Responsive Architecture

A Place Making Design Strategy

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ABSTRACT

The area of responsive architecture is at the conceptual intersection of architecture, design, and technology. It presents an opportunity to investigate the potentials for engaging place-dwellers in an interactive exchange with each other and with the built environment, and can be regarded as an experimental medium for conceptual investigation. The concept of creating responsive architecture is synonymous to creating experiences in place, and for building site-specific interventions within the built environment that use computational technologies to choreograph or facilitate engaging experiences for visitors, spectators, and place-dwellers. From this perspective, responsive architecture can be regarded as a place-making design strategy that is informed the by theories and histories of architectural design practices, and also by concepts and studies on space, place, the body, experience, and perception.

This research attempts to present responsive architecture within the context of place-making and as a place-making design strategy. It conducts an overview which reads the history of experimentations in endowing architecture with feedback and adaptability in response to presence and interaction, and contextualizes this research by performing an inter-disciplinary reading in the history of arts and science to better understand the rise of these tendencies in the light of development of other forms of creation such as theatre, dance, and the advances in science and technology. This research also conducts a theoretical overview on the concepts of space and place, and their relation to active bodies and perception.

The second part of this thesis is a research-creation component which presents a design strategy that investigates the ways in which computational and digital media can be conceptualized, diffused, and used to create engaging and interactive experiences in place. It presents a set of experiments that were conducted by the author of this research, provides a conceptual pretext for the responsive design strategies that were used in each experiment, and draws similarities and distinction from the ensemble of the experiments that investigate a certain aspect of each strategy.

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1 INTRODUCTION

The 21st century marks the era where the promise of corporeal interaction with a ubiquitous computational intelligence permeating everyday space has come true. New ways of looking at technology, data, and their relation with the built environment, in addition to the exponential increase of computing power and networking bandwidth, and the availability of mobile devices and consumer-level prototyping technologies, have given birth to new paradigms of computing that are accessible to professions like design and architecture. Thus, circuit boards and computer code have turned into powerful design tools to embed potentials for communication and intelligence in everyday places and objects.

The vision of digitally connected places that are controlled and interfaced through natural speech and bodily gestures, which used to only exist in science fiction literature and Human Computer Interaction (HCI) research projects, are now a reality. This allows designers and creators to open new horizons where places fuse and interweave by means of digital networks that facilitate remote presence and control, and where new modes of interaction are created by interpreting bodily gestures and movement through motion tracking and motion sensor computation. Parallel to such technological advancements, we find growing conceptual and institutional interest in rethinking public space as a platform and medium, and in reconsidering the role of media in shaping our perception of place and reshaping city dynamics and identity. A diverse society in a complex urban and social fabric, which is increasingly dependent on media and networked technologies, necessitates change in the process of designing inclusive, open, and diverse public spaces beyond the passive containers for everyday activities they were once thought to be. New attention is being paid to the inevitable role of networked technologies and real-time media in shaping the built environment and shaping the dynamic relations between urban dwellers and their built environment.

The bi-directional influences between technological advancements and the morphology of the built environment are symptomatic of the post-industrial era where transport technologies changed the definition of locality and accessibility by allowing the working force to settle outside city centers in suburban regions that were made accessible through public transportation. This triggered a transformation in the urban dynamics of the city and the ways in which open spaces, residential zones, and commerce areas are defined in city planning. This transformation

continued with the rise of networked communication and interactive technologies that, through the work of researchers and visionaries in the late 20th century, paved the way to the creation of information-rich universes that overlay, or exist in parallel to, the built environment.

William's Gibson's introduction of the term cyberspace in his science fiction novel *Neuromancer* (1984) offered the following definition: "A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nanospace of the mind, clusters and constellations of data. Like city lights, receding." (Gibson 1984) The visions of data grids that flow across the urban structure and overlay the real with the virtual, and the illustration of data exchange as the movement of virtual objects from one place to another—all common representations in science fiction movies and novels—made for an acceptable illustration of the virtual as a parallel spatial construct which connects objects that belong in the real world.

William J. Mitchel describes the early days of the internet by calling cyberspace a territory, and using an architectural and special metaphor that compares the network between computers to the railway lines that connected the cities in the pre-industrial era: "a frontier region populated by the few handy technologists…., [the grid] is the new land beyond the horizon, the place that beckons the colonists, cowboys, con artists, and would-be conquerors of the twenty-first century." (Mitchell 1996) His spatial metaphors are contextualized by differentiating the real and the virtual at the levels of materiality, stability, and tactility. He described virtual reality as a tool to create spatial experiences that are separated from the physical construction, mass, and tactility; an experience that eliminates the subject's physical surrounding and substitutes them with electronically constructed ones: "With this technology you can walk or fly through virtual landscapes and virtual architecture, crash through enclosing surfaces without feeling a thing [..] Because there is no material to transform, there is no weathering of surfaces with the passage of time, and the forms and relationship of the spaces are not necessarily stable; they can be programmed to shift and reshape themselves whenever the designer wants." (Mitchell 1998)

Dyson argues that the popularity of cyberspace is a metaphor for escaping the passivity of the controlled mediation of the "real" world, which is mainly manifested in print and broadcast media. The promise of this new space—a space for immersion, imagination, and habitation—

transformed *being* into an attribute to the new forms of media and communication. Thus, cyberspace becomes a "mode of *being*, and the *cybernaut* is a new kind of human." (Dyson 1998) This notion of cyberspace as a refuge is not about escape as much as it was about curiosity and experimentation. This alternative universe of existence allows one to escape the rules of the real in exchange of creating one's own narrative. This was manifested in the rise of the mostly-themed, avatar-based 3D online communities and chat rooms such as Blaxxun, Active Worlds, Second life, and the rise of the VRML, the open-source 3D programming language for constructing web-based virtual reality worlds. The ability to construct, teleport, and control the content in one's virtual world was a true translation to the promise of cyberspace as an alternative mode of existence that is about communication, data, and control. These universes offered the option for sci-fi and mythology-based narrative construction of virtual places, while also allowing users the option to construct their worlds using items and textures that are based on existing urban landmarks, thus creating a Second Life version of New York city, Berlin, and London.

This contrast between the materiality of the built environment and cyberspace as a networked interactive medium, and between the ability to create one's own experience and narrative in cyberspace, opposed by the rigidity and absoluteness of the built environment, gave way to the concept of interactive architecture: new ways to interact and engage with the built environment and those who dwell in it, where "networking and computing are no longer tools for building alternative worlds, rather tools for enhancing the multidimensionality of the real world." (Bullivant 2005)

Lucy Bullivant's editorial in the *Interactive Architecture* book presents the work of designers, interaction designers, and architects who experimented with "unique and profoundly moving ways of navigating and occupying space as a social interactive medium." The examples she presents "[blur] the boundaries between work and play, information retrieval and use." (Bullivant 2005) The significance of this publication by the Architectural Design series lies in identifying the term interactive architecture as a new form of rethinking the built environment in the age of embedded intelligence, where technological interventions and embedded communication go beyond the immediate functional application, and become tools for crafting and choreographing new forms of social interaction and play in already existing places. This concept also enables place-making strategies that read from, and reinterpret, the social, cultural,

and affective qualities of architectural and urban places in the context of technological and networked augmentation.

These tools and technologies present designers, architects, and social scientists with opportunities to propose new methodologies and strategies for creating interventions in the built environment that transcend the traditional practice of building. These tools are now accessible for the practices of placemaking which are anchored in the physical space, yet focused on the relationship between people and their places, and the relationships among people in places. (Schneekloth and Shibley 2000)

This research adopts the term responsive architecture to discuss interactive interventions in the built environment in the context of place-making as a cultural and design practice. This research will present responsive architecture as a theoretical and artistic hybrid form of creation that exists across traditional design and technological practices, and at the borders of formal professional architectural practices. Conceptualizing responsive architecture as a tool for placemaking is a process that is informed by theories of place and architectural spaces, embodied and enactive engagement with the built environment, and a reflective analysis of the narrative and performative aspects of such interaction. The technological nature of such architecture is also informed by the theories and practices of the field of Human Computer Interaction (HCI) and software design.

Research on computation and technology in design and architecture is largely focused on the tools and techniques of algorithmically generating shapes and volumes, rapid prototyping, material science, crowd and environmental simulations, as well as the integration of technology in the optimization of the building and construction process. On the other hand, research in embedded computation and sensing is mainly focused on energy and environmental performance monitoring, with some examples of buildings that condition themselves by sensing fluctuations in environmental factors--for example, Jean Nouvel's Institute Du Monde Arabe whose façade is made of mechanical iris-like elements that open and close to regulate the amount of sun that is allowed into the building. Research on placemaking is not traditionally concerned with interactive technologies as tools for intervention in the built environment and is generally focused on longer-term solutions that are products of traditional architectural and urban planning practices.

The issues of technology, the body, and space, on the other hand, have been a topic of interest and experimentation in the domain of performance for quite sometime[1]. There is a large body of cross-disciplinary research and practice in design, performance, and computational media, with experimentations that date back to the early work of Dumbtype, Stelarc, Atau Tanaka and the Sensorband.

Can we propose responsive participatory architecture and interactive experiential design as a place-making strategy that engages the public within space in collective experiences? Can a cross-disciplinary investigation in architecture, technology, arts, and philosophy, as well as a historical analysis of contemporary work that uses interactive and computational technologies in public spaces, allow us to identify and propose a conceptual and theoretical framework that inform the design process and intervention strategies?

This research attempts to situate itself at the intersection of these disciplines by performing an interdisciplinary examination of the potentials of responsive architecture, where technology and computation are tools that enable people's interaction with space and with each other in the space. The concept of designing for interaction and play as a way to engage people in public spaces, and the idea of designing for interaction that is location-specific, yet able to create portal and virtual tunnels to connect with other places and locations, allow us to evaluate responsive architecture as a place-making strategy: a strategy that is outside the expert culture of traditional architectural practices, and at the borders between modern and postmodern thought in politics, aesthetics, and science (Schneekloth and Shibley 2000). This research will look at this form of hybrid design as an ephemeral intervention strategy that lives within an already existing architectural and urban context: a minor, critical, light, and sometimes invisible architecture that lends itself to the realm of the experimental rather than the purely positive (Sha 2011b).

This research will look at some of the strategies that inform and influence the design decisions, not from an art-making perspective that has tended to favour aesthetics and personal narratives, nor from a traditional techno-centric interactive installation perspective that can favour complexity and experimentation over content. Instead, the focus will be on the reflective and critical nature of the debate that informs the design and intervention strategies; the aim will

[1] Example of this can be found in the work of Josef Svoboda, Alwin Nikolais, William Forsythe, Philippe Decouflé, and more contemporary dance companies like Dumb Type and Hotel Proforma.

be to highlight conceptual considerations that could potentially inform the design process by anchoring these in their historical and conceptual context, which in turn reads from design traditions and technological trends over the years. This research will also present experiments and installations that were designed to investigate and conceptualize some of those conceptual processes within the domain of academic and practice-based frameworks. In conclusion this research will establish strategic links between theory and practice and propose a roadmap to future investigations into the area of technology and research.

2 PROBLEMATIC AND METHODOLOGY

This research is primarily concerned with the processes and strategies of designing computationally-activated architectural spaces that are geared towards building subjective and collective experiences in the built environment. Such design strategies, in their broader lines, are no different from the traditional design process for urban and architectural interventions, and should in fact follow some of the same thought processes which inform the design decisions in architecture such as the preoccupation with the program, forms and spaces, perception, and the social morphogenesis that results from such designs and interventions. However, introducing change and feedback to the built environment as a result of interaction provides new ways for thinking about the relationship between the built environment and those who dwell in it, and a novel perspective on designing urban and architectural interventions with interaction as a core design component and strategy. Therefore, there is a need for a methodological approach to studying bottom-up, interaction-centric design strategies in the built environment with consideration for architecture, space, place, and the body. From this perspective, the process of designing for an architecture of interaction is different from the traditional design process for an architecture of static volumes and spaces in which the interaction takes place. The point of departure between the two design approaches can be abstracted to the dynamics between the container and the content, and the a-priori relations between them.

The traditional architectural design process starts from the program, space, form, and materials. This process remains relevant in designing an architecture of interaction, yet more expandable and potentially redefined by the new opportunities that are made available by computational technologies. This thought process enables us to ask the following questions:

1. How can we rethink the role of the architectural program as a starting point to designing an architecture that conditions itself based on the interaction and presence of people, and what are the alternative processes?
2. Is the historic debate over the a-priori relation between function and form still relevant in an architecture that can redefine itself, on a material and immaterial levels, based on computational decision-making hierarchy that is triggered by interaction and presence?
3. The continuous emergence of new philosophies of place, space, and the body, in addition to constantly re-reading existing philosophies in a contemporary sociopolitical and

technological context, have always informed the architectural design process in ways that have introduced significant design paradigm shifts over the course of modern history. What can we read from modern and contemporary philosophies to arrive at new design strategies in the light of introducing interactivity to the design process?

4. What constitutes a building material in computationally-enabled interactive architecture?
5. Can software design and technical considerations inform, or restrict, the design process in ways that can provide new potential relationships between spaces, volumes, and subjects?

This debate around a methodological approach to designing responsive architecture is still lacking as it requires deconstructing some of the main approaches to architecture, and rethinking some of the key assumptions and proposals that are already established in the traditional design process. Therefore, this research proposes that such debate should not be approached from a purely traditional architectural perspective. In fact, this research proposes that the debate should not be anchored in any one discipline at all, inviting an interdisciplinary approach that reads from architecture, art, philosophy, sociology, and technology, and that performs a relevant historical reading and a critical analysis of existing methodologies, techniques, and designs, contemporary or otherwise, to present this issue in a historical and practice-based context. This research will propose new design considerations that take the above questions as intellectual starting points. This master thesis is an interdisciplinary research-creation that attempts to conduct theoretical examinations through design and implementation. Proposing design strategies and methodologies through creating experimental designs is an iterative process that starts with a concept and validates the concept through implementation. This reads from Sha Xin Wei's take on the atelier-lab as "creation of apparatuses for ethico-aesthetic improvisation" that "approaches process-based articulation from the perspective of continuous, material experience." (Sha 2011, 63-64) This view, which was the mantra of the Topological Media Lab that Sha established at Concordia University in 2004, and at which I was a resident researcher throughout my master studies, approaches research creation as a mode of experimental investigation in art research that "creates knowledge via aesthetic as well as critical inquiry, and engages material and embodied experience as well as concepts. […] Rather than promoting a particular methodology, it can draw general knowledge from the creation of things or events." (Sha 2011, 65-66) Therefore, the research-creation design experiments that will be presented in this thesis are not art works, nor do they aspire to achieve the aesthetic levels of a

finished art piece. In fact, they validate themselves as conceptual research tools through their unfinished in-the-process state, which is also a statement about the status of this research as a step forward rather than a process which ends with a definite answer.

Myron Krueger echoes this way of thinking, in his reflection on his early works in creating computational networked and interactive installations in the 1970's; I will be present and discuss his work in Chapter 3 of this thesis. For Krueger, the design process should not regard the visual responses for such systems as art nor should sounds be thought of as music. The only aesthetic concern is the quality of the interaction and the constantly evolving relationship between the audience and the work. (Krueger 1977)

Response for Krueger is a medium rather than a result: the medium is comprised of sensing, display, and control systems; it accepts inputs from or about the participants and then outputs in a way they can recognize as corresponding to their behavior. The relationship between inputs and outputs is arbitrary and variable, thus allowing the artist to intervene between the participants' action and the result perceived. The idea of response-as-a-medium for Krueger places the artist and designer somewhere between the computer and the participant, leaving the computer as the conductor of the orchestra, and the artist as the provider for the score, to which both the audience and the conductor are bound. This allows for a conceptual interpretation of the nature of the interaction where "the simplest responses are little more than direct feedback of the participants' behavior, allowing the environment to show off its perceptual systems." (Krueger 1977, 387)

This concept adds to the definition of a computational design experiment as a research-creation tool for conceptual investigations. Those experiments, while automated and largely characterized by their definition as computer systems, are not mere software processes that are independent from human intervention, nor are they intended to evolve and change over time by means of machine learning or artificial intelligence techniques. The designer-researcher is always present throughout the experiments to change and tune the behavior of the system as the human input changes, and as the research processes implies. This is why the Topological Media Lab adopted the term *state machine*, where these installations/experiments go through different cycles and response states where the behavior of some of these states are human-driven, and the switch between these states can also be triggered by human intervention.

The design process for such experiments, as described in detail in Chapter 5, does not follow the same design processes for computer software. The assumption of instant input-output system feedback is not necessarily characteristic of such experiments;.the experiments' state during idle time demands equal conceptual reflection as during active presence. Input, unlike traditional computer software's definition of input, is not necessarily an active process or gesture; rather, it can be a lack of action or presence in the system, or a synchronized set of actions by one of multiple subjects. This is why it is more relevant to think about the process of designing for a responsive architecture as an exercise in experience design rather than in software design, even if we acknowledge the complex technological nature that is inherently characteristic of such responsive architecture.

This research will start by conducting a historical and theoretical overview of theories and concepts that help set the grounds for the proposed design strategies. Chapter 3 will conduct a conceptual and historical survey on what can be thought of as precedents for responsive architecture as conceptual and practical design frameworks, and explore relevant designs and artworks that are inspirational precedents to interactive and responsive architecture. Chapter 4 will discuss the theoretical basis for space and place in philosophy and architecture, the use of technology as place-making tool, and the possible bridges between the conceptual ground for current practices in place-making and the possibilities that can be offered by technology as a place-making tool. Chapter 5 will use the concepts and research in chapter 3 and 4 to propose design strategies that deal with the questions about deconstructing the architectural design process which were listed above in this chapter. Chapter 5 will then evaluate the proposed strategies by describing the research creation experiments that I have conducted throughout my studies, in an attempt to answer some of those questions through implementation and design.

Chapter 6 will conclude this research by making closing arguments about the work and process presented here and propose future avenues to further develop this work on conceptual and practical levels.

3 RESPONSIVE ARCHITECTURE

3.1 Automata, machines, and responsive architecture

Figure 1- The Mechanical Turk - Front view. Source: Wikipedia

One of the earliest instances of an interactive automata, a machine built to be viewed as human, was the *Amazing Turk,* sometimes also called the *Mechanical Turk*, in the 1770s. The Turk was an automaton shaped like a man dressed in traditional Turkish attire and able to skillfully play chess with volunteers from the audience, thus becoming one of the earliest documented instances of interaction between humans and machines that demonstrate agency and intelligence. The Turk was designed as a gift for the Habsburg Archduchess Maria Theresa by the inventor and engineer Wolfgang von Kempelen. After the Archduchess' death, her son revived the Turk by sending it with von Kempelen on a tour in Europe where it was put on display in front of a curious and astonished crowd and played chess with audience members who included Napoleon and Benjamin Franklin.

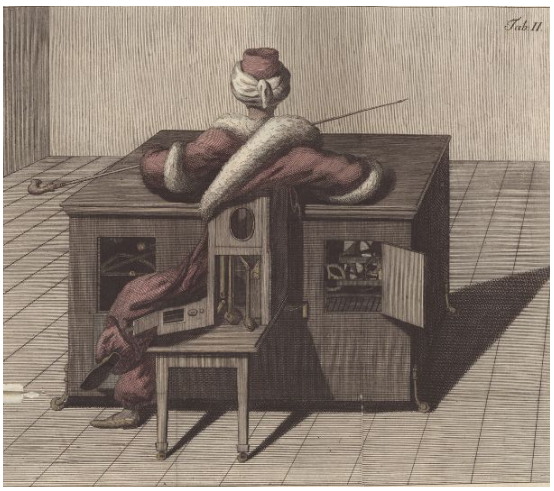

Figure 2 - The Mechanical Turk - Back view. Source: Wikipedia

When the show starts, von Kempelen began his demonstration of The Turk's workings by "opening the doors and drawers of the cabinet and shining a candle inside each section, Inside were cogs, gears, and other clockwork. After closing the cabinet, von Kempelen invited a volunteer to serve as the Turk's opponent." (Morton 2015)

The mystery of how the Turk managed to beat those players swept Europe and triggered many theories and speculations. The Turk and its mysterious inner working were subject to curiosity and speculation between the 1770s and the 1780s; viewers thought the Turk was the result of a deal between von

Kempelen and the devil, and later thought the machine was remotely controlled by von Kempelen through strings and magnets. The secret of the Turk was revealed towards the end of the 1800s: it was operated by a master chess player from inside the cabinet who pulled levers and strings to move the Turk's arms. (Clark, Golinski, and Schaffer 1999)

Despite being an elaborate hoax, the Mechanical Turk can be considered an early instance of an interactive object that emulates human agency through interaction, and invites speculation and curiosity over the nature of this interaction. This provides us with a departure point for studying the entity we call responsive architecture, which is an architectural automaton that is capable of feedback through interaction. Robert Wiener's cybernetic perspective considers that "living systems [are] particular types of machines equipped with the principle of feedback." (Guattari 1995, 33) This perspective leverages our initial definition of responsive architecture as it clearly emphasizes *feedback* as a property of living systems and machines that simulate living systems. Throughout this thesis, I will sometimes alternatively refer to such living responsive systems as "Organisms that Person," to borrow Arakawa and Gins' term from their work on *Architectural Body* (2002). By doing this, we are expanding the definition of Wiener's living systems as machines with feedback, and looking at them as organisms that display certain human-like traits, namely agency and response.

This perspective allows us to look at the *Amazing Turk* beyond the trickery and deception of faking machine intelligence through human control, and rather accept The Turk as an organism that persons through representation and control, where choosing to present it in the shape of a human being is very much in tandem with having a human being control its actions and interactions. What allows an organism to person, from an initial look, is its ability for decision making based on input, and its ability to generate feedback based on such process. El-Khoury et al study this from the perspective of cognition and decision making, where they propose that cognition emerges from situated and embodied interaction with the world as a complex and distributed stream of information, and where decision making is based on collecting information from the environment through embodied and situated interaction and synthesizing these information into *decisions* or emergent phenomena (El-Khoury, Marcopoulos, and Moukheiber 2012). This decision-making process applies to human subjects that dwell in a dynamic and changing environment and interact with it, but can also be expanded to a responsive architecture as a self-aware automaton whose machinic nature allows it to condition itself as a

form of feedback by sensing and processing information from the world, thus allowing it to *person*.

It is useful to underline one thing before we go further with our definitions: the use of the terms *machine* and *machinic* here does not refer to a mechanical mode of operation, and is not a symbolic reference to the technological nature of the creation process of such responsive architectures and living systems. In fact, the machinic state here precedes technology, and "has a self-consistency that spans the physical, the biological, the affective, the symbolic, the social, and the institutional, producing specific enunciative effects that are reproducible but are not themselves representational." (Smoak 2011, 139) This allows us to look at the machinic state as a process rather than a metaphor for tools, which makes responsive architecture a medium or a milieu rather than a thing of itself.

I will expand on this subtle differentiation in the context of my research: many architectural theorists look at architecture as a tool for social engineering, which is especially evident in Space Syntax as a field of knowledge that studies how the arrangement and functions of buildings and spaces influence the movement and behavior of people and performs a certain level of social engineering. This view endows architecture with the ability to transform something, by means of its own functionality and arrangement, into something else, or at least influence a state-change over time, which enables a view of architecture as a machine, or as something that is of, or has, a machinic state.

Le Corbusier's concept of "the house as a machine for living in" (Corbusier 1931), while it immediately implicates dwelling as a process of transformation, is in fact anchored in the modernist view of the era[2] that regards form as a product of function, which gives power to the program, or the function, to be the tool for the transformation of architecture and the act of dwelling. Bill Hillier, one of the prominent theorists of Space Syntax, has a different take on buildings as machines: "If the building is to be seen as a machine, then this implies that relation between the plan and the life that takes place in the plan is in some sense mechanistic, and that the former is either determinative, or a strict expression, of the latter."

[2] The concept of "form follows function", coined by Louis Sullivan, was a topic of debate in architectural design strategies in the early 20th century, starting from Sullivan's article *The Tall Office Building Artistically Considered* (1896) where he advocates for buildings that are "Solid, Useful, and Beautiful" in this specific order, and Adolf Loos rejection of ornaments and the advocacy of "useful objects" in his article *Ornament and Crime* (1910),

(Hillier 1996, 292) Like Le Corbusier, Hillier's analysis also departs from the theoretical dynamics between architectural form and function although he regards architectural spaces as the machine, not the building itself in its physical manifestation of bricks and mortar:

"although the parts of a building do not move, through their configurational differences they do affect the pattern of movement, in that, other things being equal, the degree to which spaces are used for movement is a function of their configurational position. […] Buildings are thus probabilistic space machines, able to absorb as well as generate social information through their configuration. In a very restricted sense then, we can say that buildings are machine-like, in that they are physical systems which through their spatial properties produce well-defined functional outcomes. In another, equally restricted sense, buildings are language-like, in that they embody, impart and transmit social information. But we would not understand either of these restricted truths unless we had first understood that, in their essential nature and dynamics, buildings are neither machine nor language. In that they are probabilistic space machines, buildings resemble nothing else." (Hillier 1996, 303-305)

The above perspective, while somewhat reductionist and restrictive, strives to provide a historical account on architecture when viewed as a machine for engineering social behavior, which spans across modernist to post-modernist scholars and architects. This thesis's departure point is an architecture that is agnostic to function and social engineering in the traditional sense, and that exists regardless of building as a physical manifestation. This take is analogous to Bernard Tschumi's rejection of the concept of "usefulness," which I interpret to be synonymous to "function," when studying architecture, and in tandem with the view of responsive architecture as a *minor architecture*, which I will discuss in a later section of this chapter. "To envy architecture's usefulness or, reciprocally, to envy artists' freedom shows in both cases naiveté and misunderstanding of the work. Buildings might be about usefulness, architecture not necessarily so." (Tschumi 1996, 106)

Circling back to the concept of responsive architecture's machinic state as a process rather than a tool, this research presents responsive architecture as a medium that enables playful and reflective conceptual experimentations, not as a tool for influencing or engineering social behavior. This distinction draws clear separation between the concept of architecture as a machine, and responsive architecture as a machinic state of production.

3.2 Minor architecture

After differentiating between responsive architecture as a process or a medium rather than a *thing,* I will further propose two conceptual points that relate to the process of production:

1- Responsive architecture is not about designing smart buildings that leverage technology for functionality and utility. It is not, from a conceptual point of view, designed to collect or analyze any metrics or data that are meant to inform design decisions or condition the life and behavior of those who dwell in it. The perspective that I will be presenting in this thesis is about creating subjective experiences, and not about creating data-driven tools for social engineering. I will present the case of *The Fun Palace* (1964), a conceptual architecture that adapts itself to people's behavior, later in this chapter to highlight the contrast between those two concepts.

2- Responsive architecture is not about building. As mentioned earlier, it is agnostic to physicality and function, and is meant to overlay or co-exist within the built environment and can be of an immaterial form. From this point of view, architecture is not necessarily, and maybe shouldn't be, built to be responsive; rather, existing architectural spaces can be activated. This subtle difference highlights the relevance of using the terms *process* and *medium*, which I will be using repeatedly throughout this research.

3- Interaction with responsive architecture is necessarily an embodied interaction, and the feedback of the environment is the result of an embodied perception that is unique to the perceiving body. Broglio quotes from Merleau-Ponty's *The Primacy of Perception*: "our bodies and sensations carve a particular sort of perceived space-time within the environment which we then call "world." Other creatures with different bodies and perceptual apparatus have a different sense of space and world." (Broglio 2011, 189) Broglio uses David Seamon's work in *Body-Subject, Time-Space Routines, and Place Ballets* (1980) to describe the embodied interaction in relation to the environment. Seamon's work initially sounds very similar to Space Syntax's approach to regarding architectural spaces as a deterministic factor for the behavior of bodies in space. He then clarifies how the habitual actions of the body are, in fact, originating from the body itself,

> but triggered by external forces such as space, architecture, and co-presence with other bodies. He writes, "habitual body behaviors are coordinated over time and according to cues from the environment and other people in the shared space […] the habitual nature of movement arises from the body, which houses its own special kind of purposeful sensibility" (Seamon 19908 cited in Broglio 2011, 189)

In that context, responsive architecture can be otherwise called a *minor architecture*, to use Sha's and Broglio's adaptation of Deleuze and Guattari's concept of minor literature: an entity that negotiates its existence within the larger context of architecture as a major form of production. (Broglio 2011, Sha 2011) In this context, responsive architecture is fragile, transparent, invisible and in contrast to the prominent structures within which it exists. It is also ephemeral, temporary, and playful. Playfulness as a main property of architecture, and interaction as a force of change in architecture, are evident in Littlewood and Price's *Fun Palace* where dynamic spaces and structure are conditioned by the behavior and interaction of the visitors. *The Fun Palace* was designed as a major technologically and mechanically complex architectural structure. But it also doubles as a minor architecture, as it was designed without a fixed plan or functional program, and with the intention to have it demolished and dis-assembled after 10 years.

It is important, however, to note that the temporary and ephemeral nature of such systems are not necessarily analogous to portability and the ease of reproduction. Responsive architecture is a site-specific design that is contextualized by its container and site. Context is crucial to architectural meaning, which is a notion that Alberto Perez-Gomez expands to cover the "situation on the ground" and the "world of the work,", where the work is not to be reduced to a geometrical object in a Cartesian space, and the context which relates to the identity is never an objectified and measurable site (Pérez-Gómez 2016, 134). This concept allows us to draw distinction between what constitutes an interactive art installation and what I am calling a responsive architecture: the portable nature of the technology which endows the space with interactive properties is not a pretext to the portability of the responsive space itself. This is why most of the black-box experiments—to be presented in Chapter 5—while adhering to the un-identity of the experimental black-box space, are authentic to their black-box context of conception and development, even if the place itself is character-less, which makes re-building these experiments elsewhere an entirely new process of creation.

3.3 The early days: Performance and Happenings

The ancient eastern forms of public story-telling, in which a narrator recounts tales and myths to a live audience, can be thought of as early forms of performance that allow audience interaction in a narrative and theatrical context. The narrator would sometime resort to engaging his audience, when reaching a narrative climax, by asking them for a verdict on the fate of one of the character. When the audience voted 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 boundaries between the roles of the spectator and author are blurred. (Kassab-Hassan 2013)

The role of the spectator in its traditional sense is put into examination in this chapter: I will present examples from the contemporary history of performance arts and theatre where the role of the passive spectator, calmly observing and examining the spectacles in front of them, is challenged and redefined. Rancière calls for a theatre without spectators, rather an audience with a redefined relationship which engages them in the act, just like ancient story-telling traditions invited the audience to patriciate in rewriting the story line: "Theatre is the place where an action is taken to its conclusion by bodies in motion in front of living bodies that are to be mobilized" (Rancière 2009, 3).

These local storytelling traditions continued to exist in parallel to other more contemporary forms of non-technological interactive performance in the 20th century; Yoko Ono's *Cut Piece* (1964) invited the audience to cut pieces of her dress while she sat passively on stage. In Marina Abramović's *Rhythm 0* (1974), Abramović sat in a gallery space, next to a table that has several objects on it, such as a knife, whip, chain, a bullet, a gun and so on. She invited the audience to use the objects against her while she sat and observed passively. Such works not only allow the audience to create unique performances, but also turn spectators into temporary performers whose contribution to the event flow can be as critical as the artist's role herself.

There was a growing trend in the 60's and 70's to move arts and performance away from the rigid model of passive spectatorship and into a more engaging model where participants are invited into unstable and variable contexts in which they could react to changing stimuli as part of a larger organism. (Salter 2010, 304). A testament of this can be found in Chris Salter's account of the Living Theatre's *Paradise Now* (1968) and Richard Schechner's *Dionysus in '69,*

two works in which audiences were intended to be active participants in the performance, thus abolishing the authoritative structure that divides spectators and performers. For Salter, this is a tendency that cannot be separated from the political, social, and technological revolutions of the time. (Salter 2010, 304) The works of Arianne Mnouchkine and other artists of the same era equally challenged the concept of spectatorship and brought the performers to the same space as the audience, thus bridging the space-time of the audience with the space-time of the spectacle, allowing for a flow between the two spaces that became united by the narrative of the performance. (Auslander 2003, 310)

At the same moment, events that came to be known as happenings were occurring in various sites around New York. Bound by ordinary aesthetics and mundane tasks, blurring the boundaries such as that between art and life, performer and spectator, theatre and street, the happenings are an important historical precedent for their embrace on alternative spaces such as lofts and store fronts. (Kirby 1995, 6)

It is also important to recognize the influence of integrating technology as a medium for design, choreography, and performance art, which can be traced back to the 60's and 70's due the growing tendencies for interdisciplinary inclusion of state-of-the-art engineering research into stage arts and performance arts. This is evident in the work of the Bauhaus's Moholy-Nagy and Schlemmer on developing new performance forms, new stage design concepts, and machine-based performance environments in the Bauhaus stage workshop. Their work read from the Bauhaus' research into total theaters which focused on stage designs that remove the boundaries between the stage and the viewer, integrate media and mechanical apparatus that create total sensory experiences, expose the technology as part of the performance, and transform static performance spaces into dynamic spaces through technical means. (Salter 2010, 41)

These ideas and concepts found their way in the later part of the century where their enduring legacies influenced some of the performance and installation in the 60s and 70s but also more recent work by contemporary artists and collectives like Dumb Type, Big Art Group, LAb[au], F0am, and many others.

3.4 Reconfigurable / Mobile Environments

Almost two hundred years after The Amazing Turk created intrigue as a performing machine, British theatre director Joan Littlewood, in 1964, wanted to create a public architecture "that enable[d] the audience participation without the engagement of a performer, and through the exploration of quotidian through play." (Franinovic 2011, 130) Littlewood collaborated with the architect Cedric Price to propose the concept of *The Fun Palace*, an architecture of play, participation, and engagement, that is made without a fixed form or a plan: a flexible frame with movable modules that can be re-arranged and reconstructed to accommodate people's interaction and actions. Rooms, walls, and halls were to be arranged per changes in environmental factors such as light, sound, and temperature to create room for emergent types of social behavior. Littlewood and Price called the palace "a laboratory for pleasure," which would have been an attempt to use technology to engineer social behavior without a top-down approach, a "public theatre without divisions between spectator and performer and event and visitor in architectural form." (Salter 2010, 310)

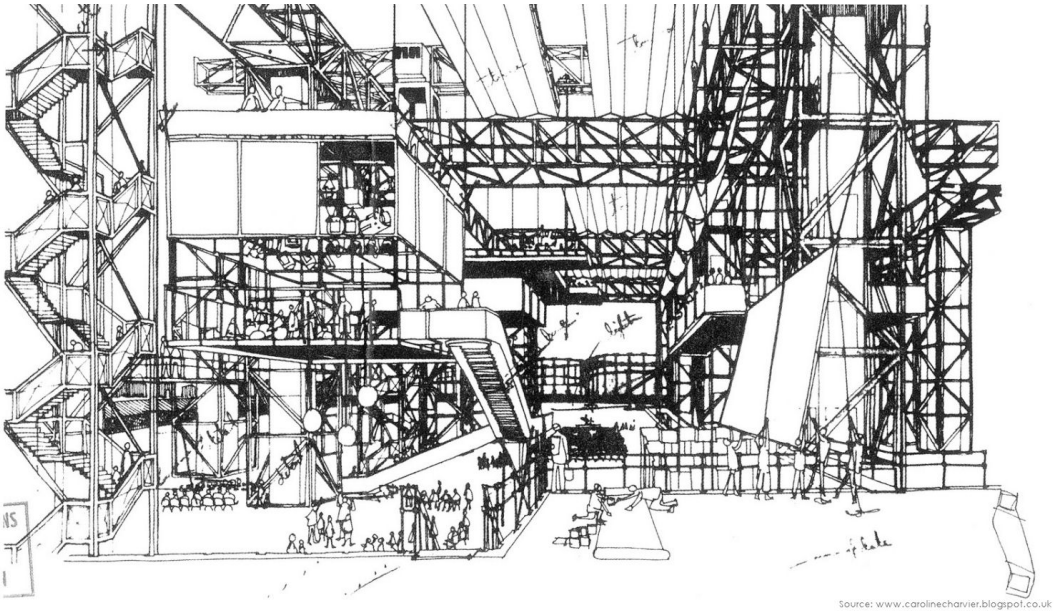

Figure 3 - Fun Palace (1964). Source: World News Architecture: http://www.worldarchitecturenews.com/project/2012/21461/cedric-price/reader-review-fun-palace.html

Littlewood and Price contacted the renowned British cybernetician and psychologist Gordon Pask to collaborate on the project. He proposed to automate the transformation of *The Fun Palace* by continuously tracking visitors' activities (type, size, location, quality) through a distributed array of sensors. For Pask, architecture had to serve those who dwell in it, but also had to have a certain level of control over those people, so if an equal number of people were predicted to want to perform two kinds of activities then the palace will create two spaces to accommodate these activities. Pask's model included an information pillar (proposed by Roy Ascott) which provides visitors with information about the activities and interests of other visitors in the palace. This introduction of mathematical predictions steered the project away from its intended function as a fun exploratory responsive design which allows for conflicts and mistakes. Pask's model turned *The Fun Palace* into a control machine of an automated society that prevents voluntary interaction. (Franinovic 2011, 131) This was around the same period of Le Corbusier's concept of "the house as a machine," where functionality took precedence over form and experience. Pask's concept demonstrates the modernist vision of architecture as a machine for social engineering but from a technological and mathematical perspective that was influenced by the curiosity and interest in computation as a tool for prediction and calculation, which were popular concepts after the Alan Turing machine and its prediction algorithms after the end of WW2.

This mathematical model of prediction and control remains present in the design strategies of modern and current incarnations of responsive architectural installations. The idea of control and guidance through computational and simulated feedback, while it superficially maintains the improvisational aspect of turning spectators into actors and the architectural space into a stage, limits the possibilities for emergent behavior, for both the space and the visitors. Osman Haque calls this deterministic form of interaction a *single-loop interaction*: an interaction that is built on associating expected actions with predetermined results:

"What happens when you enter an art installation that presents you with a visual effect that is the result of your movement in space? Would you call this interactive? Although you might not, on entering the gallery, be expecting particular visual effects to be triggered by your movement in space, it is likely that the artist had already decided which visual output would be associated by certain inputs - either knowingly, by filtering for the aesthetic desired, or

unknowingly but just as deterministically, through the complex but unchanging structure of the computer program." (Haque 2007, 58)

This kind of interaction, when translated into computer logic, follows the if-this-then-that logic which enables for higher levels of control. Yet it reduces the potential emergent forms of interaction to simple predetermined scenarios that, as in Franinovic's take on Pask's intervention in Littlewood and Price's *Fun Palace*, result in a structured and controlled social engineering of such responsive environments. Haque, however, argues in favor of a Pask'ian mode of interaction design that relies on interaction between humans, machines, and environments; these may engage in a constructive exchange of information without needing to rely on perfect communication with each other. In Haque's view, this "provides us with a method for comparing our conception of spatial conditions with the designed machine's conception of the space." (Haque 2007, 60) Haque recognizes an opportunity in Pask's methodology to blur the lines between the roles of the designer, owner, and occupant. This approach potentially allow for a bottom approach in the co-creation of the architectural environment.

Figure 4 - Archigram's Walking city (1964).
Source: The Archigram Archival Project http://archigram.westminster.ac.uk/project.php?id=60

At the same time of the conception of *The Fun Palace* in 1964, Ron Herron from Archigram released a proposal for a *Walking City*, a mobile inhabitable pod structure that roamed a post-apocalyptic earth. The *Walking City* "anticipated the fast-paced urban lifestyle of a technologically advanced society in which one need not be tied down to a permanent location."

(Blake 1968) The pods roam the earth by means of their artificial-intelligence controlled mechanical capabilities, occasionally connecting with other pods to form larger structures that "support the needs and desires of people who work and play, travel and stay put, simultaneously" (Blake 1968).

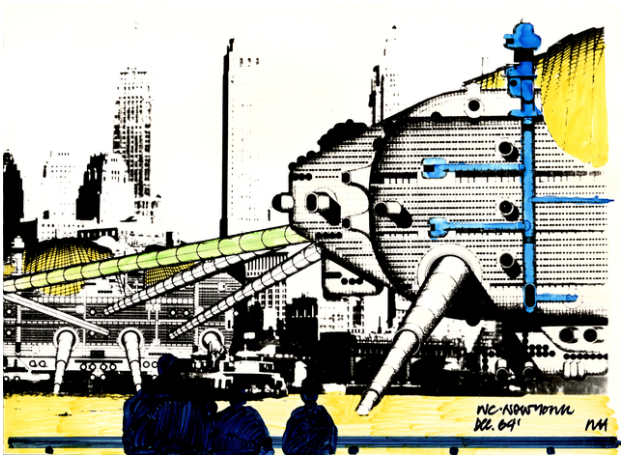

Figure 5 - Archigram's Walking City (1964). Source: The Archigram Archival Project http://archigram.westminster.ac.uk/project.php?id=60

The *Walking City* was inspired by the spirit of the era: the NASA space race, their mobile launch pad, and their proposed hover space crafts, in addition to the looming threat of the cold war and the scenarios of a post-apocalyptic earth. The *Walking City* was also a reflection on the expanding mechanical and industrial capabilities, and the potentials they brought for a reconfigurable and automated world. The *Walking City* was "a half-step between the mechanical (problem solving) assembly and the really free-ranging set of parts that respond to personal needs." (Cook 1999, 50) The *Walking City* was a design experiment as much as it was a conceptual and intellectual exercise that calls into question the basics for architecture urban design, as it intertwines the concept of a home and a car, and the need of mobilization for quotidian activities such as going to work and returning home. The *Walking City* is a response for an increasingly complex society

Fun Palace and *The Walking City* exemplify an architecture that explores scientific and computational possibilities that, when combined with the mechanical, can turn the design process away from an architecture that is primarily functional, and into an architecture that is an experimental medium for play and social interaction. "The gesture of translating events from a formal limitation to a mechanized liberation began to be symbolic more than directly necessary Perhaps some necessary conflict between gestures and the great desire to manifest: to build: to experiment." (Cook 1999, 50)

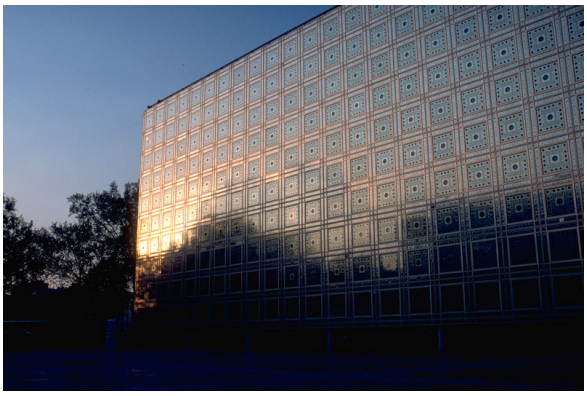

Figure 6 - Institut Du Monde Arabe (1987).
Source : Agha Khan Award for Architecture :
http://www.akdn.org/architecture/project/institut-du-monde-arabe

Unlike the previous two projects, Jean Nouvel's Arab World Institute (Institut du monde Arabe), which was completed in 1987, looks like a steady edifice that is sitting comfortably on its soil, demonstrating the traditional traits of architecture: immortality and stability. The southern façade of the building, however, is a fully-responsive curtain wall of mechanical iris-like metallic plates that sense the intensity of light and open and close to control the amount of sunlight that should enter the inner halls of the building. The design for such plates was inspired by a traditional ornament (*Mashrabiya*) which could be found in the architecture of the middle east and Mediterranean region.

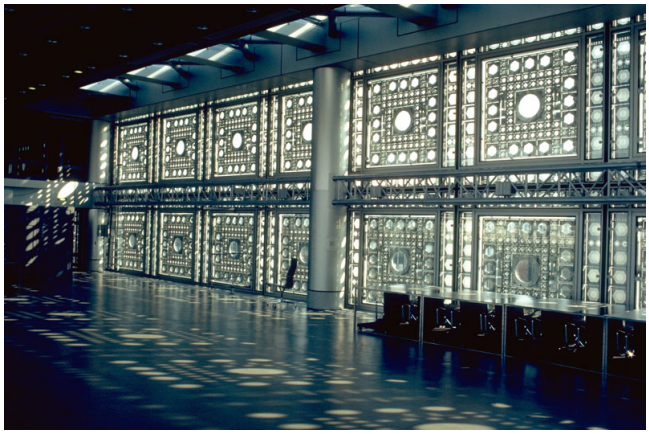

Figure 7 - Institut Du Monde Arabe (1987
Source : Agha Khan Award for Architecture :
http://www.akdn.org/architecture/project/institut-du-monde-arabe

This curtain wall conditions the inner ambience of the building by controlling the transparency and visibility of the southern façade. This is done by opening the iris to allow light to enter the rooms to some extent, and closing it proportionally to the rising intensity of the light, thus maintaining a steady atmosphere in the room. This building is an example of an architecture that conditions itself to the environmental factors and not in response to the actions of those who dwell in it, which makes it similar, in some aspects, to Archigram's *Walkable City* yet it demonstrates response by performing surface and volume morphologies, thus impacting the ambience and perception of their visitors. The design consideration for the iris wall, while verging on the utilitarian side of using technology for improving the status quo, leverages slow transformations over longer periods of time.

3.5 Connected Architecture / Telepresence: Computational Environments

Myron Krueger was one of the pioneers in creating human-machine interactive environments that invite active participation rather than passive and observant spectatorship, where the interaction with computer technologies in space was regarded as a medium, not a side feature of the artwork. Some of his early experiments in using computation to mediate the interaction with the built environment include the work of Dan Sandin, Jerry Erdman, and Richard Venezsky at the University of Wisconsin with a piece called GLOWFLOW (1969).

GLOWFLOW is an interactive art piece that is designed for a small crowd of 10-20 visitors who enter a darkened room whose walls are lined with four transparent tubes that are filled with phosphorescent particles. By sensing the footsteps of the visitors, through placing pressure-sensitive pads in specific zones of the room, a central computer is notified to illuminate the tubes, by shining lights to activate the phosphorus particles, and to play a pre-composed synthesized sound through a 6-speaker array. GLOWFLOW was designed with a small delay between detecting the footsteps of a participant in the room and the computer response, so that "the contemplative mood of the environment would not be destroyed by frantic attempts to elicit more responses." (Krueger 1977, 379) This work not only marks one of the early attempts to create computational responsive environments where response is triggered though interacting with the architectural space, but also marks an attempt to conceptualize interaction and response as a medium for creating experiences rather than indulging in computational experimentation.

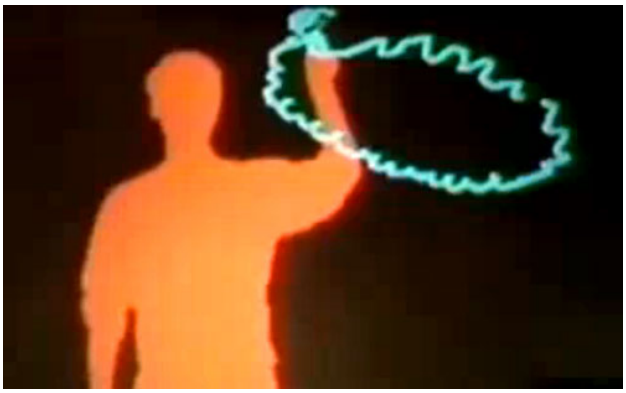

Figure 8 - Metaplay (1970).
Source: The Digital Age Wiki.
http://thedigitalage.pbworks.com/w/page/22039083/Myron%20Krueger

In Krueger's other project, METAPLAY (1970), participants enter a room in a gallery space that contains a 10' x 8' video projection screen which superimposes a live feed of the participant with a live drawing by an artist in a remote location. The artist, who is placed in another building, receives the live feed of the participants in the main gallery space, and draws over the camera feed with a digital pen on a tablet. That drawing is transferred to the main gallery room in real-time and projected on the wall to overlay the live feed of the participants in the gallery. The artist

communicates with the participants through drawing shapes and writing words that appears over their feed, inviting them to engage in playful exploration of their space and body. This improvised interaction with a spatial manifestation of an omnipresent agency that is capable of verbal and direct communication highlights Krueger's emphasis on interaction and computation as a medium for creating experiences rather than an end goal, and endows architecture with characteristics that are usually associated with living beings, such as playfulness, awareness, and response.

The conceptual underlining of this piece resembles that of the Mechanical Turk where an invisible human endows non-human objects with agency and communication, which in turn invites and elicits interaction. This piece serves as a pretext to current interactive installation trends, where participants face a projection screen with computer tracking systems that allows them to create computational representation of movement and actions on that screen.

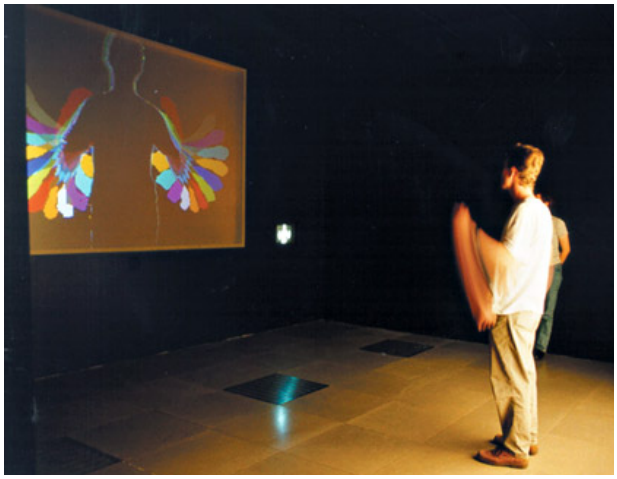

Figure 9 - Videoplace (1975).
Source: The Digital Age Wiki.
http://thedigitalage.pbworks.com/w/page/22039083/Myron%20Krueger

Krueger's *Videoplace* (1975) is a conceptual environment that allows people to interact visually and through video across remote, physically disconnected places. People enter a darkened room that has a 8'x10' rear-projection screen that is projecting a live video feed of their own image. This video screen is also projecting a superimposed live video feed of other persons in similar remote rooms, thus creating a sense of a shared presence through the projected image. Yet *Videoplace* didn't reach its full conceptual potential. Krueger wanted to compensate for the inability of visitors to interact through physical means like touch and proximity. He proposed a computer vision model that synthesizes the outline of the self-image of each visitor and compares this with the images of people in the other rooms and with virtual objects that he will furnish the rooms with through the use computer graphics. This way, a detection of close proximity at the pixel level can be interpreted as touch and the physical sensation of touching can be replaced by playing a certain sound. He even experimented with the video images being able to pick up and interact with the

virtual objects distributed in the video representation of the room; and he manipulated the video image to defy gravity and allow visitors to fly or change their size through interaction. He played further with the concept of overlap, where the overlap of the video images of two visitors can cause them to disappear, change the scene, or even allow for the image of a third person to show up, enabling possibilities of play and experimentation with the concept of presence and the other. For Krueger, "every person has a very proprietary feeling towards his own image, what happens to his image happens to him. In fact, when one person's image overlaps another's, there's a psychological sensation akin to touch." (Krueger 1977, 385)

This concept of a connected and remote *other* that is capable of interaction across computer networks and through their representation in architecture is a topic that has become prominent in the work of many artists and researchers with the increasing popularity of fast networking capabilities. The issue of transmuting gesture and movement into filters to synthesize video is a research interest of the Topological Media Lab: *IL Y A* (2012), is a double-sided video membrane that was developed by the Topological Media Lab (2010-2012) by Sha Xin Wei, Harry Smoak, Jean-Sebastien Rousseau, Tyr Umbach, Michael Fortin, Navid Navab, and Julien Stein.

Figure 10 - IL Y A (2012).
Source: courtesy of the Topological Media Lab

IL Y A mixes live video feed from the two sides of the membrane, transforming the opaque screen into a glass-like material. The movement and gestures of visitors on one side are synthesized to change the opacity of the membrane, thus allowing them to see through to the other side. Moreover, the synthesized motion allows for a temporal synthesis of the video image, which overlays the real-time video feed with recorded images from a few seconds ago. Revealing the images and showing images from the past is done through a particle and fluid simulation that resembles shaking off smoke or dusting off particles to reveal what's behind. The effect is symmetrical as the other side can

condition their own view through movement and gestures. While *IL Y A* is not a networked solution per se, as the other is standing on the other side of the screen and not in a remote and different location, it shares the same essence of the other that is perceivable through a synthesized image that is projected over an architectural element, but not directly perceivable as present within the same place.

The Table of Content (2014) is a collaborative communication and collaboration meeting table that functions as a portal between remote locations. *The Table of Content* works by mapping presence, gestures, and sounds to the dynamic manipulation of a visual video feed, and to the environmental features (light, sound) control systems in opposite locations.

Figure 11 - The Table of content (2014).
Source: courtesy of the Topological Media Lab

Remote spaces influence, and are influenced by, the dynamics of the bodies that inhibit these spaces and the dynamics of the conversation itself. Lefebvre argues that active bodies create their spaces and themselves through their action and the energy that is available to them (Lefevbre 1991), a concept that is applied in this project by allowing the conversation participants to transmute their activities and motion to change the media properties in the other. This project, while similar in essence to commercial video chat software, has a lot of similarity with *IL Y A* in that it attempts to bend and suture remote spaces by means of physical, representational, and non-representational data exchanges that control the modalities of communication. This is done by emphasizing the affective quality of the conversation rather than

the basic exchange of audio and video streams, and by extending the conversation beyond the communication medium and into the space, thus allowing spaces to leak into and influence each other.

Figure 12 - The Table of Content (2012)
Overlaying an image of a click in Arizona with the clock in Montreal
Source: courtesy of the Topological Media Lab

A video feed is mapped to the meeting table in the Topological Media Lab at Concordia University in Canada, and is connected to the meeting room in the Synthesis Center - a sister-lab run by Dr. Sha Xin Wei at the Arizona State University in the United States.

The close collaboration between the two research centers, and the joint seminars between graduate students in the two institutions, triggered a conversation about the need for a communication environment where gestures and sound are communicated in their affective value, in the same way images and sounds are communicated. Motion quality and audio features are analyzed and broadcasted alongside the audiovisual streams. This data is mapped to a visual particle system deformation tool that overlays the video feed on the table, and to a light control program in TML's media choreography system. The table is rigged with 4 speakers under the surface, and the incoming audio stream is spatialized to reflect the positioning of people who speak on the other side.

Therefore, a silent and still audience on Side A of the conversation removes their image from the meeting table on Side B (through the accumulation of white particles over the feed) and also increases the room light intensity on Side B, thus switching focus to the active side of the conversation. Once Side A becomes active again (via people talking or gesturing), their sound is channeled through the appropriate 4-channel table-speaker system on Side A, and the sound emitters scatter away the particles over the corresponding image zone, thus revealing the person who is speaking.

The significance of *The Table of Content* comes from the ability to overlay the two spaces by mapping the video from the two tables over each other, thus allowing two people to sketch together through overlaying the physical sketch pad in one place with a projection of the same pad from the other side, and drag objects of conversations to the middle of the table in one place, and have that object show on the table in other location. This overlay connects two remote architectures with different physical layouts and properties through computationally overlaying common anchor points, such as the table, which enables a mental construction of what remains in the other place.

The Table of Content is an experiment in the correlation between the physicality of place and the virtual representation of the remote place. The two identical tables in the two labs, and overlaying papers and objects from the two tables, creates an overlay of the two places and allows for a conceptual place-making process that builds a mental representation of the remote place and people in that place.

3.6 Materiality / Immateriality / Media as Architecture

Is architecture always defined by its physical manifestation of walls and ceilings? Architecture can also be immaterial and rely on perception and cognition to build mental models in which spaces are connected and divisions are erect. This is best illustrated in the work of pantomimes and street performers: feeling and moving alongside invisible walls, by placing the performer's hands flat, and at an equal distance from the body, suggests the presence of a level invisible plane or a transparent separation between the performer and the audience.

Pantomimes play on the dynamics between the body and our social and cultural comprehension of the physicality of the built environment. Their gestures and actions are what Edward Casey terms "performative remembering," which informs the body's action through the resurrection of similar previous experiences of interacting with solid surfaces and planes. (Casey, 1996, 148). It also works on a suggestive and cognitive level on the side of the observer. The pantomime's performance implies the presence of solid surfaces but also suggests transparency: the performer's body can be seen yet is unable to cross this spatial division. These actions and hand gestures are habitual and familiar bodily gestures that trigger a certain body memory of

dealing with the solidity of walls and glass planes. Casey's essay on body memory, and performing tasks as rituals that summon past experiences, provides powerful conceptual tools to understand habitual body performances. Such performances help create mental models of immaterial spaces and architectures which can in turn come to inform design and implementation.

Figure 13 - Dogvile (2003) - Lars Von Trier

Another attempt to use visual and sonic cues to summon the audience's cognitive construction of immaterial spaces and architecture can be found in Lars Von Trier's film *Dogville (2003)*. The film set is an open space where the village houses are drawn as architectural plans on the floor instead of as literal and physical sets. The acts of opening doors, walking the streets, and leaping over steps, are achieved by enacting the appropriate gestures, and playing sound effects typically associated with such interactions, without needing to show the original object. Therefore, opening a door becomes the act of extending the hand forward, grabbing an invisible object, and then retracting the hand closer to the actor's body while hearing the squealing sound of the door hinges revolving along their axis.

These enacted interactions also play on our social and cultural body memories, and our cognitive modeling of objects and spaces. What is considered inside and outside in Von Trier's film is not defined by physical enclosures of walls and ceilings, as there were none, rather by our mental construction of this narrated and implied architecture through the use of media and perceptual cues such as plan lines on the floor. Von Trier's attempt, while conceptual and dependent on a

mental construction of space and places, still retains certain visual representation of architecture and spatiality, which, in the case of Janet Cardiff's Audio Walks (1991-2012), is entirely dependent on imagination and mental constructions of alternate realities.

Cardiff's Audio Walks offer further examples of the mental and cognitive construction of space and objects through sound narrative. Cardiff's narratives often describe the space in which the listener is walking, and sometimes describe things that were present during the original recording but not during the walk. This creates parity between the two time-spaces, and allows for a mental superimposition of the narrated over the perceived reality without the need to use any sensory activation or media presence. The common elements between the narrated and perceived time-spaces function as bridges and portals, which enable the listener to perform a constant back and forth between the two realities.

Figure 14 - Blur building: DS+R (2002).
Source: DS+R http://www.dsrny.com/projects/blur-building

But how can we attempt to imply architecture and space, and experiment with the concept of materiality, when designing in the built environment for architecture and responsive environments? How can the profession of architecture, which is traditionally anchored in materiality, design for immateriality? Diller, Scofidio & Renfro created one of the most notable attempts in *Blur* (2002), which was a project that was built for the 2002 expo in Switzerland. *Blur* is a steel and aluminum base structure built over Lake Neuchatel and that can be reached by a bridge from the lake shore. The building is made entirely of fog that is generated from the water of the lake itself, and visitors walk into that fog and lose their visual and acoustic references of the outside world. Instead, they become immersed in a sonic universe of the noise generated by the fog nozzles. The architects describe the experience of walking into the blur building as follows:

> "Contrary to immersive environments that strive for visual fidelity in high-definition with ever-greater technical virtuosity, Blur is decidedly low-definition. In this exposition pavilion there is nothing to see but our dependence on vision itself. Is an experiment in de-emphasis on an environmental scale." (diller scofidio + renfro 2017).

In their book: *Blur, the making of nothing*, the architects underline the conceptual complexity that was presented by the immateriality of *Blur* in the final phases of the design process: the project generated a lot of confusion among city officials about whether or not it should be considered a *building* or not, in order to decide whether building safety and evacuation code should be applied to the project or not. (Diller and Scofidio 2002, 274)

Figure 15- Blur building, Arial view DS+R (2002)
Source: DS+R http://www.dsrny.com/projects/blur-building

The café section of the project sold bottled water from the lake, the same water that was used to generate the fog of the building, which was a symbolic reference for the visitors who can now "drink the building", as AD+S mention on the project entry in their website[3]. While the non-physicality of the architecture of *Blur* is not to be confused with non-materiality, it enables an architecture that is highly conceptual and mostly experiential, even as it launches a conceptual debate over the a priori relation between architecture and physicality.

Attempting to experiment with materiality and immateriality when coupled with technology, the Topological Media Lab designed *Einstein's Dreams* (2014) as a three-week residency at the Concordia Hexagram's BlackBox research facility. The theme of the residency was based on Alan Lightman's book, also called Einstein's Dreams, which deals with the concept of the passing of time.

[3] http://www.dsrny.com/projects/blur-building

Figure 16 - Einstein's Dreams (2014)
Source: courtesy of the Topological Media Lab

Researchers at the Topological Media Lab created a set of tableaus of responsive media ecologies that relate to concepts of time and temporality and change. The result was an open installation that invites the public to play and experiment within these ecologies that enabled a computational synthesis of motion and gestures, in addition to experimentations in the transmutation of the properties of materials and matter. *The Einstein's Dreams* experiments were all carried over a sand pit, as a symbolic reference to the concept of time, which was open for people to walk over, roll over, and dance on. The space was flooded with infrared lighting for motion tracking, overhead and frontal projections, as well as and embedded pressure sensors and transducers.

Figure 17 - Einstein's Dreams (2014)
Source: courtesy of the Topological Media Lab

This media ecology that was deployed in the space was based on the concept of a state machine, which means that the environment can switch states and condition the media based on the detection of change. The environment can therefore detect movement and leave video imprints that fade out with time. The environment also switched between negative and positive shadows system where bodies become beacons that turn lights on and off. The most significant of those changes is the ability to construct temporary and ephemeral media topologies by throwing sand in the air, capturing the sand by the motion tracking system, and projecting video on the sand as it flies through mid-air, which gives volume to the media in the air. This gave the participants the ability to create temporary immaterial architectures by means of active gestures. *Einstein's Dreams* was an experiment in the transformation of matter, and an examination of the correlation of gestures, media, and transformation.

Taking the experimentation in immaterial and conceptual architecture to the next level, the Topological Media Lab's Dr. David Morris, Dr. Sha Xin Wei, Zohar Kfir, and Patricia Duquette, embarked on a research creation project titled *Memory, Place, Identity* (2011). The research motivation for this project starts from the following ideas:

- Our sense of the space and the edges of space are informed by our experiences in that space, and more by our repeated experiences in that space. Those experiences, according to Edward Casey, are functions of the lived body or what Merleau-Ponty calls a *habitual body*. These experiences rise from the repeated movements of the place-dweller's body, from customarily walking repeatedly in this space, and from the memorial wake left by these walks. (Casey 2015, 25)
- Making way through a place is what gives a sense of the place, its layout, and dimensions, and it also condenses body memories of that place.
- Blindfold subjects, like persons who are blind from birth or through injury, do already have a knowledge of space, even if it is only through the world of sound or the space of bodily action with tactile and kinaesthetic feedback (Lenay and Steiner 2010)

The concept of this research is to replace the physicality and permanency of the built environment by a dynamic, ephemeral, and immaterial architecture that is implied by a computationally activated touch sensation. This is inspired by the work of Edward Casey on Body Memory, and the Tactile Vision Substitution System of Paul Bach y Rita, or what is sometimes referred to as *Sensory Substitution* (Lenay and Steiner 2010, 940). Such platform allows for the dynamic morphology of this implied architecture by manipulating certain ephemeral elements in the space, namely: light sources.

Figure 18 - Memory, Place, Identity (2011)
Source: courtesy of the Topological Media Lab

To examine these concepts, a wearable computing device was built to be the interface between the body and space through light sensing and haptic feedback. Subjects were asked to wear a glove-like item which had a small photocell mounted to a prosthetic extension of the glove's index finger, and a small actuator placed under the fingertip of

the glove. The glove was connected to a microcontroller unit that handled the computation and signal processing locally and in real time. Once the photocell detects the presence of light (above a certain threshold, to focus on direct light source detection instead of environmental and refracted lights), the small actuator, which is placed on the fingertip, gets activated, therefore giving the haptic sensation of touching a solid object. The sensing process works on discreet on/off modes, which makes the haptic feedback similar to the presence, or lack thereof, of solid objects in real-life.

Figure 19 - Memory, Place, Identity (2011)
Source: courtesy of the Topological Media Lab

Participants were asked to walk blindfolded through an indoor space that is equipped with a light source (lamp) in a fixed position in space. They were navigating the space with their hand extended to the front to feel the presence of light through the actuator's vibration and turn away from it in the same way a person would walk away from a wall.

Participants slowly integrated the light source into their spatial memories, and subjects were avoiding the light source in their navigation. This is within the lines of Ed Casey's suggestion that "an active immanence of the past in the body that informs present bodily actions in an efficacious, orienting, and regular manner" (Casey 1996) but on a shorter and more compact timescale that is based on short-term active memory.

The main theoretical design consideration for this experiment was to go against the traditional responsive architecture model where the sensing is external to the body and embedded into the space, rather internalize the sensing process by focusing on the body as the epicenter of the perception.

3.7 Epilogue

This chapter presents an overview of the concept, theory, and historical precedents that inform and validate some of the main characteristics of an architecture that is capable of producing feedback and response through computational process that cause a change of state to media materiality in space. Starting from the days of the conception and display of the Amazing Turk in the 18th century, I listed several attempts and concepts that experimented with different ways to endow or simulate agency and intelligence, and implement feedback and response mechanisms in inanimate objects and architectural spaces.

On an architectural level, I presented three historical trends that relate to what I had proposed to be traits and properties of a responsive architecture:

- attempts to condition and change the built environment as a response to human and non-human influences and interaction, which was the case for the *Walking City, Fun Palace*, the Arab World Institute, and GLOWFLOW.
- Attempts to connect, overlay, and suture distant spaces by means of computer networking, and experiment with using the built environment to amplify or imply remote presence and interaction, which was the case of *Videoplace, Metaplay, IL Y A*, and *The Table of Content.*
- Experiments in deconstructing concepts of materiality and physicality as main components and characteristic of architecture, and examining ways in which architecture is created, re-invented, or reimagined through the use of mechanical and mediated control, which was the case in *Blur, Einstein's Dreams*, and *Memory, Place, Identity*.

This chapter shows that a responsive architecture that re-conditions and re-interprets itself by means of computing presence and interaction, and the manipulation of media and matter, is not a novel concept. In fact, it is deeply rooted in an interdisciplinary historical approach that reads from art, architecture, and technology, and that is informed by theories and concepts of space, the body, and memory, some of which predates computational and sensory technologies by decades. This chapter provides a historical and theoretical context that informs and inspires the experiment design strategy which will be presented in Chapter 5 of this thesis, and set ground for the strategies and methodologies for which those experiments attempt to examine and validate.

4 SPACE, PLACE, AND PLACE-MAKING

Definitions of place and space have been a topic of investigation for many researchers, academics, and philosophers over the past century. While definitions vary according to the perspective of the research, many anchor their definitions in physicality, mobility, embodiment, the senses, and activities. Yi-Fu Tuan defines *place* as "an object in which one can dwell" and a product of motion and activity, or the lack thereof: "place is pause; each pause in movement makes it possible for location to be transformed into place. (Tuan 1977, 12, 6) On the other hand, *space* for Tuan "can be variously experienced as the relative location of objects or places, as the distances and expanses that separate people and link places, and – more abstractly- the area defined by a network of places." (Tuan 1977, 12)

For Merleau-Ponty, space consists of the dynamic relations between the elements within a milieu rather than a geometrical delineation of a void where things are placed in measurable distances and dimensions. (Merleau-Ponty 2012) Salome Voegelin adds to this concept by interpreting Merleau-Ponty's space as a product of experience and perception: "Merleau-Ponty's subject performs the unity of space through a synthesis of things experienced not as discrete objects, but as distinct viewpoints which are connected through the agency of perception producing a visual realization of space." (Voegelin 2010) These concepts are echoed in Tschumi's *Questions of Space* (1996) where he asks if accepting the immateriality of space will lead us to accept space as the result of spatial relations between material objects, or as a mental synthesis of things and experiences. (Tschumi 1996, 54)

It is important to recognize, however, that endowing place with physical and sensible properties does not imply that space is a mere void which only exists as the void between objects and places, or as Alberto Perez-Gomez puts it: "space is not something object-like (geometrical), but is also not nothing." He negates the nothingness of space by citing experience and perception, which is why the perception of space in Paris is different from that in Melbourne. (Pérez-Gómez 2016, 144)

Accepting place as a physical manifestation where bodies dwell and embodied interaction takes place, and accepting space as a perceptual experiential medium that results from the synthesis of the spatial dispositions of objects in space in relation to one's body, are foundational premises for this research, as I look into the role of the media in place-making.

Place-making is a broad term that covers different community-and-human-centric practices in urban and architectural design. Place-making as urban-design practice is concerned with the idea of the public spaces as collective, inclusive, and engaging spaces that are designed for the community within the built environment. Traditionally, it has focused on designing public spaces based on the feedback of, and the interaction with, the community which uses those spaces. William H. Whyte, an architect and urban planner from New York, defines place-making as: "designing cities for people, not just cars and shopping centers." (Project for Public Spaces 2009)

While these practices have been generally agnostic to media and technology, the new advances and trends in mobile media and location-aware devices are generating a lot of academic and professional interest in studying placemaking as a product of such technologies, and in considering those technologies as tools for placemaking. Place-making, in that case, does not follow the traditional definition of human-centric designs from the perspective of using dialogue and feedback from the community. Using technology, however, allows us to think differently about the concept of designing for the people by enabling new spatial practices and new experiences in space and place, which can only be possible by using the capabilities and features of such technologies.

Location-aware mobile devices open the doors to consider new place-making tools that were not previously available to urban designers and architects: GPS location tracking, digital co-presence, and digital memory. As an experiment in digital proximity and co-presence, Christian Licoppe and Yoriko Inada describe their study of *Dragon Quest 9*, a handheld Nintendo game, as a proximity game, where players within a certain distance from each other can change their play-mode from single player mode to multi-player mode, and can appear on each other's screens if they were within a smaller distance or range. The game's topology and landscape is transformed when this proximity is established, and new doors and buildings appear when some players are within certain proximity of each other (Licoppe and Inada 2012, 62). This game translates physical and embodied co-presence into digital, screen-bound co-presence where embodied proximity in the physical world enables a dynamic placemaking and topological morphology in the digital space. However, this game does not tell you where to go to look for other players; therefore, while based on detecting physical proximity in the real world, it does

not directly influence the behaviours of people in space to send them looking for each other, which limits its direct impact to the virtual world.

Mobile location-based games do not only affect place-based events and activities in the virtual world, they can also alter our place-based practices and the way with which we define our relations to place and the built environment. Jonathan Firth and Jason Kalin discuss route taking and digital memory in relation to hand-held games, and how people would change the routes they usually take in the city in order to achieve gaming goals. They discuss a game called *Fog Of World,* in which one creates a digital route archive by the way they navigate the city, which in turn influences the navigation pattern of other players. The game places "collectables" in different parts of the city, so the players' chances of finding those collectables are higher in areas that have not yet been visited by other players: "Fog of World specifically transforms the user's experience of the physical world by turning personal mobility into something memorable, that is, something worthy of being collected, archived, and remembered to spur present and future mobility." (Frith and Kalin 2016, 48)

This idea of tracking and plotting motion on maps demonstrates the possibilities of using mobile hand-held devices to overlay memory and mobility over representations of place. Mobile devices present new ways to influence the behavior of urban dwellers in the city, which is illustrated by a trend for urban joggers who, in their quotidian active life, choose their running path in ways that could plot meaningful imagery over the map of the city. This way, choosing the right path for a run is no longer influenced by safety, scenery, and walkability, but rather follows the lines and curves that contribute to the digital plot over the city map. Yet the idea of using location-enabled mobile devices to represent motion traces on maps as representations of the experience of being in place does not really tell us anything about the experience itself. Those traces are a-temporal, and, according to de Certeau, reversible and

> "set in the *nowhen* of a service of projection, which makes invisible the operation that made it possible. […] The trace left behind is substituted for the practice. It exhibits the (voracious) property that the geographical system has of being able to transform action into legibility, but in doing so causes a way of being in the world to be forgotten" (de Certeau 1984, 97).

From this perspective, digital technologies enable us to synthesize being-in-place, and a subset of the activities in place, into screen-bound digital representations. Those techniques and digitally-stored representations can, in turn, influence the behavior of others and create new

patterns of motion and activities in place. This, however, limits the role of such technologies to altering digital worlds and the digital representations of the physical place on devices and computer screens. The specificities of place, and the human experience which results from it, are lost in the digital representation. Edward Casey uses the example of the US government's use of GPS technology to track migrants that are attempting to cross the USA-Mexico border as a policy to keep track of "evil doers:"

> "GPS does not tell me anything significant about where I am. [...] My GPS device may well indicate that I am at 45 degrees latitude and 32 degrees longitude, or four miles east of Longmont, but what does such information tell me about the very place in which I find myself? […] I have found my site in space but lost my way in place." (Casey 2012, 176)

Therefore, within the context and the theoretical basis of this research, and by adopting Casey and De Certeau's positions, it is possible to propose that using mobile and handheld technologies to influence spatial practices and activities in place are limited in scope as they lack the ability to convey personal and collective experiences in space through digital representations. Moreover, they are intended for willing and active participants that engage in a structured social engagement such as games and similar activities. The concept of the perception of space by synthesizing the dynamics and relations between the body and objects is potentially lost within such setting, as objects in such games and activities are virtual rather than physical, and the focus of active participants remains centered on the handheld device's screen rather than the world around, which makes the experience a solitary one, even if it was based on connecting to digitally-present others.

Therefore, it is more relevant to the scope of this research to consider the role of technology in placemaking beyond location-aware mobile and hand-held devices by bringing technologies into the place as elements that shape collective experiences rather than individualized, screen-bound experiences. This, of course, does not dismiss the importance of mobile technologies in choreographing and informing spatial practices, nor does it assume that one form of technological intervention is better or more relevant than the other.

Ginette Verstraete discusses Anna McCarthy's work on Dara Birnbaum's video installation *Rio Videowall* (1989), which the artist installed in a downtown shopping-mall in Atlanta. She describes the video wall as a twenty-five-screen installation that displayed layers of imagery from two sources: live news from the Atlanta-based CNN, and footage showing the site

before the mall was built (a grass slope sparsely dotted with trees). Footage from the previous site's landscape would appear on-screen whenever a shopper would enter the installation zone: a computer-based keying system would digitize the shopper's image as a silhouette and use it as an electronic video cutout through which one footage (the landscape) could be seen through the generated human outline, superimposed on the other footage (CNN). (Verstraete 2016) What's interesting about this project is that the television screen, a physical medium in place, becomes a window that brings together two temporal realities of the same site through movement and action. Verstraete considers that

> "the screen functioned like a dynamic, expansive frame with moving times and spaces of its own [calling for consideration of] the place of television as a relational practice without reducing this to a social setting in which screens are ubiquitous and even banal or superfluous to the point where they disappear." (Verstraete 2016, 312)

The Rio VideoWall is a relevant example that can be used to set ground for discussing the role of computational technology as a place-making tool, and the concept of a screen as a medium that initiates or shows the feedback of interaction. Unlike the case for mobile and hand-held games, the technology here works on the level of physical presence and interaction to enable site-specific experiences and spatial practices. The Rio VideoWall is a place-bound mediated experience that is not only present in place, but is also about the place it stands in, as the material it presents are historical footage from the site of the installation, and the interaction with the screen engages the audience and spectators in creating an overlay between the spacetime of the event, with the spacetime of the image, and allows for a collective and playful interaction within the space. The architecture itself is static and not adapting to the interaction, like the case of Littlewood and Price's *Fun Palace*, and Archigram's *Walking City*, but the placement of this intervention was meant to "gather buyers (and thus money) in the shopping center by drawing the visitors in technologically and involving them in an electrifying sense of place" (Verstraete 2016, 312)

The next chapter will present a design strategy for building responsive architectures that condition themselves through the interaction and presence of visitors and spectators. Further, I will address the concept of the physicality of objects in space and the immateriality of computational media. Presenting a series of research-creation projects, I argue that each project

belongs to a design point-of-view on how to deal with media in place and how to implement interaction design strategies as place-making strategies—the goal is for an architecture that is designed for the people and for building subjective and collective experiential places.

5 DESIGN STRATEGY

The English translation of the booklet that accompanied the Mechanical Turk during its tour in the early 1880s was titled *Inanimate Reason.* The introductory text suggested that "deception must be involved in the automaton's design." (Clark, Golinski, and Schaffer 1999, 156) Looking beyond the negative connotations of the term "deception," The Turk is, again, setting precedents in proposing a design strategy that associates automata design with the borrowing of properties and traits from other objects. In the case of the Turk and responsive architecture, those properties are agency and feedback.

This chapter presents the research-creation component projects and experiments built during my extended residency at the Topological Media Lab and Hexagram at Concordia University, and my research residency at the Synthesis Center at the Arizona State University. They comprise the research-creation component of my Master's thesis, presented here as a set of open-ended experiments that examine aspects in the design process of a computationally-enabled responsive architecture.

Informed by the theoretical and historical frameworks presented earlier in this thesis, this work builds on a vision of responsive architecture as a continuation of an already existing interdisciplinary and transdisciplinary approach to rethinking the relationship between architecture, technology, social sciences, and performance art. Conceived as experiments, or sketches, this work does not follow the same discourses of scientific experimentation: that is, they do not produce figures or numbers, nor do they yield any concrete results. These experiments are applied examinations of certain conceptual processes that are illustrated or examined through physical and computational design implementation.

As discussed in Chapter 3, designing for a computationally-enabled responsive architecture remains very similar to the traditional architectural design process, which implies thinking about volumes and structures, the spaces they create, and the social order they dictate. Responsive architecture as a concept, however, invites designers to think beyond the immediacy of matter and material, and consider elements and strategies that work on the level of the senses and the creation of experiences where volumes and structures are not neutral to the presence and interaction of people. Unlike the regular architectural design process, which implies the immortality of the architectural edifice, it is very helpful to approach the design process of

responsive architectures as a process that is focused on producing ephemeral and light creations that exist as layers within the built environment. This is why I adopted the terms minor, ephemeral, and immaterial when discussing responsive architecture in Chapter 3. While interactivity and dynamicity in responsive architecture can be achieved in many ways, from mechanical displacement and deformations of space and matter to the sonic and tactile construction of perceptual spaces, I chose to work with visual media as a principal tool for placemaking in the context of ephemeral and immaterial computational architecture. The projects I present examine concepts and questions that are essential to using visual media as a tool for place-making such as:

1. Using representational vs. non-representational media.
2. Diffusing media in space and the deconstruction of the concept of a screen.
3. The materiality of the medium vs. the immateriality of the media.

Working with visual media does not imply creating exclusively visual experiences that exclude the other senses, nor does it promote visual media as a better or more comprehensive tool in this design strategy. This research does not claim to propose any comprehensive or complete solutions, rather attempts to present a modest contribution to the process of conceptualizing anthropocentric experiential and interactive design methodologies and the way they accommodate computation and interactivity as part of the program.

It is also important to underline a shortcoming in most literature and prior experiments dealing with creating interactive spatial experiences, something this research is also guilty of: most interactive installations and experiences are designed for an erect and healthy body that is fully capable of moving and gesturing, and that is capable of using all senses. This is an important point to reflect on when conceptualizing design strategies that are inclusive and accessible. Proposing solutions for experiential designs that cater to the physically and developmentally challenged is outside the scope of this research. Nevertheless, I believe, that a step towards drafting design strategies and methodologies for responsive architecture is a step towards providing a framework that enables the debate over assumptions and prejudices about the human body and its capabilities.

5.1 Computational media and the screen

5.1.1 Prologue

This research stream examines the diffusion of media on and around visitors and objects in space rather than resorting to framed and formally contained projected media on the geometrical delineates of space such walls and floors.

Many projects that use screened and projected media have been generally confined to geometrical diffusions that maintain and emphasize the original rectangular production format of the media, and would resort to disseminating this media on rectangular screens and frames of uniformly distributed pixels and illuminated dots. Even with the recent popularity of mapping projected media onto architectural surfaces, walls, and floors, the media still maintained a uniform quality that amplifies the geometrical nature of the architectural edifices and structures, which turned theses surfaces into flat canvases for animated simulations, even if these surfaces are themselves not flat.

The framing of digital and representational media, and its diffusion in space, can be viewed as a natural evolution to the framed painting canvases, murals, and ceiling drawings, which date back to the renaissance days. Since the early days of the perspective drawings of Leonardo Da Vinci and other classical painters, the representation of space and depth in one-point perspective paintings attempts to construct an entirely different space-time that co-exists with the world of the viewer, and attempts to connect the two worlds and invite the viewer in, but leaves them unable to fully enter, thus creating a distance between them and the represented scene (Higgins 2009).

These paintings become portals and thresholds that allow the viewer to peek into a different space-time without allowing them to be fully immersed. What bridges those two worlds at this point is the portal itself (the framed canvas or the digital screen), and the narrative that situates these “other” space-times in proximity with the physical space where the viewer is.

This visual frame continued to accompany media and performances since then, from theater stage backdrops to the proscenium, the Indonesian shadow puppet’s back-lit screen, the early mixed forms of cinema and live action, all the way to the recent experiments in video arts, and now interactive installations (Salter 2010).

The experiments presented in this chapter follow the same principle, creating total and unbounded sensory experiences in the space by attempting to challenge the concept of the screen as geometric flat surface of diffusion, and the idea of the space between the subject and the object of attention (the media). The experiments that will be presented in this chapter examine other ways to diffuse the media in space, using bodies, ropes, and screen fragments.

5.1.2 The Experiments

5.1.2.1 *Inside_Out* (2013)

Omar AL FALEH

Inside_Out was an early study prototype that I built in the Hexagram video production space in 2013 as a 2-day design experiment. I created it as an attempt to challenge, and reflect on, the concept of screens as a means by which the subject is separated from the object of attention, which is the media in our case. This experiment examined the concept of using spatially distributed media as co-habitant of the space by creating perceptual, and almost immaterial, media-augmented sub-spaces.

Figure 20 - Inside_Out – Projection flow on the body

Using off-the-shelf ropes that extend from the floor to the ceiling in specific design patterns, I defined walking paths within the research space which allowed a human figure to wander in and immerse with the media. The ropes in this structure are spaced well enough to be non-obstructive and almost invisible, yet prominent enough to imply divisions and separation in the space. The ropes were mapped with video patterns and shapes that change and move over time. By playing with visibility and animation of the media, I could create depth and layers while maintaining transparency and lightness. Having the media in close proximity to the body enabled tactile curiosity where the visitor could touch the rope and therefore touch the media itself; at the same time, he or she could create a displacement in the rope to enable the media to disappear as the rope shifted away from the projection space.

Figure 21- Inside_Out – Media blending the body in space

The ropes were arranged to allow participants to walk between them and navigate through the spatially distributed media, which sometimes makes the body a temporary screen for the linear projections, further blending the body in the environment and blurring the boundaries between the body, the space, and the media. This project attempted to experiment with projection mapping on non-flat surfaces as a conceptual exercise in bringing the media within the space and around the body without being mapped to the walls and screens. This project generated many question, some of which I attempt to answer in the coming experiments. Some of these questions are: how do we design a mediated space without edges starting from a central focal? How do we design for one-dimensional mediums in ways that do not dissolve the body in space, yet blend and mesh with it? And at what point does the body seize to exist and allows the media to take over?

This prototype, while crude and unfinished, was a pretext for the two experiments which I will present next, and that go further in exploring the body as a screen, and bringing the media within the space rather than around it.

5.1.2.2 *Striped Bodies* (2013)

Omar AL FALEH, Elizaveta Solomonova

Striped Bodies is a playful, experimental, media-rich interactive game that examines the correlation of movement, body, and space through setting simple performance rules for the participants to generate an aesthetic and interesting experience in space, and to allow for a conceptual study of bodies in space.

In this installation, the role of the body as an active agent in changing the environment, and a co-author of the experience, doubles with the concept of using the body as a screen and a medium for representing interaction and to bring the media within the space rather than keep it mapped to its extremities. The system uses non-representational abstract media that is mapped to the bodies of the participants. Resorting to non-representational media enabled us to avoid

potential issues such as identity and bodily representation, which are outside the scope of this project, and focus on the disappearing and re-appearing body as a result of abstract forces like movement and presence.

Figure 22 - Striped Bodies – Projecting on Bodies in Motion

The visitors and participants for this work were mostly not trained in performance arts nor in summoning expressive body language. They engaged in a responsive media narrative that followed a predefined set of rules handed to them upon commencing the game, and they will be asked to verbalize their experience of space once they finish playing for further study.

With its first iteration happening at the TML, the game scene is a dark empty space surrounded by black curtains to ensure isolation from outside environmental conditions. The elimination of visible boundaries makes the space look and feel infinite, and enhances the sense of intimacy to eliminate the social inhibitions of being watched. Invisible infrared lights flood the scene to facilitate gesture and movement tracking; an infrared camera and a high-definition projector are installed in the corner of the room to capture the movement and map the participants' bodies with the projected visual feedback.

Figure 23 - Striped Bodies – Projecting on semi-active bodies

High contrast black and white stripes are generated and projected on the participants' bodies, where the size and speed of the white portion of the stripes is proportional to the averaged movement in the scene, which is collected and computed by the infrared camera. Idle state of the participants generated zero-height white stripes, thus leaving the bodies in darkness. This allowed participants to play with

the ability to see each other and to allow themselves to be seen, which is done by changing the intensity of their movement. The movement average is also mapped to a sound engine that changed its gain to reveal and hide ambient and active sounds, thus coupling visual perception with aural sensing. A background sound track played throughout the entire experiment, unchanged by any environmental factors.

Participants are split into teams of two, a leader and a follower, and are instructed upon entering the scene to follow the following set of rules:

I. The leader assumes a pose and waits for the follower to imitate her.
II. The leader is to change position only when the follower has successfully imitated her.
III. Change of background sound for the first time reverses the roles of leader and follower.
IV. A change of the background sound for the second time is the cue for both participants to improvise movements independently

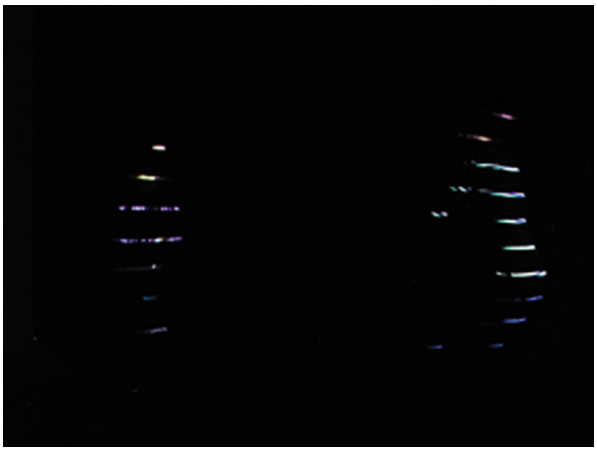

Figure 24 - Striped Bodies: Projecting on still bodies

This leader-follower pattern created synchronized movement choreography with a small delay between the performers, and kept the focus on the bodies rather than the representational projection of movement on the bodies. The choice of black and white stripes for the visual feedback gives the scene a sense of regularity through repeated motion, and hides body details to make participants blend in the background, only to reveal themselves through the progression of continuous movement. These conditions draw from the concepts of mobility and sight as main elements in constructing space, where idle bodies disappear in darkness, and movement enables sight, thus building the common space between the participants.

At the end of the experience, participants were asked to fill out a short survey consisting of open-ended questions. They were asked to first close their eyes and focus on the questions at hand: What was their perception of space? What was their perception of the other participant? Which movements did they perform, why, and with what effects? They then attempted to verbalize how the experience felt, as opposed to simply describing its action. Synthesizing the

answers from different participants showed a very interesting link between movement and sound. Most participants wouldn't go in details about describing the space in its physical manifestation; rather, they focused on the other body in front of them, and the effect of the mirrored movement on their perception of the body of the other as a reflection, or an extension, of their own.

Below are some of the answer that were received from the participants:

> "I was the bird moving in the space. Free, but the music created a space that I could not leave (…) it limited the space, and (…) the light came as windows to a new universe."

> "Giddy sense of play yet focused. A very concentrated experience involving the other participant; on one hand, a sense of intensity, and on the other, an aspect of play and improvisation. (…) Deep music resonated well, making me feel the sensation mentally as well as physically. (…) Surreal and dynamic, perspective of space changed while moving throughout the space."

> "The sounds and noise levels travelled through my veins as I mimicked yoga moves. I felt sort of an out-of-body experience where I knew my body was moving but I almost had little or no control over the movements (…) At some point (the other participant) felt as though she was part of me and my movement, but at other times she almost felt like a burden or a heavy shadow"

The participants were randomly selected from undergraduate students in the Computation Arts department at Concordia University, which implied a level of understanding and interest in experimenting with responsive media and the behavior of responsive systems, and a certain level of curiosity. Participants knew each other to varying degrees through their classes, which also provided a corresponding level of comfort in improvising and performing in front of each other. It was observed that those who were more familiar with each other performed in a more relaxed way and felt more freedom to explore the space in the third improvisational stage of the experiment.

5.1.2.3 *Temporal Fractals* (2016)

Omar AL FALEH

Following the research stream of designing responsive architecture where the media is removed from its traditional projection mediums of walls, floors, and uniformly-shaped screens, and brought closer to the subjects of interaction: the visitors of the space, *Temporal Fractals* is an experiment in the disposition of multiple time scales over the physical space: a fragmentation of space-time that is spatially-distributed and coupled with corporeal features such action and presence.

This experiment was conducted as a one-weekend research residency in the Hexagram video production space at Concordia University. The space is comprised of eleven ceiling-bound screens, each of which is mapped to a different time-scale displacement of a live camera feed. The system captures the live feed from the experiment space and creates a random seed upon which eleven different video delay zones are generated, and then diffused back into the space where each feed is mapped to a screen in the space, thus creating multiple timescales of the same object at once.

Figure 25 - Temporal Fractals – Fragmentation of media and timespace

The design challenge was to conduct an exploration in temporal displacement that is site specific, yet conceptual enough to be a methodological exploration rather than an art installation. The research space had a 4 x 2 ceiling grid for hanging projectors and lights, which is where the screens were to be positioned. That grid was a starting point for the fragmentations and dynamic displacements. The grid squares were therefore shifted in a rotational system in tandem with the order of computer-generated projected image delay. The resulting shift was then tessellated and displaced on the three axis to create a non-uniform topography that was not flat and screen-like, but rather gravitated downwards to surround those who were in this space of exploration. This project was a pure experiment in design where the space and the interactive system stem from the same conceptual process where the dynamic qualities of computational media are reflected in the dynamic dispositions of the diffusion surfaces in spaces.

Figure 26 - Temporal Fractals- perspective from inside

Visually, the result resembles a shattered mirror where different fragments show different perspectives of the same space, and in a different time scale. The downward hanging screens are meant to alter the viewing angle of the visitors in a way where they are indeed looking up, but in an angle that maintains their view of the space and those in it. Flat ceiling-bound media forces an unnatural angle of the head and neck, and excludes the rest of the space, and those in it, from the field of view of the visitor, which mutates what could be a collective experience of space into solitary spectatorship.

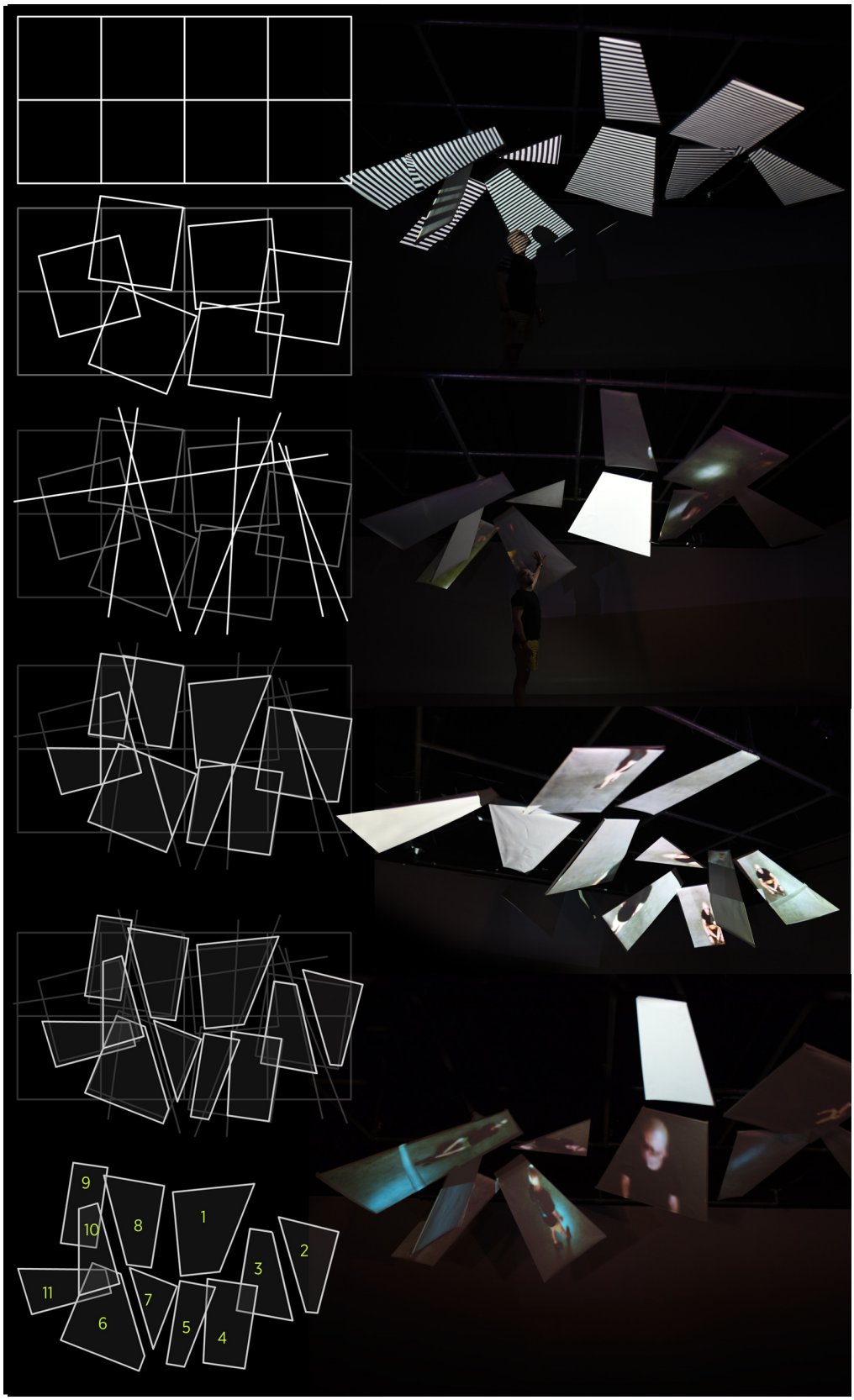

Figure 27 - Temporal Fractals – Design diagram

The screens themselves were semi-translucent paper cuts that are fixed over a light wood skeleton, hanging from the ceiling grid with transparent fishing wire. I chose the materials to be light and portable to emphasize the duality between the ephemeral nature of media and the ephemeral nature of the architecture that is built with such media. The screens could be repurposed for other projects. However, this contradicts the conceptual process that created them from the properties and traits of the space itself, which made them a fragmentation of that specific space, not any space. Therefore, screens were ceremonially destroyed at the end of the residency.

The system is motion/presence sensitive. When the room is empty, all screens display a whitewash image, with random fragments of previously recorded feed that are played as a one second flash on a randomly-selected screen, this cycle is called: the random memory generator. When presence is detected, the random memory generator is paused, all screens fade to white, a random delay seed is generated, and the camera feed is then diffused over the eleven screens with gradual delays that are based off the random seed, slowly replacing the whitewash on the screens with the delayed live image. Unlike the rest of the projects that are presented in this chapter, *Temporal Fractals* does not have a sonic component that is computationally processed with the rest of the input. The system used the Microsoft Kinect 2.0 as a camera, and as a motion/presence detector, and the processing was done over two networked computers using Max/MSP/Jitter as a computing platform.

This experiment opens doors for another stream of research on the concept of temporality and displacement. While observing the visitors to the experiment, I noticed two separate cases where the visitors were doing sudden expressive movement patterns and then looking around all screens. When interviewing them about their experience after finishing the visit I asked them about the reason behind those sudden movement, and one of the answers were: “I was trying to find where’s *the now* in those screens.” The other answered that they were trying to “understand the logic that governs time delays and its corresponding location in space.”

The concept of a spatially distributing the temporal displacement of a live camera feed, and the link between this and body gestures as key points that tie those multiple timespaces together is a topic of great interest that might be one of the future paths for my research.

5.1.3 Epilogue

The experiments that were listed in this chapter propose ways in which the media can be diffused and disseminated within the space, and in proximity to the visitors and dwellers in the space, which makes the interaction with the media personal and intimate, and moves the design away from spectatorship and into experiential co-authorship.

The experiments also demonstrate a two-tier design strategy that is not exclusively applicable to responsive architecture, but critical to consider when proposing a methodological design process. First I proposed and implemented an experiential design based on specific concepts and topics of interest and curiosity, and then I sought feedback from those who visited the space to get a subjective evaluation of their experience in space, and the success, or lack thereof, of this design in portraying or conveying a the concepts that initially inspired the design.

While there is no clear way to evaluate the success and failure of such experiments, it is possible to extract, through verbal interaction with the visitors of the space, whether -or not- the experiment design managed to meet some of the assumptions and proposals that were put forward initially at the conceptualization phase of the experiment design. Conversations with those who interacted within, and with, the space showed their interest, intrigue and curiosity over their proximity to the media and the influence of such proximity on the experience. The implementation of the scripted, game-like interaction in *Striped Body*, and the dynamic change of the temporal structure of the video projection in *Temporal Fractals*, which triggered some visitors to experiment with their body movement to understand displacement of time, were reported to be inviting and engaging, which opens the door to take these strategies further both on the design and the conceptual levels.

The two experiments present distinct concepts for interactive media: representational vs. non-representational. They also present completely different conceptual takes on choosing the mediums for diffusing the media in space: the body vs. screen fragments, and two ways of looking at time: real-time interaction vs. delayed visualization of the interaction. Any or all of these concepts are seeds for future experimentations and investigation, and are design elements and tools that can be considered when designing a responsive architecture that caters for subjective and personal experiences.

5.2 Light as a medium

5.2.1 Prologue

Controlled, visual, non-representational computational media in space is the second and more prominent research stream in this study, wherein I chose to work with light as the medium of choice. Light works on the level of the object itself by alternately showing or hiding features of the object in and with its surroundings. Peter Zumthor proposes that sensing, smelling, touching, tasting, and dreaming in the dark is not enough; he argues that life needs a minimum amount of light for us to experience things. (Zumthor et al. 2006) Jean Nouvel considers that light in architecture is what gives transparency its essence, through the interplay of the visible and the invisible: "If we use certain materials, we'll be able to program a building differently over time and play with ephemeral effects.... Working with transparency involves nothing more than working with matter to give a building different appearances." (Baudrillard and Nouvel 2002, 62)

I initiated this research angle as a critique of the current trend of video projection mapping over architectural edifices where, most commonly, the projection hides the characteristics of the buildings and maps them with videos that treat architecture like a screen rather than a medium, which makes the video neutral to its projection. In contrast, light is an essential element to architectural design and atmosphere and a main characteristic of the built environment. Maroussia Levesque, with the help of other researchers at the Topological Media Lab, created a piece called *Blink!* (2005), in which we spread across the 11 floors of the newly inaugurated Engineering, Computer Science and Visual Arts Building (EV) at Concordia University and manually flickered the light switches in the main labs of the building. The effect was to make the building flicker in random, but organic, rhythm from the outside, thus bringing the building to life in ways that are true to its own design characteristics. The Topological Media Lab and The David O'Brien Centre for Sustainable Enterprise proposed another project in 2013: a controlled modulation of the lights in the EV and the Guy-De Maisonneuve Building (GM) building at Concordia University as a visual response to changes in the sonic structure of the Quartier Concordia urban structure.

Inspired by many artists who work with light as a medium, from James Turell to United Visual Artists, this stream of work starts with one main question: how can we build a conceptual

architecture by associating light, presence, and behaviour, and how can gesture and motion create and extend the computational representation of presence and personal spaces. Most of the designs that I will present in this thesis start from the ideas a personal space is dynamic and directly related to the actions and motions of the body. Therefore, we can extend the concept of a follow spot, which associates presence with light, by dynamically changing the properties of the light with the changing motion and actions of the body. This concept can be extended through motion tracking, device tracking, and by working with the property and diffusion of the light beyond a simple follow spot.

In this section, I will present four different experiments created or co-created with fellow researchers from the Topological Media Lab and/or friends. These experiments work with light in various forms and present a way to design and conceptualize light as a key element in responsive environments.

5.2.2 The Experiments

5.2.2.1 Fireflies in 512 channels (2013)

Omar AL FALEH

Fireflies was the first experiment in using household lights as means for computational lights. Inspired by the seemingly random flicker of fireflies in a forest, the installation runs a random temporal interval in which random musical midi notes are generated, and at least one of the 12 lights are activated. Other than creating a visual, spatialized presence of the generated sound, *Fireflies* also acknowledges the computational nature of the generated sound by exposing the cables and light bulbs in the middle of the space. When not in the visualization state, *Fireflies* moves into a follow-and-catch state where the visitor walks on a specific path and lights turn on and off along this path to match the movement of the visitor, thus simulating a follow-and-catch behaviour which is usually demonstrated in traditional motion tracking research. This behaviour was pre-programmed and not dynamic, which was a design decision as this experiment was meant to be a sketch and a prelude to something more established. This way I was able to evaluate the experience and test the visual effect without having to go through the technical exercise.

Figure 28 - Fireflies in 512 channels (2013)

This experiment stems from the research interest at the Topological Media Lab in building amorphous light networks where lights are not necessarily placed in a pre-determined fixed positions in order to be made computationally responsive. The idea behind the amorphous light network is to enable designers to walk into a space and distribute light elements in ways that are not constrained to the traditional grid-on-the-ceiling model, and then easily adjust their programming to match the new positioning of the elements instead of following the traditional computational model of predetermined grid distribution.

While this experiment is not necessarily responsive in the traditional concept of computing motion and position into media behaviour, it serves as a pre-sketch where the esthetics and control of computationally-controller household light are examined. At the same time, the potential of interaction with light, and the resulting light effects, are evaluated. This experiment was a pretext that enabled the evolution of the project that I will discuss next.

5.2.2.2 Experiments in Light and Mapping (EILM) (2014)

Omar AL FALEH, Nikolaos Chandolias

Following *Fireflies*, this project looks at the ways in which light can have volume and physical attributes within the space without resorting to synthetic environmental effects like fog or smoke machines. We placed the light inside transparent plastic tubes that were hand-sanded to ensure a gradual diffusion of light. The coarseness of the sanding was highest around the light bulb area to ensure higher diffusion, decaying gradually towards the other end. Sanding the transparent tube ensured that a portion of the light was diffused in the environment, yet left a halo or a hotspot on the surfaces and walls that face the other end of the tube.

This project was done as a one-week residency in the Hexagram video production studio at Concordia University, which is where conception, programming, and the cutting and sanding of the tubes took place. We started with six transparent tubes that were 6’ long with 2” diameter,

and cut them into various length to have enough tubes in the space. The 2” opening allowed us to easily fit any household light bulbs inside the tube. The light and chord were then taped to the tube, and the light cord was used to hang the light from the ceiling grid. We used black opaque tape around the light bulb to hide the direct glow of the light and to force the light to roll out towards the end of the tube, which transformed the point light into linear diffusion that we could distribute in space.

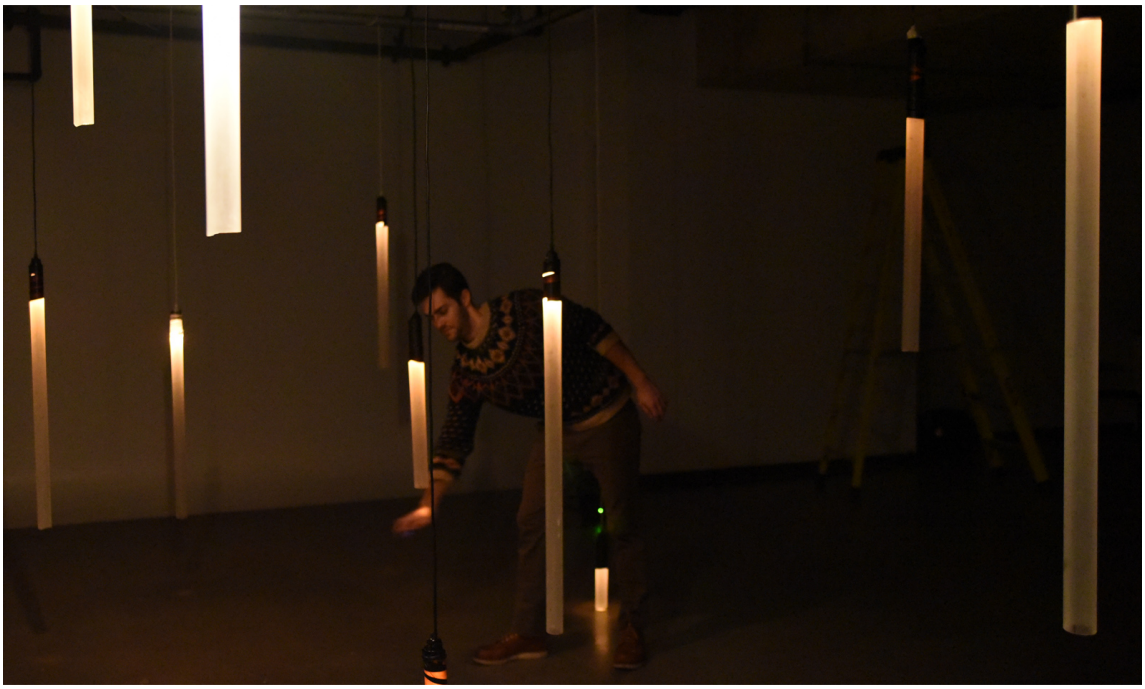

Figure 29 - Experiments in Light and Mapping- the effect of light on bodies and space

We experimented with a combination of video projection mapping on the tubes, light animation and control, and a combination of the two.

Behaviour:

Designing the behaviour of the light happened in multiple steps:

1. First we went with the follow/catch behaviour where visitors would walk in the space and leave a trail of decaying lights. Infra-red emitters filled the space with invisible infra-red light, and an infra-red ready camera tracked the visitor’s position in space and turned lights on and off (with a decay effect) accordingly.

Figure 30 - Experiments in Light and Mapping – mixing video projection and light

Designing the tubes with various length, and hanging them as various heights, enabled us to break away from the traditional track-from-above, light-from-above computer vision follow-spot tacking model, as some of the tubes were almost at the level of the floor and lower than the visitors themselves (some tubes were cut to be 1' long and placed a couple of inches above ground). The tracking used background-subtraction and frame-differencing techniques to track the position in space regardless of the tubes that were obstructing the views of the camera.

2. Second, we mapped the behaviour of the light to sound, where we placed a microphone in the middle of the space (above the visitor's head, hanging from the grid), and captured the audio in space. The audio gain would then be mapped to the intensity of the light where loud sounds would turn all the lights on to an intensity that is relative to the loudness of the sound, and when the sound stops, the lights would decay slowly to a complete black.

3. Third, we programmed an iPhone app which captures the accelerometer values of the phone (rotation and speed) and uses them to generate a gradient model which shifted the intensity of the light based on the angle of the phone. The visitor would calibrate their devices in space and start waving their phone around to change the dynamic properties of the light. Using the iPhone was the quick and efficient way to build that sketch, but the

same effect could be achieved using a wearable sensor with networked capabilities, which would allow us to map hand and body gestures to establish the same effect.

4. Fourth, we did a combination of video projection and light control where the tubes were mapped with an animated red wash that faded away as the light turned on, and faded back in as the light turned off. The same tracking techniques as before were used to animate the lights but the previous on/off model was changed to light-on-video-off/light-off-video-on. Multiple video projections were used, from animated black and white stripes to animated red wash, to regular projected imagery. The red wash was the most natural to the shape and quality of lights.

Findings:

This experiment was never meant to be a finished installation or a performance. Rather, it was supposed to be a learning experience and a conceptual playground for two main concepts: to explore the physicality of materials and the physicality of light; and to explore ways to design interaction for an amorphous distribution of light, which is not uniform or fixed to a regular distribution system such as a grid. With that in mind, we ended up with the following findings:

1. On a physical and material level, we found out that the heat of the light bulb was enough to melt the tube if it was turned on to full intensity or if it stayed on in a lower intensity but for an extended period. After experimenting with multiple combinations of light intensity and duration, we settled on maxing our output to 25% intensity on each light as an experimentally-measured safe value. This produced a visually attractive result as the lights were not too bright and allowed people to come close and examine the tubes without hurting their eyes. However, this also proved to be not bright enough for larger spaces. Therefore, we decided to sacrifice the aesthetically-pleasing tungsten light in favour for the brighter LED lamps that produced no heat, but that are also harder to dim.
2. On a visual and control level, it was decided to abandon the video mapping: as in all standard video projection mapping techniques, the projection surface must be steady and static. However, the core concept of this experiment was to allow visitors to interact with the light through pushing and swinging the tubes, which threw the video mapping off. The concept of allowing for physical interaction with the tubes was core to our design:

we wanted to give the lights a body and substance which has physicality and volume. Assuming steadiness of the tubes, in order for the projection mapping to work, was naïve and not in tandem with the core design concept. Therefore, we opted to leave video lighting out of the experiment, especially that the aesthetics of the tungsten light was much more pleasing that the over-saturated video lights.

3. The tubes, especially the ones closer to the ground, produced a very aesthetically-pleasing halo that was surrounded by traces of the light that refracted off the inner body of the sanded tube. This halo changed shape as we swung the tubes further around the axis, which created a projected perceptual extension for the tube on the floors and walls.

As a preliminary sketch, EILM aimed to build ground for future projects on the level of understanding light and its material behaviour, and understanding the possibilities and limitations of designing behaviour within particular environments. The next two projects were designed based on this experiment.

5.2.2.3 Light and Rhythm Residency (LRR) (2014)

Omar AL FALEH

The Light and Rhythm Residency (LLR) was a week-long research residency in the Synthesis Center at the Arizona State University's Faculty of Media and Engineering. The goal was to examine patterns and attractors in computationally-controller lights.

The conceptual baseline for this experiment was to build continuous light behaviour that flows a specific pre-programmed temporal pattern. When an interrupter is introduced to the system, such as a foreign object that enters the light zone, lights switch behaviour and snap to the object by computing an animated path of the lights towards this new nucleolus, changing its interactive behaviour and pattern. When the foreign object leaves the zone, the lights return to their original behaviour.

Figure 31 - Light and Rhythm Residency: Light followspot

Branching from the behaviour and tracking concepts of EILM, and the general design methodology of designing state machines for responsive systems, the LRR worked on two levels of light computing: the Synthesis space was equipped with a grid of theatrical flood lights, which were responsive, dimmable, and sensitive to dimming values; and a second grid of neon light tubes which, by the nature of their neon gas properties, had different ways of responding to dimming and animating. These neon lights were part of the set for two projects titled *Wald-Forest*[4] and *Forest 2*[5] by Chris Zeigler, a professor at the Arizona State University, that also experiment with computationally activated light elements in space. The concept was to map the flood lights to position tracking, and the neon light to a combination of position tracking and motion analysis.

When the space is clear, both the neon lights and the flood lights animate on a predetermined pattern. When an object enters the space, the light animation stops and the system saves the last state of the animation. The position of this object is calculated, and the lights will animate from their last position in the interrupted animation to the position of that object in the space. They do so via the calculation of the shortest sequential path towards this position and animating the lights to create a fading light trace. This creates a lit zone around the subject, leaving everything else in darkness, and switches the system into the interactive state.

In the interactive state, light intensity is augmented by calculating motion in that area: the more active the zone is, the higher the neon light intensity. When the motion intensity becomes higher than an arbitrarily defined threshold, lights start spilling outside the "zone" and activating lights in the larger surrounding area.

[4] http://www.movingimages.de/?type=performing&txt_id=2&lng=eng
[5] http://www.movingimages.de/?type=performing&txt_id=21&lng=eng

The action of leaving the space creates the same faded trace of lights that follow the object outside of the space. Once the space is completely empty, it resets the lights back into the animated state, retrieves the last saved state of the animation, animates the lights back to that last saved active node, and continues the animation from where it stopped.

Figure 32 - Light and Rhythm Residency: Mapping motion to light

Working with two types of lights, with two different types of computational responses that depend on their properties, was a way to create a certain character for this experiment. Designing and drawing the two light states, and the transition strategy between the two states to avoid the abrupt change, allowed for experimentation in endowing the space with a life of its own when there is no one around. The first design challenge lay rooted in the proverbial question of the tree that falls in the forest: what do responsive spaces do when there is no one around? If we are borrowing the properties and characteristics of living systems and organisms and designing the space to have such qualities and properties, shouldn't we also assume that responsive spaces, when left to their own, should not be idle and inactive? This enforces the idea of responsive architecture as a manifestation of Arakawa and Gin's *organism that persons*: an agency that does not switch off when not in use, like electronic devices do, but one who's behavior can extend beyond presence, or one who can replay or reflect on the previous presence of spectators and visitors.

The second design challenge involved deconstructing the tracking zone or the tracking spot, generalized to include the conceptualization of a personal body space in responsive systems. Traditional tracking techniques imply that an active object only influences its immediate surrounding, which is why the computer vision lingo refers to the tracked object as a "blob." The implementation of a certain , after which the influence of a "blob" extends outside its immediate zone is an illustration of Edward T. Hall's proposal that the extent of personal space is larger in dominant species. (Hall 1966) Therefore, the experiment was built with the

concept that bodies that are more active than others can extend their personal space, which can potentially create a space for competition over dominance in the space through light control.

5.2.2.4 Acatus (2015)

Omar AL FALEH, Nikolaos Chandolias, Marcello Licitra

This project was developed in collaboration with Nikolaos Chandolias and Marcello Licitra during the P.A.R.E residency (Place, Architecture, and Responsive Environments) at the Topological Media Lab in the Hexagram Black Box in 2015, and was made possible by Hexagram funding granted to Nikolaos Chandolias as a co-creator.

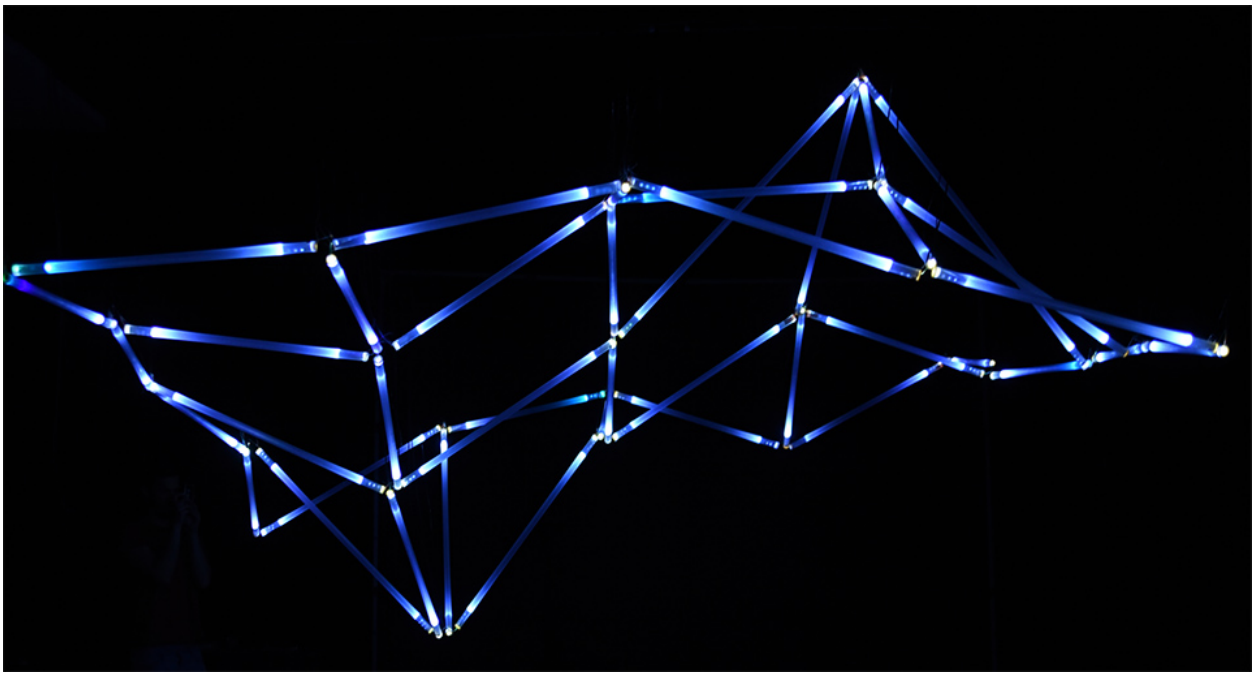

Figure 33 - Acatus (2015)

Acatus, a Greek word that means floating vessel, is an interactive floating canopy that examines the concept of order and displacement as well as volume and representation, in an embodied interactive context which spans across spectatorship and speculation. The design of *Acatus* enabled interactive media to leak into the space in a physical form, breaking the model of spectatorship and reserved experimentation, which is prominent in screen-based interactive installations. It encouraged visitors to experiment with the limits of the system dynamics by

pushing and pulling the structural elements of the design while watching the structure as it adapts to presence and motion.

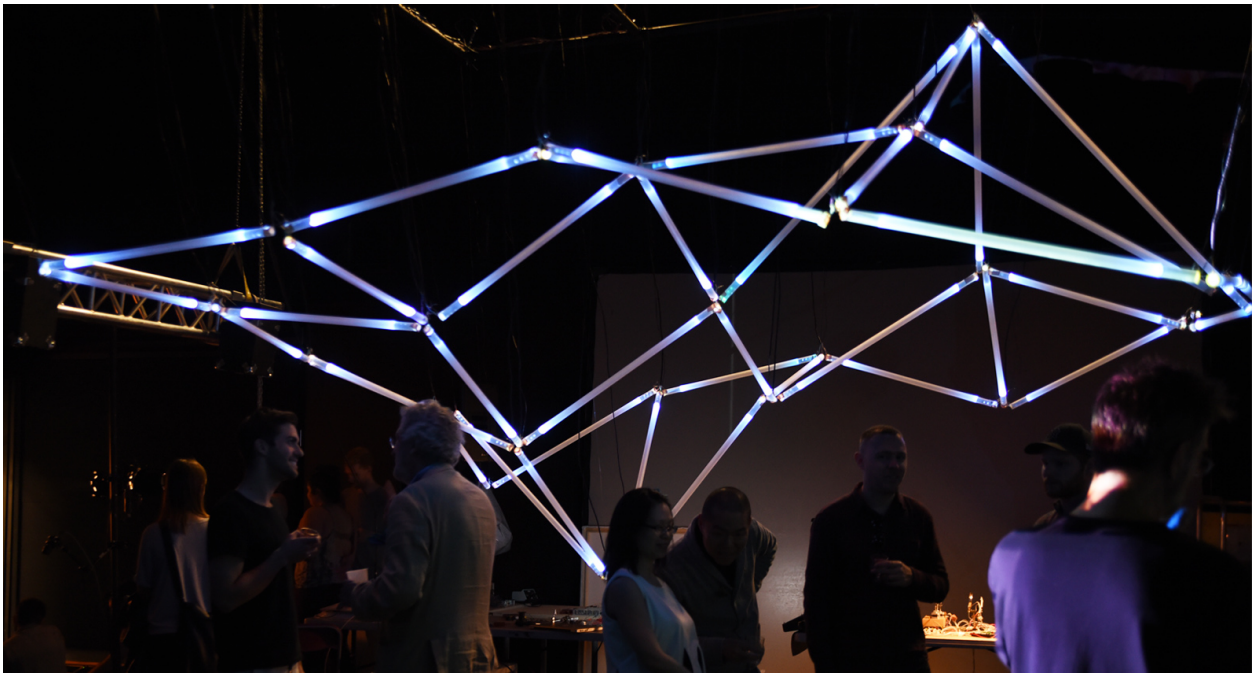

Figure 34 - Acatus: Human scale

This project continues my research in computational lighting and the ways it can be distributed in a physical form, which started with the EILM and LRR projects and which will continue in the VIUN series (detailed in the Chapter 6). The design starts with a grid shape pattern which, through repetitive vertex displacement, morphs into a geometric cloud shape that is suspended over the visitors in the space. The grid here is a representation of order, rhythm, and systems in general. *Acatus* is a continuously applied dynamic change to the system, which represents the will to evolve and revolt against modularity. Therefore, the resulting cloud shape is not final, nor is the change finite. The current manifestation of *Acatus* is but a mere snapshot of the system in a flux, where *Acatus* will always be in a state of becoming rather than a state of being. This is inspired by Aaron Betsky's description of Zaha Hadid's work as an "explosion of a tenth of a second," (Hadid and Betsky 1998, 6) which refers to Hadid's work as a snapshot of a dynamic built environment in constant state of flux.

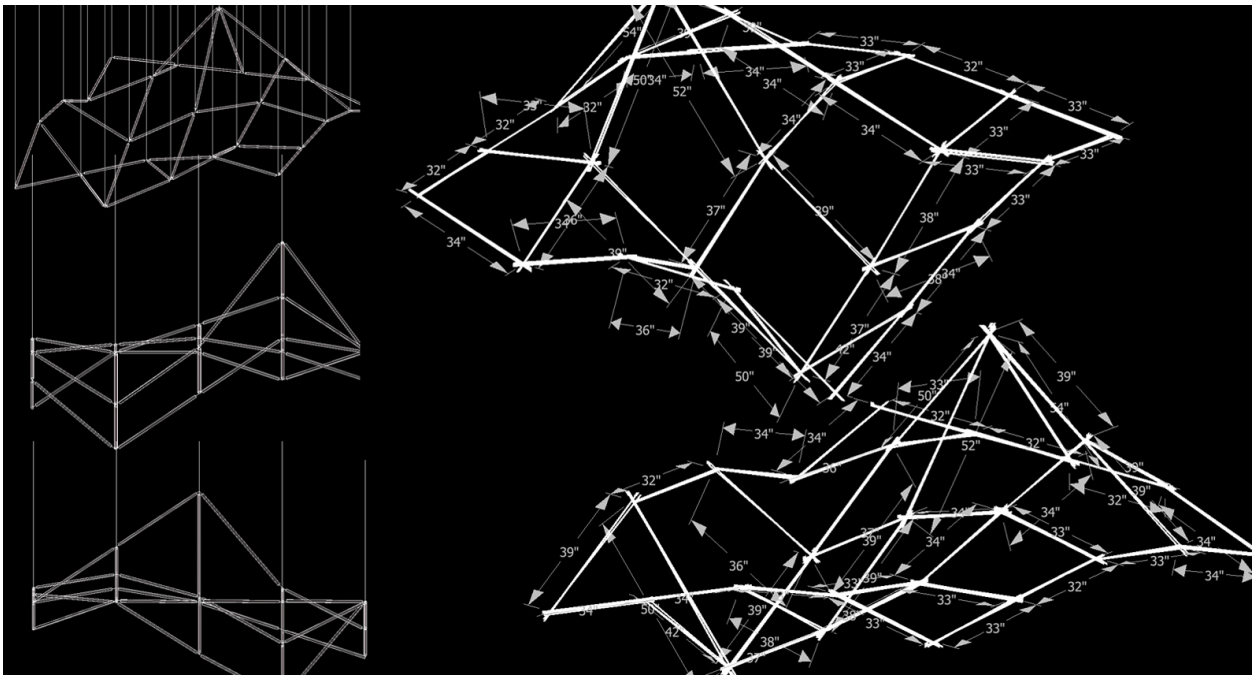

Figure 35 – Acatus: design and structural sketches

As a geometrical form, the *Acatus* grid maintains its projected square shape; the displacements for its vertices are always on the 3rd (vertical) dimension which is a conceptual rendering of the dynamics of growing and evolving. Classic religious architecture built its temples with towers and minarets that reach up to the sky to connect to god and heaven. *Acatus* fluctuates between its will to ascend to a higher level of becoming and the will to descend towards people.

Light in *Acatus* is a representation of a state rather than a representation of itself. By highlighting different points and edges at different points of time, *Acatus* communicates with visitors to demonstrate awareness of their state and whereabouts, and to encourage interaction and exchange. Different states are activated remotely by the system programmer, but can also be automatically decided by detecting and computing presence and motion. When no one is in the space, *Acatus* goes into a state where the light animates in sync with a low-frequency ambient soundtrack that floods and activates the space. The light modulation is synced with a change of volume and gain of the computationally-generated soundtrack. When visitors enter the space and start walking around, two states are possible:

I. Light intensity is increased, while still modulating to the changes of the ambient soundtrack. This state is called the "Observer" state, in which visitors walk about and explore the shape and dimensions and the limits of the system.

II. Lights turn on and off to highlight the visitors' position in space. This state animates the lights of each vertex based on a motion tracking algorithm, which functions like a follow-spot around the visitor, only suspended higher above their head. In this state, called the "Follow" state, light intensity is augmented by a multiplier which is mapped to the volume of the sounds in the room. This way, when a user talks, claps, or shouts, the already-activated light nodes augment their intensity to match the new sound level. This allows the system to respond to activities that are not only motion based, but also audible.

The suspension system for *Acatus* is done on a grid structure with transparent fishing lines that connect the intersection points to the cross points of a secondary grid that is built from PVC pipes, which is in turn suspended from the ceiling of the space. This design allows *Acatus* to be built and functional as a structure regardless of available ceiling suspension.

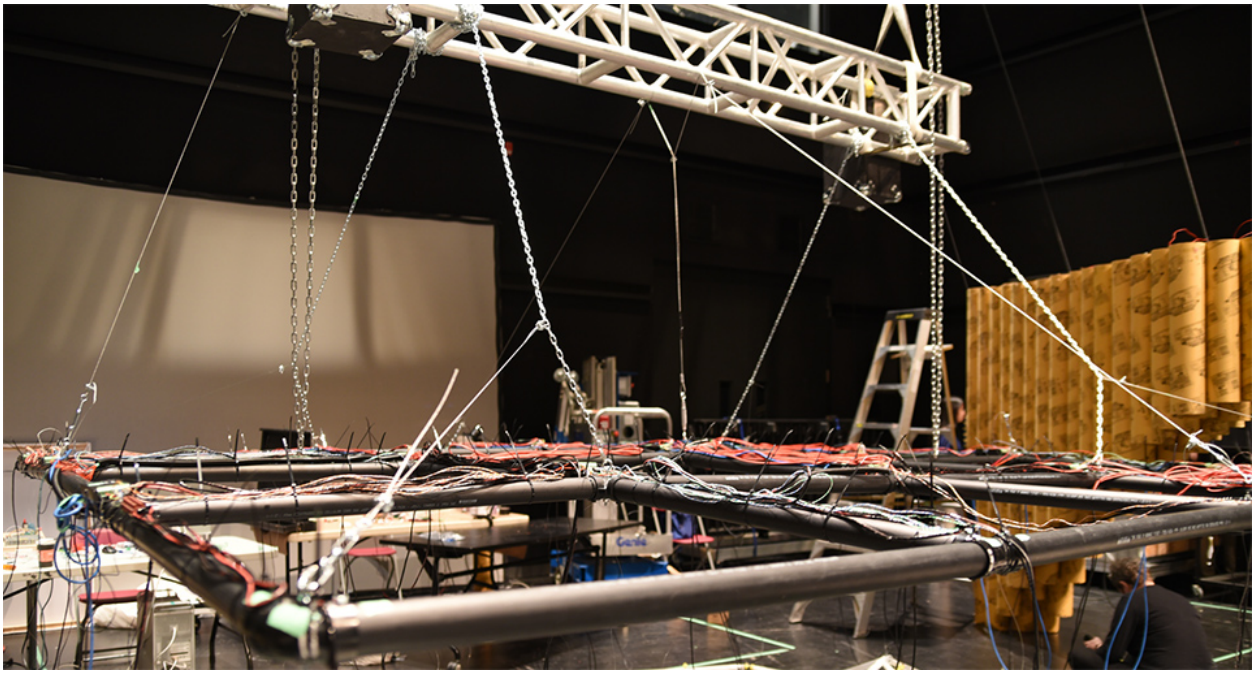

Figure 36 – Acatus: suspension details

Like EILM, the lights are inserted in transparent plastic tubes that are hand-sanded to enable for gradual and coherent light diffusion. The tubes for *Acatus* are 6' long and measure at 1" in external diameter. After the technical drawing is prepared and the exact dimensions are calculated, the tubes were hand-cut to the projected size of the grid. Unlike EILM, *Acatus* uses RGB LED strips, which come in rolls of 6' and 10.' We cut the rolls to multiple 1.5" 3-led strip bits, soldered them in pairs, and connected the pairs to the same cable connector. This way, each pair was inserted on one of the two ends of each tube, where a point of intersection of 4 tubes is considered one pixel, and is made of 4 pairs of the small LED strips, and each point of intersection of 3 tubes is considered one pixel, and is made of 3 pairs of the small LED strips. All LEDs for each pixels turn on and off together. The LEDs were connected to DMX-Con3 and DMX-con6 boxes which were connected in serial and addressed in order. Each DMX-Con3 represents one channel (which is digitally made of 3 channels: Red, Green, and Blue), and it turns 4 or 2 or 3 LED-strip pairs, depending on the point location on the Acatus grid. The first DMX-Con box was connected to a USB-To-DMX box that converted the computer signals to DMX signals. We used Max/MSP to control the lights, sound, and camera tracking.

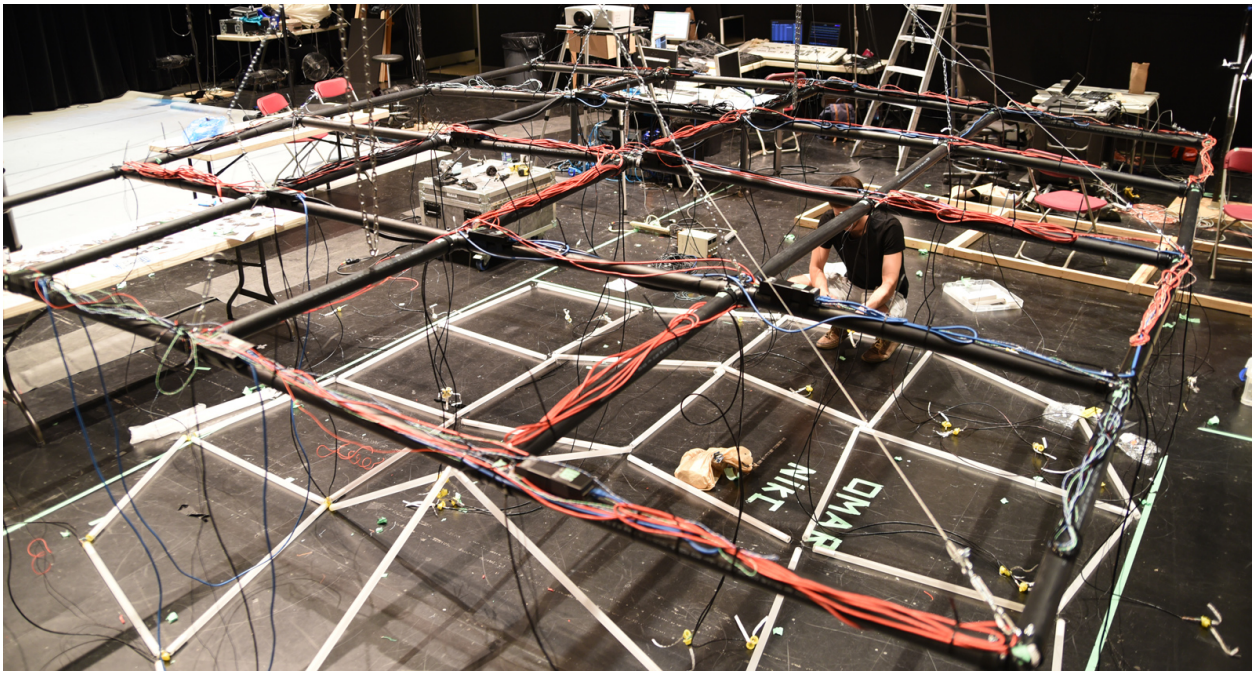

Figure 37 – Acatus: wiring and connectors

Acatus presented us with a different technical challenge that we did not have to deal with in EILM and LRR, which is why the setup for this piece was much more complex and needed in-depth experimentations and research to choose the right technology. We needed to address a significantly larger number of light nodes, choose the lights carefully to avoid the potential overheating that can melt down the tubes, which can be hazardous given their suspension status, and guarantee a fast response time to the environmental input like sound and motion. We also had to plan *Acatus* in a way that made it extensible and adaptable in order to be able to reconfigure it easily in different settings.

Visitor tracking was done using a fire-wire infra-red camera that is suspended over the grid, and 3 LED illuminators were used to flood the scene with invisible lights for tracking. Using software background subtraction and motion flow (using the cv.jit package and Jamoma objects) we were able to map the motion blob location and map it to the appropriate pixel to turn them on and off. The value which was passed to the light (0 for off, 255 for full intensity) was dampened by a numeric multiplier dependent on the sound gain in the environment, which was captured using a microphone that was suspended over the grid and connected to an external fire-fire soundcard.

5.2.2.5 The VIUN series

Omar AL FALEH, Nikolaos Chandolias, Andrea Peña

Viun is the result of a collaboration between myself and Nikolaos Chandolias as interactive designers, and Andrea Peña as choreographer interested in media and sound as integral elements in performance design. Based on the work of EILM, and on a project already under development by Andrea, we designed *Viun* as a dance performance that is situated in an interactive media-rich installation space of light, sound, and architectural fixtures, where dancers, as well as the audience in some of the performance's iterations, can condition the space with their actions and movement. When *Viun* is performed, the computational lights and sounds are choreographed and responsive to the temporal structure of the dance, the movement of the dancers, and to the sonic changes of the performance soundscape. *Viun* was produced in three different installments: a full dance show in Theâtre de Maisonneuve as part of the Quartier Danse Festival in September 2015, a performance/installation at the Espace Infropresse as part of

Montréal en Lumière in February 2016, and a full dance show in Theatre Zone Homa in August 2016.

Viun-1 (2015)

The initial *Viun* development occurred in a two-week residency at the Topological Media Lab in July 2015 where we experimented with different scenarios of interaction/performance/light/ behaviour. The purpose of this residency was to develop a unified identity between media, the space, and the choreography; a common language of design and choreography where media and the performers are equal partners in the creation of the work. The main objective was to develop an organic, two-way relationship that avoids the follow/lead model, so that the dancers are not only following changes in the media, and the media is not only matching the tempo and scenography of the dance.

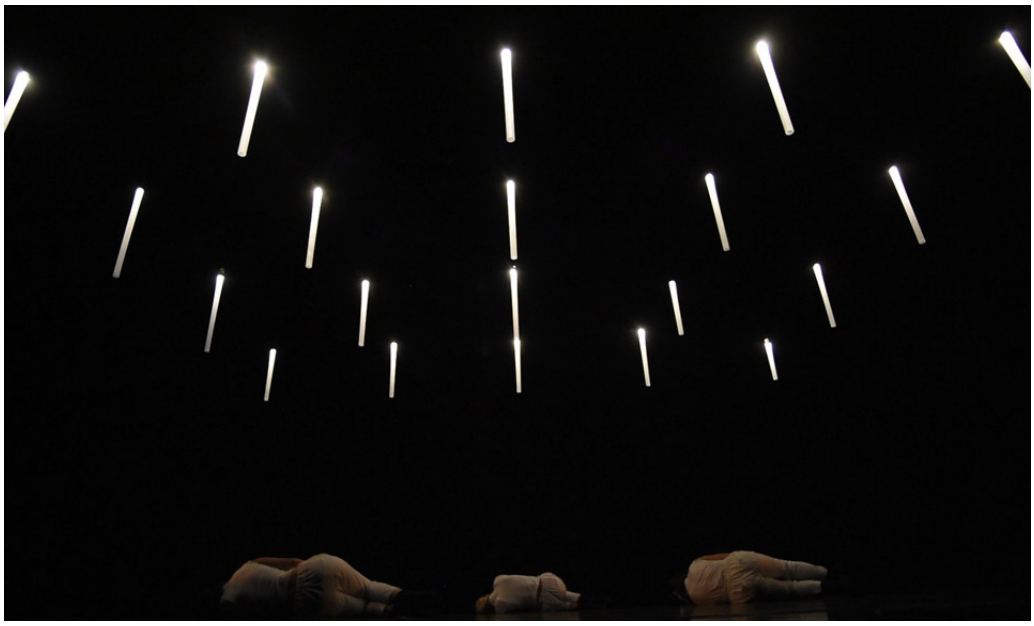

Figure 38 - Viun-1: Light tubes over the stage

We used the same sanded plastic tubes and some of the light behaviour and techniques which were developed in EILM. To avoid the problem faced in EILM, we used regular dimmable household LED light bulbs which could last for hours without heating and melting the tube. Working with LED light bulbs was challenging from the technical perspective of the market implementation of LED dimming, which causes a coarse ramping of values as opposed to the

smooth ramping tungsten lamp. Therefore, the light behaviour needed to be adapted to match this challenge.

Figure 39 - Viun-1: Light tubes over the dancer

The show set up for *Viun-1*, unlike some of the design principles of EILM, followed the track-from-above, light-from-above model, where the lights were distributed in a grid above the dancers. At almost equal heights, creating an interactive canopy of vertical tubes. The lights switched between manual animation control, where we switched between queues based on dancers' queues, choreographed states where pre-animated patterns were fed into the light engines and the dancers followed, and an interactive mode where the lights were controlled by a computer vision tracking of the dancers, conditioning the light behaviour and intensity to the location and motion quality of the dancer.

The show gave us pretexts and contemplative material to think about *Viun-2* from a completely different perspective, which will be explained next.

VIUN-2 (2016)

VIUN-2 was designed with the concept of blurring the lines between the role of performers and spectators and breaking the traditional model of spectatorship where the audience

is separated from the performance space. The audience in this piece is invited to interact with the media in space and experience first hand how the space responds to motion and presence. When presented within the exhibition space, *VIUN-2* begins as an installation that's open for the public to play and interact with, via the responsive light fixtures and the soundscape. At a certain moment in the show, dancers make their way to the performance space from within the audience, and the installation switches to performance mode, where lights switch back and forth between choreographed and interactive modes. When the performance is over, performers leave the space through the audience, and invite the audience to walk back into the space, which is now in installation mode again. When the performance begins, the audience does not leave the performance area and retreat to their seats; instead, they just leave space for the performers to move and form a circle around the performance area, which maintains the intimate connection between themselves and the performers and the media.

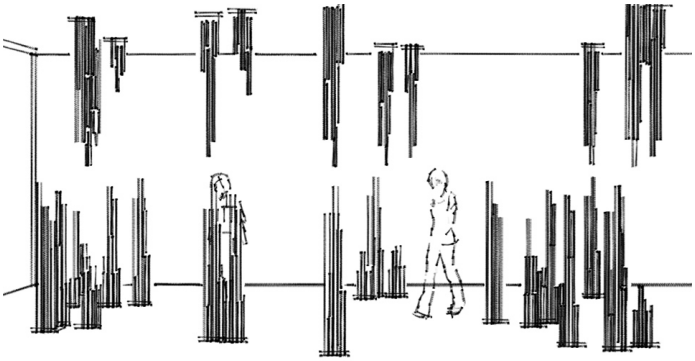

Figure 40 - VIUN-2: Conceptual sketch

When presented as a pure installation, the lights are responsive to the movement and presence of the audience in the interactive space, in the same way that some of the tableaus in the performance were designed. The two modes of *Viun* (performance/installation) are not distinct or mutually exclusive; the space is conditioned to run in a multi-state computational mode that changes behaviour with a simple switch of a button.

The design of *VIUN-2* started from deconstructing the concepts which were implemented in *VIUN-1* where the media was removed from the space of the performance and placed above it. We wanted to design a performance space where the media to leaks into, and grows from, the physical space of the performance. Using the concept of stalactites stalagmites as a metaphor for an architecture that "leaks" into the space instead of geometrically defining it, we conceptualized clusters of tubes that work as modules which are scattered in the space, placed on the floor or on the ceiling. We used the same tube design as before but combined them in a 9-tube cluster that is fixed to a square-shaped wooden base used to create modularity and to hide the electronic components that were used to control the lights.

The design followed the same amorphous design thinking where light positions are agnostic to the preconceived notions of the grid, which is analogous to the technical grid on which lights and cables are fixed. The bases were therefore placed in a non-regular distribution along the space, and the programming was adjusted to the design.

Figure 41- VIUN-2 in installation mode: public interaction with the space

The venue, where the performance was going to be presented, enforced safety restrictions on hanging elements from the ceiling as they did not have a ceiling grid, so we had to abandon the ceiling-bound modules and work with floor-bound modules only. For the lights, we used the same technique as in *ACATUS* where we used LED light strips inside each tube, and hid the DMX-CON boxes inside the wooden bases. Ethernet connectors between the boxes were gaffer-taped to the floor to enable the performers and audience to walk safely between the tubes without tripping over them. The tracking was done using a regular ceiling-fixed analog camera instead of the usual digital infra-red system. The light noise within the space made it impossible to have a steady and controlled light flow to enable reliable background subtraction and motion analysis for position tracking. Therefore, we had to work with motion quality analysis instead of position analysis, which made the interaction more meaningful for larger groups of people as it goes beyond simple presence detection, which easily loses significance around larger groups as follow spots would merge and blend together. Motion analysis systems acknowledge the presence of

active bodies, which allows for a more direct experience as active presence is agnostic to the size of the crowd and only sensitive to their actions. This makes the design more human-centric rather than crowd-centric, and encourages the audience to engage with each other and with the space.

Figure 42 - VIUN-2 in performance mode: conceptual spaces and bodies

On the night of the performance, we started the system and invited people to walk and play within the interactive space and between the tubes while playing the performance soundtrack in the back at a lower volume. At a certain hour, the soundtrack became louder, and the dancers walked into the space from between the audience, thus triggering the start of the performance. The performance, which was an improvisational take on the previous show in *VIUN-1,* lasted for 15 minutes, and the dancers walked outside the light area when they were done.

VIUN-2 never reached its full potential as the show could not be performed with ceiling-bound modules out of safety and practicality reasons in most venues. Using floor-bound bases only, while creating a physical presence for the media in space, created a visual obstruction to the performance, and was more suitable for an installation instead. Also, larger numbers of modules were needed to adequately populate the space and create the dynamic typologies that were in the original design. This made the organization and management of the modules more

complex and time-consuming. These observations created a conceptual dialogue which paved the way for *VIUN-3*, which I will discuss next.

VIUN-3 (2016)

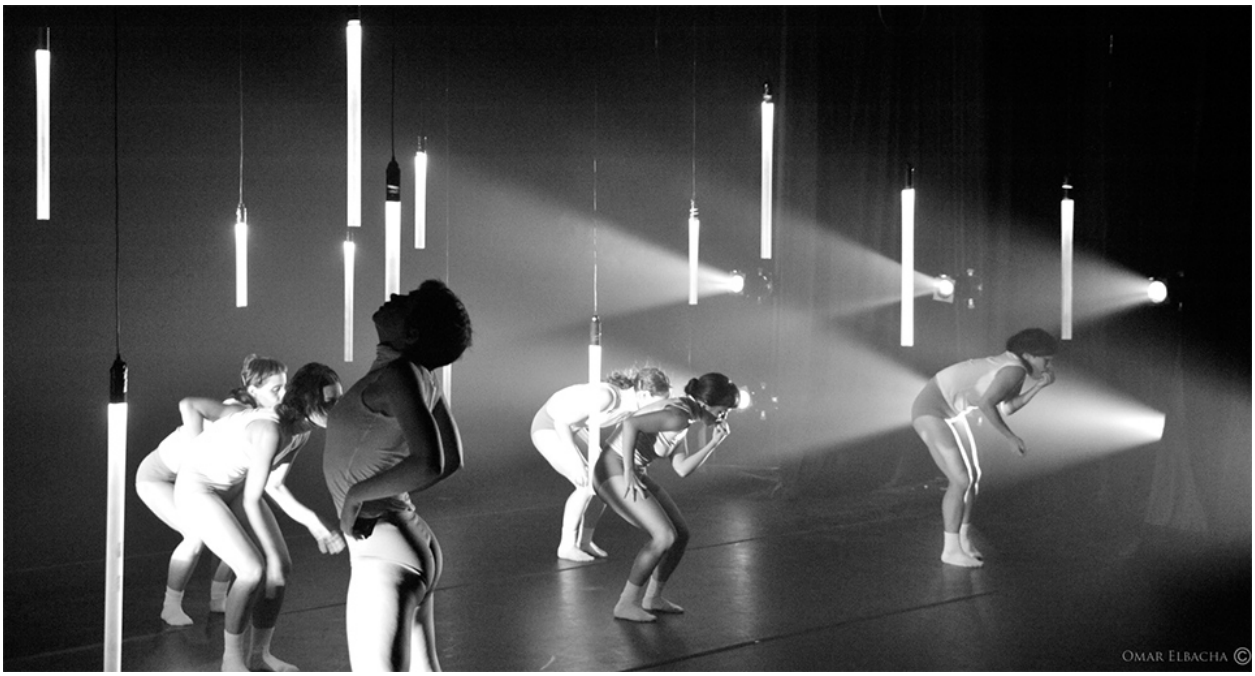

Figure 43 - VIUN-:3 Bodies and light view

VIUN-3 is the latest, and most mature, incarnation of the piece, which took off from where the other two shows ended. *VIUN-3* was a performance-only piece in a traditional stage-in-a-theatre setting. The lighting strategy followed *VIUN-1* where the tubes were hanging from a ceiling grid with nothing on the stage floor. We went back to using house-hold LED light bulbs instead of the LED strips used in *VIUN-2*. Using the LED strips gave us finer control over the light quality and different shades of color, but it was cumbersome to sustain and move from the rehearsal space to the theatre as connections would easily break and had to be soldered again every time the tube's location was changing.

Figure 44 - Viun-3: Sub performance spaces

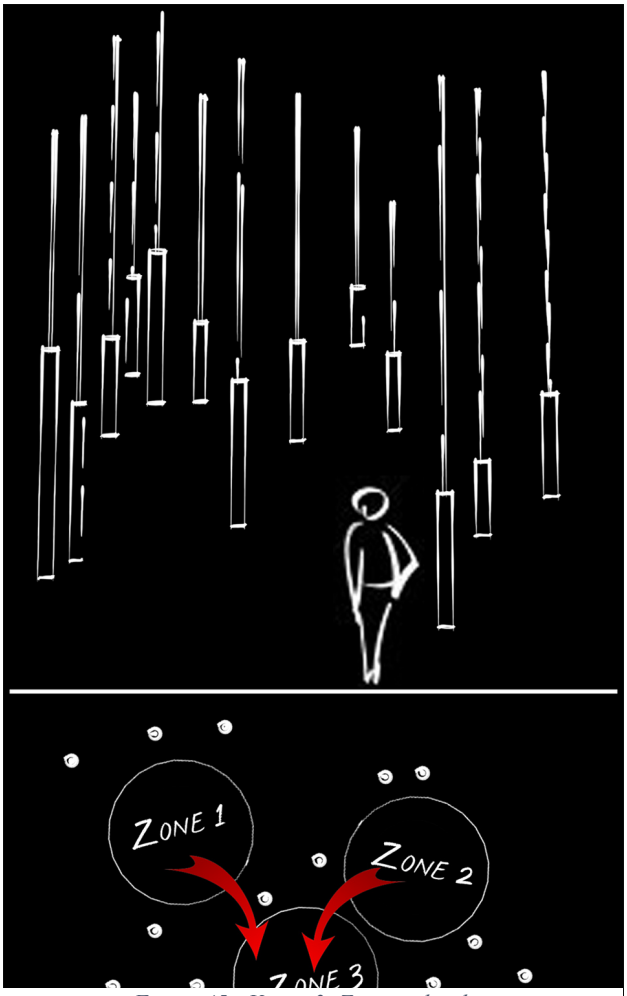

Figure 45 - Viun - 3: Zoning sketches

However, the redesigned scenography didn't place the tubes in a grid over the dancers' heads. Rather, we went back to the placement strategy which was used in *EILM*, where the tubes were placed in different eights, some almost touching the floors and some higher than the performers heads. We clustered the tubes together in a formation that left three subspaces of performance and interaction, where the lights behaved together at times during the performance, thus conditioning spaces of anticipation and reflection rather than spaces that are clearly delineated and segregated.

In another return to the original concept of *EILM*, the tubes became objects of interaction again, where the performers would touch the

tubes, swing the tubes, and acknowledge their physical reality rather than their light properties only. This enabled us to validate the tubes as integral part of the performance and as a physical manifestation of light rather than a decorative object and a stage prop.

The sound strategy was also different in *VIUN-3*. Unlike the first two shows, the score was performed and mixed live on stage by a musician and composer who composed and pre-recorded scores and sound bits. This enabled us to create a direct connection between the light behaviour and the sound where we could alternate between a sync'ed behaviour state, where the lights will follow the pitch and the gain of the sound, a pre-composed state where the light behaviour is pre-composed programmatically to match the rhythm and feeling of the sound, and manually controlled where we would compose both the lights and the music live on stage.

5.2.3 Epilogue

On the conceptual level, the experiments presented in this chapter are illustrative of a design strategy that elects to use ephemeral, non-representational media as building elements of an experimental responsive architecture that examine the following concepts:

1. How can we transmute the immateriality of media, computational and otherwise, to give it a physical presence and a tangible manifestation in quotidian and performative spaces, and how can we design such spaces to allow the media to co-habitate the space and shape the experience in and of space?

   The *VIUN* series and the *EILM* experiment resorted to containing the lights within objects whose material is opaque enough to contain the light in a physical container, yet transparent enough to allow the light to flow through and affect the visual property of the space and the elements within this space. The material used in these experiments were sanded transparent plastic in a tube-shaped container, with varied levels of sanding coarseness on the surface to control how much of the light do we want to diffuse. The arbitrary choice of containing the lights inside tubes became essential to the design of the experiments and performances within this line of research: the diffusion of light along the rounded edges of the tube, and the lack of edges and sharp ends, made the light diffusion smoother and more natural, and made the tubes more inviting to touch and interact with.

Clustering tubes together was conceptually relevant: clustered tubes would present themselves as one block or one element, yet the spaces in between, which are enforced by the circular nature of the tube, maintained their individuality and modularity within this cluster.

2. How can we define spaces of anticipation: speculative, minor, and immaterial architectures that influence the behaviour and movement flow of visitors and performers in a space, and demonstrate feedback and response to their presence and actions? In *LRR*, I experimented with motion analysis and tracking techniques that conditioned the light behaviour to expand or contract the users' representation of presence in the space, which were defined and visualized by light, based on their motion and activity and not only presence. *EILM* and the first version of the *VIUN* series followed the same strategy of mapping presence and activity to the intensity of light in their tubes. The second and third *VIUN* performances went a step further by placing the light tubes in a special arrangement that created subspaces and carved niches in the space, which allowed the performers to transverse conceptual spaces within the same physical stage.

How can a low-resolution, ceiling-bound light grid give representation of presence and interaction, and bind the perception of light to presence in space? *LRR* relied mostly on a light grid that was only capable of creating spotlights on the floor. However, the neon lights that extended into the space, while still distant from the body itself, gave a stronger sense of connectedness

5.3 Conclusion

The majority of the experiments that have been presented in this chapter were in-progress investigative design experimentations whose main purpose was to validate one or more theoretical angles of the proposed design strategy. Some of the experiments became part of finished public performances and installation pieces, like the VIUN series, while the others maintained their open-ended, in-progress state, making them part of a continuous investigative research process where the next iteration will be built upon the current works' observations and findings.

Most of these experiments were built in dark, controlled, and neutral black-box environments. These environments provided optimal conditions for computationally processing movement and gestures in space, which are not representative of the conditions of chaos and the unpredictability in the everyday built environment. However, working in a controller, dark black-box environment enabled me to focus on the interaction and experience design without having to worry about technical tuning and troubleshooting.

These experiments are meant to present a model for designing embodied interaction in space by using spatially distributed media elements. Therefore, and as mentioned earlier in this research, moving these experiments outside of the black-box and into the built environment is not a simple re-location and re-positioning of elements in different contexts, rather it constitutes a redesign for the spatial settings of the work to match the end environment while maintaining the same interaction design model of the experiments. Therefore, presenting these experiments in completely featureless dark environments illustrates their temporary and site-less state, which makes them a model that is created to be relocated, and redesigned to fit into different sites in the everyday built environment.

6 CONCLUSION AND FUTURE WORK

This research discussed responsive architecture as a form of intervention in the built environment which enables interaction and exchange among those who dwell in it, as well as interaction with architecture and the public space. Chapter 3 presented a view of responsive architecture as an automaton that is capable of feedback and response, and discussed the concept of space and architecture as *machines for living in* as a pretext for expanding on the concept of machines and machinic states to consider responsive architecture a medium and a process for creating experiences rather than a thing itself.

As a designed intervention, I presented a view of responsive architecture as a minor architecture, an ephemeral intervention within the built intervention that negotiates its existence within a larger context of the architecture of prominence and permanence, and proposed to consider responsive architecture a conceptually charged experimental medium that allows for playful and curious examination of the relationship between the body and space, the body and other bodies, as well as different and remote places. I also presented a historical and contemporary overview that highlights some of the notable experimentations and architectural designs as theoretical and conceptual precedents to responsive architecture, which puts this research in a historical context where the idea of feedback, adaptability, and continuity have been an area of curiosity and examination before modern technologies allowed artists and designers to conduct the experimentations and explorations that we see today. Examples such as Littlewood and Price's Fun Palace (1964), Archigram's Walking City (1964), and Myron Krueger's VideoPlace (1975) are but a few of the examples that illustrate the interest in creating a connected and adaptable architecture that is capable of feedback and change.

Chapter 4 provided a theoretical overview of space and place and the dynamics between them, and used this overview as a pretext to introduce the concept of place making as a human-centric design strategy for engaging the community and building opportunities for exchange and interaction within architectural places. This chapter presented and critiqued some of the attempts in using mobile technologies as tools for engaging people with place by using location-capable networked hand-held devices. At the end of the chapter, I proposed responsive architecture as means for engaging with the built environment and space without resorting to layers of portable and wearable technologies. This proposal allows for a collective and connected experiences

between people that is anchored in place rather than a portable digital manifestation of virtual worlds and maps.

Chapter 3 and 4 built a theoretical and critical framework to introduce a design strategy for working with computational technologies as tools that create responsive, minor, and ephemeral architectural interventions that maintain their in-progress experimental and conceptual status. Chapter 5 introduced a set of selected design experiments and performance pieces that use computational technologies as tools for creating responsive experiences, and investigate the potentials of different mediums and techniques to elicit response from the built environment. These designs experiment with different mediums such as light, video, and sound, and with the different ways to diffuse the media in space, such as mapping the bodies and mapping different elements in space that are non-uniformly shaped and non-uniformly distributed. Using light as a medium was an especially interesting and potentially a rich experimental medium, as it works on the level of highlighting the body and the environment rather than augmenting and erasing the surrounding with projected media, which makes working with light true to the concept of human-centric design as it does not reduce the human body to an invisible trigger of interaction, and does not reduce architecture to passive screens and membranes.

In conclusion, creating responsive architectural interventions that engage people with the space and with each other requires adopting a design strategy that places equal conceptual emphasis on the medium as well as the dynamics between bodies and space. While the built environment provides the context and conditions for the interaction, designing interventions that illicit this interaction is conceptually similar in essence to the architectural design process which starts from the program, the distribution of spaces and architectural elements, and the materials of construction; The difference in designing responsive architecture is that materials are synonymous to media, the distribution of spaces is synonymous to the diffusion and placement of the media, and the program is synonymous to the concept of interaction as it relates to the architectural place and the nature of the social interaction, which is not to be separated from the specifics of the place.

I have mentioned in chapter 5 that one of the immediate critiques of current design strategies is assuming an erect and mobile body that is capable of using all senses. This excludes a significant portion of the audience, participants, and dwellers in such architecture, which is a

major shortcoming when proposing a place-making strategy for a built environment Another major critique of these experiments revolves around the use of black box studio environments as an experimental space, as it is not representative of the complexity and contradictions of the built environment, and is sheltered from all potentials chnages that technology will need to adapt to when deployed in everyday environments. Therefore, the proposed design strategy remains incomplete and inconclusive until the same considerations are tested in everyday spaces and with non-suspecting participants and crowds. This is represents a major step in my future work: build the experiments in a public space, and design for an interaction that is specific to the location of the design. This step takes the concept of responsive architecture to the next step where it seizes to be a medium for conceptual and technological experimentations, and becomes a tool for choreographing and initiating social interaction in the public space.

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