Responsive Architecture

A Conceptual Framework for the Re-Examination of Space, Embodyment, and Perception

Omar Al Faleh
Topological Media Lab, Concordia University
http://www.omarfaleh.com
omar@morscad.com

This paper is a discussion and a re-examination of the materiality and the perception of architecture and architectural spaces beyond the physicality of bricks and mortar and beyond the geometrical delineation of walls and ceilings. This paper presents our research in responsive architecture, computational and interactive media, and the phenomenology of space perception, presence, and embodiment. We will introduce some of our experiments where we design and implement immaterial spaces and potential architectures through sensing, moving, and non-linear narratives, and attempt to revisit concepts of perception, space, and spatiality, when technology is used in architecture not as tools for design and visualization, rather as a framework for designing of engaging and meaningful experiences.

Keywords: *Architecture, Computational media, perception, Embodied experience, Space*

INTRODUCTION

"Buildings have been erected without drawings, but Architecture itself goes beyond the mere process of building. The complex cultural, social, and philosophical demands developed slowly over centuries have made architecture a form of knowledge in and of itself."

Bernard Tschumi, 1996

Mythologies and folk tales tell the story of king Nebuchadnezzar who built the city of Babylon in the fifth century BC. As the local tales go, he ordered his engineers to show him what his majestic city will eventually look like, centuries before drawn and plotted representations of plans and technical drawings came to being. Therefore, the engineers and planners of that age, rushing to come up with solutions to this representational challenge, laid hay stacks in the open fields where the city will be erected, and invited the king to stand on the hill that overlooks this eventual construction site. They proceeded to set the hay on fire and watched from atop the fiery layout of the streets and city blocks, simulating the urban layout of what will eventually be one of the most prominent cities of that era. This folk tale, regardless of its authenticity or accuracy, is probably the first documented case of attempting to simulate and represent immaterial and potential architectures as they over-

lay the physical landscape, by using ephemeral representations that co-create cognitive materialization of this potential built environment, or what we may consider an ancient attempt at augmented reality.

Many centuries later, and after many perspective drawings, computer-generated 3D renderings, and experimentations with virtual and augmented reality, the challenge to construct representations and simulations of immaterial and potential spaces over the existing perceived reality remains as new and interesting as ever. New technological advances continue to offer us new modalities and mediums to experiment with; The rapid evolution of real-time graphics and simulation techniques allow us to go beyond drawn and printed representations of the potential architecture, and into animated, interactive, and immersive experiential virtual environments that co-inhabit our reality in a non-competing manner.

This paper will present experiments and studies in the perceptual and sensorial construction of non-material spaces and architectures beyond the production of representational imagery and animations. These potential architectures are subjective sensorial constructions of parallel realities that become available to us through sensory and cognitive activation rather than resorting to wearable or hand-held gadgets and technologies. These experiments do not attempt to replace existing architecture; they co-exist with our built environments as interactive ephemeral layers that are space-time specific.

The projects that will be presented in this paper are interactive and responsive environments that are informed and inspired by the theoretical and conceptual studies in perception, presence, memory, and embodiment. The paper will anchor these attempts in the historical and theoretical precedents that informed and inspired these experiments, challenge existing mediums and techniques of representation, and draw conclusions and recommendations for future studies.

What we call experiments in this paper do not follow the traditional scientific discourse of measuring data and generating results, we base our work on making design decisions that are inspired by relevant studies and philosophies, implementing these designs with the subject as the main point of interest, and finally evaluating the experiments through interviewing the subjects and evaluating their described experiences. This methodology, process, and evaluation results will not be part of this paper but will be briefly mentioned in the experiment description.

RESEARCH MOTIVATION

The most common practices that imply potential and immaterial architecture are street pantomime performances. 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" (Casey, 1996) which informs the body's action through the resurrection of similar previous experiences of interacting with solid surfaces and planes. It also works on a suggestive and cognitive level on the side of the observer. The pantomime's performances imply the presence of solid surfaces, but also suggests transparency: the performer's body can be seen but yet unable to cross this spatial division.

These actions and hand gestures are not made up or improvised in any way, they are rather 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 build our experiments with what we considered to be habitual body performances that help create a mental model of immaterial spaces and architectures.

Another attempt to use visual and sonic cues to summon the audience's cognitive construction of immaterial spaces and architecture is Lars Von Trier's

Figure 1
The Village in Von Trier's Dogville - an Aerial view

film Dogville. The set (figure 1) is made of an open space where the village houses are drawn as architectural plans on the floor instead of building them with physical materials on the set.

In this film, the acts of opening doors, walking the streets, and leaping over steps, are achieved by enacting the appropriate gestures, and playing the normally associated sound effects of interacting with that object, without the need 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 plays 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, rather by our mental construction of this narrated and implied architecture through the use of media and perceptual cues.

Janet Cardiff's Audio Walks (1991-2012) is another example of the mental and cognitive construction of space and objects through sound narrative. Cardiff's narrative describes the space in which the listener is walking, which allows them to identify and match the narrated version with the listener's physical surroundings. These audio walks sometimes describe people and objects that were present during the recording but not there anymore. This creates parity between the two timespaces, and allows for a mental superimposition between the narrated and the perceived reality without the need to use any sensory activation or media presence. The common elements between the narrated and perceived timespaces function as bridges and portals, which enables the listener to perform a constant back and forth between the two realities.

Bernard Tschumi's Questions of Space (Tschumi, 1996) talk about the materiality of space and architecture, and whether a space (Euclidian or non-Euclidian) should be regarded as a series of events

over time or a geometrical representation. This leverages the definition of space as 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, 1945). This emphasizes experiencing the space through motion, action, gestures, as well as sonic input, not only through visual perception of shapes, volumes, and scale.

Salome Voegelin argues that *"[..] Merlot-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"* (Vogelin, 2010). This synthesis of the experience, which we attempt to achieve by using computational and interactive sensory stimuli, are the techniques and tools with which we imply space, delineation, and scale of potential and immaterial architectures.

PROJECTS: MEMORY, PLACE, IDENTITY

2011: Dr. David Morris, Dr. Sha Xin Wei, Zohar Kfir, and Patricia Duquette.

2014: Dr. Sha Xin Wei, Omar Faleh, Nina Bouchrd.
This project follows a prototype that was initiated in 2011 by the Topological Media Lab, at Concordia University and re-visited later by other researchers in the same lab in 2014.

The research motivation for this project starts from two ideas:

1. Our sense of the space is informed by the way we get in touch with the world

2. 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. Blindfolded 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, Steiner 2010)

3. Blindfolded 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, 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 (Lenay, Steiner 2010). The potentials of such platforms allows for the dynamic morphology of this implied architecture, with its divisions, scale, and delineations, by the process of manipulating certain ephemeral elements in the space, namely: light sources.

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 has a small photocell mounted to a prosthetic extension of the glove's index finger, and a small actuator that is placed under the fingertip of the glove. The glove is connected to a microcontroller unit that handles 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.

In the 2011 phase of this project, subjects were asked to walk blindfolded through an indoor space that is equipped with a light source (lamp) in a fixed position in space (refer to figures 2 and 3). Subjects were navigating the space with their hand extended to the front to feel the presence of light. What we

observed was that participants slowly integrated the light source in 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.

Figure 2
A subject in the space, navigating and sensing the location of the light source

Figure 3
A subject in the space after the location of the light source was encoded in their body memory and they navigated away from it

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.

In the later phase of this experiment, the sensing mechanism was connected to a global spatial computing system that reads the signal from the light sensor, adds sonic feedback to the interaction, and allows for a dynamic change of the topology of this immaterial architecture through the manipulation of light sources in the space and the spatialization of sound.

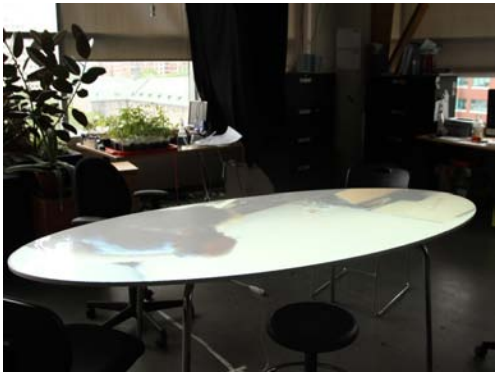
This connectivity allowed the integration of this experiment in the TML's OZONE ecology (Sha et al. 2010), which is a fully integrated media choreography system that includes a computational light control, an integrated spatialized sound engine, and a computer vision tracking system. The integration of this experiment with OZONE allows us to transcode the position of the subject in the space through camera tracking and remotely activate/deactivate the sensing process in the glove based on predefined areas in the space.

PROJECTS: THE TABLE OF CONTENTS

2014: Evan Montpelier (TML, Concordia-Montreal), Assegid Kidane (Synthesis, ASU-Phoenix), Omar Faleh (TML, Concordia-Montreal), Michael Montanaro (TML, Concordia-Montreal). The table of content (TOC) is a collaborative communication and collaboration meeting table that functions as a portal between remote locations. TOC 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.

In TOC, 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), which is applied in this project by allowing the conversation participants to map their activities to the physical changes in remote spaces through the computation of the affective quality of their motion and interaction.

This project, while similar in essence to commercial video chat software, 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.



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 in the Arizona State University in the United States (figure 4). The close collaboration between the two research centers, and the joint seminars between graduate students in the two institutions, triggered the conversation over 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 OZONE media choreography system (figure 5). 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 (start talking or gesturing), their sound is channeled through the appropriate 4-channel table speakers system on *Side B*, and the sound emitters scatter away the particles over the corresponding image zone, thus revealing the person who is speaking.

This project, while still in the development phase, attempts to connect multiple communication sources instead of two. This poses the challenge of implementing multi-channel feeds on the table without resorting to split-screen representation like video chat applications do. For this purpose, image depth is implemented into the visualization system by placing the video feeds on various depths, and displacing the active feed to the top while pushing the inactive ones to the bottom. This computational swap is overridden by the recipients' hand gestures and motion. This is done by "dusting off" the surface feeds to reveal the ones at the bottom, which implies an alternative spatial superimposition within the space itself, and emphasize the new role of table as a portal

Figure 4
The Table of Content: Standard communication mode

Figure 5
The Table of Content: Remote source inactivity and light control

instead of an irregularly shaped screen.

PROJECTS: STRIPED BODIES

2012: Omar AL FALEH (TML, Concordia-Montreal, Elizaveta Solomonova (TML, Dreams and nightmares lab, University of Montreal). Striped Bodies is a playful experimental media-rich interactive game that examines the correlation of movement, body, and space through a choreographed construction of personal spaces. This experiment considers space a product of the senses, which is a concept that transcends the physicality and materiality of architecture to focus on perception and mental constructions of spaces, where space is considered a mental extension of sight (Nouvel, 2002), and a dynamic entity that extends as far as the senses can reach (Gins, Arakawa, 2002).

The role of the body as an active agent in expanding and shrinking its personal space, and the epicenter of perception and sensing, is emphasized through the interaction and the exchange of roles between subjects in our experiment.

Participants, who were mostly not trained in performance arts nor in summoning expressive body language, engaged in a responsive media narrative that follows a predefined set of rules, to examine concepts of dynamic and immaterial spaces and perception. The experiment is held in a dark empty space, surrounded by black curtains to hide the characteristic of space and give the impression of a neutral void. The elimination of visible boundaries places the experiment in what looks and feels like an infinite space, which 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 without placing any visible lights in the scene; 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.

High contrast black and white stripes are generated and projected on the participants' bodies (figure 6), 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 covering the bodies, and the space, in darkness (figure 7). 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.

Figure 6
Striped Bodies, striped projection on participants' bodies

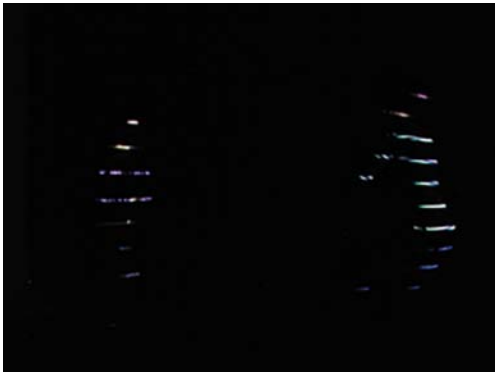


Figure 7
Striped Bodies, participants in near idle state

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:

1. The leader assumes a pose and waits for the follower to imitate her.

2. The leader is to change position only when the follower has successfully imitated her.

3. A change of the background sound for the first time reverses the roles of the leader and follower

4. A change of the background sound for the second time is the cue for both participants to improvise movements independently

Animated black and white stripes give a sense of regularity through repeated motion, and hide body details to make participants blend in the background, only to reveal themselves through the progression of continuous movement (figure 8).

Figure 8
Striped Bodies, striped projection on participants' bodies

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 questionnaire consisting of open-ended response items. They were asked to first close their eyes and focus on the question at hand (their perception of space, of the other participant, of the movements that they performed, etc.), and then attempt at verbalizing the best they could how the experience felt, as opposed to simply describing what it was.

This method was inspired by work of Claire Petitmengin (2007) on the phenomenology of lived experience , as well as by Eugene Gendlin's work on experiencing and focusing techniques. Both approaches advocate for dropping the more explicit descriptions of the obvious, in favor of studying the source of experiential subjectivity by isolating and focusing on how an event felt. Getting in touch with the felt dimension of an experience undoubtedly requires a certain degree of training, willingness and concentration.

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 focused on the other body in front of them, and the effect of the mirrored movement in their perception of the body of the other as a reflection, or an extension, of their own.

The participants in our experiment game were random selection from undergraduate students in the Computation Arts department at Concordia University, which implied a level of understanding of 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 in exploring the space in the third improvisational stage of the experiment.

CONCLUSION

Designing and implementing immaterial architecture through sensory activation and augmentation

can create meaningful and powerful experiences for users, and can provide us with the tools and platforms to apply and study theories of space, spatiality, and embodiment. These experiments can provide a conceptual framework for the considerations and implementation of responsive systems in existing architectural spaces to create a dialogue between the subjects and their surroundings, and to create meaningful and enjoyable experiences. These experiments propose ideas and concepts for ephemeral architectures and spaces that do not require handheld or isolating wearable visualization devices, nor do they require the rendering and the construction of complex augmented and virtual realities. Non-representational computational media, visual or otherwise, allow for a cognitive and mental construction of alternative realities that leave space for subjective individual and collective experiences.

REFERENCES

Baudrillard, J and Nouvel, J 2002, *The singular objects of architecture*, University of Minnesota Press, Minneapolis, MN

Casey, E.S 2000, *Remembering: A Phenomenological Study*, Indiana University Press

Gins, M and Arakawa, S 2002, *Architectural Body*, University of Alabama Press

Lefebvre, H 1991, *The Production of Space*, Blackwell publishing

Lenay, C and Steiner, P 2010, 'Beyond the internalism/externalism debate: the constitution of the space of perception', *Consciousness and cognition*, 19.4, pp. 938-952

Merleau-Ponty, M 2012, *Phenomenology of Perception*, Routledge

Petitmengin, C 2007, 'Towards the source of thoughts: The gestural and transmodal dimension of lived experience.', *Journal of Consciousness Studies*, 14.3, p. 54–82

Sha, XW, Fortin, M, Navab, N and Sutton, T 2010 'Ozone: continuous state-based media choreography system for live performance', *Proceedings of the international conference on Multimedia. ACM*, Firenze

Tschumi, B 1996, *Architecture and disjunction*, MIT Press

Voegelin, S 2011, *Listening to noise and silence: Towards a philosophy of sound art*, Continuum