupled inputs and outputs. This simply defines a map of causes and effects that associates an action of the user to a response produced by the interactive space. Systems authored with this method tend to produce applications that are repetitive and shallow.[…]" [130]

We need instead systems that can "choreograph" narratives, where the media opposition can vary according to each individual input nuances in a *response-response* relationship. It is noteworthy to mention that narrative is defined as an account of connected events [OED Third Edition 2010][131], however these events might be disconnected prior to the narrativization process, which happens for example in dream logic.

Technology allows us to build systems that are not based on causal, action-reaction logic. On the contrary we can build non-deterministic systems that do not assume a '*telos*' and that somehow could be described as '*auto-poetic*'. It is up to us to decide how we are going to use technology; we can code 'interactive systems' that are based on if-statement blocks that wait for an action to trigger a pre-determined reaction, or we can build systems as ecologies that perform and evolve on their own and that are able to co-perform and interact with the spectator, without dictating an effect or playing the role of puppeteer. By developing such systems we should enable the viewer to

take the role, not only of spectator, but simultaneously of creator; where their behaviour creates the environment, and the environment conditions their behaviour. “In so doing they find themselves in a position of contemplation, a position where it is necessary to develop a cognitive map of the relationships between behaviour and environment, between action and reaction, between individual and communal” [Paine 2004][132].

This idea of identifying living systems with machines as non-teleological systems has been introduced and described by Maturana and Varela. This is clearly depicted in the design process I am proposing above, where responsive environments are being presented as *autopoietic, non-teleological,* adaptive intelligent ambiences. As the writers state in their book *Autopoiesis and Cognition,* “everything said is being said by an observer”. That means that the description and observation of the function of a system don’t necessarily pertain to the same domain as the functions themselves [133]. However, I will argue that in the context of interactive systems, though the components of an autopoietic system might function in parallel and autonomously, they need the whole system to manifest this *autopoietic* function. The mind can function on its own with the proper input/trigger, but without a body it cannot see and perceive the manifestation of this function. In order to be understood, everything needs to be measurable/manifestable to some extent and medium.

On the other hand, although such systems are possible to create, there is still the question of how they are manifested and perceived by the audience/performers that interact with them. When in an immersive environment, does the magic of technology overcome the purpose of the system or is the system indeed inviting you to co-perform and co-exist in the same space, and how can we develop that relationship? By calling systems interactive, designers are usually expecting significant movements and steps from the human/user in order to function as they should. If I go now to my computer and tell it to make me a coffee (even with voice recognition), it will not understand. Even *Siri*, which is a remarkable step for the field of voice recognition, will suggest places to go for coffee, thereby ignoring my need, which was initially a craving for an instant cup of coffee. This stems from a design process that requires the user to follow a series of actions in order to achieve her or his goal through a cause and effect scheme.

The possibility for a computer to make coffee does not yet exist, obviously this is an exaggeration, but that is not the point. This is pursuant to what Haque observed about designers who “‘often use the word ‘interactive’ to describe systems that simply react to input” [134]. What I am trying to emphasise here, is the lack of empathy. In addition, the computer’s disability to learn, to be adaptive, which makes most of the systems reactive and not interactive. It is true that ‘*usability and utility alone are too narrow a perspective to understand the relation between humans and technology from a design point of view*’ [Kuutti 2009][135]*.* Thus, we should focus, especially in the

field of human-computer interaction, on creating systems that will be constantly evolving and will continuously be learning and adapting from and to the user and the surrounding environment. In such a way, we will be able to create non pre-determined experiences.

By emphasising this kind of user-system relationship, in a sense we are forging the interaction design with a touch of empathy — as an adaptive process. “Empathy helps us better understand consequences in two ways: We anticipate the effects of our actions on others, and we experience the emotions of others who have made similar choices” [Fabricant 2009][136]. The simulation and anticipation of social experiences in digitally enhanced spaces might be helpful for research and creation of such spaces, however it is not enough nor my intended goal. When designing responsive environments and interactive systems, I would suggest that we (the designers) should not focus on the creation and coding practice to support only one particular narrative.

> “Different design strategies need to be implemented when constructing interactive improvisational environments, for the traditional predetermined action->reaction model yields limited set of results for the performer, and turns the improvisation into a structured game within a predefined set of rules with little space for expressivity, intentionality, and nuanced control. Therefore, the design process should be flexible and organic enough to allow stakeholders a wider array of possibilities, a finer control over the system, and a common language between the performer and the designer to allow better communication of needs and obstacles” [Alfaleh, Chandolias 2014][*137*].

3.3 Approaches in Interaction/Responsive System Design

Through my investigations, I have approached the creation of interactive systems from four different points of view: the *engineering*, the *design*, the *philosophical* and the *performance* perspective. These four parameters form an excellent ensemble for the creation of a successful interactive system. One could start by approaching an initial idea and research question, which is inevitably informed by the rest of the components as well, by developing a well engineered system in order to be able to investigate and to fulfill the intended goal. Thereafter, to further advise and optimise the results, one would have to implement some design techniques as well. Eventually, when reflecting and analysing the system and the performance from a philosophical point of view,

the results can offer insights for how the performance was actually perceived and felt by the performer and the audience.

Dubberly et al. [138] identified and described several iterations of interactive systems. They have categorised interactive systems according to their static or dynamic qualities. Dynamic Interactive systems that are formed from intelligent enough components and have a *learning* or *feedback interpreting* mechanism, belong to the *Second Order Systems*. This paradigm defines interactive systems capable of readjusting their goal by measuring the effects of the previous interactions between the different components (systems) to the environment [139]. As Lympouridis has recognised and I will adopt, there are three types of these *second order systems* that appear to be more pertinent for this genre of work; *Learning Systems, Managing and Entertaining Systems, Conversing Systems.*

> "A Learning System: The output of a linear system provides input for a learning system. If the learning system also supplies input to the linear system, closing the loop, then the learning system may gauge the effect of its actions and [adapt its behaviour].
>
> A Managing and Entertaining System: The output of a self-regulating system becomes input for a learning system...Often the application's goal is to keep users engaged, for example, increasing difficulty as player skill increases or introducing surprises as activity falls, provoking renewed activity.
>
> A Conversing System: The output of one learning system becomes input for another. This type of interaction is like peer-to-peer conversation and the systems learn from each other" [140].

Further reflecting on his theory, Lympouridis identifies three types of systems that could portray the responsive relationship that exists between the performer (being either a user, a performer or a spectator) and the interactive system, as *methodical*, *empirical* and *dialectic.* With the *methodical* system, he describes a system that pertains to the *Learning System* where the performer's actions are mapped to specific responses. The *empirical* system is in consonance with the *Managing and Entertaining System,* where the system is enhanced with more advanced processes and algorithms that can evolve through time, creating a dynamic relationship between the performer and the responsive environment. The user is invited to improvise, learn and adapt to the system responses. Finally, the *dialectic* system that pertains to the *Conversing System,* is closely related to artificial intelligent techniques, where the interactive system can interpret and analyse the performer's input as feedback and respond accordingly. These types of systems could be closely related to living organisms, with organisational, behavioural and learning properties.

Bearing all this in mind, and in combination with how Dixon classified the relationships that potentially can be formed between the performer and an interactive system, as *Navigation, Participation, Conversation and Collaboration,* we could argue that any combinations of this complex design process could offer a different yet valuable perspective in the field.

For my two research-creation projects for my thesis work, *Orbital Resonance* and *Storytelling Space,* I have tried to experiment with, and combine, the above mentioned techniques, according to what my collaborators and I agreed about in the process. Meanwhile, it is noteworthy to mention that I am personally driven from the idea of systems being able to converse with the performers/ interactors, and although I haven't developed any digital agents (as defined by A.I.) per se, this intention is clearly demonstrated by the way the systems I have developed, and worked with, are functioning.

An example of systems that manifest in a similar way as the one described above is a descendant of the TGarden performance space, the Ozone4 [141] system. It is a

> "media choreography system[142] based on layered, continuous physical models, designed for building a diverse range of interactive spaces that coordinate arbitrary streams of video and audio synthesised in realtime response to continuous, concurrent activity by people in a live event. Ozone4 provides an expressive way to compose the potential 'land-scape' of an event evolving according to the designer's intent as well as contingent activity" [Sha et al. 2010][143].

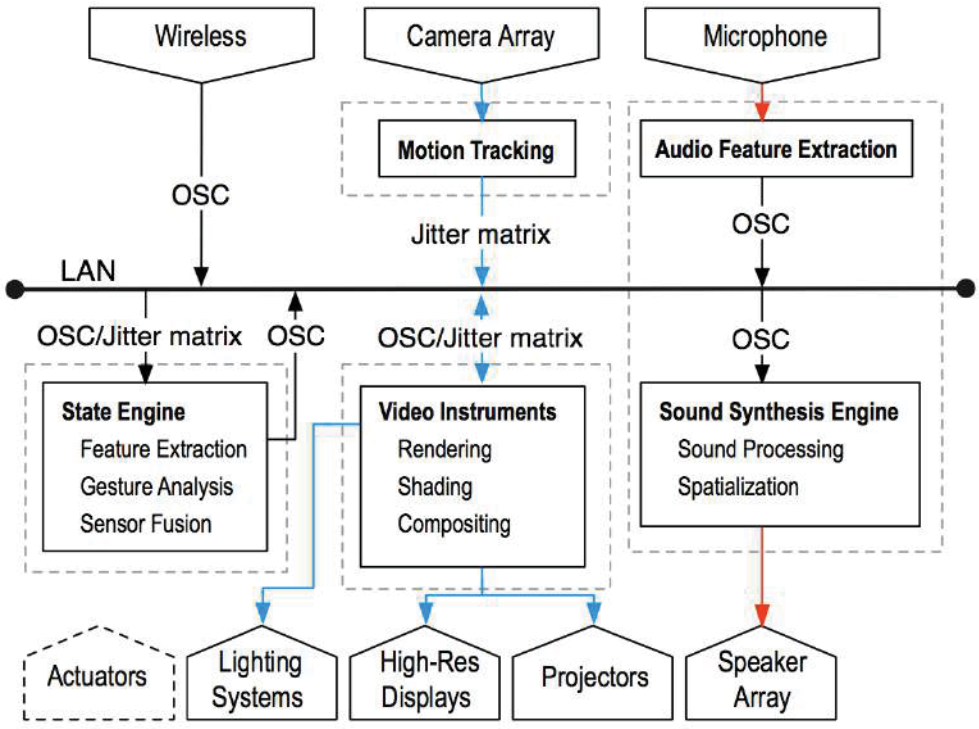

Figure 12: Ozone4, system diagram, by Topological Media Lab and Sha Xin Wei

The media are driven from a state-engine, that drives different predefined states, based on the designer's intentions and the performer's input to the system. The users are invited to explore freely the enhanced space where *Ozone4* resides, since it is not based on any form of linguistic rules or narrative scenarios. Trained or untrained bodies can explore, navigate and converse with the system since the state-engine will analyse and generate responses for any amount of sensor input data, or even in absence of them.

For the completion of my research and experiments, listed here are some methods, which in combination with the above mentioned techniques, are crucial in order to examine and develop new methodologies for responsive performative environments. The technological design I am proposing, always being informed by and for the body, voice and speech, as I mentioned before, follows threads of adaptive, processual programming (software, movement analysis, voice-speech analysis) in combination with visual and modular programming techniques and hands-free systems. Although intriguing work has been done in the field of interactive performances, exploring the body and movement in relation to digital technologies and the design of interactive media, the potentialities of voice and speech in this context have been left floundering. Numerous artistic installations have tried to explore this field, but most of the explorations are evolving around specific artistic events. I am proposing a system that will provide a continuous ontology to explore the potentials of syntactic and semantic analysis in the field of interactive art and multimodal applications in combination with whole body movement. By using constant data streams, this research permits the provision of ongoing qualitative data, referencing momentary changes in behaviour, movement, speech and voice patterns, which is depicted in the *Storytelling Platform*.

The process and methodologies undertaken for the research creation projects under discussion are quite complex due to the fact that my involvement in the projects is not only that of a creative engineer, interactive media developer and technologist, but also that of an active participant and performer, especially in the *Orbital Resonance* workshop process and performance event. It is important to note that an attuned focus on maintaining a horizontal collaborative spirit with other artists, performers, musicians and creative technologists, was key at all times. This involved continuous discussions around language, methods, learning and teaching, patience with different practices, and an understanding of knowing and accepting limits, whether with the technology or within me. In order for these experiments to be successful and fruitful for all parties involved, it is necessary to implement different design strategies when constructing this responsive improvisational environment. Therefore, the "design processes followed must be flexible and organic enough in order to permit participant to have a wider array of possibilities and create a common language between the stakeholders to allow better communication of needs and obstacles" [Alfaleh, Chandolias et al. 2014][144]. For instance, in the Orbital Resonance Residency, Margaret Westby and I were involved throughout the whole process of movement and technology

creation, because collaboration as such, I will argue, is a key aspect when we want to create environments and systems for performative spaces.

In addition, experimental music practices including Deep Listening by composer Pauline Oliveros [145] and improvisational techniques by Topological Media Lab in both sound and movement informed my process and creative content.

Correspondingly, the notion of experience is fundamental to my explorations. In order to create powerful and meaningful experiences, it is necessary to examine emergent narratives that occur in such digitally enhanced spaces. Inevitably, as in any other field, narrative and narration forms have been involved in the digital era, starting from *multiform stories* [Murray 1998][146] to interactive narrative, and moving into more recent territories of emergent narrative that is mostly used in the digital game industry and the Object-Oriented Interactive Cinema (OOIC). This informs my work in this thesis for the way that experiences and narrations work. As Marie Laure Ryan writes in her book Avatar's of story "[…] sense making can also result from the drawing of analogies and contrasts between phenomena, rather than from the chronological and causal ordering of individual events" [147]. Generally speaking, narrative could be any account of connected events. Creating environments where the event is the environment itself, conversing with each individual's input nuances, allows the creation of an event that is uniquely experienced and felt by each person. In these environments, multiple parallel narratives can flourish in tandem.

Murray states the importance of spontaneity, audience involvement, and the combination of the pleasure of witnessing a performance while simultaneously participating in the creative invention, by proposing simplicity in structure so that the event can be easily grasped by the users but also flexibility so that it can capture and respond to a wider range of human behaviour [148]. That is pursuant to Richard Walsh's *Emergent Narrative in Interactive Media,* where an emergent narrative is not the result of a topdown script but what emerges from the interactions among the members of the group—that is, the elements of the system. This can get quite complicated in the context of digital media. To clarify, he later quotes Tinsley Gaylen:

"We all construct narratives out of our daily activities to help us remember, understand, categorise and share experiences. It is this skill that many interactive systems exploit. They give us environments to explore. We, by combining the elements of these spaces with our goals (the user's goals), allow a narrative to emerge. If any narrative structure (or story) emerges it is a product of our interactions and goals as we navigate the experience" [149].

In that sense, we are talking about a narrative that is more related to experience and sense making. Thus, in this case, I am not referring to narrative as a script-based, user-system interaction

in a mediated environment, but rather as something that should be perceived as a user sense-making process for the interactions that occur in the space; thus, a *semiotic* use of the system.

There are several frameworks that allow us to create these types of interactions and systems. To name but a few, there are MAX/MSP, OpenFrameworks, Processing, TouchDesign and Isadora. In my design, I aim for solutions that combine the concepts of dynamic morphology and adaptive software development. This combination provides a particularly strong and customisable framework for the realisation of multimodal systems that go even beyond the scope of its original design. This will allow the system to evolve over time and to provide a range of outcomes that will enunciate the input dynamics as Garth Paine suggests for the design of similar systems [150]. The advantage of an object-oriented programming (in Java, C++, C#) approach is that units of functionality can be dynamically created, combined, detached and disposed, so that they fulfill the momentary requirements of the program.

4. Storytelling Platform

In this chapter, I describe an in-depth investigation for the realisation of a system that is able to combine gesture and vocal recognition for interactive art, live events, speech based expressive applications and performative spaces. I propose a responsive environment that is not based on pre-determined interactions, but on building a dynamic system as an ecology that performs and evolves on its own and that is able to co-perform and interact with the spectator, without dictating an effect or playing the role of puppeteer. Practically, the result of these investigations is the creation of a flexible platform for collaborative and improvisatory storytelling, combining voice and movement. This work advances both conceptual and technical research relating speech, body, and performance using digital technologies and interactive media.

The Storytelling Space is an immersive, responsive system that responds to vocal and gestural inputs. Speech implicates speaking bodies, a subset of bodies in motion. Thus, I concentrate on how natural language and body movement and presence can work smoothly and non-hierarchically together to construct meaning in live performance. The purpose is not to duplicate the performance but to supplement and augment the experience of the story that is being unfolded with a performer and the audience. Leveraging TML's realtime media manipulation frameworks and mapping strategies, in combination with the advanced and innovative speech recognition and analysis system, speech is no longer exogenous but forms an essential part of the surrounding media, as animated glyphs, visual graphics, light fields and soundscapes.

4.1 Introduction

> "The voice appears to be the most familiar thing. When I say "voice," when I use this word without further qualification, then the most immediate thing that comes to mind is no doubt the most usual one: the omnipresent use of the voice in our everyday communication. We use our voices, and we listen to voices at every moment; all our social life is mediated by the voice[…]" [Dolar 2016][151].

This platform has been deployed to take into consideration the semantic values of the spoken utterances but also the prosodic features and the quality of the voice, creating complex and

meaningful interactions that are not only focusing on speech visualisation or mapping techniques that are aiming only for an aesthetically plausible effect.

Informed by previous applications exploiting speech to text representation and signal analysis of features of the voice, I advance this genre of work by fusing natural language processing (NLP) techniques and semantic networks together with realtime signal analysis adapted from music and sound processing. These techniques allow me to investigate the potentials of speech (pattern) tracking instead of solely performing speech recognition (more generally pattern recognition) [152]. This chapter describes the platform, its technical design, and the conceptual contexts and implications for this work.

Golan Levin and Zachary Lieberman[153] point out that speech visualisation has generally been treated as a scientific problem, but artists have begun to use these techniques in installation and performance. Although their work focusses on non-utilitarian speech representation and voice patterns and encases the viewer in equipment, it is still valuable to examine when dealing with voice and speech in interactive art [154]. Practitioners in those fields have developed or refined a range of widely adopted and useful visualisation techniques, including waveform graphs, spectral and formant plots, etc., which help solve the problems those practitioners encounter. The *Storytelling Platform* adjoins semantic and prosodic patterns from continuous speech and voice input in order to provide nuance and gesturality derived from vocal performance for unencumbered whole body movement and dance.

The platform is designed for the situation where the interactor will walk into the *Storytelling Space* already intending to verbally and gesturally tell a story. It could be an already known story, such as a fable, or it could also be a story of his/her own that he/she makes up on the fly. As the story unfolds, his/her words will be displayed partially (only words with 'high lexical' value – a context-dependent function) in the room in various forms. The words are then visually displayed and morphed according to the voice characteristics, so that the same voice that creates the text glyphs also deforms and eventually extinguishes them. Speech characteristics are used to create the appropriate ambience for the story, augmenting the experience. For example, if the word 'forest' is spoken once then almost nothing may happen, but if it is continually repeated, or words that are associated with it according to the semantic analysis, then the ambience of the room may suggest that of a forest, by modifying the lighting (light animation) and the sound field, creating a multimodal, real-time responsive media environment. So the story becomes the centre of the storytelling environment, creating its environment and changing its state according to the lexical/ semantical content and prosodic qualities of the speaker's voice.

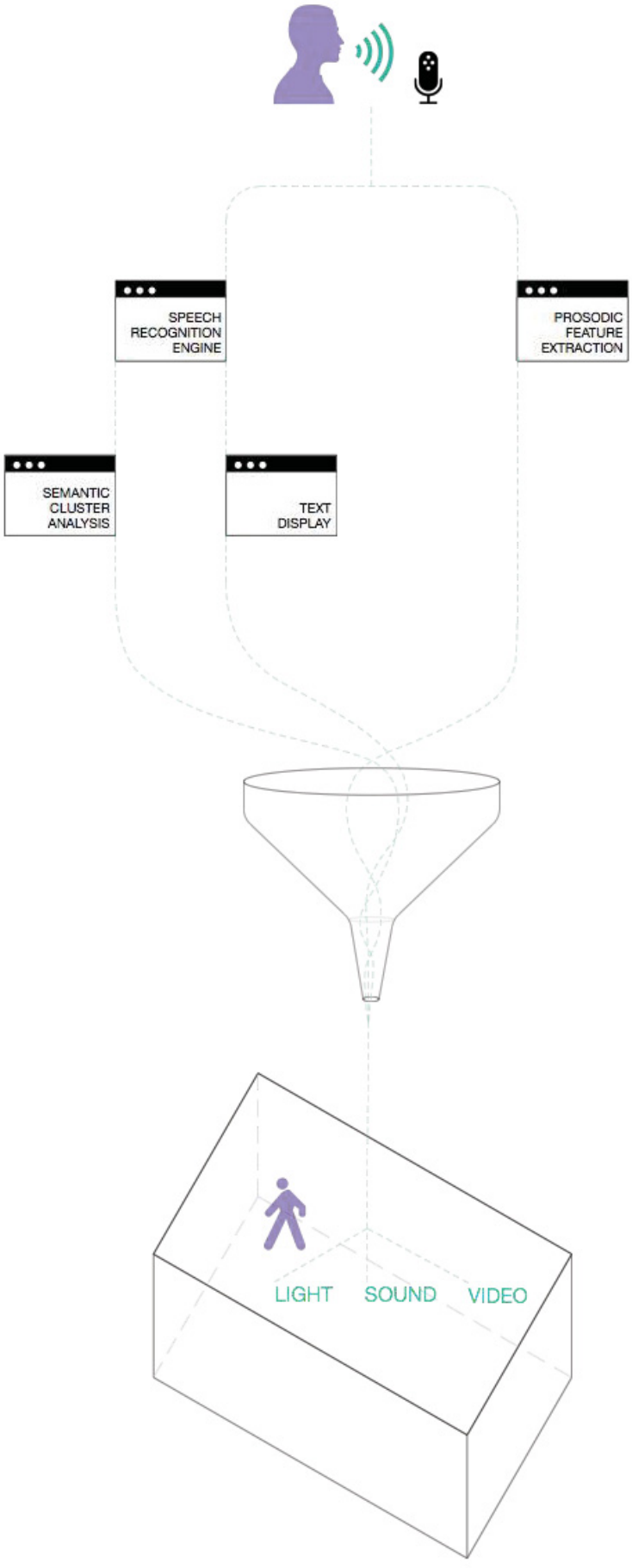

Diagram 1: Storytelling Platform System Architecture

The motivating research question arising in artistic practice is: how can performance combine movement and spoken word or textual image without one of the two being merely the gloss or illustration of the other? How can movement and speech or text offer independent yet related perspectives that allow the viewer to imaginatively span them?

4.2 Storytelling Platform: Technical Context

For the purposes of the *Storytelling Platform*[155], the development of a new speech recognition engine was crucial. By leveraging advances in speech recognition that permit real-time, speaker-independent use, I propose to re-engineer some common, robust underlying sound and speech analysis engines and to create new interfaces that move away from their original design purpose – transcribing speech into documents (files) or for issuing commands to a computer – to live performance where we do not require word by word transcription but rather continuous feature indices. Thus, instead of speech recognition (more generally pattern recognition), I engineer *speech (pattern) tracking*.

The main observations that set my initial perspective for the investigation in speech recognition concerns an absence, so far, of a design approach (in the speech based interactive art), which leverages speaker-independence and relaxation of demands on user-based training of the recognition system.

The Storytelling Platform has been developed in *Java SE 1.6* and uses the API's of the *Stanford Parser*[156] for the linguistic analysis, *Apache Commons*[157] for the communication with the databases and *Open Sound Control (OSC)*[158] for transmitting and receiving time-stamped data streams between applications on a network. The prosodic features of the voices are extracted with the help of fairly powerful *IRCAM* libraries: *OMAX*[159], and *CATART*[160] and the *zsa.descriptors*[161] under the *MAX/ MSP 6* [162] realtime data flow programming environment for manipulating and synthesising time-based media.

4.2.1 Speech Recognition Engine

Live speech comes from within the body; it even starts with one of the most fundamental movements of the body: breathing. The performer wears a wireless microphone which transmits acoustic data continuously to a fixed computer, while time-based media – sound, video, lighting fills the space modulated by the inhabitants' actions. Diagram 1 outlines the platform's architecture.

In order to obtain all the necessary information, as well as for the research to be well articulated, I am extracting both linguistic and prosodic information, from the voice and speech input. Thus, the voice signal is processed through the system and provides us with the cooked sensor data that consist of the transcribed text of the spoken words and the prosodic characteristics of the voice. The process that is followed for the speech recognition to happen is demonstrated in Diagram 2.

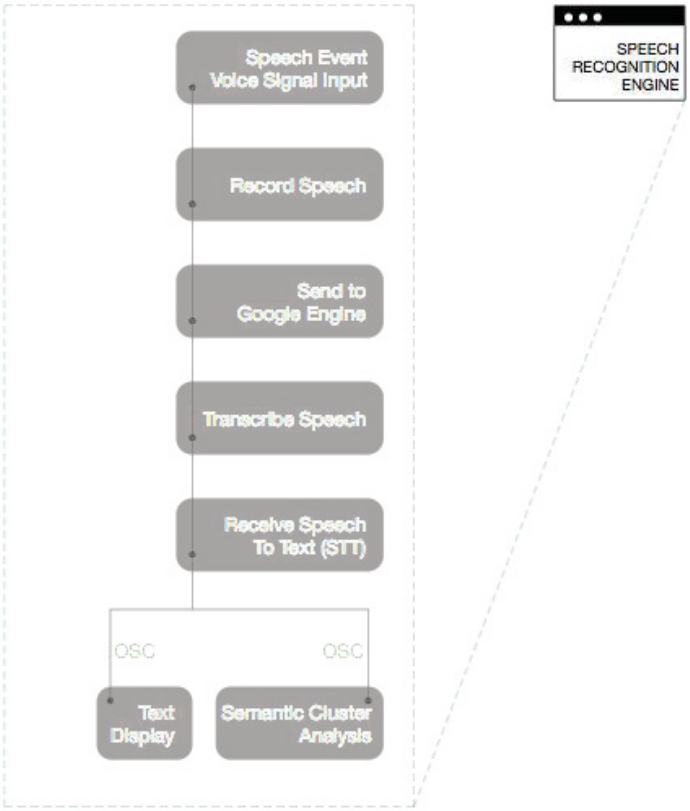

Diagram 2: Speech Analysis

For the speech recognition engine I am using Google Chrome's HTML5 feature that enables speech recognition for input fields, implemented as a Java Library through an interface, created for usability purposes. The interface allows for on-the-fly access to the settings of the speech recognition engine, such as language changes, as well as auto calibration processes for the voice

input in order to adapt to each environment, as seen in Figure 14. The interface is also enabled to communicate Open-Sound-Control (OSC) messages with the rest of the system, allowing continuous flows of data to be used for media manipulation and analysis.

At this point, it is noteworthy to mention that all the components of the Storytelling Platform have been developed as different independent modules that can function on their own as well as in tandem with each other, like most of the technological systems that I have developed and examined for my research purposes. That means that the components of the system can be separated, recombined or even used on their own in a different context. Modular programming enforces logical boundaries between components and improves maintainability. In case a module ceases to function, it will not disrupt the function of the other modules.

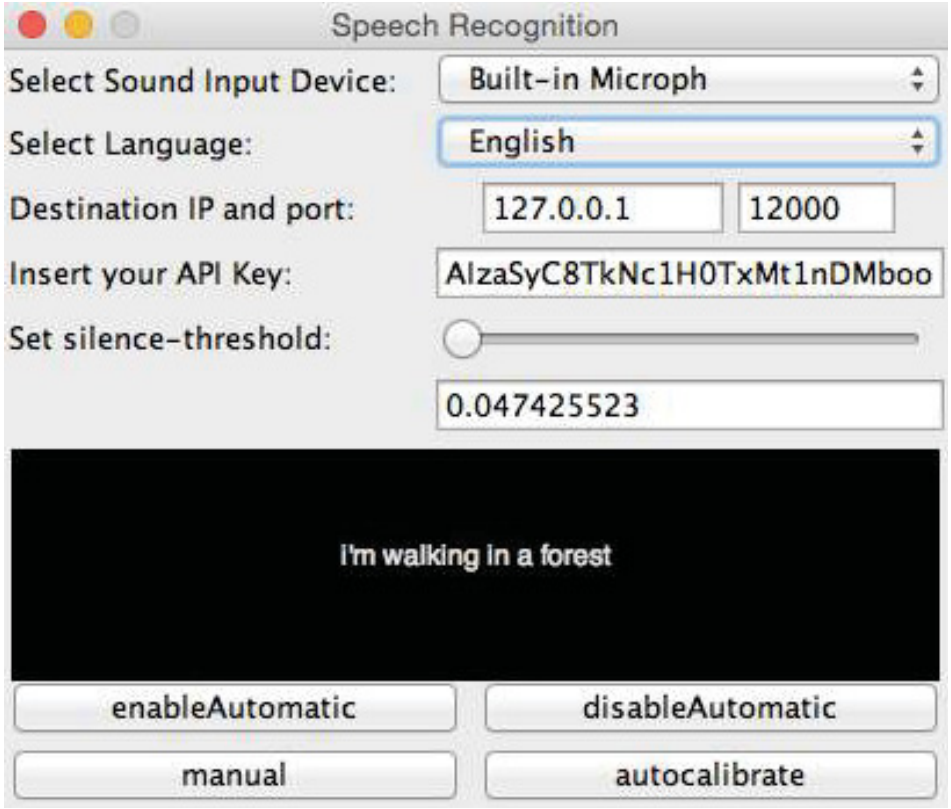

Figure 14: Speech Recognition Engine

The languages that the system can recognise (set in advance) are English, French, Spanish, German and Chinese without requiring any training. There are more languages and different dialects that the system can interpret and transcribe [163]. The speech recognition is achieved by recording a sound file of the uttered speech, sending it to Google's servers, transcribing it to text and then receiving it back as a string. The speech recognition can be performed either automatically or manually. In automatic [164] mode the system measures the environment's noisiness

and sets the threshold to record and subscribe anything that passes the threshold, as soon as the person stops talking or a short silence is detected, the analysis is performed. The automatic mode performs exceptionally well in a silent environment where the silences and small pauses in between the sentences are easily detectable. The manual mode allows the user to decide when the speech recognition commences and when it stops. Given that the speech recognition is being performed on recordings and is based on a network connection, smaller recordings are transcribed proportionally faster than larger recordings. The latency depends on the network connection. The silence (or noisiness) threshold can also be set manually in either mode. Once the speech has been recognised and transcribed, the text utterance is saved in a database in order to be used for the creation of the responsive environment and is forwarded (with the use of OSC) to the S*emantic Cluster Analysis Module*.

4.2.2 Natural Language Processing Engine

Once the utterance has been saved in the database, the system uses the Stanford Parser[165] to analyse each word by using Natural Language Processing (NLP) techniques, which extract the key concepts and relationships that characterise each utterance. Natural language processing (NLP) techniques from a scientific point of view mainly focus on the interactions between humans and computers on a (natural) language level, and although this is surely fascinating, nevertheless, the problem itself is quite complex: natural language understanding is referred to as an unsolved, strong Artificial Intelligence (AI) problem, which requires extensive knowledge about semantics and the ability to compute semantics. [166] The utilisation of requirements-extraction methodologies [167] allows me not only to be able to extract linguistic data from the spoken words but also the relationship of the words as well as the part of the speech (PoS) they belong to. The system creates two two-dimensional lists. In the first, we have lists with all the information concerning each token (word) of the utterance, and each list contains the word, the stemmed word and the PoS tag. The second includes the lists with the dependencies between the words. This means that it includes the words themselves, the correlations between them and the number of the token (placement of the word in the utterance). In Table 1 we are demonstrating the result of the parsing of an utterance: ”I am in a forest”.

Tokenizing and Parsing: I am in a forest				
Tokens:				
I	am	in	a	forest
Word, Stemmed Word and PoS:				
[I, I, PRP]	[am, be, VBP]	[in, in, IN]	[a, a, DT]	[forest, forest, NN]
Typed Dependencies:				
nsubj	am	I	2	1
det	forest	a	5	4
prep_in	am	forest	2	5

Table 1: Example of Tokenizing and Parsing a sentence with Stanford Parser

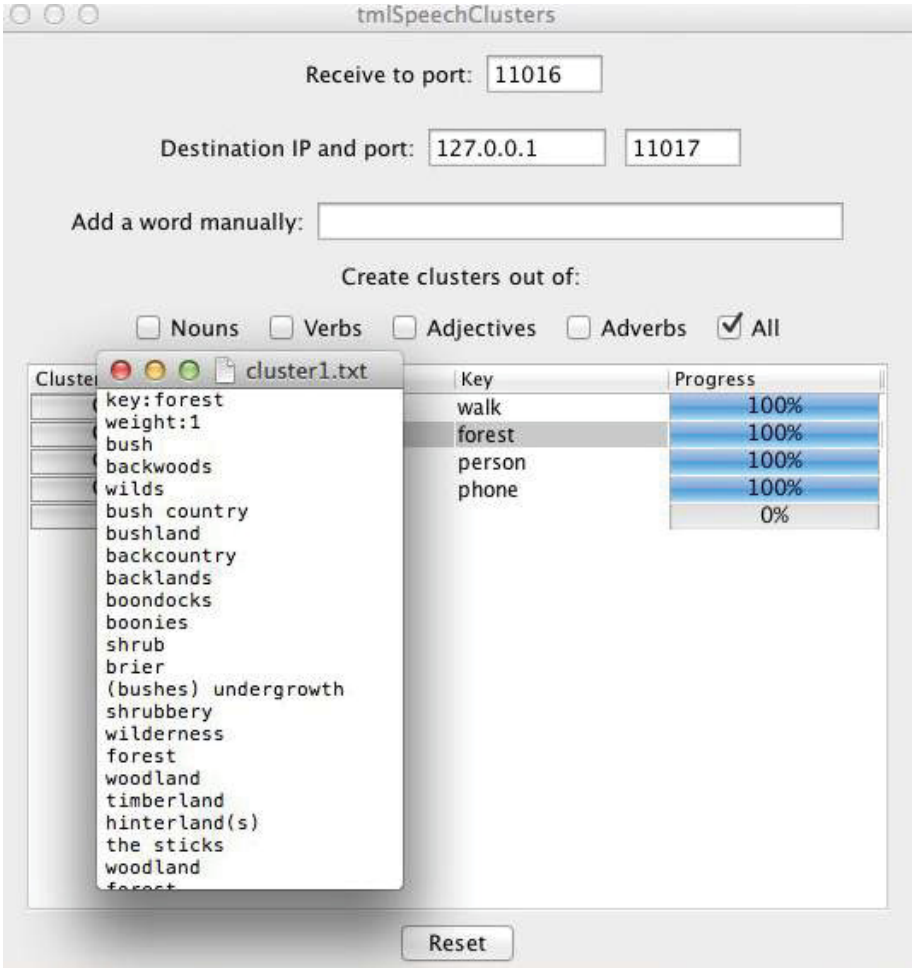

Figure 15: Semantic Cluster Analysis Module

This word to word category disambiguation enables the system to analyse specific parts of speech (verbs, adverbs, nouns or adjectives), utilising its functionality to the maximum with a minimum amount of latency for the analysis to occur. Furthermore, this data could be used to further

investigate and enunciate the speech and performative acts that occur in the space. For instance, if we choose to receive information about the verbs that are being uttered in the Storytelling space, then we could analyse the content and see if they semantically imply some sort of action (something active, like running etc.). Further along, we could modulate the media of the environment to enhance the content of the conversation that takes place. The system itself is now an active participant in the act of speech. For the purposes of this thesis, I have focused my investigation on the creation and analysis of semantic network clusters. The above mentioned potential is possible, since the analysis data are there, but have not been fully developed.

Once the analysis has finished, the system extracts the words that have the most semantic information and creates the semantic clusters. After the NLP analysis occurred, the data are sent to the Oxford American Writers Thesaurus (OAWT)[168]. The process of creating the semantic clusters is shown in Diagram 3 and the interface in Figure 15. As the stream of text is parsed and tokenised, and dependencies are extracted using Stanford Parser, the system identifies the most semantically significant lexical units and constructs appropriate semantic clusters. The process of construction of the semantic classes relies on the semantic network of the Oxford American Writer's Thesaurus. In Diagram 3 you can see the graph of the process that is being followed in order to create the semantic clusters, the keys and the states.

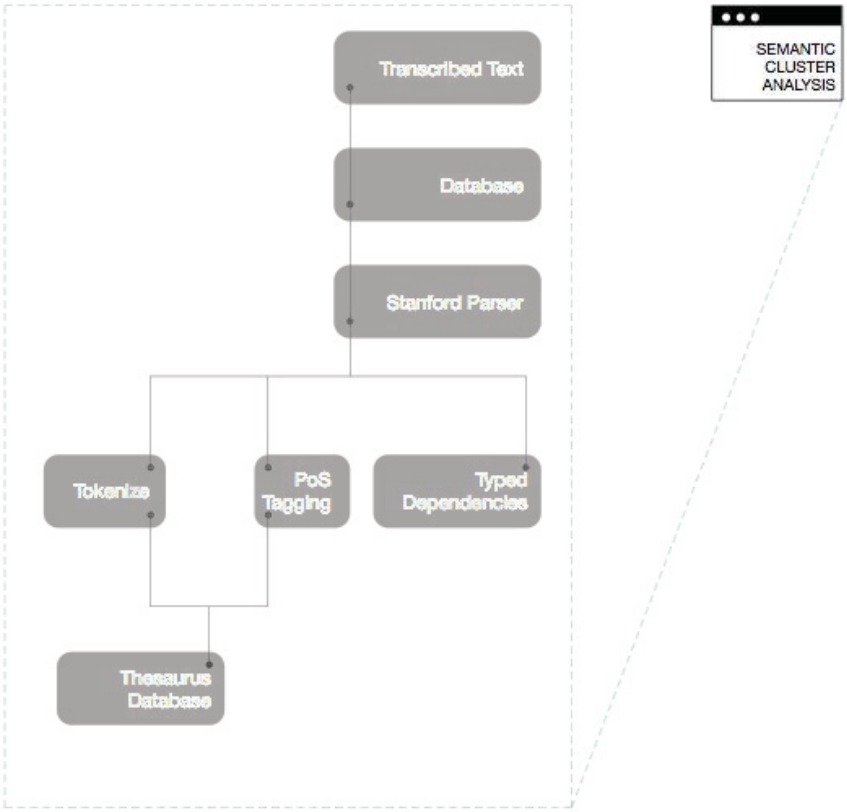

Diagram 3: Semantic Cluster Analysis Process

Once the cluster (pattern) of a token has been created, it is directly associated with a key. The key is the word that triggered the creation of the semantic cluster. Each semantic cluster also has a weight that is used to measure how many times the key has been generated, or in other words, how many times the semantic idea that the cluster holds has been implied in the story that has unfolded in the active space.

The OAWT is a rich synonymy knowledge base for (human) writers, available as a printed version or through the Dictionary program in the OSX. These data have been automatically extracted from the OSX's application dictionary, and represented as a database with a simple schema, reflecting the networked nature of the thesaurus [169]. The OAWT database accommodates two sets of entries: a set of "nodes", i.e. all the terms that are mentioned in the thesaurus, and a set of "edges", i.e. the links between the nodes as they appear in the OAWT. Overall, the database contains 53,009 nodes and 276,235 edges representing all Part of Speech (PoS).

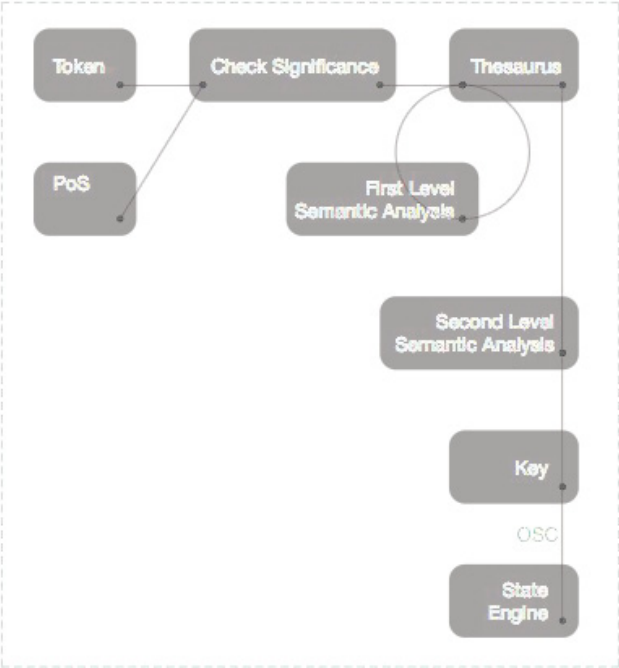

Diagram 4: Cluster Creation Process

The sample entry in the OAWT is shown in Table 2, where the headword (forest) is provided with the list of synonyms. All the words in the entry 'forest' are contained in the table 'nodes' and for every pair of headword-synonym (forest-woods, forest-timberland etc), there exists a directed edge in the table 'edges'. Also, every edge is labeled with the word sense label. In the case of the 'forest' entry, the edges are labeled 'noun1' since there is only one word sense and 'forest' is a noun. For many other terms in the OAWT that are polysemous ('wood' as 'a hard fibrous material' and 'an

area of land') and/or belong to multiple POS ('plant' is a verb and a noun), word sense label is an important way of disambiguation.

forest
noun
the cooling shade of the forest: wood(s), woodland, timber- land, trees, bush, plantation; jungle, rain forest, pinewood; archaic greenwood; taiga, boreal forest, Carolinian forest, Acadian forest.

Table 2: OAWT entry for forest

Each semantically significant lexical unit initiates its own semantic cluster (or gets attached to some existing one in case the cluster has been already generated) which is iteratively expanded over the corresponding entries in the Oxford American Writer's Thesaurus (OAWT). If during the live performance the word 'forest' has been identified as semantically significant, the first run over the OAWT expands the semantic cluster of 'forest' with the words appearing in Table 2. In the following iteration, every string that is contained in the expanded cluster undergoes the process again. For instance, for the cluster that was started by 'forest', the terms appearing under the headword 'wood' in the OAWT will be appended to the semantic cluster at this point.

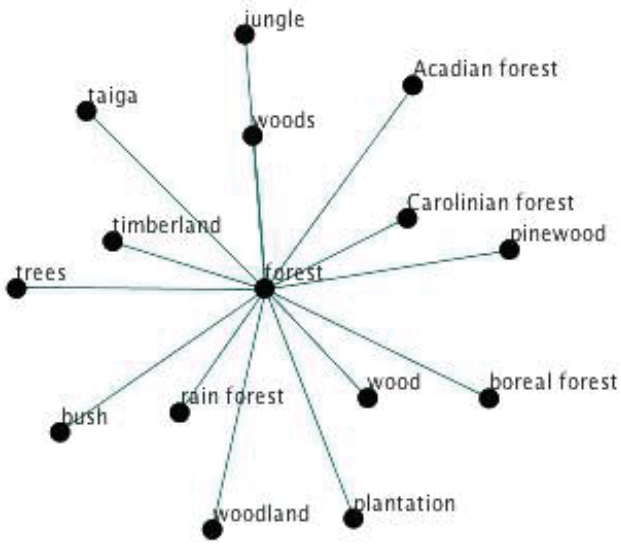

Diagram 5: First Level Semantic Analysis

The part of the platform that we have described so far has a latency of some seconds due to the computational complexity. However, we do not worry about that because this part is running in the background in order to gradually and magically transform the space according to the spoken words. By design, we can pace the state of the story-augmentation system to the pace of theatrical ”beats” that typically endure for minutes.

The system creates a two-dimensional list which contains lists with all the semantic families of the processed word (up to two levels). Here, for example in Diagram 5, we have the first semantic cluster of the word: ‘forest’. The same procedure for each word of the first cluster is being followed to create the second level semantic cluster. For example, here you can read the result below, in Diagram 6. The result of the above mentioned analysis is a network of semantic clusters that is generated from the uttered words.

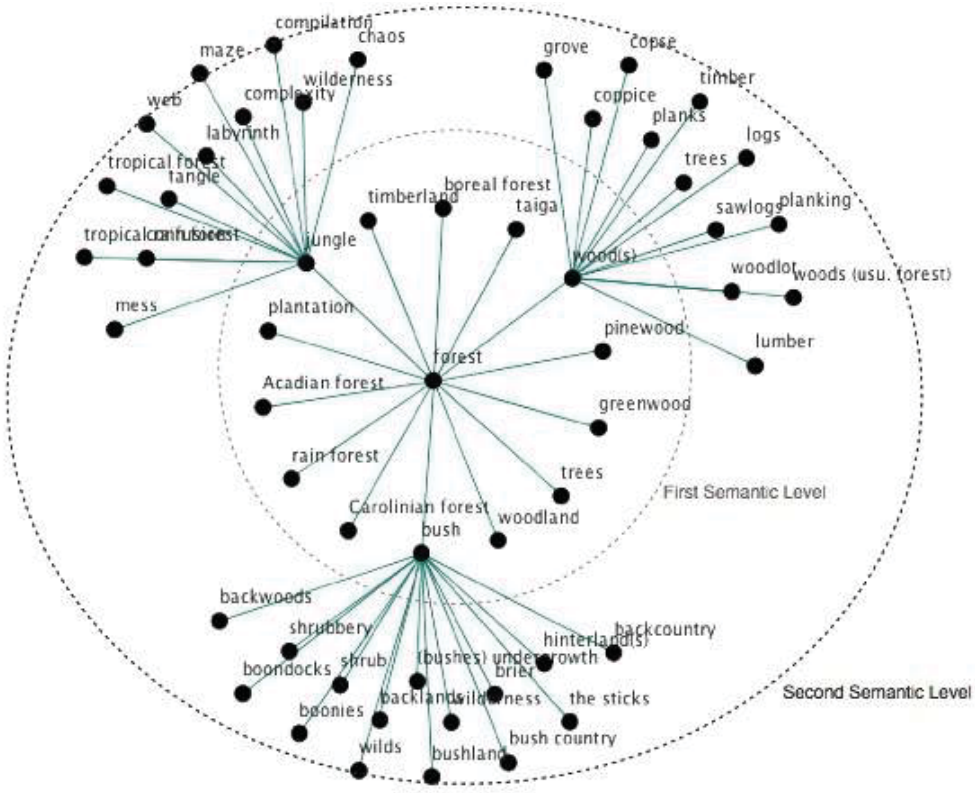

Diagram 6: Second Level Semantic Analysis

4.2.3 The State Engine

The state-engine maps voice and speech data into fields of time-based media such as video and sound derived from the continuous states of an event imagined by the designer. The Storytelling Space state-engine is built for our specific purposes but it could also be used as a general composition system that can yield a great variety of installation-events since it is based in a similar idea of the Ozone's system state-engine. The states are being used in order to create the ambience of the environment. Once the cluster keys have been generated, as described above, they are sent to this state-engine. As described by Sha Xin Wei et al (for *Ozone*), the state-engine idea refers to a specific system

> ”as a software system for choreographing media in concert with people's activities in a responsive environment. It maps data into fields of time- based media such as realtime video and sound derived from continuous states evolving over a simplicial complex defined on metaphorical labels on possible states of an event imagined by a designer.' This idea 'allows composers to intuitively design a ”landscape” of possible states that evolve in response to the players' activities. The state evolution system generalises from a finite- state machine to continuous evolution of superposable states with reproducible kinematics” [Sha et al. 2010][170].

When there is no activity in the space, the mediated environment is in the *abyss state*, where everything is frozen. When the performer starts to unfold a story, the system analyses the input data, as previously described, and passes them to the engine. Then, the state-engine maps the data in the states that have been labeled by the designer, enhancing the environment accordingly. When data comes in that has not been mapped or does not necessarily correspond to the linguistics of the states that the designer has set, the platform's architecture allows the designer to physically drag and drop the unmapped data and correlate them with one of the metaphorical states.

That way, the designer's and the performer's intuitive thinking is being provoked, allowing them to create poetry by developing direct contact on the fly between semantic components that might not be linguistically, directly connected, but can be meaningfully combined to drive the state of the environment and the performance. By developing such systems, the performer is enabled to take the role not only of interactor, but also simultaneously of creator; their behaviour creates the environment and the environment conditions their behaviour.

For instance, in the example of the state-engine that we provide in Figure 16, it is obvious that in the beginning, the *abyss state* is active since there is no activity in the Storytelling space, but as the performer begins to improvise a story, data come through our system feeding the different states, thereby mediating the environment with sound, lights and video projections. When the data are not linguistically connected to our states, we allow the media artist to map them in the different states depending on how he/she sees poetically appropriate for the performance.

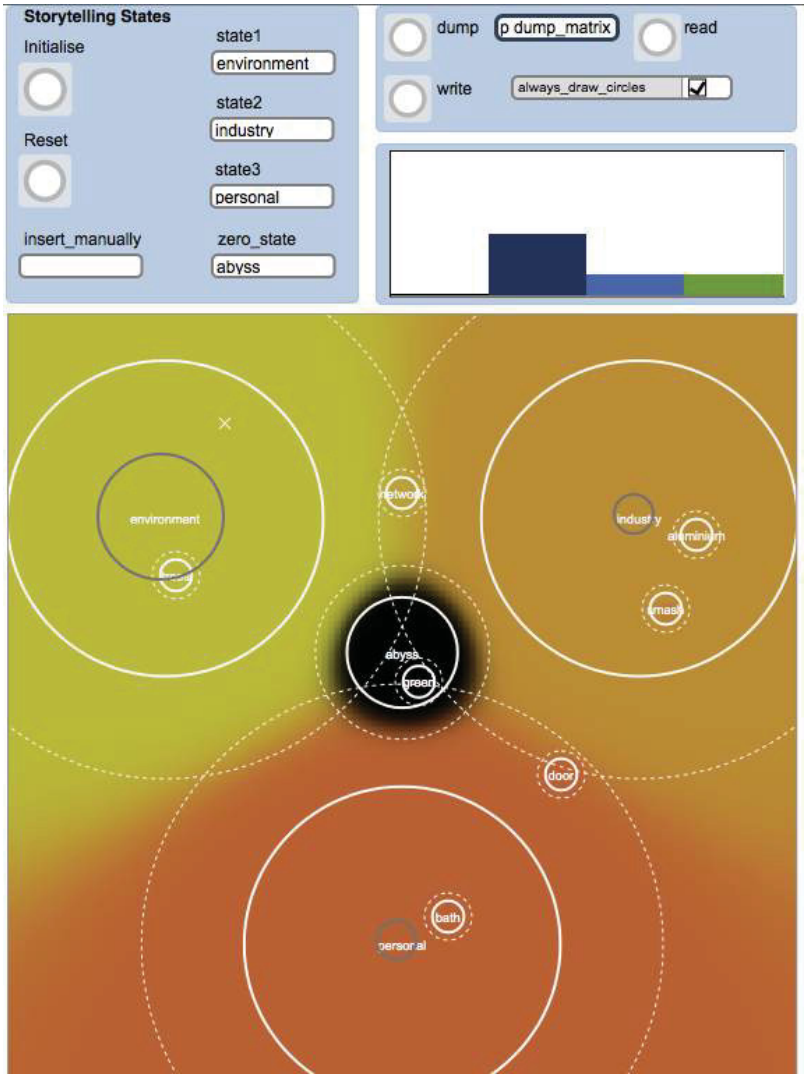

Figure 16: Storytelling Platform state-engine

In the prototype presented in Figure 17, I am exploring and demonstrating some of the possibilities of Natural Language Processing in the context of live performance. As the performer speaks the system analyses the spoken words as described above. As the story is being developed by the performer the environment is shifting from one state to another, according to the censoring data that occur from the system analysis. The projected videos shift from an industrial environment to a more forest-like environment accompanying the shift in the improvisatory story of the performer.

Figure 17: Semantic Cluster Analysis in live performance, performer: Michael Montanaro

As the performer (Michael Montanaro) stated after the demo-performance in March 2013 at Concordia's BlackBox, it was really intriguing for him to tell a story in the activated space. There were moments, as he admitted, that the space itself and the mediations that occurred from the storytelling analysis, were leading the narration since he could perceive the modulations that were happening in the space and he was trying to either follow them or change them, in a sense converse with them. This was not just driven out of mere playfulness, but I would ague that it was an attempt to co-construct all the potential con-current possibilities with the system. The linguistic interactions that occur in the *Storytelling Space* position language as a tool that is not just used for communication or the transmission of information, but as a factor that can mediate behaviour and affect the cognitive re-construction of the space through the different mechanisms of mediation that reshape the space itself.

4.2.4 Real-time Speech Processes

Simultaneous with the process that is described above, the transcribed speech instantly creates animated text from the same utterance. For the glyphs animation, different softwares and techniques have been tested and developed.

4.2.4.1 Transcribed Speech Animation

Initially, to animate the glyphs I have explored the potentialities of using Vector-Based Video technics, such as the NextText library [171], designed by Jason Lewis for poetry and spoken word performance. NextText is a Java library for building applications to display dynamic and interactive text-based applications. The library uses TrueType fonts to render text, which moves and changes shape according to a set of rules. The programmer has full control over the text and the rules defining its behaviour.

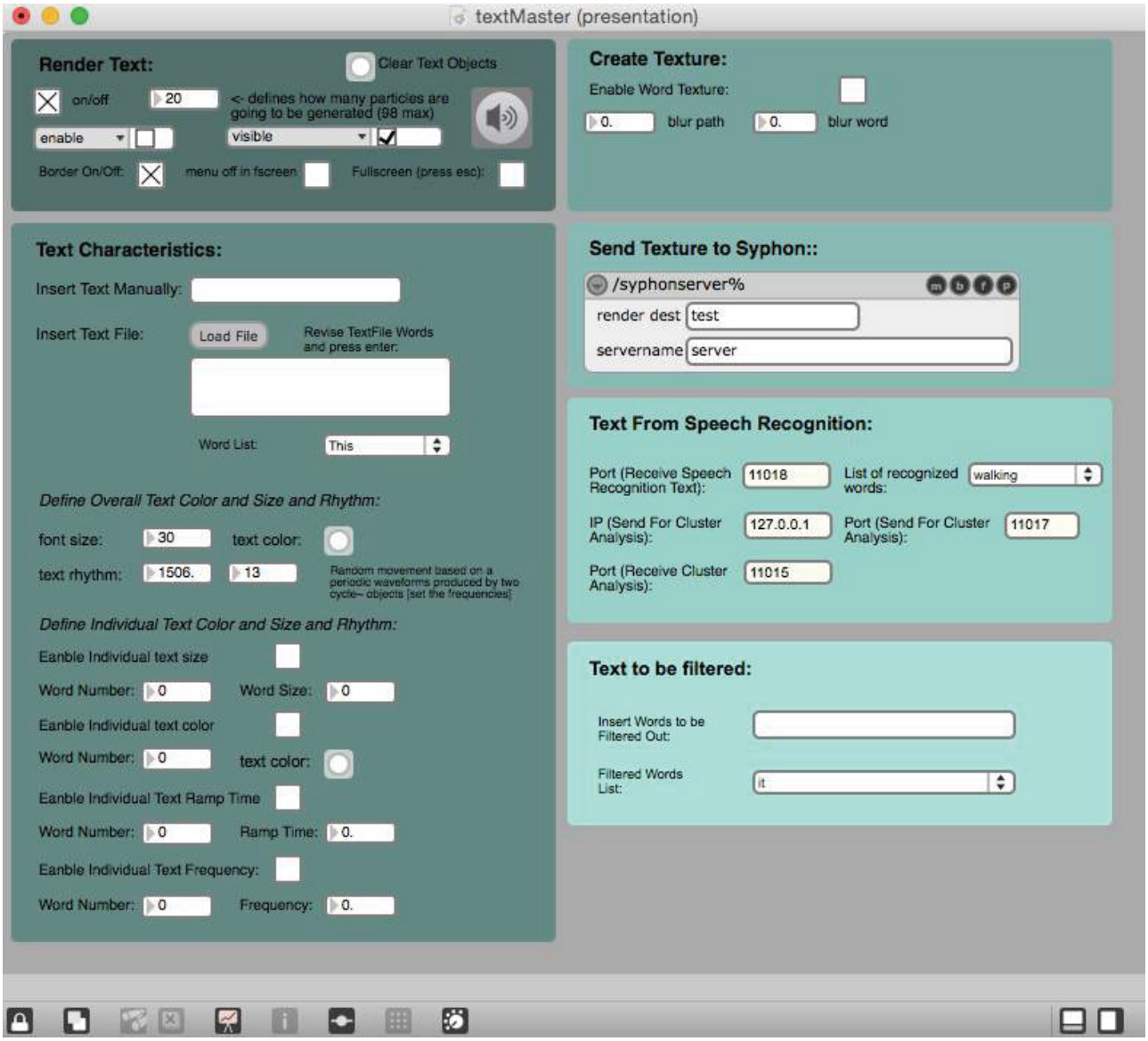

Figure 18: Text Display Module

From the above experimentations, a module for text display and manipulation emerged. The module receives through OSC the transcribed utterances and after filtering the words in comparison to a programmed list of unwanted, or inappropriate words (always depending on the

context of how and where the platform is being used) displays and animates the words according to the desired behaviour. In one state, the words are projected on the floor, and their size is affected by the volume of the voice. As the performer moves, the words scatter away from his/her body or follow him/her, as if they have agency of their own. In another, the words are mapped around the performer's body and surround him/her. Furthermore, different textures have been embedded in the system, enabling it to even further blur the line between the words as a burier of semantic signification or a responsive light structure in the space. Additionally, on another iteration, the words are being made out of particles that burst into thousands small particles as you move and crossover them inside the space, only to go back to their original position to shape the word again.

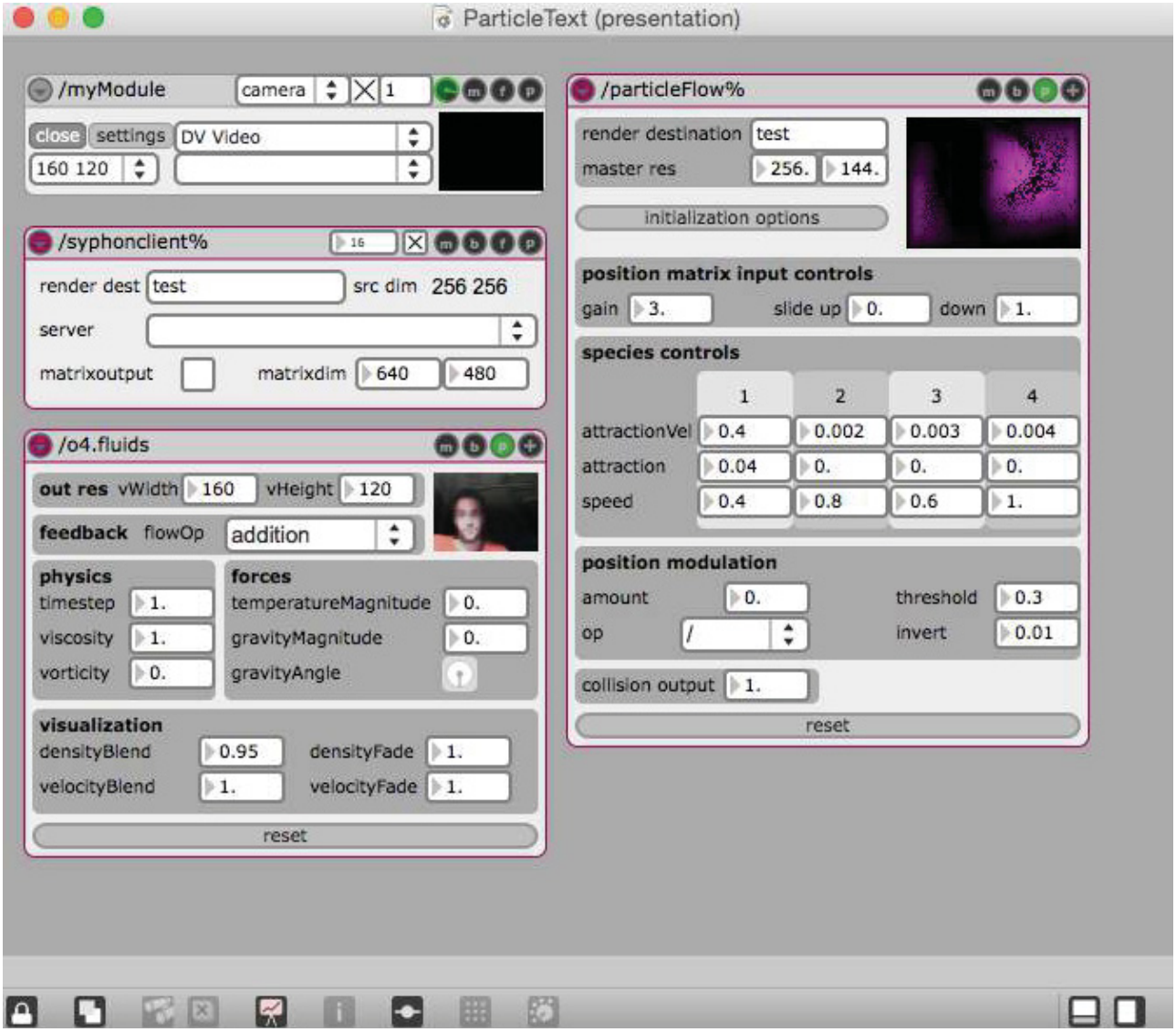

Figure 19: Text as Texture to Particle System Module

4.2.4.2 Speech Prosodic Feature Extraction

Furthermore, despite the speech to animated text process, the system provides a very sophisticated algorithm that analyses the features of the voice. The features that I am extracting by processing the voice signal are, among others: Loudness (which will be the amplitude of the input signal), Periodicity and Noisiness, among other prosodic features of the voice that give information for the speech and the quality of the voice.

This module (Figure 19) has been created inside the Max/Msp framework. As Mikhail Malt and Emmanuel Jourdan mention in their paper[172] , by using the Zsa.Descriptors library, the system extracts spectral information by performing the Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT), intended to provide a set of audio descriptors specially designed to be used in real-time. The system itself manages the necessary signal windowing, overlapping and adding needed to create a real-time Short Term Fourier Transformation (STFT) analysis, aiming to provide an easy way of getting unique descriptors.

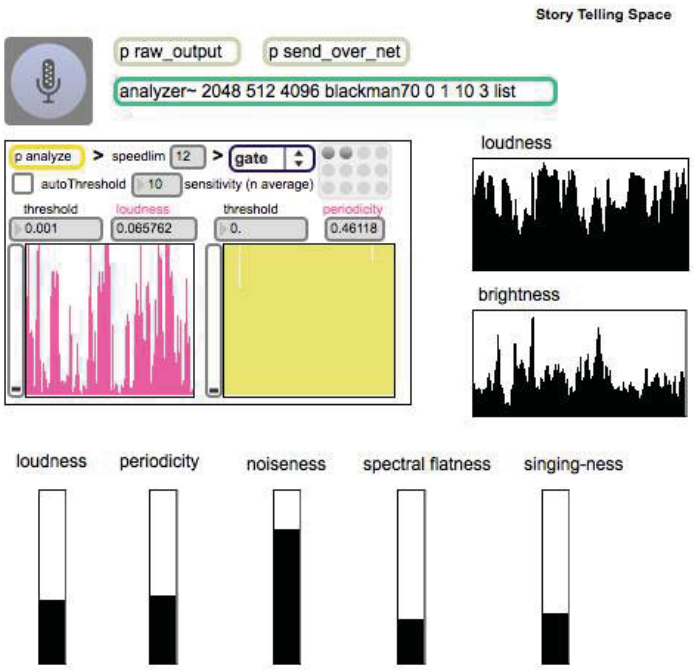

Figure 20: Prosodic Feature Extraction Module

As Nygaard et al. state in their paper [173], research into prosodic characteristics of speech has focused almost exclusively on two aspects of its contribution to communicative events. The first concerns the processing and disambiguation of the structure of spoken language and the second

concerns the role of prosody in indicating the emotional or attitudinal state of the speaker. Considering this valuable scientific research, I am proposing to extend the use of the prosodic features beyond the semantic representations by searching for ‘sonic patterns’ of speech that can be treated as prosodic textures that can modulate time-based media, which condition a live-action event.

Semantic representation may seem more canonical from the perspective of NLP. However a speaker can make utterances that all map to the token ‘hello’ but in countlessly different ways. In our research, we are investigating how we can overcome the obstacle of simple representation and use the prosody of the speech and typography to enhance the experience. An example of the current system is shown in Figure 20.

Figure 21: Excerpt from Text Visualisation Module - Voice Amplitude mapped to Text Size

4.2.5 Characteristic Time

At this point, it is notable that the NLP implementations I am proposing are up to three orders of magnitude slower than the signal processing techniques, seconds instead of milliseconds. However, I suggest that we turn this to the system’s advantage because this works quite well with the state-based event design method introduced earlier. It’s true that a dramatic state has the characteristic time of a theatrical beat – seconds or minutes of time as experienced by a spectator. However, in order for media to feel palpably correlated to the performer’s vocal and gestural nuance, the media ”physics” must be coupled tightly to the corresponding bodily or vocal gesture.

In fact, the media system is designed for response with negligible perceptual latency, depending on modality. The state-based composition approach is naturally suited to treat the cluster analysis as labels on theatrical states that evolve as the performer builds her story with the audience in human time, rather than computer processor time.

The temporal scale also affects the clusters' network. The network expands and populates itself with new utterances that arise from the story constantly. The new utterances, depending on the semantic associations that they carry, could merge under a state-label with other already existing clusters, or could shift the attention of the story to another state-label, creating a constant semantic fluctuation that is intertwined with the narrative.

4.3 Contextualising in Practice

In summary, the innovative technical contribution is a story-telling platform that fuses Natural Language Processing Algorithms, Semantic and Prosodic gestural labeling of a verbal stream in order to provide a framework for continuously blending streams or sequences of multimodal media with speech.

4.3.1 Prior Art

Hubbub [Sha, Lewis, Korpi et al. 2004] is a prior application of the TML research treating speech as a computational substance for architectural construction, complementary to its role as a medium of communication. Hubbub installations may be built into a bench, in a bus stop, a bar, a cafe, a school courtyard, a plaza, a park. As you walk by a Hubbub installation, the words you speak will dance in projection across the surfaces according to the energy and prosody of your voice. For example, loud speech produces bold text. As you walk through a Hubbub space, your speech is picked up by microphones and then is partially recognised and converted to text. Associated text is projected onto the walls, furniture and other surfaces around you, as animated glyphs whose dancing motion reflects the energy and prosody of your speech.[174]

Intralocutor [Lewis et al. 2007] is an interactive installation that has been made in the Obx labs. Intralocutor allows two participants to play with ways of visualising their speech. A real-time video capture is made of the two and projected onto a wall behind them. The video has been altered so that all observers see is the silhouettes of the two. As they begin speaking, the speech of person A becomes visible, moves from person A's mouth and interacts with person B's silhouette. Depending on the qualities of person A's speech, such as speed, volume, pitch and rhythm, his/her words might bounce off person B's silhouette, or penetrate it, or simply stick to the "skin." The appearance of the words also responds to the speech qualities. For instance, words said with stress appear elongated and shaky; words said with a heightened volume expand; words said with a quickened rhythm come out crowded together.[175]

Figure 22: Hubbub Installation, Topological Media Lab, 2002

Figure 23: Intralocutor Installation, Obx Lab, 2008

4.3.2 Conceptual Stakes

What is at stake in my research, with speech tracking for story-telling, is where and how meaning is made when people use language with each other: i) the distinction between lexical/syntactic representation and pragmatic semantics, and ii) the distinction between language as a tool for information transmission and communication vs. theories of *languaging* as a process of making meaning and shaping experiences through language [176].

In the case of storytelling, this means, for example, that we do not focus only on the performer or the story, but we take into account all the stakeholders of the event. This means that the story, the performer, the media, the environment and the relationships between all these form a system, where each element is in a constant conversation with the rest. Storytelling, is not a matter of one disembodied mind transmitting units of information to other isolated minds that build up a ”mental model” of a situation, but a co-construction of a shared field of regard, attention, aspirations, objects, situations, imaginative scenarios, and fictive history. The storyteller’s words build beacons and landmarks, characters and relations into the unfolding event. The storyteller modulates her voice to shape, orient, or drive the pacing and emotional dynamics of the shared retrospection, attention, and anticipation of the entire assembly of people that are present in the responsive media environment.

By including quantitative movement analysis algorithms in the system, everybody who is present in the intelligent ambient space is able to *perform*, modulate and shift the story by moving in the space and being in converse with what is happening. The collective movement (from each individual), in tandem with the voice and speech/story of the performer, can modulate the light and sound files, which in turn influence the story itself. Deepening the work in a performance art context gives me the opportunity to further investigate the potential of the system under the demands of live improvised actions. With the use of language and speech, certain questions arise and the relations between body and mind, movement and language become thus most profound.

These relationships are further highlighted when thought, as Sha Xin Wei wrote about the *Hubbub*[177] installation:

> ”United States law recognises ’fighting words’ – utterances that when spoken under certain conditions have the same legal impact as a physical blow, so you can sue for such speech as if you had been physically attacked. Why? Beyond the semantic content of the words, speech is sonic; its sonic field co-permeates both the body of the one who speaks and the one who hears, rendering them acoustically coincident

> in their tissue and blood. Ethically one holds responsibility for what one does corporeally with respect to another body. Therefore the sonic field, since it permeates all bodies present, constitutes an ethical medium by its very trans-corporeal extension".[178]

Hubbub is not only trying to address the spatio-temporality of speech but is also attempting to populate the theoretical gap between speech and text by materialising glyphs that dance according to the prosody of live speech but persist with text's iterable durability. Correspondingly, David (Jhave) Johnston has claimed that pieces of text, when encountered as audio-visual forms animated by quasi-intelligent dynamics in digital media, become widely perceived as animated entities. People regard animated glyphs as things to be tamed or played with rather than a functional and abstract system of communicative symbols [179]. Extending Johnston's concept further raises a practical challenge for artists and engineers: accepting the suggestion that the animated glyph has a dynamical behaviour that greatly exceeds a simple mechanical model of coarse macroscopic action and reaction, how should we most effectively and efficiently choreograph the continuous nuances of bodies of text together with bodies of performers?

Figure 24: Transcribed Speech to Text Animation Experiment, performer: Patricia Duquette

It is true that "[the voice] makes the utterance possible, but it disappears in it, it goes up in smoke in the meaning being produced" [180]. The spoken words of the performer carry a communicative

value that they already have attached to them, a semantic component that has evolved and transformed throughout the history of language. In parallel, the sound of the voice (its sonic qualities) is also vanishing, as noted by Frances Dyson [181]. By introducing the above mentioned technological mediations (techniques of speech recognition and signal feature extraction), speech is no longer ephemeral, but it is embedded in and forms part of the space itself. In the experiment depicted in Figure 23, I am exploring such possibilities of transcribed text from spoken utterances. The text is being projected on the ground and the performer's movements in space displace the words as if the performer was walking on particles of sands. Sometimes they move away fast and sometimes they change slowly, manifesting a form of agency themselves. The qualities of the voice are depicted in the text's size. In another experiment, the words themselves are made of particles and as the performer moves across them, the words scatter into a million pieces, only to retreat to their initial position after a while, moving back and forth between aesthetic abstractions and lexical notations, embracing the performer's movements.

By using text from live utterance and combining it in animated form with movement, I aim to highlight its potential, not as a synchronic representation of some fact or past situation but as a temporal, dynamic dimension of live performance. Highlighting the prosodic features of the voice raises fundamental questions about the tension between language as representation versus language-ing as performance. However, I do not propose to eliminate the linguistic factor, but by using semantical and prosodic aspects of the voice together, a robust dynamical system for verbal expression is created. Indeed, eliminating one or the other aspect impoverishes expression. Certainly, the voice undergoes some social filters to be materialised as speech, however the questions raised deal with the voice (and speech) both as a *vehicle of meaning* and as an *aesthetic admiration.* [182]

"We constantly inhabit the universe of voices" *[183],* where humans already perform richly with verbal expression, thus the intention is not to interpose computational processing between human interlocutors, but in parallel, to augment their coordinate activity of making stories. It is essential to note that the methods described make the physical features of the sonic field available for the shaping of the ethico-aesthetic aspects of a live event. The process of speaking endures over an extended time and place, and has temporal and spatial extent. Borrowing more precise semiotic language, my approach gives equal weight to diachronic as well as synchronic ("snap-shot") aspects of speech. In addition to the reduction to a form of writing afforded by tokenization, and subsequent "semantic" analysis, the system not only treats speech's semantic content but also indexes its variation related to corporeal – vocal, manual, whole body – gestures in physical space and energy.

4.3.3 Reflections

A major issue of the continuous speech recognition engines, despite the fact that now they allow the users to speak almost naturally, is that speech recognition methods typically parse the speech stream[184] with silence detection algorithms. That means that utterances might be recognised in different chunks than the ones that were originally spoken. More profoundly, this assumes that meaningful units must be separated by stillness, whereas many features of coordinating and co-structuring an event span across local ”zero-crossings.” In any case, I use this feature to our advantage as the system ’re-arranges’ the spoken words leading to unintended but meaningful utterances. Especially, when the spoken words derive from poetry, the results could lead to many fresh interpretations.

Another issue that I have encountered during the development and the experiments with the storytelling platform is the fact that transcribed speech, although it might yield expressive and interesting results from a spectator’s perspective in an installation context, in an improvisation performance, might easily grow stagnant for the performer. Initially, a playful activity that pans between body movement and speech actions appears appealing to the performer inside the active space, but if this relationship remains the same, and the mechanism remains unchangeable through time, then this conversation could become trivial. By introducing different states of possible responses that deftly weave together all the activity inside the space, the goal is not complexity but an enriched environment. However, as the performer Patricia Duquette and I have noted, the relationship between the semantic attribute of the word and the projected/animated word is an issue that is hard to overcome. This might be received as an opposition of the work being presented above, nonetheless it is a concern, cultivated from the power of language that I am trying to address through these different experiments. That is one of the reasons why I firmly believe that introducing the use of NLP techniques and a dynamical state evolution system could tackle this subject. [185]

5. Orbital Resonance

The use of different strategies for creating technologically augmented improvisation performances, focused more on the sonic qualities this time and on technological designs that are informed by and for the body, led to a two month-long residency (experimental workshops) at Concordia's Hexagram Blackbox and to a performance presentation entitled *Orbital Resonance*.

Orbital Resonance is an exploration into responsive environments and live performance events. The stakeholders come together from multiple disciplines, including dance, engineering, performing arts and electroacoustic, to collaborate on a technologically augmented dance performance. The work explores the potentialities of sound and movement improvisation through breath, voice and body sensors, including x-OSC, Pulse Sensor, Muscle Sensor and Heartbeat transmitter. In the process, the performers experiment with different internal physiological states of their bodies, outwardly displaced in light and in sound, to create an immersive sensual environment for them and for the audience. The larger environment merges the interactions of various elements (audience, performers, light, sound, architecture, sensors) into a unified, existential orbit.

The workshops were consisted of a combination of kinaesethic methodologies and technological apparatuses. By applying a wide variety of sound spatialisation techniques, motion analysis techniques and experimenting with different sensors, we explored different competent data extraction and mapping approaches. These investigations informed our movement and system design processes, which led to unique relationships between the performers' bodies, sound, sensors and the audience. The interactions among all elements become blurred where co-creation of situations arises within the responsive environment.

5.1 Introduction

> "...a subject only becomes interesting, deep, profound, worthwhile when it resonates with others, is effected, moved, put into motion by new entities whose differences are registered in new and unexpected ways" [186].
>
> Latour

The project is a collaboration with artist, researcher and PhD in Humanities candidate Margaret Westby, with participation from experimental musician and sound artist/researcher Doug Van Nort and transdisciplinary researcher, dancer and multimedia artist Anne Goldenberg. Given our different backgrounds, we were able to dive into a fruitful collaborative process and establish a skill-sharing relationship, especially with Westby, by participating non-hierarchically in both the technological and body-based practices.

As Westby and I wrote [187],

> "[the] name Orbital Resonance reflects the practical, conceptual, and aesthetic aims of the work. In the field of celestial mechanics, "orbital resonance" describes the phenomena when two or more orbiting bodies exert a natural frequency of momentum to remain synchronised based on their periods of revolution. To extend the metaphor of orbital resonance to technologically augmented performance, this involves merging technical apparatuses with moving bodies in an immersive environment. The results are a relationship that is always in flux where both stability and instability operate within all the interactive components. Following this notion, and, in particular, the idea of resonance as that which involves aural intensification within a body, whether human or other, the element of sound was crucial to create an intimate, sensorial experience. Originating from the bodies of the performers, the sound creates a continuous feedback loop in multiple dimensions, ever expanding with others to create an orbital resonance".

Resonance[188] only occurs when an object is vibrating at the natural frequency of another object by transferring energy. The word itself derives from the Latin word *resonare*, meaning 'to make a prolonged or echoing sound', which in a more technical context can be described as the "reinforcement or prolongation of sound by reflection or by the synchronous vibration of a

surrounding space or a neighbouring object" [189]. The idea of resonance as that which involves aural intensification that starts from within a body and interpolates with the surrounding environment and bodies, whether human or other, reflects the goals of *Orbital Resonance*: to create a resonating sound from our moving bodies in space through breathing, vocal sounds and physiological states, to intensify and spatialise these specific sounds in the whole environment, and to vibrate and transfer the sound to other objects like vibrating wooden platforms, the floor, the audience and technology, thereby weaving together all these elements into synchronous and asynchronous resonating correlative entities.

In a sense, orbital resonance, in the context of a technologically augmented dance performance, merges technical apparatuses with moving bodies, creating an immersive environment where all the interactive components are always in flux. Moving away from the discrete processes and typical interactive settings, we approach the building systems and the moving bodies as a unified '*living organism*' [190]. An *ambience* evolves through time, according to the sensory input data that it has been fed, forging a participatory event. This notion of ambience (atmosphere) in the digital realm, refers to, as I wrote earlier, systems that are able to evoke dynamic interactive engagement, and to converse with and adapt autonomously to the environment, the objects and the people that are inhabiting it, while considering all the spatial and temporal parameters. This '*aural metaphor'*, as Frances Dyson writes, evokes "affective states within social situations" where "mood, affect, emotion, and feeling" [191] all form an essential part of the experience and the co-creation of the event. Bearing in mind that these analogies, and the thought of atmospheres as such, "returns us to breath, to the continuous and necessary exchange between subject and environment, a movement that forms a multiplicity existing within the space necessary for sound to sound, and for Being, in whatever form, to resonate" [192].

Commencing from the body, the sound field evoked continuous interactions and interpolated between all the stakeholders and all the elements of the environment. The environment merged the interactions between all these elements (audience, performers, light, sound, architecture, sensors) into a unified, orbital resonance. The material, produced in real-time, resonated back into the space. The traces created their own life, interacting with themselves for new configurations and interpretations to arise among the participants (spectators and performers).

5.1.1 The Outcome: Performance Event

The performance event [193] took place in a black box space that consisted of a sound system, three computers used for the technical components of sound, the interactive lighting and the body sensor data, as well as two circular platform stages. The sound system consisted of eight speakers spread evenly around the space, four speakers above on the grid and two subwoofers in the back of the space. In addition, we implanted two transducers below the surface of the space, in the active area and under each platform, to create a fully immersive sonic and haptic environment.

Figure 25: Orbital Resonance, Concordia's Blackbox, Performance Event April 23-24, 2014

In the beginning, the space was submerged in pitch darkness, with the four performers (Westby, Van Nort, Goldenberg and I) dressed in black, equipped with wireless microphones, regulating our breathing, which was spatialized in the surrounding environment, unamplified. The audience was welcomed inside and invited to inhabit the space; there were no arranged seats except for the circular platforms that were part of the performance. Progressively, the improvisation moved from breathing to vocal noises that were amplified, filtered, and spatialized in real-time throughout the space while audience members were free at any point to participate in the improvised vocalisations and humming, as well as to move around the space. Suddenly, a faint spotlight appeared, corresponding to the bodies in the space, following and responding (by expanding and

contracting), according to the designed cues, to one of the performer's voices. The state reached a climax in volume, the light disappeared, and the attention shifted to the platform's vibrating sine waves and pulsed to our heartbeats by light (from underneath) and sound. Eventually, the performers started pulsating themselves, an impetus that initiated an improvisation in movement and in sound. The interactions among all elements became blurred where a co-creation of situations arose within the responsive environment.

5.2 Techniques

Focusing on a transdisciplinary approach, Westby and I initiated the project from a common interest to combine technology and dance, by creating a sonic, movement-based, immersive performative event, where the dance does not appear to be a stooge for the technology and vice versa.

There were two main goals (regarding movement, physicality and technology) that I wanted to achieve with this project, and they are also reflected in Westby's approach to the project. Firstly, I was interested in actively using and initiating all practices from the body - that means not only the movement but the technology itself. Instead of re-engineering already existing techniques, we were interested in implementing apparatuses that are already tested and used in a performance event by re-contextualising them in the service of *Orbital Resonance*. Secondly, an objective was to adapt these systems in a way that allowed us to step away from the computer screen, interrupting the (usually) typical digital performance set-up. This necessity forms an integral part of *Orbital Resonance*, since all of the stakeholders assume the roles of engineer/developer behind the screens and of performer/mover in the active space. *Orbital Resonance* explores different ways of approaching the typical set-up of a performance event, the different agencies in action, and the development of play within the environment for both performers and audience members.

During our experimental workshops, we followed current threads in open source projects (in software, hardware and movement creation) and the DIY (do-it-yourself) ethos, focusing on a more kinaesthetic approach. The kinaesthetic sense is imperative to comprehend bodies-in-motion in the context of technological design. As Loke and Robertson note, there is a wide range of technologies that mediate and encompass the human experience,

> "[yet] despite this growing focus on the lived, experiential body there is still a distinct lack of attention given to the central role of movement in perception and cognition, in our agency to act in the world and our experience of it [Merleau-Ponty 1962; Sheets-Johnstone 1999]"[194].

Therefore, in order to accomplish that, we do not just need virtuoso programmers and performers, but a necessity to manifest "an embodied approach that takes full account of the central role of the body and movement in lived cognition" [195] that can account for the multiple perspectives of "mover, observer, and machine" [196].

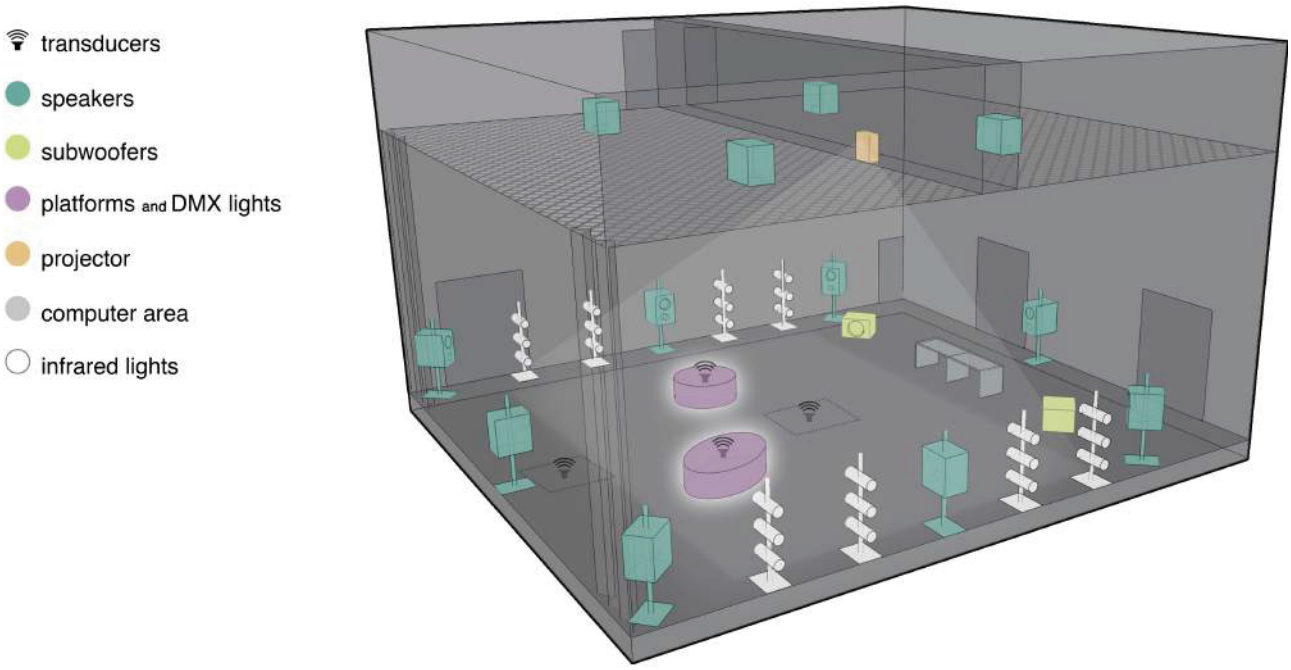

Figure 26: Orbital Resonance set-up at Concordia's Blackbox

5.2.1 Technology: Sounds, Sensors, Tracking System and Light

The most crucial component of *Orbital Resonance* was the creation of sound. Our objective was to create an immersive sonic environment that will evoke interesting movement improvisations and a participatory event, blurring the line between performer and spectator. As Garth Paine writes,

> ‘sound is perhaps the best medium with which to achieve a sense of immersion. It presents as a homogenised sound field, but may contain points of spatialized information, points of interest that seem separate, dynamically mobile and yet part of the whole. In order to achieve these objectives, the sound generation algorithms must be designed in such a way that the position of the spectator is considered in the sound spatialisation, and that the aesthetic of the sounds reflect an organic and approachable quality” [197].

In *Orbital Resonance*, the sound originating from our bodies created a continuous feedback loop, ever expanding in the environment.

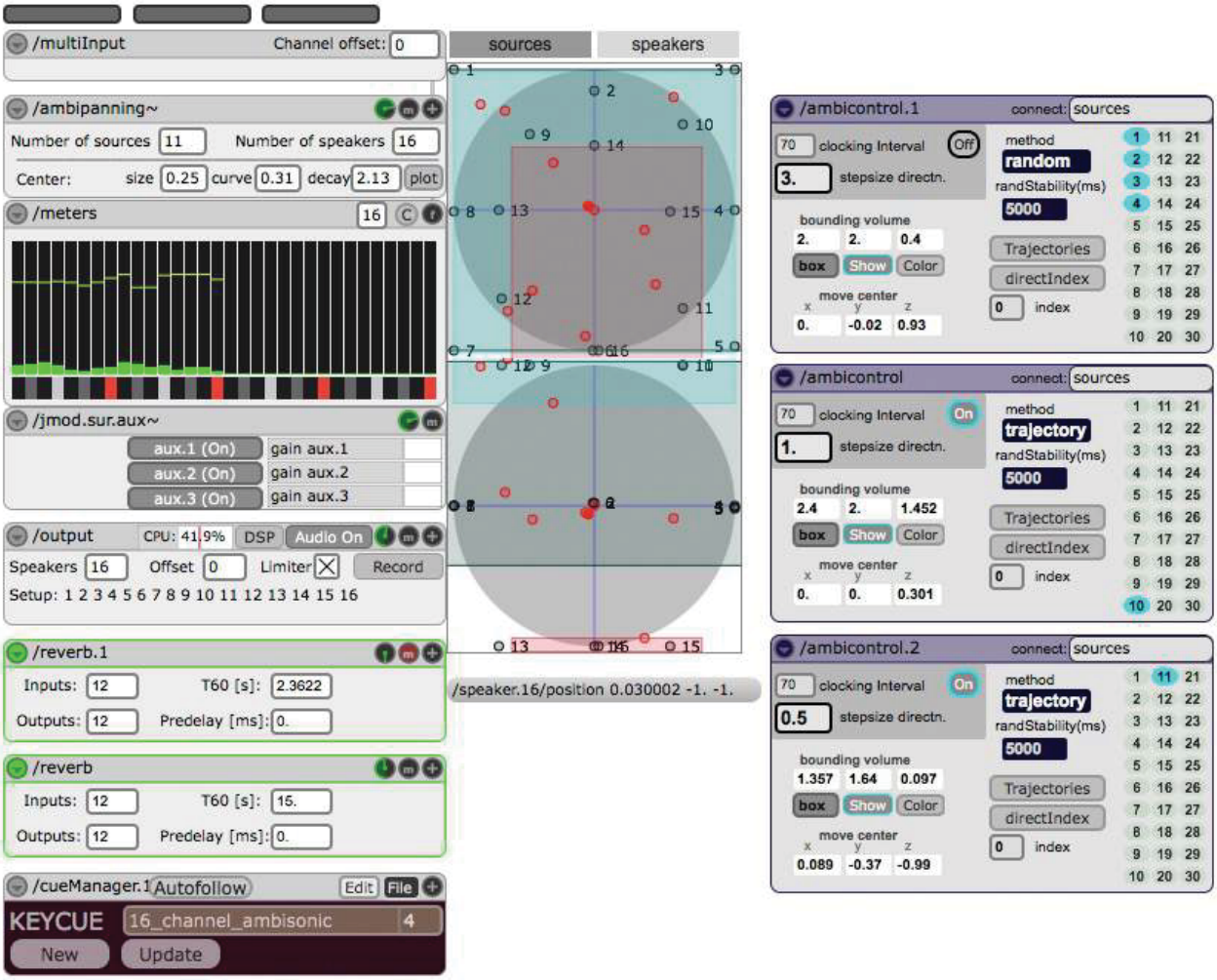

Figure 27: Spatialisation System

During our residency at Concordia’s Hexagram BlackBox, we experimented with different techniques, spatialisation systems and sensors to explore what meaningful associations and sonic transformations could arise from our bodies in sound and motion. This process informed what areas of insight and creation we wanted to investigate. We were all comfortable working with our

bodies through voice, but when more physicality was demanded during improvisational movement studies, not all participated. Personally, my interest bridged software development and movement creation, by experiencing the technologically augmented space and incorporating the role of developer and performer at the same time. Borrowing the optimistic approach of dance researcher Scott deLahunta, and given my background in both software engineer and dance, I too believe that dance and software development can ‘share knowledge’ [198].

In the course of the residency, we experimented with movement analysis algorithms and infrared tracking techniques to sonify our individual movements but also the relationships between our bodies in the space. The movement data were mapped in various ways to extract and output different information and manipulate the live sound. By extracting position data from our bodies in space, as well as tracking and extracting qualitative movement data information, we accomplished the performance of different experiments and improvisation exercises.

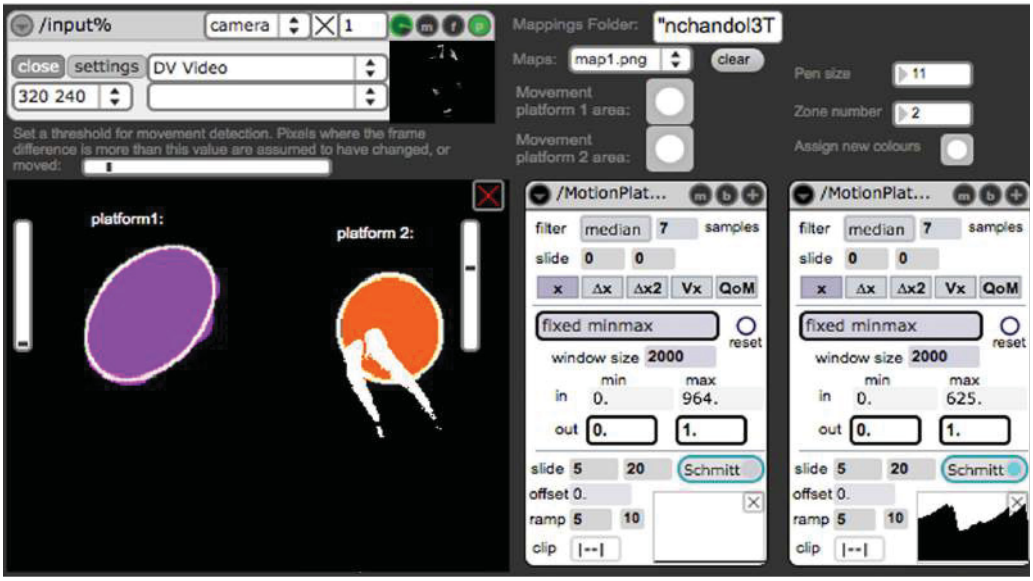

Figure 28: Mapping Zones System

During workshops, three of us (Westby, Goldenberg, and I) would improvise while blindfolded in multiple short dance studies, and at times, led by the sonic qualities of our voice that were being manipulated by our movement in the space, as noted by Westby. The attention then to inwardly communicate and touch outwardly was quite a different experience than when performing with eyes open. The sonic clues were the prime material in play, informing us about where and how much action exists in the surrounding space. We achieved that by mapping specific zones of the space with specific sonic qualities. When the improvisation took place, all of us started slowly, initially familiarising with our lack of sight and slowly accelerating our movement, taking into consideration our co-performers and the architecture of the space. A sound occurred in the

darkness and for an instant we couldn't tell if it was produced by us or someone else in the space. By establishing this relationship, as well as through the spatialisation, we were able to eventually identify if it was coming from our body or from another body in the space. This illuminating experience was something we wanted to convey to the audience, and it is one of the reasons why the performance started in pitch black.

Figure 29: Orbital Resonance Workshop, Blindfolded and Movement Sonification Experiments, April 2014

In this other experiment, our goal was to discover different methods of sonifying correlated movement. Through our Infrared (IR) camera tracking system, we were able to extract distance information between 2-6 people. By mapping different sounds in order to delineate the changing distances between our bodies in the overall space, we created a playful mechanism that made us aware of our relational positions in space.

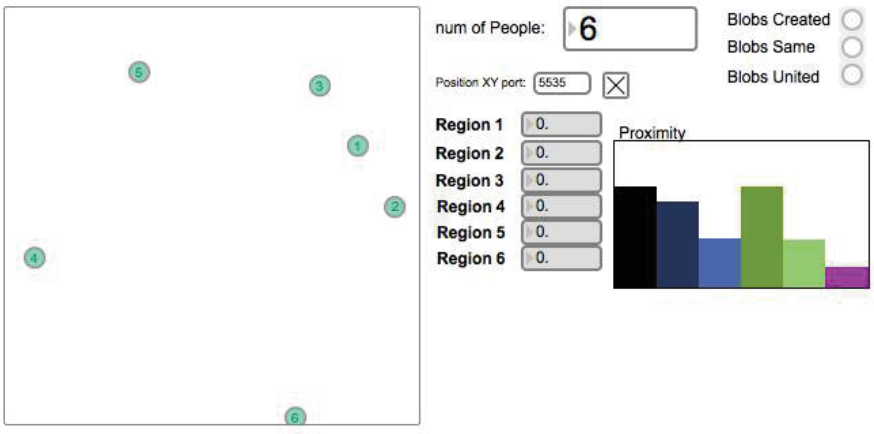

Figure 30: Distance Calculation System

We dove into the experiments with micro-controllers and sensors on the body to detect detailed micro-movements and physiological data. We used the xOSC wireless board (that includes a built-in gyroscope, accelerometer, and magnetometer) and placed the sensor on different parts of our bodies (neck, waist, ankles, wrists, spine) while changing movement qualities, such as acceleration, deceleration, orientation and more. The sensor was mapped to different sonic qualities and sources (coming from our voice recordings of various textures and words). The designed patches created in Max/MSP extracted the data from the built-in xOSC sensors. There are multiple advantages of using the x-OSC device to detect micro-movements as inputs to map sound, lights, and any other computer-controlled data as outputs. The device is affordable and quite small, allowing integrated use with various body parts, costumes and sets. Due to configuration through a web browser, the device is more stable than most micro-controllers available. We explored a lot of sensors [199] while experimenting in the black box. Given all the various apparatuses we wanted to try, there was not enough time to develop and build upon all our aspirations. Given the uncertainty of the artistic value of those results, we decided to focus more on other aspects of the research, since we were involved in multiple roles as developers and performers. At the final presentation of *Orbital Resonance*, we avoided attaching sensors to the body but we used some of the offline data we acquired during the experiments in the presentation.

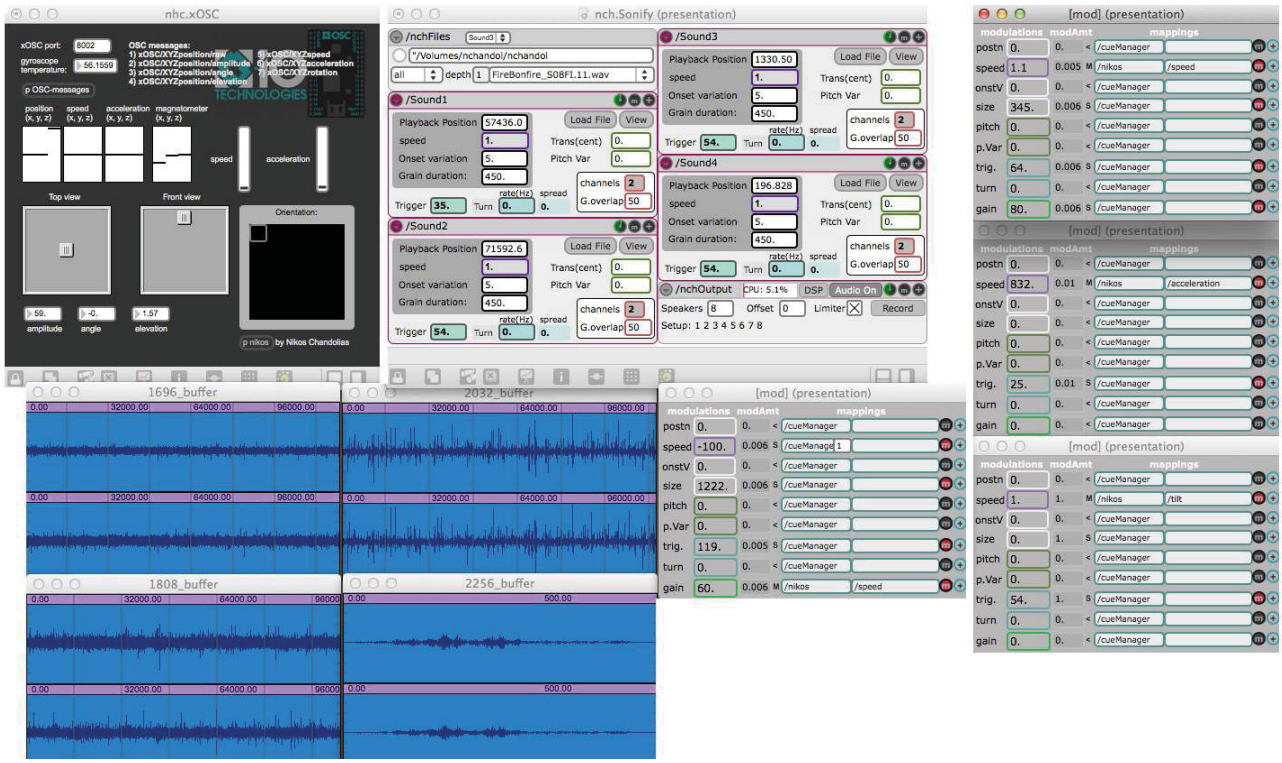

Figure 31: x-OSC Module, Movement Sonification Module (re-adapted from Navid Navab's Jamoma Modules [200])

Furthermore, in parallel with the processes described above, we created an optimal motion-tracking[201] system with the open source software VVVV, and we sent the data using the OSC protocol to MAX/MSP modules to create the different sonifications.

As aforementioned, we wanted to create (by replicating our findings) a deeply embodied experience to the audience. One of the ideas we had was to blindfold them, but due to ethical and safety concerns regarding the space, we decided to abandon that idea. Therefore, we experimented with different light stages. We utilised the tracking data from VVVV to map our bodies and the audience's to the light animation. In the performance event, we began in pitch black, where audience members commented on feeling disoriented and afraid of bumping into something. As one audience member recalled [202],

> "I felt disoriented because of the darkness and unfamiliarity with the space…I remember the spotlights came up gradually to notify to me an event was happening and heard the sound of breath which made me aware of my own fleshy, breathing body".

This navigated the attention towards our breathing sounds, and shifted the focus away from the sense of vision, which created an ominous feeling for some of the audience, as noted by Westby. Thus, the performance shifted between different light states.

As the audience and performers entered the "stage" (active area), the space was pitch black to create an intimate setting. The only stimuli present were the sounds of the performers' breath, spatialized through the speakers coming from above, around, and below the various surfaces. After a period of time, the vocal and breathing improvisation intensified and a spotlight projection appeared for each individual in the space, following them around. It started simple and clean with just a projected blob (blurred - no sharp edges) as if it was an actual theatre spotlight. As the performers continued improvising (talking, mumbling and breathing louder or noisier), the lights started trembling to their voices. Eventually, the lights started shifting in size, mapped to the performers' actions, as if they were beginning to breathe themselves. The lights began to have their own agency. The bodies in the space created the lights' presence, but after a while they could potentially manifest their own character, drifting away from the bodies, or freezing in time momentarily. At the end of this phase, the lights slowly shrank and disappeared as we moved to the next state of the event.

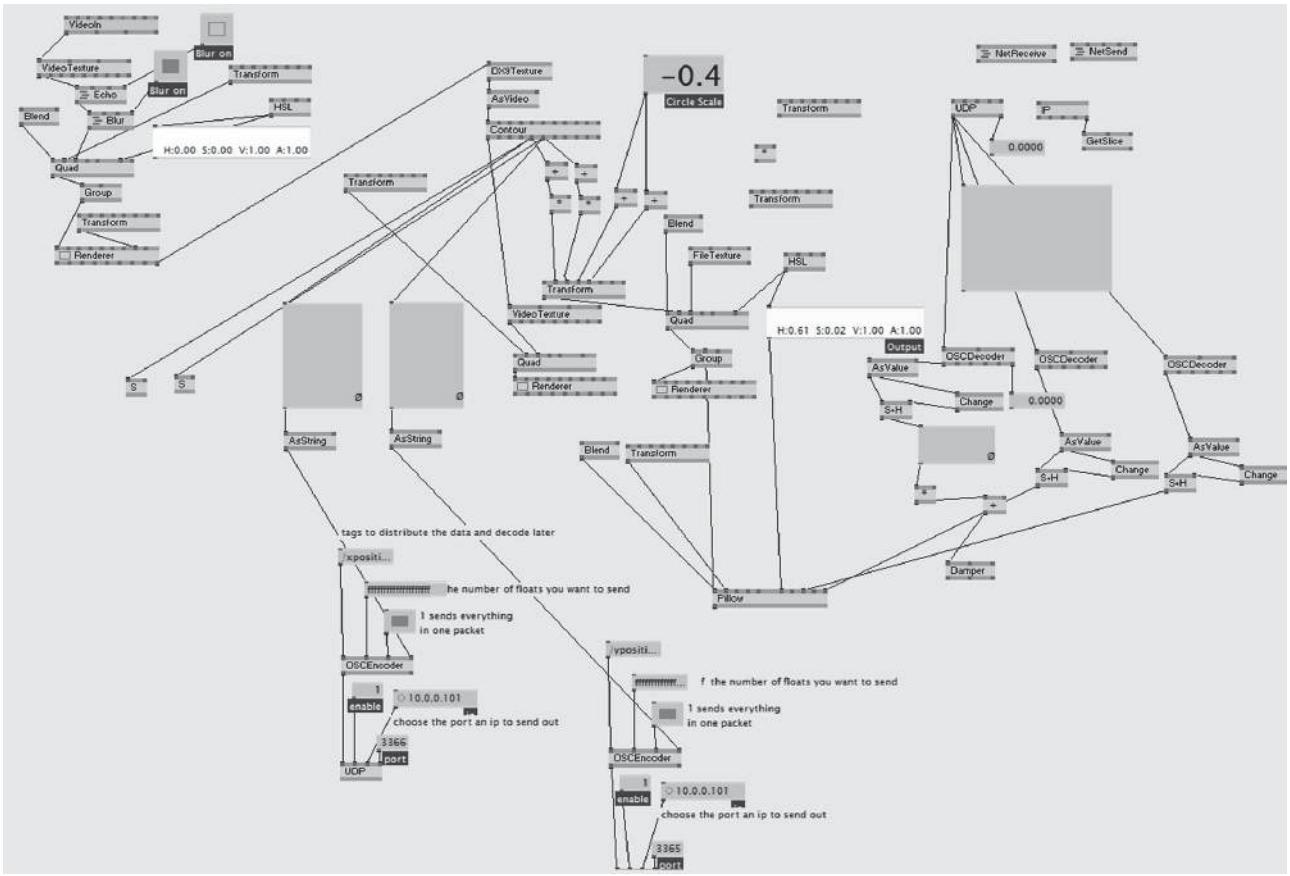

Figure 32: Blob Tracking and Projected Light, VVVV, developed with the help of Jerome Delapierre

Figure 33: Light Followers during Rehearsal, April 2014

5.2.2 Kinaesthetic Methodologies: Breathe, Listen, Move

In tandem, a succession of workshops and rehearsals informed by a cross-fertilisation of different kinaesethic methodologies occurred, including short movement studies, improvisation, automatic writing, digital video feedback and photography in a reflective practice [203], as 'a coherent framework to develop our methods and tools for deepening and documenting our emerging understandings of practice' [204]. Drawing from our own backgrounds, Westby and I from contemporary dance, Van Nort from Pauline Oliveros' Deep Listening and Goldenberg with Westby from Yoga, Open Source Forms (OSF) and Skinner Release Techniques, we dove into movement and sound experimentations that informed our research and the development of the project.

Figure 34: Movement Workshop, April 2014

While utilising exercises from these somatic practices (Deep Listening, Yoga, and Open Source Forms), as noted by Westby, "breath became a pivotal instigator for both sonic exploration and movement development"[205]. Breathing is one of the most fundamental functions of the human body; it initiates movement and speech and could demonstrate the intensity of an action. It is "a fundamental embodied process connected to action, expression and internal state and often acts as an unconscious communication between performers" [Corness, Schiphorst 2013][206]. Focusing on the breath enabled us to engage in cohesive improvisations that developed into more

interpretative vocal sounds, and into movement during the workshops and in the final performance event. Additionally, the use of improvisation was fundamental to the establishment of patterns and relationships that are both stable and unstable, challenging the intuition, awareness, and actions of all performers involved. Through technological design and somatic practices*, Orbital Resonance* "addresses the implications of bodies in the space and agencies of all materials in play" [207].

Moreover, we created our own exercises and improvisations based on conceptual frameworks in the form of text to inform movement studies. We produced text by automatic writing about our umbrella themes of breath, heartbeat, muscle, speed and spatial relationships. In random combinations of the text, we created movement studies based on a conglomerate of words with specific directives of movement qualities, positions and body parts. At the end of each study, we would write down and discuss our observations in terms of the relationships that were created, of the ease or tension felt in certain movements, of our use of space and time and of what was communicated most productively in relation to our overall intention. The improvisations and studies fostered the collaborative, non-authoritative positions we wanted to maintain. In addition, all of the methodologies tested out in the process organised the creation of the performance event to a public audience.

Figure 35: Automatic Writing during Movement Workshop, February 2014

Van Nort introduced us to the Deep Listening (DL) technique through exercises during our investigation in the blackbox. He explained to us that by eliminating the visual triggers consciously, he enables himself to feel more attuned to his own body, which allows him to absorb all the sounds

produced by him and others in the space. Reflecting on this practice and his experience with DL, Van Nort identifies the practice as a facilitator of connections, due to the immense attention it demands. It helps us "raise consciousness of [our] immediate environment soundscape and allows for "introspection" [Van Nort 2005][208]. This practice brings "people closer to the fabric that binds them through a common experience" [Oliveros 2005][209] by sound, which places it at the core concept of *Orbital Resonance*.

The notion of somatic practices as a framework that enables embodied experiences and interactions in the context technology is elaborated by Thecla Schiphorst. According to Schiphorst,

> "[somatics] is a field of study that explores the lived experience of the moving body, an experience tradition that defines knowledge through embodied practice. Just as oral traditions pass on knowledge through the spoken word, body-based experience traditions pass on knowledge directly through experience of the physical body. Contemporary somatics comprises a set of body-based disciplines that have flourished largely outside academia since the mid-19th century, including the work of practitioners such as Rudolph Laban and F.M. Alexander. Somatics offers an account of experience enacted through first-person methodologies incorporating technical expertise and reflection-in-action that is rigorous in its direct approach to practice" [210].

By utilising sound as an essential element in examining embodiment, presence, and agency in responsive spaces, allow us to examine the affordances and the semiotic values of movements, and the deconstruction of the coupling between the body and its expected sonic properties (voice, breathe sounds and speech). This is done by creating a disconnect between the present body that performs, and the displacement of the sounds produced. In *Orbital Resonance*, the distinction between who was making what sound and where that sound was located no longer existed, for "sound has no loyalty to the object being represented" [Dyson 2009][211]. This disconnect could appear as a dislocation in space, in time, and in the social and representational modes with which the body (person) is sometimes defined. A voice "ushers forth from a body", but by this process of displacement through digital algorithms, also "transforms one's body" [Myers 2011][212]. In our work, as one audience member recalled [213], "I couldn't differentiate between the voices or genders of who was making the sound, I would look at the mouths and still couldn't tell where the sound was coming from". The strategy of displacement, with the use of technology to separate the source from the material, makes the audience not only focus on their own embodied awareness but also on the way they perceive the event that has unfolded in front of them.

5.2.3 Participatory Aspects

The process of creating technological apparatuses, and the choreographic choices in the performance, were not limited to reading and computing the performers' physiological data, as theyalso captured and computed the movement and gestures of the participants', translating all input to visual and sonic representations. In the architectural design,

> "two circular shaped platforms had lights underneath to display the performers' recorded heart beat data, in consonance with vibrating sound coming from the surface transducers below these objects and the floor. The mixture of light, sound, and architectural structures created a space that does not imply parity between spectators and performers, yet can distinguish discrete data streams and physiological signals and computes them separately before combining them into a universal output. Performers, programmers and spectators are actively co-creating the space experience by improvising with their bodies and voices. When a new body enters the space, it immediately becomes integrated in the general aesthetic and immediately starts adding to the collective creation of the environment" [Alfaleh, Chandolias 2014] [214].

Figure 36: Orbital Resonance, Performers and Audience members, April 23, 2014

We researched and designed one 6x4ft oval and one 4x4ft circular wooden platform, consisting of bendable plywood and MDF for the top surface for the best sonic result and light effect. The two platforms each contained 8 different light bulbs and a DMX Controller alongside the transducer underneath the structure. Both of the platforms were placed inside the active space, inviting the spectators to enter the active space initially to sit and after a while, when they became familiar with the space, to play.

5.3 Summary and Conclusions

Orbital Resonance was an intervention in a field of exploration that remains very open. As many practitioners and scholars in the field of digitally augmented performances note (Broadhurst, Birringer, Lympouridis, Salter, Sha, among others), through the interaction of technology and performance new opportunities for expression might arise, however, as David Z. Saltz notes, “the critical discourse is still in its early states, and basic questions about the scope and definition of the field remain in play” [215].

This Research-Creation project was a platform to explore what the implications are for different disciplines of thought to join together to create new understandings about movement, light, and sound interactions. The performance was initiated by the bodies, affected by and affecting the technology through movement, sound, scenography, and imagery in an open, participatory space [216].

One of the most important aspects of this work lies in the collaborative approach that Westby and I followed throughout the process, and the development of the workshops and the final performance event. Due to Westby’s feminist sensitivity to technology, programming and her background in dance and performance studies, and my background in electrical and computer engineering and dance, we were able to tackle both the embodied experience and movement studies, as well as the technological apparatuses that were in play. During the workshop and rehearsal time, there were moments when Westby was behind the computer screens tweaking the different parameters from the sensory data, Goldenberg and I were improvising in the space, and the other way around. “The final performance event, achieved the intended goal, with a united front, and a non-hierarchical, interdisciplinary, collaborative event” [217].

6. Conclusions and Future Developments

It is fundamental to understand that the explorations introduced in the previous chapters assimilate cultural and conceptual frameworks that derive from years of research in the field by many practitioners, as well as an understanding of the technical difficulties that sometime set constraints. *Orbital Resonance* was an exploration into more sensorial interactions, whereas the storytelling platform was driven initially by the technical research which later led to new ways of interaction and engagement with such complex phenomena. The range between these projects demonstrates the creative potential of interactive systems, when developed with the proposed designed approaches presented in this thesis.

In general, future developments of this work include not only a more holistic approach to the design process, combining the findings of *Orbital Resonance* and *Storytelling Platform*, but also adopting techniques from signal processing, as well as the machine perception and artificial intelligence fields. This does aim to make the systems more complicated, but rather to enable them to further enrich their responses. Specifically, working with language and text, especially when dealing with the semantic and semiologic connotations that accompany them, makes it difficult to overcome their power, especially in an improvisational context. The works I describe in this section demonstrate the benefits of integrating the techniques presented in this thesis, in different circumstances.

1. *No Distance* - Choreographer/ Performer: Maria Kefirova, Scenography: Miguel Angel Melgares, Sound Design/ Technical Design: Nikolaos Chandolias

Collaborating with performer Maria Kefirova and dramaturgy consultant Miguel Angel Melgares, we are incorporating semantics as an integral part of the performance context. *No Distance*[218] deals with the actual, metaphorical, emotional and social distances, intervals and measurements in the realm of factual and lived perception. Kefirova produced several texts as part of the performance and we are using the cluster analysis system to further elaborate these texts. The results of the analysis are not only acoustically displayed in the performance space, but also, as Kefirova stated during our rehearsal times, inform the quality and intention of her movements, forming a crucial part of the ethico-aesthetics of the performance. The software generates a semantic cluster around the word *distance* and the body searches to disrupt its natural patterns of movement following the notions of the cluster. For example, talking about *distance*, words like gravity, divorce and diversity come into the performance space, allowing access to multiple supplementary layers that enhance our understanding of the event, shifting our momentary perception of distance.

Figure 37: No Distance, Open rehearsal, February 2015, Hexagram's Video Production Studio, Concordia

2. *Semantic Shifts* - Software Development/ Installation Design: Nikolaos Chandolias

Exploring further the use of language and transcribed text, this is a new idea derived from the storytelling platform that deals with how we can use transcribed utterances, natural language processing techniques and semantic clusters to rethink the way we perceive and interact with text. This project would be an installation where the text is projected on a piece of paper, and each time someone approaches or interacts somehow with the paper and the text, a new semantic aspect of the text will appear. By projecting the text onto a piece of paper, every time a movement is detected (like swapping or changing-page movement), the text reiterates itself and is recomposed in the same syntactical structure with words that derive from the initial semantic analysis. The system could apply transformations to different parts of speech (PoS), for example just verbs, adverbs, nouns etc., creating infinite possibilities of semantical transformations, depending on each individual's movement intensity and the designer's choices. Like in the example, the "this is perfect and stable" text becomes "this is steady and summons", and on another iteration, "this is permanent and appraise".

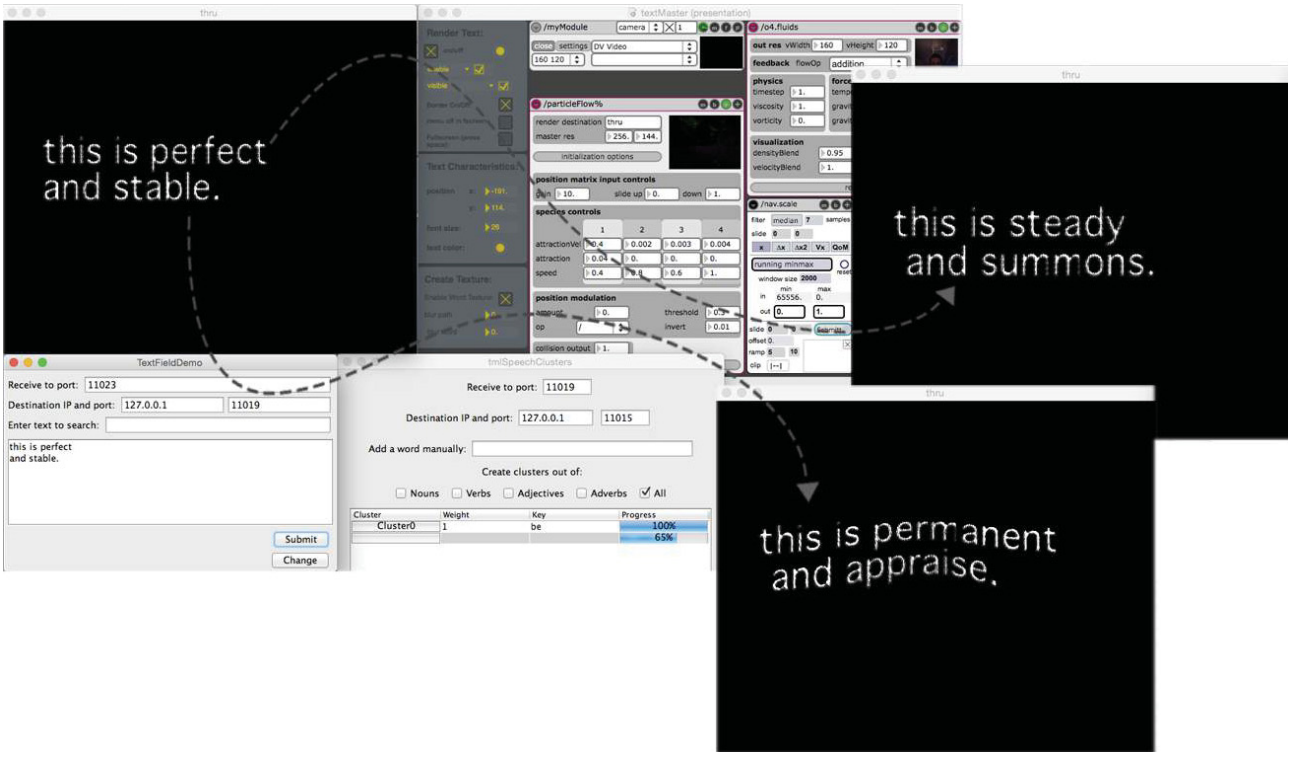

Figure 38: Semantic Shifts Experiments and Modules, March 2015

3. *Light Modules* - Software Development/ Installation Design: Omar Alfaleh and Nikolaos Chandolias

Another approach that I am investigating is to introduce different portable-responsive elements in the space, which I believe can enable corporeal and vocal interactions to occur in any kind of setting, inducing a notion of performativity. This new research project aims to adhere to my already existing research and projects by building modular lighting instruments that could be remotely activated, modulated, and controlled over a wireless network. These investigations form part of a collaboration project with Omar Al Faleh, an interactive media developer and architect, whose work investigates embodiment and presence.

The system reads the semantic clusters from the speech recognition program, and combines it with location tracking, motion analysis, and measuring live voice pitch. The generated data activate the space through modulating lights that are embedded and distributed in the space. This allows the system to work on the physical and aesthetic properties of objects. In addition, it makes the system portable and able to work outside of controlled environments and traditional performance spaces, which turns everyday spaces into activated performative environments. The lighting instruments are modular sets of electronics and LED lights that are controlled by wireless micro-controllers. They will be embedded in neutral objects like translucent tubes and other geometrical

or elastic shapes, which can be deployed and embedded in any space within its existing furniture and elements, and allows for a flexible addition or removal from the system without affecting the performance of the other modules.

Figure 39: Light Modules Experiments, January 2015, Concordia Hexagram's Video Production Studio

4. *Table of Contents* - Concept: Sha Xin Wei, Software Development: Evan Montpelier and Topological Media Lab, Implementation: Omar Al Faleh, Nikolaos Chandolias, Synthesis Centre ASU, Speech and Voice Analysis: Nikolaos Chandolias

Another ramification of these works deals with social interaction, though for the *Table of Contents (ToC)* [219] project, that implements different modules of the storytelling platform into the system, which will allow the designer to have access to speech recognition and natural language processing Algorithms. These techniques could be used in many ways to enhance the experience of the ToC. For instance, the words spoken from the other side get projected in the space. In that way, speech is no longer ephemeral and gives us the opportunity to use a new form of note taking and embedding messages that arise in the sutured spaces.

Furthermore, the use of key words or phrases, or semantically associated words in a specific context, could establish or terminate a connection between the different locations. In order to avoid trivial voice-commanding effects, I would propose for example to have the video feed constantly being sent from the different locations without being visible or audible. When there is a lot of action accumulated on one side, a message is being transmitted to the other side and translated into another medium, such as light. Let's say there are five people in Arizona having a meeting in the ToC and want to connect; movements at the table could modulate the particles on the TML table-side and the lights. This means that the other side is trying to reach TML, and if we want to establish the connection, the keyword/phrase should be uttered and the connection will be established. Another way we could use the speech and the content of the conversations that are happening around the ToC is to try to establish connections with the spaces where people are talking about similar ideas and subjects that are semantically connected. Once the natural language processing algorithms recognise a similar subject, a connection can be established.

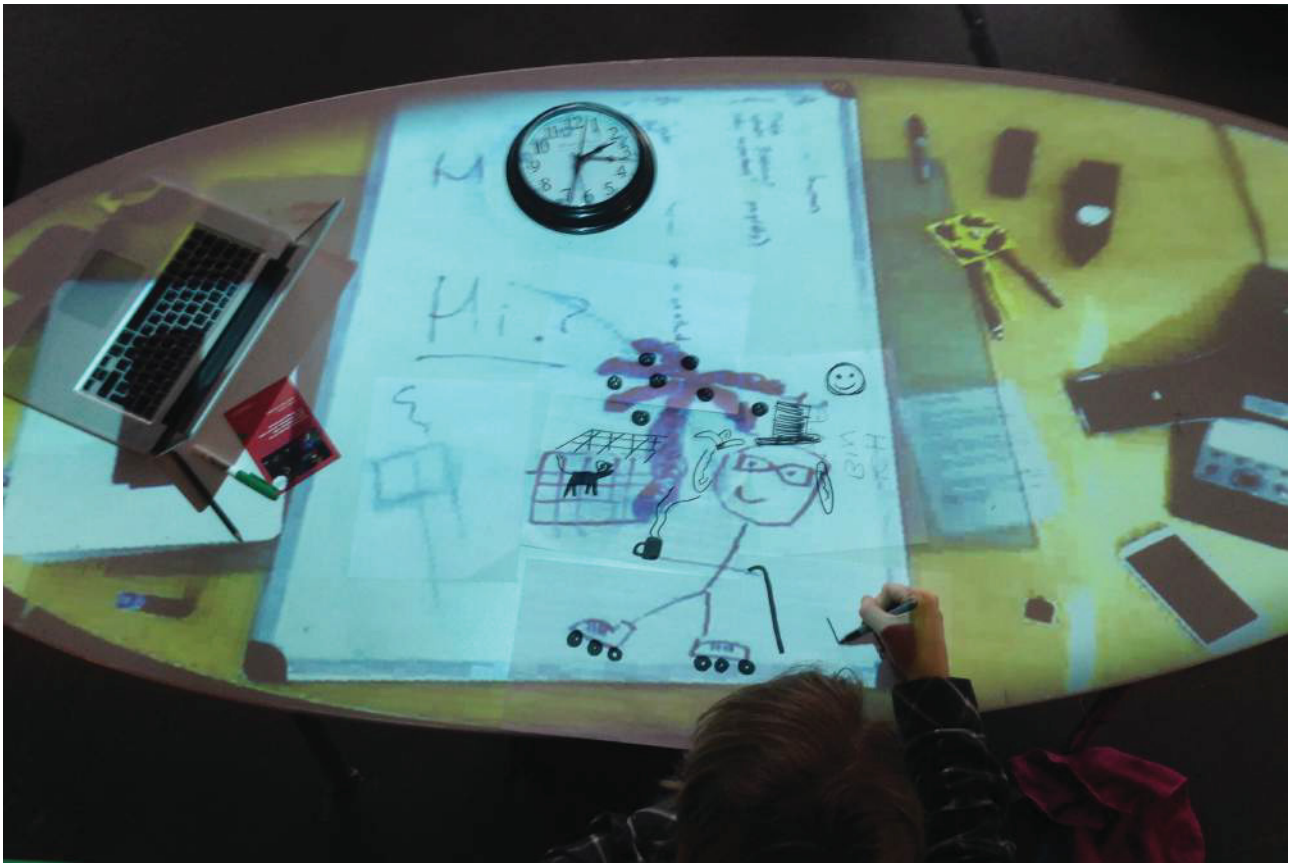

Figure 40: ToC Co-Drawing Experiments between Topological Media Lab and Synthesis Centre, March 2015

In conclusion, the works described in this thesis, among others in the field, demonstrate the necessity of moving towards responsive systems and interactive performances that take into

account all the architectural, mechanical, audiovisual and sensorial inputs that can significantly impact the experiences created, thereby diving into deeper investigations for the future of storytelling and performance making. Although I chose to work within the performance art context, the approaches adopted throughout the investigations presented in my thesis, take into consideration the usefulness and necessity of new interaction design modalities in everyday life. Moving away from screen based interfaces and towards a new era of screen-less, more natural and organic design that enables system responses through everyday movement and voice gestures, everyday objects and speech context, these investigations offer fresh innovative approaches to the field.

Appendix I

The Topological Media Lab (TML)[220] was established in 2001 as a trans-disciplinary atelier-laboratory for collaborative research creation. In 2005, TML moved to Concordia University and the Hexagram research network in Montréal, Canada. Its projects serve as case studies in the construction of fresh modes of cultural knowledge and the critical studies of media arts and techno-science, bringing together practices of speculative inquiry, scientific investigation and artistic research-creation practices. The TML's technical research areas include: real-time video, sound synthesis, embedded sensors, gesture tracking, physical computing, media choreography, and active textiles. Its application areas lie in movement arts, speculative architecture, and experimental philosophy.

Obx Labs[221] is interested in living letterforms, massively multi-contributor texts and time-travelling provocateurs. We create artwork that utilizes and motivates the software that we develop and the technologies we repurpose. Our main goal is to provide both the inspiration and the means for others to push the boundaries of computationally-based expression.

Appendix II

Languages					
Afrikaans **af**	Arabic (Bahrain) **ar-BH**	English(UK) **en-GB**	Latin **la**	Russian **ru**	Spanish(Mexico) **es-MX**
Basque **eu**	Arabic (Lybia) **ar-LY**	English(US) **en-US**	Mandarin Chinese **zh-CN**	Serbian **sr-SP**	Spanish(Nicaragua) **es-NI**
Bulgarian **bg**	Arabic (Oman) **ar-OM**	Finnish **fi**	Traditional Taiwan **zh-TW**	Slovak **sk**	Spanish(Panama) **es-PA**
Catalan **ca**	Arabic (Saudi Arabia) **ar-SA**	French **fr-FR**	Simplified China **zh-CN**	Spanish (Argentina) **es-AR**	Spanish(Paraguay) **es-PY**
Arabic (Egypt) **ar-EG**	Arabic (Tunisia) **ar-TN**	Galician **gl**	Simplified Hong Kong **zh-HK**	Spanish(Bolivia) **es-BO**	Spanish(Peru) **es-PE**
Arabic (Jordan) **ar-JO**	Arabic (Yemen) **ar-YE**	German **de-DE**	Yue Chinese (Traditional Hong Kong) **zh-yue**	Spanish(Chile) **es-CL**	Spanish(Puerto Rico) **es-PR**
Arabic (Kuwait) **ar-KW**	Czech **cs**	Hebrew **he**	Malaysian **ms-MY**	Spanish (Colombia) **es-CO**	Spanish(Spain) **es-ES**
Arabic (Lebanon) **ar-LB**	Dutch **nl-NL**	Hungarian **hu**	Norwegian **no-NO**	Spanish(Costa Rica) **es-CR**	Spanish(US) **es-US**
Arabic (Qatar) **ar-QA**	English (Australia) **en-AU**	Icelandic **is**	Polish **pl**	Spanish(Dominican Republic) **es-DO**	Spanish(Uruguay) **es-UY**
Arabic (UAE) **ar-AE**	English (Canada) **en-CA**	Italian **it-IT**	Pig Latin **xx-piglatin**	Spanish(Ecuador) **es-EC**	Spanish(Venezuela) **es-VE**
Arabic (Morocco) **ar-MA**	English (India) **en-IN**	Indonesian **id**	Portuguese **pt-PT**	Spanish(El Salvador) **es-SV**	Swedish **sv-SE**
Arabic (Iraq) **ar-IQ**	English (New Zealand) **en-NZ**	Japanese **ja**	Portuguese (brasil) **pt-BR**	Spanish(Guatemala) **es-GT**	Turkish **tr**
Arabic (Algeria) **ar-DZ**	English (South Africa) **en-ZA**	Korean **ko**	Romanian **ro-RO**	Spanish(Honduras) **es-HN**	Zulu **zu**

The supported languages and dialects are depicted in the table below:

Supported languages, using the Google Speech API are similar to those supported by voice search For that Google utilises standard language codes, which is consistent across its services.

Through experiments with the voice recognition engine, I came to the conclusion through a series of tests that:

- If a language is not supported, recognition falls back to en-US (english USA)
- You can specify language only, like: ‘en’ for English, or language-dialect: ‘en-US’
- Sometimes if the language is not fully supported or the utterance is far from a recognisable word, the returned result might be in English. For example, in Japanese and in Chinese.

Appendix III

One of the main interests for all of us as collaborators at *Orbital Resonance* was the question of how to obtain different information from the body and translate that data into different stimuli. We explored different body sensors and micro controllers that could offer an insight into the changes that occur during the movement process of the body and the way they are measured and manifested by this machinery.

We wanted to uncover three major components: what values the sensors perceive, how noisy those values are, and what meaningful interpretations arose for both performers and audience, separate from the machine's capabilities.

Given all the various apparatuses we wanted to try, there was not enough time to develop and build upon all our aspirations. Given the uncertainty of the artistic value of those results, we decided to focus more on other aspects of the research, since we were involved in multiple roles as developers and performers. Most of the sensors that are listed below were used during the experiments in the two-month long residency.

The *x-OSC*[222] is a wireless I/O board that includes 32 high-performance analogue/digital channels and on-board sensors (gyroscope, accelerometer, magnetometer). The data is sent via OSC[223] messages over WiFi. There are multiple advantages of using the x-OSC device to detect micro-movements as inputs to map sound, lights, and any other computer-controlled data as outputs. The device is quite small, allowing integrated use with various body parts, costumes, and sets. The device is simply configured through a web browser and is more stable than most micro-controllers available. Sebastian Madgwick[224] spearheads this project, partnering with dance choreographers and other artists for further capabilities of this device.

The *minibees*[225] (of Sense/Stage) began as a research/creation project at Concordia University, designed by Marije Baalman[226]. These battery-powered, wireless PCBs can be worn on the wrist, sewn into clothing, or embedded in different objects. Despite the endless possibilities of this device, the configuration and inclusion of other sensors added to the board was quite complicated. We did not have enough time in the process and rehearsal phase to productively incorporate this device in our work. Furthermore, the use of bluetooth for communicating between receiver and transmitter, given the size of Concordia's Blackbox, was another issue that we had to take into consideration.

BITalino[227] is a low-cost toolkit to learn and prototype applications using body signals. Although perhaps an ideal conceptual device to experiment with our goal of disseminating different ways to output internal physiological states of the body to the audience, we did not have enough time to actively test all of the different components. We hope to be able to implement and explore this in a further development of the work.

Pulse Sensor[228] is an open source hardware project by Joel Murphy and Yury Gitman. Practically, the device measures your heart rate by infrared light reflected by the blood circulating inside your body. One of the key components of our project was to ideally measure the heart rate of the performers in real-time, taking into account the differences that might occur by encounters with performers and audience members alike. Unfortunately, the placement of the sensor was crucial and if it is not stable enough, the data could easily become just noise, or random voltages that occur due to differences in the light factors.

The *T31*[229] band was a stable and accurate transmitter to measure the body's heart rate. Through the interface board designed by danjuliodesigns[230] and SparkFun, we were able to transmit the data through Bluetooth, but we were restricted by the amount of transmitters (only one worked at a time) and range. Through the data obtained by this heart rate, we visualised the information by mapping the lights underneath the platforms.

The *Muscle Sensor v3 Kit*[231] measures the filtered and rectified electrical activity of a muscle, outputting 0-Vs Volts depending on the amount of activity in the selected muscle, where Vs signifies the voltage of the power source. The sensor was quite complicated and unstable for the type of application needed for actual moving bodies. In the future, a more wearable-sensitive device to measure muscle activity will have to be created.

Appendix IV

During the *Orbital Resonance* workshops, we also experimented with the open source Core Vision Community's [232] platform. It takes a video input stream and can conduct background subtraction, movement analysis, orientation and identification of moving bodies in the space with no sensors attached.

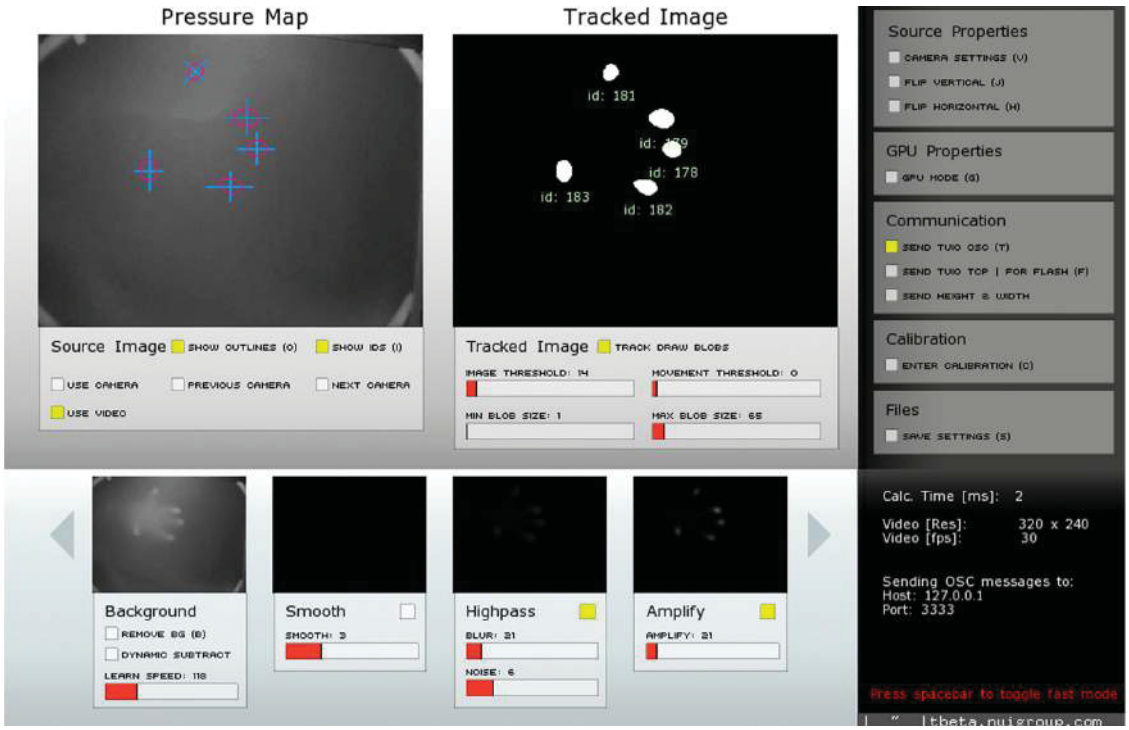

Figure 40: Core Vision Community Program

Appendix V

List of Conferences, presentations and publications:

Papers and Publications:

Al Faleh Omar, Chandolias Nikolaos, Del Tredici Felix, Montpellier Evan, '*Towards An Integrated Design Process For Improvisational And Performative Interactive Environments*.' Vancouver CHI, Vancouver, Canada, July 2014

Chandolias Nikolaos, Elena Frantova, Xin Wei Sha, '*Storytelling Space: Responsive Environment for Improvisational Voice and Body performance*'. 5th Annual International Conference on Visual and Performing Arts, Athens, Greece, June 2014

Al Faleh Omar, Chandolias Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces*'. 5th Annual International Conference on Visual and Performing Arts, Athens, Greece, June 2014

Westby Margaret, Chandolias Nikolaos, '*Choreographing Computational Materiality: Interventions in Technologically Augmented Dance Performance.*' 5th Annual International Conference on Visual and Performing Arts, Athens, Greece, June 2014

Awards and Grants:

Hexagram - CIAM 2015, for the development of *Light Modules*, part of the *Storytelling Platform*

Runner-Up Master Thesis 2014*,* for the *Orbital Resonance* Poster, presented in the INDI Student Research Day at Concordia University

Fine Arts Travel Grant 2014, for the dissemination of *Orbital Resonance* and *Storytelling Platform* at the 5th Annual International Conference on Visual and Performing Arts, Athens, Greece, June 2014

Mitacs Accelerate Grant January to August 2014, research internship in collaboration with Alkemie Atelier and prof. Paul Shrivastava.

Hexagram - CIAM 2014, for the development of the *Orbital Resonance,* submitted by Margaret Westby

Carolyn & Richard Renaud Teaching Assistantship Award September 2013*,* by Concordia's School of Graduate Studies

International Tuition Fee Remission Award May 2013, by Concordia's School of Graduate Studies

Partial Tuition Scholarship 2012-2014, by Concordia's School of Graduate Studies

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[24] Chris Salter, '*Entangled: Technology and the Transformation of Performance'*, 2010, pg XXXIV

[25] What is interesting is that the exact same notions of spatio-temporality of performance and the need of experiencing, witnessing and movement can be found as well at Peggy Phelan's essay on Dance and Performance Theory, '*Of The Presence Of Body'*, edited by Andre Lepecki, pg. 17, where she writes about Brown's memories of the death.

[26] Johannes Birringer, '*Dance and Interactivity'*, 2005, Dance Research Journal pg. 91

[27] Rudolf von Laban and Lisas Ullman, '*Choreutics'* 1966 as cited by Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'*, MIT Press, 2013, pg. 70

[28] Chris Salter, '*Entangled: Technology and the Transformation of Performance'*, 2010, pg 229

[29] Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'*, MIT Press, 2013, pg. 20

[30] Johannes Birringer, '*Dance and Interactivity'*, 2005, Dance Research Journal pg. 89

[31] Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'*, MIT Press, 2013, pg. 59

[32] Roy Ascott, '*Telematic Embrace: Visionary Theories of Art, Technology, and Consciousness'*, 1966, pg. 129

[33] '*Cage's most famous work, 4'33"*, *took conceptual music about as far as it could go. A musician walks out onto the stage, sits in front of a piano and does absolutely nothing for four minutes and thirty seconds. The sounds of the audience rustling, the traffic outside and any other ambient noise that might happen during that time period become a part of the piece.'* link to source: 4'33"

[34] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation*', Preface pg. xii

[35] Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 13

[36] The Events were: 1. Deborah Hay, Solo, 2.John Cage, Variations VII, 3. Robert Rauschenberg, Open Score, 4. Alex Hay, Grass Field, 5. Steve Paxton, Physical Things, 6. Whorled Explorations, 7. Nico Vascellari, Codalunga, 8. Manfred Pernice, dosen,cassetten,Zeugs, 9. Marvin Gaye Chetwynd, Bat Opera 2

[37] http://www.fondation-langlois.org

[38] ibid.

[39] Figure 2, link to source: 9 Evenings: Theatre & Engineering - "Bandoneon ! (a combine)"

[40] Jack Burnham, '*Beyond Modern Sculpture: The Effects of Science and Technology on the Sculpture of This Century'*, New York: George Braziller, 1968, 416 pp. *The Future of Responsive Systems in Art*

[41] Figure 3, source: As:If - by Laurie Anderson

[42] Chris Salter, '*Entangled: Technology and the Transformation of Performance'*, 2010, pg 156

[43] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation*', Preface pg. 107

[44] Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 17

[45] ibid. pg 13

[46] Povall, R., '*Making emotional spaces in the secret project: building emotional interactive space.'* In '*Reframing Consciousness*'. Intellect Books. Exeter (UK). 1999 pp. 64–68. 17

[47] Johannes Birringer, '*Dance and Interactivity'*, 2005, Dance Research Journal pg. 91-92

[48] An example of those improvisatory - responsive interactive technologies can be found in the work of the Topological Media Lab (TML). TML was established in 2001 as a trans-disciplinary atelier-laboratory for collaborative research creation, led by Sha Xin Wei. In 2005, TML moved to Concordia University and the Hexagram research network in Montréal, Canada. Their research work explores interactivity through experiments, installations and interactive performances.

[49] Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter*', MIT Press, 2013, pg. 81 - 82

[50] ibid. 81

[51] link to source: T-Garden

[52] Also noted by Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 12

[53] Chris Salter, '*Entangled: Technology and the Transformation of Performance*', 2010, pg 330

[54] Project Credits: Co-Workers & Funding: Project Initiators: Sha Xin Wei, Maja Kuzmanovic, Chris Salter, Laura Farabough, Concept: sponge, FoAM and associates, Project Management and Art Direction: Chris Salter, Maja Kuzmanovic, Technical and Systems Design Director: Sha Xin Wei, Tactile Media Design (Textile and Garments): Evelina Kusaite, Maja Kuzmanovic, Cocky Eek,Peggy Jacobs, Marcel van Doorn, Sensors + Wearable Computing: Stock (V2_Lab), Ozan Cakmakci, Computer Vision Tracking Algorithms: Yifan Shi and Aaron Bobick (Georgia Tech), Room Dynamics: Sha Xin Wei, Nik Gaffney, Yon Visell, Steven Pickles, Sound System Design and Sound Interaction: Joel Ryan, Chris Salter, Visual Design and Video Interaction: Maja Kuzmanovic, Hiaz Gmachl, Network, Systems Administration: Nik Gaffney, link to source: T-Garden

[55] Johannes Birringer, '*Dance and Interactivity'*, 2005, Dance Research Journal pg. 89, 'Furthermore, dancemakers, researchers,and teachers have used film or video as a vital means of documenting or analysing existing choreographies. Some scholars and software programmers published tools (LabanWriter, LifeForms) that attracted attention in the field of dance notation and preservation as well as among choreographers (e.g., Merce Cunningham) who wanted to utilise the computer for the invention and visualisation of new movement possibilities.'
Also at, Johannes Birringer, '*Media & Performance: Along the Border'*, 1998, pg. 95, '… Cunningham is interested in LifeForms as a way of discovering "unthinkable" movement…'

[56] Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 14

[57] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation'*, Preface pg. 185

[58] Noted as well by Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems'* 2012, pg. 14 and Chris Salter, Entangled: Technology and the Transformation of Performance, 2010, pg 267

[59] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation'*, Preface pg. 190 and Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'*, MIT Press, 2013, pg. 34

[60] Siobhan Scarry, '*In Step with Digital Dance'* link to source: In Step with Digital Dance

[61] link to source: Ghostcatching

[62] Figure 5, ibid.

[63] Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 16

[64] For more information look at: Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems'* 2012, pg. 12-18, at Chris' Salter, '*Entangled: Technology and the Transformation of Performance'*, 2010, pg 266-268 and at Marc Downie, '*Choreographing the extended agent',* 2005

[65] Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems*' 2012, pg. 18

[66] link t source: In Plane - TroikaRanch

[67] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation'*, Preface pg. 196

[68] Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'*, MIT Press, 2013, pg. 81

[69] credits: Michael Montanaro :Creative direction, art direction and coordination, Sha Xin Wei : Phenomenology of time perception, Jerome Delapierre: Realtime video, visual design,videography and photography, Navid Navab: Real-time sound, sound design, sensor system design, Julian Stein: Realtime lighting, realtime sound processing, photography, videography, Nicolas Chandolias: Speech and Voice Processing, Natural Language Processing, Nina Bouchard: Videography and photography, Katerina Lagasse: Event coordination, publicity, videography and photography, Figure 6, link to source: Einstein's Dreams - TML Flickr

[70] *Einstein's Dream* (2013): Sha Xin Wei, Michael Montanaro, Jerome Delapierre, Navid Navab, Julian Stein, Omar Al Faleh, Nicolas Chandolias

[71] link to source: Einstein's Dreams - TML

[72] Al Faleh, Omar, Chandolias, Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces'*, 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. This part was taken as is, with very minor changes.

[73] Lightman, Alan, *Einstein's Dreams*, 1994

[74] Sha Xin Wei et al. *Einstein's Dream,* Topological Media Lab, link to website: Einstein's Dreams Website

[75] Al Faleh, Omar, Chandolias, Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces'*, 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. This part was taken as is, with very minor changes.

[76] ibid.

[77] In Einstein's Dreams my involvement was both as a performer and a creative technologist. I have helped organise it, installed equipment, developed and deployed various specialised apparatuses. Moreover I have explored the technologies their applications and potentialities as a performer. Together with fellow researchers and participants from the fields of contemporary dance and somatic theatre, we examined how enhanced space affects the body and broadens the scope of live improvisational theatre.

[78] ThespianCrew Meet-up Notes March 13, 2013, In attendance: Jennifer Spiegel, Nikolaos Chandolias, and Patricia Anne Duquette, noted by Patricia Anne Duquette.

[79] As noted by Al Faleh, Omar and I in '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces'*, 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. Also, look at Sha Xin Wei, '*Poiesis and Enchantment in Topological Matter'* and Chris Shalter's, '*Entangled: Technology and the Transformation of Performance'* , as mentioned earlier in this chapter.

[80] ibid

[81] AL Faleh, O, Chandolias, N et all, '*Towards An Integrated Design Process For Improvisational And Performative Interactive Environments*', ACM Designing Interactive Systems – Workshop on Human-Computer improvisation, 2014

[82] ibid.

[83] Al Faleh, Omar, Chandolias '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces'*, 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014.

[84] Steve Dixon, '*Digital Performance: A History of New Media in Theatre, Dance, Performance Art, and Installation'*, Preface pg. xii

[85] Al Faleh, Omar, Chandolias '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces'*, 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014.

[86] link to source: iSA

[87] link to source: Same Difference

[88] More discussion over the use of linguistics, semantics and language will follow in the chapter were the Storytelling Space is being presented since it is in the core of my research. For further information in the details of the performances mentioned here as well as for an extensive case study on both of them please look at Jessie Eggers, *Moving Speech: The Use of Live Spoken Language in Dance Performances,* MA Thesis 2008/2009

[89] link to source: The Secret Project - v2

[90] Richard Mark Povall, '*Creating Emotionally Aware Performance Environments, a phenomenological exploration of inferred and invisible data space'*, 2003 pg. 225

[91] Johannes Birringer, '*Dance and Media Technologies',* Edited, with an Introduction, by Johannes Birringer , 2002, pg. 88

[92] link to source: Remark

[93] Figure 7, link to source: ibid.

[94] Figure 8, link to source: hwnv

[95] ibid.

[96] link to source: MessaDiVoce

[97] Levin, G., and Lieberman, Z. '*In-situ speech visualisation in realtime interactive installation and performance'*, NPAR '04, Proceedings of the 3rd international symposium on Non-photorealistic animation and rendering, pg. 7 - 14, ACM New York, NY, USA, 2004

[98] Figure 9, link to source: Messa Di Voce -The photo is slight edited by the author of the thesis for display purposes.

[99] ibid.

[100] The process of semiosis (from the Greek: σημείωσις, *sēmeíōsis*, a derivation of the verb σημειῶ, *sēmeiô*, "to mark") refers to a process that involves signs and the production of meaning.

[101] link to source: The Giver of Names

[102] link to source: Same Difference - Network Dance, The performance seems concerned with c*ommunication or rather with the impossibility of communication in language. Same Difference is performed by seven dancers (with one of the male dancers performing a female stage character) who dance and play the role of characters, and generally express themselves through body and verbal language-ing.*

[103] link to source: iSA - i*SA is looking for a counter color to its dynamic dance and the oven violent motional language, for silence opposed to chaos. Elegance and subtle movement side by side with explosive dance. íSA is inspired by Scandinavian sagas about the pain and beauty of time passing. In a monochromous and ethereal landscape, between the tall walls and windows of a desolate house, the legend unfolds of íSA, the ice queen. Her chilling cry sounds through the mist, message of death at hand. íSA is like a danced folk legend of departure, seclusion, return and atonement.*
The performance tells a cold story about people, about that what decides us and what we can't get our grip on. Kristel van Issum (choreographer) said: 'Inducing this performance are thoughts on transiency; everything can perish without a reason. With íSA T.r.a.s.h. creates a performance about the quest of a soul for a body. Personas engaging into a body and disappearing, determining the sculpture and sound of a body. The simplicity, the abundance, the resolution of Nature is a source of parallels towards that incomprehension and inevitability in a human life. The international cast responds to this subject with personal biographies in which frozen water is a metaphor for their contained memories.'

[104] Jessie Eggers, '*Moving Speech, The Use of Language in Live Dance Performance*', Thesis Master Program Theatre Studies, University of Utrecht, 2009 pg. 16

[105] Media Choreography names how the creators of a play-space (responsive environment) put all the media together using continuous dynamics and quasi-physics, rather than rules, databases, and procedural logic. This is both an aesthetic and an operational heuristic. More information on the Design of Responsive Spaces chapter.

[106] Hans-Thies Lehmann, '*Postdramatic Theatre'* translated and with an introduction by Karen Jürs-Munby, Routledge, London and New York 2006

[107] link to source: Maria Kefirova - Portfolio

[108] link to source: Maria Kefirova - Endlessend

[109] link to source: Maria Kefirova - Corps.Relations

[110] As noted by Eggers - Giorgio Agamben, '*Infancy and History*: *On the Destruction of Experience'*, 1978. Trans. Liz Heron (London, New York: Verso, 2007): pg 62.

[111] Figure 11, source: .txt - figure project: .txt - project

[112] Later, in the Design of Responsive Spaces chapter this notion of ecosystem will be further discussed.

[113] Rancière Jacques, '*The Emancipated Spectator*', Translated by Gregory Elliott, London, New York: Verso, 2009, pg. 13

[114] ibid. pg 15

[115] Chris Ziegler - Portfolio

[116] This is an unpublished experimental work that have been introduced to in private talks with prof. Sha Xin Wei and Omar Al Faleh

[117] Harrison, S., Ph. Sengers and D. Tatar (2007). The three paradigms of HCI. San Jose, CA, USA. 45

[118] Rhee, Jieun. "Performing the Other: Yoko Ono's Cut Piece." *Art History* 28.1 (2005): pg. 96 - 118

[119] Biesenbach, Klaus Peter, ed. Marina Abramović: the artist is present. The Museum of Modern Art, 2010

[120] Al Faleh, Omar, Chandolias, Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces*', 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. This part was taken as is, with very minor changes.

[121] Chapter 2 this is also extensively discussed in the works cited in this Thesis by Chris Salter, Johannes Birringer and Andre Lepecki

[122] Chris Salter, '*Entangled: Technology and the Transformation of Performance'*, 2010, pg. 37 - 52

[123] Dr Garth Paine, '*Interactivity, where to from here?'*, Organised Sound, 7(3), 2002, pg. 295-304, pg. 300

[124] Xin Wei Sha, '*Poiesis and Enchantment in Topological Matter'*, The MIT Press, 2013, pg 54-55

[125] Al Faleh, Omar, Chandolias, Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces*', 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. This part was taken as is, with very minor changes.

[126] Lefebvre, Henri. '*The production of space'*. Vol. 30. Oxford: Blackwell, 1991

[127] Al Faleh, Omar, Chandolias, Nikolaos, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces*', 5th Annual International Conference on Visual and Performing Arts, Athens (Greece), June 2014. This part was taken as is, with very minor changes.

[128] ibid.

[129] Xin Wei Sha, *Poiesis and Enchantment in Topological Matter*, The MIT Press, 2013, pg 31-34 and 95

[130] Sparatsino, Flavia, '*Natural Interaction in Intelligent Spaces: Designing for Architecture and Entertainment'*, Sensing Places and MIT, Multimedia Tools and Applications, July 2008, Volume 38, Issue 3, pp 307-335

[131] Oxford Dictionary of English (3d.)

[132] Dr Garth Paine, '*Interactive, Responsive Sound Environments A Broader Artistic Context, Music, technology and Innovation',* De Montfort University Leicester, UK, 2004

[133] Maturana and Varela, '*Autopoiesis and Cognition'*, The Realisation Of The Living, Volume 42, pg 80-87

[134] Dubberly, H., P.I Pangaro and U. Haque (2009). '*On Modeling: what is interaction?: are there different types?*'. *interactions* 16(1), 69–75.

[135] Kari Kuutti, *('Re)searching the Digital Bauhaus',* Springer, London, HCI and design: uncomfortable bedfellows?, University of Oulu, Department of Information Processing Science Oulu, Finland, In Binder, Löwgren Malmborg (eds.) 2009, pp. 43-59,

[136] Robert Fabricant, '*Design With Intent, How designers can influence behaviour*', published online December 16th, 2009, available on: Design With Intent

[137] Al Faleh, Omar, Chandolias, Nikolaos, Del Tredici, Felix, Montpellier, Evan, '*Towards An Integrated Design Process For Improvisational And Performative Interactive Environments*', Vancouver CHI, Vancouver (France) , juin 2014.

[138] Dubberly, H., P.I Pangaro and U. Haque (2009). '*On Modelling: what is interaction?: are there different types?*'. *interactions* 16(1), 69–75. 46, 47, 140, A more holistic approach can be also found in Vangelis Lympouridis, PhD Design Strategies for Whole Body Interactive Performance Systems 2012, pg. 45-49

[139] According to Dubberly, there are two kinds of systems, the static and the dynamic. Inside the dynamic systems we can recognise the ones that can react and the ones that interact. '*Some of the systems that interact have specific goals and are self regulating in order to achieve these goals. The goal of these systems, which are called first order systems, can only be adjusted by something outside the system. Second order systems have a built in learning or feedback interpreting mechanism, which can measure the effect of the first system on the environment and adjust the system's goal according to how well its own second order goal is being met.'* For the context of this thesis I will examine just the second order systems, because they are the ones who seem to have a more pertinent relationship with the systems I have developed. See also, Dubberly, H., P.I Pangaro and U. Haque (2009). '*On Modelling: what is interaction?: are there different types?'*. *interactions* 16(1), 69–75. 46, 47, 140, and a more holistic approach can be also found in Vangelis Lympouridis, PhD '*Design Strategies for Whole Body Interactive Performance Systems'* 2012, pg. 45-49

[140] As cited by Lympouridis from Dubberly, H., P.I Pangaro and U. Haque (2009). '*On Modelling: what is interaction?: are there different types?*'. *interactions* 16(1), 69–75. 46, 47, 140

[141] Xin Wei Sha, '*Poiesis and Enchantment in Topological Matter'*, The MIT Press, 2013, pg 201 - 209

[142] Ibid. pg 205, According to Sha Xin Wei, 'a media choreography system is a set of software (and hardware) frameworks that extract features from sensor data tracking what is going on in a physical space, and creates or modulates ambient media (video, sound, lighting kinetic material, or objects) in real time, concurrently with that activity. The mapping from activity to media dynamics can follow one of many strategies. (1) fixed timelines, (2) if-then logic, (3) stochastic methods, (4) written scripts.' For more information look at Ibid. pg 205 - 227

[143] Xin Wei Sha, Michael Fortin, Navid Navab, Tim Sutton, Topological Media Lab, Concordia University, '*Ozone: Continuous State-based Media Choreography System for Live Performance'*, 2010

[144] Al Faleh Omar, Chandolias Nikolaos, Del Tredici Felix, Montpellier Evan, '*Towards An Integrated Design Process For Improvisational And Performative Interactive Environments',* Vancouver CHI, Vancouver, June 2014.

[145] Oliveros, Pauline. '*Deep Listening: A Composer's Sound Practice.*' New York, Lincoln, and Shanghai: iUniverse, Inc., 2005

[146] '*I am using the term multiform story to describe a written or dramatic narrative that presents a single situation or plotline in multiple versions, versions that would be mutually exclusive in our ordinary experience'* — Murray, Janet H., '*Hamlet on the Holodeck, The future of Narrative in Cyberspace'*, The Free Press, London, 1998, pg. 30

[147] Marie-Laure, Ryan, '*Avatar's Of Story*', Electronic Mediation Series, University of Minnesota Press, 2006

[148] Murray, Janet H., '*Hamlet on the Holodeck, The future of Narrative in Cyberspace'*, The Free Press, London, 1998

[149] Walsh, Richard, '*Emergent Narrative in Interactive Media*', Narrative, Volume 19, Number 1, January 2011, pp. 72-85 (Article) DOI: 10.1353/nar.2011.0006 pg. 76

[150] Paine, Garth, '*Interactivity, where to from here?'*, Organised Sound, 7(3), 2002, pp. 295-304.

[151] Mladen Dolar,, '*A Voice and Nothing More*', MIT Press 2006, pg 13

[152] Pattern recognition refers to the ability to recognise similarities in data sets and is a term that is vastly used in computer vision techniques. On the other hand pattern tracking refers not only to the ability to detect the pattern but also to the ability of tracking the different states that it might undergo through time and space.

[153] Levin, G., and Lieberman, Z. '*In-situ speech visualisation in realtime interactive installation and performance'*, NPAR '04, Proceedings of the 3rd international symposium on Non-photorealistic animation and rendering, pg. 7 - 14, ACM New York, NY, USA, 2004

[154] See Chapter 2

[155] Appendix I

[156] Klein, D., and Manning, C. D. '*Fast exact inference with a factored model for natural language parsing'*. Advances in Neural Information Processing Systems (NIPS) 15 (2003), 3–10. Cambridge, MA: MIT Press.

[157] Apache. Apache commons lang, March 1, 2013.

[158] Freed, A., and Schmeder, A. Features and future of open sound control version 1.1. In New Interfaces for Musical Expression (NIME) 2009, and Schlegel, A. oscp5: A implementation of the OSC protocol for processing, December 19, 2011 2010.

[159] Assayag, G., Bloch, G., Chemillier, M., L´evy, B., and Dubnov, S. '*Omax'*, December 8, 2012 and Assayag, G., and Dubnov, S. '*Using factor oracles for machine improvisation'*. Soft Computing 8, 9 (2004). Also, Dubnov, S., Assayag, G., Lartillot, O., and Bejerano, G. '*Using machine-learning methods for musical style modeling'*. IEEE Computer 10, 38 (2003).

[160] Schwarz, D., Beller, G., Verbrugghe, B., and Britton, S. '*Real-time corpus-based concatenative synthesis with catart*,' 2006.

[161] Malt, M., and Jourdan, E. '*Zsa.descriptors library for real-time sound descriptors analysis for maxmsp'.* In Sound and Music Computing (2008). http://www.e–j.com/

[162] Cycling74. Max / msp / jitter, 2013

[163] For more information please read Appendix II

[164] As of May 2014, you need a developer's API key to use Google's speech API. The new API has a limit of 50 requests/day for Speech Recognition. In order to tackle with this problem I have declare multiple projects that require the API, on Google developers website, in order to have many API Keys that will allow the speech engine to run for approximately 2 hours.

[165] Klein, D., and Manning, C. D. '*Fast exact inference with a factored model for natural language parsing'*. Advances in Neural Information Processing Systems (NIPS) 15 (2003), 3–10. Cambridge, MA: MIT Press.

[166] Chandolias Nikolaos & Dimitra Micha, '*An Application Creating an Animation Video Based on a User Generated Script in Natural Language'*, MSc Thesis, Thessaloniki, Greece, July 2012

[167] Requirement extraction algorithms are vastly used to extract functional/valuable information from a large set of data for Software development and prototyping. This approach in the Storytelling system is depicted with the use of XML data mining techniques in order to extract the useful information from the Stanford Parser and the OAWT database.

[168] Lindberg, C. A. Oxford American writer's thesaurus, 2nd ed. Oxford University Press, New York, 2008. 2008031259 compiled by Christine A. Lindberg. Writer's thesaurus 26 cm

[169] Frantova, Elena, '*Graph-based features for flexible emotion classification*'. PhD thesis, Concordia University, 2013.

[170] Sha, X. W., Fortin, M., Navab, N., and Sutton, T. '*Ozone: A continuous state-based approach to media choreography'*. In ACM Multiimedia, Topological Media Lab, Concordia University (2010), 12.

[171] Lewis, J., and Obx Labs. Intralocutor, 2007

[172] Malt, M., and Jourdan, E. '*Zsa.descriptors library for real-time sound descriptors analysis for maxmsp.'* In Sound and Music Computing (2008). link to source: zsa.descriptors

[173] Nygaard, L. C., Herold, D. S., Namy, L. L., '*The semantics of prosody: Acoustic and perceptual evidence of prosodic correlate to word meaning.*', Published in Cognitive Science, Volume 33, Issue 1 pp. 127-46, January 2009

[174] Sha, X. W., and Topological Media Lab. Hubbub, 2004

[175] Lewis, J., and Obx Labs. Intralocutor, 2007

[176] This section brings up the notion of telementationalist and theories of languaging as adapted from Roy Harris in Sha's Xin Wei book '*Poiesis and Enchantment in Topological Matter*'. He states that *'[a] theory of languaging assumes disconnected minds transmitting pieces of writing that conduct thought from mind to mind.'* Furthermore, in one of his earlier papers, '*Differential Geometrical Performance and Poiesis*', Xin Wei defines telementationalist as '*a technology for recording a writer's thoughts in a nonvolatile medium, transporting this nonvolatile recording to a remote reader, and decoding the meaning by the receiver.'* For more information see also: Harris, R. '*Signs of writing*'. Routledge, London ; New York, 1995. Roy Harris. ill. (some col.) ; 24 cm.

[177] Sha, X. W., and Topological Media Lab. Hubbub, 2004

[178] Xin Wei Sha, *Poiesis and Enchantment in Topological Matter*, The MIT Press, 2013, pg 99

[179] Johnston, W. D. j. '*Aesthetic Animism: Digital Poetry as Ontological Probe'.* PhD thesis, Concordia University, 2012.

[180] Mladen Dolar,, '*A Voice and Nothing More'*, MIT Press 2006, pg 15, as quoted from by Frances Dyson in Sounding New Media, Immersion and Embodiment in the arts And Cultures, 2009 pg. 8

[181] ibid.

[182] For more information the matter and a more detail analysis on the terms used here, look at Mladen Dolar,, '*A Voice and Nothing More'*, MIT Press 2006 and Frances Dyson in '*Sounding New Media*, *Immersion and Embodiment in the arts And Cultures'*, 2009

[183] ibid.

[184] Radha, V., and Vimala, A. C. '*A review on speech recognition challenges and approaches'*. World of Computer Science and Information Technology Journal (WCSIT) 2, 1 (2012), 1–7.

[185] More comments on the issue and more recent experiments are featured in the Future Developments section

[186] As cited by Myers Natasha, Dumit Joe, '*CHAPTER 13. HAPTICS: Haptic Creativity and the Mid-embodiments of Experimental Life*', part of the book '*A Companion to the Anthropology of the Body and Embodiment*', Edited by: Frances E. Mascia-Lees, Wiley Blackwell, 2011

[187] Margaret Westby, Nikolaos Chandolias, '*Technologically Augmented Performance: Orbital Resonance'*, Paper for Review MOCO 2015

[188] For a detail conversation on Resonance and the use of it in Design, as well as the different ramifications of the word itself please read: i) Design as Rhetoric in the Discourse of Resonance Veronika Kelly, School of Art, Architecture and Design, Division of Education, Arts and Social Sciences, University of South Australia, Adelaide, Australia, and ii) The New York Times, On Language "Resonate" by Ben Zimmer, November 18, 2010

[189] OED Third Edition, March 2010

[190] The notion of Responsive Environments as Living Organisms and Ecosystems has been discussed earlier in the Thesis. For further information please refer to: i) Maturana and Varela, '*Autopoiesis and Cognition, The Realisation Of The Living*', Volume 42, ii) Dyson, Frances. (2009). *Sounding New Media: Immersion and Embodiment in the Arts and Culture'*. Berkeley: University of 'California Press, Introduction pg. 16-17 — According to Dyson, this tendency of comparing systems with ecosystems/living organisms/ambiences, blurred the lines between art, technology and life.

[191] Dyson, Frances. (2009). '*Sounding New Media: Immersion and Embodiment in the Arts and Culture*'. Berkeley: University of California Press, Introduction pg. 17

[192] ibid.

[193] Video documentation: Orbital Resonance

[194] Loke, Lian and Toni Robertson. (2013, March). '*Moving and Making Strange: An Embodied Approach to Movement-Based Interaction Design'.* ACM Transactions on Computer-Human Interaction. Vol. 20, 1, Article 7. (2013), pg. 1

[195] ibid. '*see Levisohn and Schiphorst [2011] for an account of how movement and somatic awareness are vital to experience-oriented approaches to technology design'*

[196] ibid.

[197] Paine, G. (2006). '*Interactive, Responsive Environments: a Broader Artistic Context'*. In Engineering nature : art & consciousness in the post-biological era (pp. 312-334). Chicago: University of Chicago Press, Intellect LTD

[198] Scott deLahunta, interview by Emmanuelle Quinz, Body-Machine Interfaces Design; This '*emerging interface technologies are actually almost more useful for the ways in which they open up questions about practice, not for how they represent some sort of alien machine from which we stand back as pure bodies. However, in engaging dynamically with these sorts of questions, dance can be in a position to perhaps begin to ask questions about the direction of technology development – and dare we think perhaps have some influence on it?*' Article can be found here: Scott deLahunta - Interview

[199] a detail list of them can be found in Appendix III

[200] For more information on the Sonification Modules used with the x-OSC, please refer to http://navidnavab.net

[201] more options we explored are listed in Appendix IV

[202] Interview, September 10, 2014, contacted by Margaret Westby

[203] Margaret Westby, Nikolaos Chandolias, '*Technologically Augmented Performance: Orbital Resonance*', Paper for Review MOCO 2015

[204] As cited by Margaret Westby at her 2nd PhD Comprehensive, Haseman, Brad. (2007). '*Rupture and Recognition: Identifying the Performative Research Paradigm.'* In Barrett, Estelle and Barbara Bolt (Eds.). *Practice as Research: Approaches to Creative Arts and Enquiry*. UK: L.B. Tauris & Co Ltd.

[205] Margaret Westby, Studio Comprehensive II: Research-Creation Project, *Orbital Resonance*

[206] Greg Corness and Thecla Schiphorst, Paper Abstract: 'I*ntuition as a Parameter for Interactive Performance'*, Interdisciplinary Panel 1: Creative Practices

[207] Margaret Westby, Nikolaos Chandolias, '*Technologically Augmented Performance: Orbital Resonance'*, Paper for Review MOCO 2015

[208] Oliveros Pauline - '*Deep Listening: A Composer's Sound Practice'*. New York, Lincoln, and Shanghai: iUniverse, Inc. 2005 pg. 69-72

[209] ibid.

[210] Schiphorst Thecla - '*Body Matters: the Palpability of the Invisible Computer'*, *Leonardo, Special Issue: Materials for Creativity*, Eds. Elissa Giaccardi & Lynda Candy, LEONARDO, Vol. 42, No. 3, 2009, pp. 225-230.

[211] Dyson, Frances. (2009). '*Sounding New Media: Immersion and Embodiment in the Arts and Culture'*. Berkeley: University of California Press. (2009), pg. 141.

[212] Myers Natasha, Dumit Joe, '*CHAPTER 13. HAPTICS: Haptic Creativity and the Mid-embodiments of Experimental Life*', part of the book '*A Companion to the Anthropology of the Body and Embodiment*', Edited by: Frances E. Mascia-Lees, Wiley Blackwell, 2011, pg. 249

[213] Interview, September 10, 2014, contacted by Margaret Westby

[214] AL Faleh, Omar and Nikolaos Chandolias, '*Computational media as tools for the creation of aesthetic and affective experiences in responsive spaces*', Arts Abstracts, 5th Annual International Conference on Visual and Performing Arts 2-5 June 2014, Athens, Greece

[215] David Z. Saltz - '*Media, Technology, and Performance'*, Theatre Journal, Volume 65, Number 3, October 2013, pp. 421-432

[216] Margaret Westby, Nikolaos Chandolias, 'T*echnologically Augmented Performance: Orbital Resonance'*, Paper for Review MOCO 2015

[217] Margaret Westby, 2nd PhD Comprehensive, 2014

[218] The work No Distance is a descendent of the End.Lessend project that Maria Kefirova developed in collaboration with Miguel Angel Melgares in EMPAC 2010.

[219] link to source: ToC - Documentation — ['The] Table of Content (TOC) uses tables mated with two way, continuous live-video. Each table has a projector and a camera beaming down onto the surface of the table. Video capture from one side to transmitted to the remote projector and vice versa. As a result, objects placed on one table appear projected on the other. This focuses attention on what is being discussed and on a common tabletop on which props, diagrams and simple gestures can be used with ad hoc freedom. Should the collaborators wish to see their remote counterpart's faces, they can add a standard technology like Skype. We provide an omni-directional microphone and good speakers so that people can speak at any time in the flow of conversation without having the overhead of human gaze tracking. This conveys everyone's presence and enables ad hoc concurrent engagement.' As described in the HCI 2015 paper, (which is currently under Review // Saturday, March 7th, 2015) by Evan Montpellier et al.

[220] link to source: TML

[221] link to source: Obx

[222] link to source: x-OSC

[223] link to source: OSC

[224] link to source: Sebastian Madgwick

[225] link to source: mini-Bees

[226] link to source: Marije Balmaan

[227] link to source: Bitalino

[228] link to source: Pulse Sensor

[229] link to source: Polar T31

[230] link to source: Dan Julio Designs

[231] link to source: Muscle Sensor v3

[232] link to source: Community Core Vision