Computational Shifts in Theatrical Space

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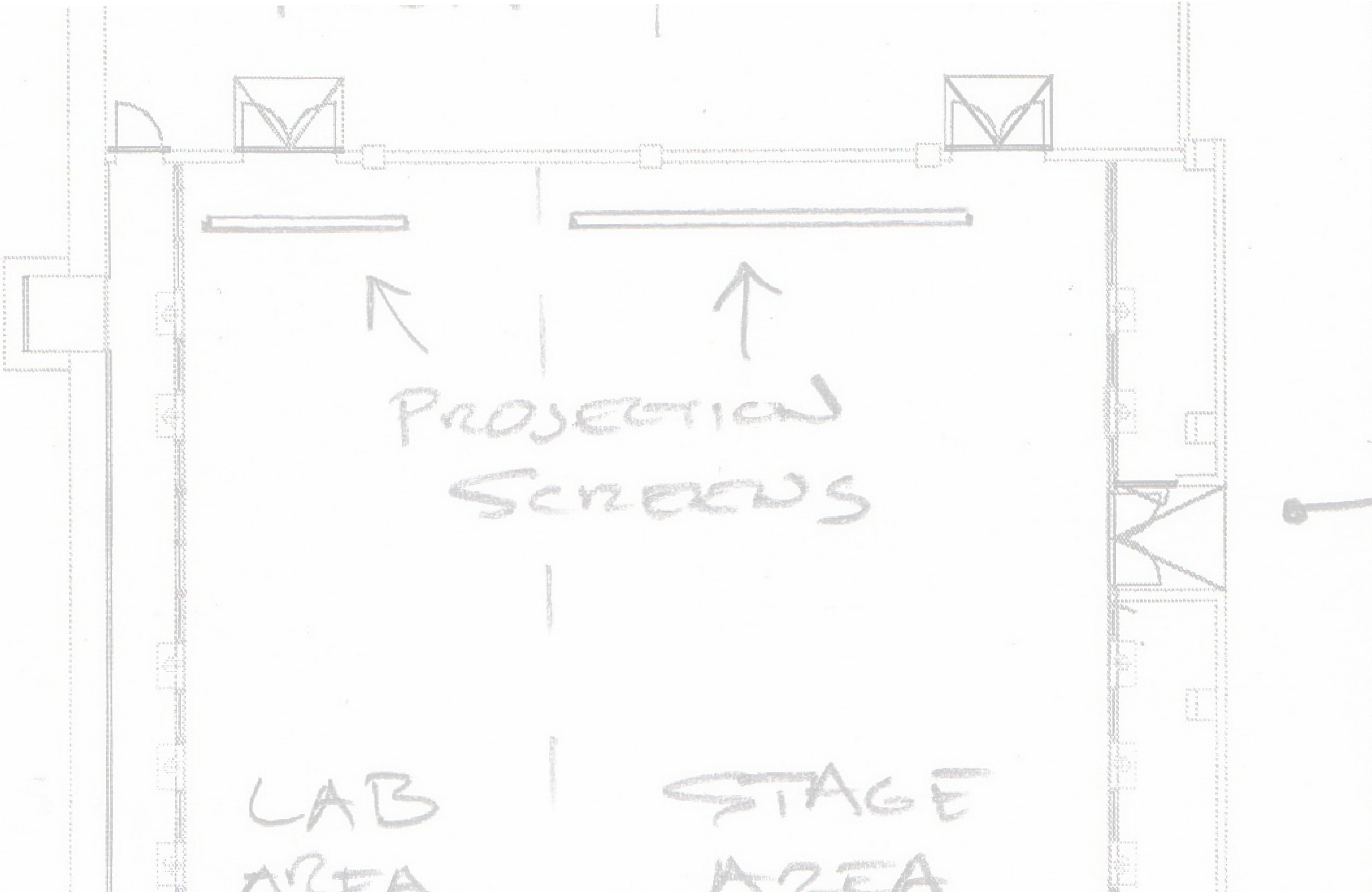
PROJECTION SCREENS
LAB AREA
STAGE AREA

COMPUTATIONAL SHIFTS IN THEATRICAL SPACE

ANDREW SEMPERE
LAUSANNE, SWITZERLAND
2015

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For all the feral voices hidden in the shadows of monuments and memorials.

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ABSTRACT

This dissertation describes a set of research projects that were conducted between 2012 and 2014 in order to answer the question **how do computational ideas alter our understanding of place?** Each project was produced in the context of the performing arts and included plays, dance performances and film and installation work.

For each project new software and hardware systems were created as a means of exploring different types of mediated communication. These systems include a scalable depth-camera based tracking system for performance on stage, a tool for manipulation of live-streamed video incorporated into stage performance, a method of tracking biometric data of performers live during the performance and a game-engine for creating interactive environments.

Collectively these experiments establish a framework for the discussion of the nature of the shifts caused by applying computational ideas to space. Finally, the results lay the foundation for further theoretical work concerning the creation of cultural artifacts that exist somewhere between the material and immaterial, the influence of computation on the nature of modeling, and the impact of ubiquitous computing on contemporary notions of performance and play.

Keywords: performance, play, computation, place

RÉSUMÉ

Cette thèse décrit un ensemble de projets de recherche qui ont été menées entre 2012 et 2014 afin de répondre à la question de savoir **comment ne idées informatiques modifient notre compréhension de la place?** Chaque projet a été réalisé dans le cadre des arts de la scène et a inclus des jeux, des spectacles de danse et le cinéma et les travaux d'installation.

Pour chaque projet de nouveaux systèmes logiciels et matériels ont été créés comme un moyen d'explorer différents types de communication médiatisée. Ces systèmes comprennent un système évolutif profondeur appareil photo en fonction de suivi de la performance sur scène, un outil pour la manipulation de la vidéo diffusé en direct incorporé dans performance sur scène, une méthode de suivi des données biométriques d'artistes vivent pendant l'exécution et un jeu-moteur pour la création interactive environnements.

Collectivement, ces expériences établissent un cadre pour la discussion sur la nature des changements provoqués par l'application d'idées de calcul à l'espace. Enfin, les résultats de jeter les bases pour la poursuite des travaux théoriques concernant la création d'objets culturels qui existent quelque part entre le matériel et l'immatériel, l'influence de calcul sur la nature de la modélisation, et l'impact de l'informatique omniprésente sur les notions contemporaines de performance et de jouer.

Mots-clés: la performance, la lecture, le calcul, le lieu

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CHAPTER SUMMARY

The work described in this document covers five specific projects; however there were a dozen projects executed between 2012 and 2014 along with seventeen discrete pieces of software created in the context of this work. A complete list of both be found in Appendix B.

Chapter 1: The introduction provides a basic theoretical framework for the approach and describes the practice-based hybrid methodology employed and the reasoning behind the use of first person throughout the text.

Chapter 2: This chapter describes how computation can occupy and transform space by allowing us to cross the boundaries of the material. This boundary crossing occurs either by de-materializing our own bodies or by physically rendering something immaterial, such as text, to create an architecture we can interact with. The work centers around a stage play called *CYBORG[AME].*

Chapter 3: This chapter describes what computation allows us to do in partnership with performers and audience and how this plays out differently in a traditional stage performance versus an interactive artwork. In particular we see how in both cases computation can be used to define our relationship to space by shifting time and shifting place and how this effect can be used to amplify physical action on and off stage through *magnification* and *resonance*. The work described here includes the dance piece *SHiNMu* and an installation called *Lines of Desire*.

Chapter 4: This chapter expands on the idea of *shift*, proposing that computational ideas have created a new visual vocabulary which has shifted our sense of place. Through a particular example of staging using technology built around the computational ideas of visual layering and context-shift I also suggest that computation can be used to shift our sense of self through both fictive and non-fictive performance. The work centers around a stage play called *LIWYATAN/ LEVIATHAN*.

Chapter 5: This chapter asks how computation has changed our relationship to the notion of experience and modeling and presents the concept of experience catalyst as both an example and a framing for considering interactive artworks and performances as parametric models of ideas. The work centers around an interactive game engine and installation called *CinemaMutation* which was used to present the film *HotelCity*.

Chapter 6: The conclusion pulls together the ideas presented in each of the previous chapters and then proposes an overarching theory of *computational epistemology* or a way of understanding the world as shaped by the internalization of computational thinking, in order to lay the groundwork or discussing this type of work. Theoretical work draws on notions of pervasive ubicomp (ubiquitous mobile personal computing) and on the constructivist/constructionist knowledge theories of Jean Piaget and Seymour Papert.

1

CHAPTER ONE INTRODUCTION

Chapter 1 is the introduction to this dissertation. It consists of two sections.

Section 1.1 introduces the basic ideas that I will use throughout the text, most importantly the distinction between *computers* and *computational*, *place* and *space* and *screen* and *stage*.

Section 1.2 Justifies and describes the hybrid research methodology I employed for this research, discussing the notion of *artistic research* and the use of first person throughout the text

1.1: WHAT IDEAS?

1.1.1: TOWARDS A NEW VOCABULARY

Over the last decade or more we have been soaked in certain computational ideas. These ideas come from the technology we use but are expressed aesthetically in terms of how we create and consume culture. They have changed the way that we tell and listen to stories. They are fundamentally changing the way that we experience space.

As one example, mobile video technology has been available for many years, but it is only in the last five to ten that has become commonplace for people to carry a high resolution camera always online with them wherever they go. Cameras do more than simply allow us to document our lives, they carry with them an expectation, a way of seeing[1] and a method of discourse. In an online context these devices purport to tell the truth while enabling us to lie in new ways. Social media allows us to spend more time with the tribes that reflect our identity[2] both real and aspirational, and to perform these roles visually. The ubiquity of networked personal cameras creates an overwhelming experience, but inundation of content is not merely a problem of quality[3] or comprehension[4]; it is itself an aesthetic[5].

The result of this is not always obvious even to close observers, especially when applying older models of understanding to interpretation of contemporary behavior. In *It's Complicated,* researcher danah boyd examines the way that social media is used by networked teenagers, describing a gap between the expected use of a technology and the way teens actually employ it in their daily life: "For example, in 2013, teens started using *Snapchat*, a photo-sharing app in which images purportedly self-destruct after being viewed. Given the assumption that teens use such services only to share inappropriate content, journalists often referred to this application in the same breath as sexting… but in casually asking teens about Snapchat, I found most were using the app to signal that an image wasn't meant for posterity. …They shared inside jokes, silly pictures and images that were funny only in the moment. …They saw the creation and sharing of these digital images as akin to an ephemeral gesture. And the used Snapchat to signal this expectation."[6]

As boyd's Snapchat example illustrates, the expectation that teenagers are using self-expiring images to avoid sexual embarrassment is both incorrect and out of line with the far more interesting truth that teenagers have internalized ephemerality as an aesthetic. Consider this and the complex reality that it encodes: everything that we think we know about digital technology on the Internet has, until recently, been focused on preservation, memory, archiving, cataloging indexing and retrieving. In the language of command and control we have been building a worldwide system in line with Google's mission statement, which is "to organize the world's information and make it universally accessible and useful."[7] The extent to which we believe this is inherently a good thing provides us with enough momentum that we feel uncomfortable when someone wants to bypass this system. Surely this is only necessary because the "user" is doing something wrong, embarrassing, abnormal or illegal? This sentiment is echoed fairly strongly in the words of Facebook CEO Mark Zuckerberg as interviewed by David Kirkpatrick in *The Facebook Effect*: "You have one identity," he emphasized three times in a single interview… "The days of you having a different image for your work friends or co-workers and for the other people you know are probably coming to an end pretty quickly. …Having two identities for yourself is an example of a lack of integrity."[8]

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[1] Berger, John. *Ways of Seeing: Based on the BBC Television Series.* Reprint edition. London: Penguin Books, 1990.

[2] Pariser, Eli. *The Filter Bubble: How the New Personalized Web Is Changing What We Read and How We Think.* Reprint edition. New York, N.Y.: Penguin Books, 2012.

[3] Arms, William Y. "What Are the Alternatives to Peer Review? Quality Control in Scholarly Publishing on the Web." *The Journal of Electronic Publishing* 8, no. 1 (August 1, 2002). doi:10.3998/3336451.0008.103.

[4] Haklay, Mordechai. "How Good Is Volunteered Geographical Information? A Comparative Study of OpenStreetMap and Ordnance Survey Datasets." *Environment and Planning. B, Planning & Design* 37, no. 4 (2010): 682.

[5] Bridle, James. "#sxaesthetic." Accessed January 9, 2015. http://booktwo.org/notebook/sxaesthetic/.

[6] boyd, danah. *It's Complicated: The Social Lives of Networked Teens.* 1 edition. New Haven: Yale University Press, 2014.

Teens who are using Snapchat to recapture "the ephemeral gesture" puts a new spin on this behavior. We find ourselves facing at least one category of people who have reclaimed a social gesture our technology discarded. The reasons for this are not shame or fear or lack of integrity, but because it is the *socially correct thing to do*. The gesture is older than the Internet but new technology has forced us to re-invent the way ephemerality is staged and performed. I might have once whispered a joke in your ear without being concerned that it would be recorded and saved for all time. I now send you a message with an expiration date.

How are we to understand these sorts of aesthetic shifts? Traditionally we have looked for ways to map existing vocabularies onto the experience brought to us by new tools. Media studies, for example, has often leaned heavily on what we learned from a century of film and cinema. As Lev Manovich writes: "A hundred years after cinema's birth, cinematic ways of seeing the world, of structuring time, of narrating a story, of linking one experience to the next, have become the basic means by which computer users access and interact with all cultural data."[9] Manovich's observations on the language of media vocabularies remain useful but twelve years later contemporary behavior is again moving across these boundaries, blending cinematic, stage and performance elements together in a way which would likely be incomprehensible to audiences of the past. To develop new vocabularies, we should consider computation itself.

One hallmark of computation is that it allows us to perform tasks faster, to iterate and experiment at a pace that is inhumanly fast. Computer technology itself evolves at this pace - quickly enough that it is not particularly useful to try and understand what is happening *now* with what happened *before*. Rather, computational time demands that we attempt to understand the world as it unfolds, in real-time and real-space. What does it mean to our notion of architectural place and space, typically imagined as static or slow to change? What implication does this have for live theatrical performance, where both authors and audience are communicating and negotiating differently than before? How do we capture and reflect on these changes?

This dissertation describes a set of research projects conducted between 2012 and 2014 to answer these questions. Each project was conducted in the context of the performing arts (plays, dance performances and film and installation work) which collectively seek to understand the nature of the shifts caused by computation by establishing a framework for their discussion. For each project I created new software and hardware systems as a means of exploring different types of mediated communication and performance (technical details of these systems are provided in the Appendix B). The goal of each performance was to produce in-context probes to uncover the nature of an emerging set of ideas I call *computational epistemology,* an understanding of the world framed by certain core computational ideas.

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[7] Google Inc. "Google's Mission Is to Organize the World's Information and Make It Universally Accessible and Useful." *Mission Statement.* Accessed January 13, 2015. http://www.google.com/about/company/.

[8] Kirkpatrick, David. *The Facebook Effect: The Inside Story of the Company That Is Connecting the World.* First Edition edition. New York: Simon & Schuster, 2010.

[9] Manovich, Lev. *The The Language of New Media.* Reprint edition. The MIT Press, 2002.

1.1.2: COMPUTERS OR COMPUTATION?

There are certain words which describe both a method and a quality to the way that computer science solves problems. These words form a style of thinking which is encoded in the computational devices that we use daily. Smartphones, laptops and tablets are not computational ideas, but they are born from them and function because of them. Computational ideas are larger and more fundamental than the objects which represent them, but before we can discuss computational ideas, we need to agree on a basic understanding of what we mean when we say *computation*.

For our discussion I propose the following model: Computation is the process of gathering data (input), manipulating the data (processing), and producing a result (output). This can be expressed linearly:

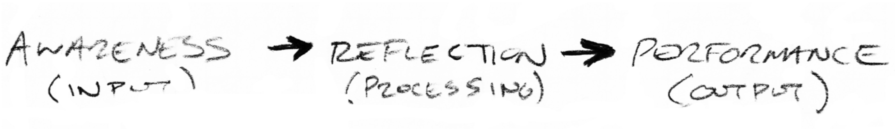

Figure 1.1: input – processing – output

Beginning with this model we add a single powerful concept: the loop. Loops are one of the most fundamental and powerful of computational ideas expressed in the founding work of digital computation done by Alan Turing[10] and others. Loops have made everything from cracking the Enigma code to downloading music possible. More recently media theorist Lev Manovich draws a connection between cinema and computer science via the loop: "Can the loop be a new narrative form appropriate for the computer age? It is relevant to recall that the loop gave birth not only to cinema but also to computer programming. Programming involves altering the linear flow of data through control structures, such as "if/then" and "repeat/while"; the loop is the most elementary of these control structures. …As the practice of computer programming illustrates, the loop and the sequential progression do not have to be considered mutually exclusive. A computer program progresses from start to end by executing a series of loops."[11]

Loops allow us to solve difficult mathematical problems and to model complex systems in faster than real-time. By combining our linear model of computation expressed above with the idea of the loop, we introduce the concept of feedback over time or *hysteresis*. We have created a system which can read the world, act on the reading and then impact the world, all the while changing its behavior through a limited understanding of history.

This computational model can be expressed in engineering terms as I have just done. Indeed in conjunction with op-amps, hysteresis and feedback loops form the basis of modern electronics and control systems, but throughout this dissertation I propose to apply these notions aesthetically and culturally. This is not done merely for the sake of metaphor. Rather I propose that the current state of culture is characterized by a deep immersion in the computational. We work, play, socialize, meet and even mourn online, using the Internet to "…speak to the parts of life that we all experience, but aren't represented in most media, …[such as] grief and loss."[12] The media that we consume (books, movies, music, television) and the media that we produce (stories, images, status updates and journalism) are conveyed digitally via the Internet. This widespread digitization of culture has profound implications not only for the way that we communicate with one another but for the form the communication takes. Our cultural feedback loops once involved only people, but now incorporate online interactions with large systems and are mediated by algorithm.

---

[10] Turing, Alan M. "Computing Machinery and Intelligence." *Mind*, 1950, 433–60.

[11] Manovich.

[12] Seligson, Hannah. "An Online Generation Redefines Mourning." *The New York Times*, March 21, 2014. http://www.nytimes.com/2014/03/23/fashion/an-online-generation-redefines-mourning.html.

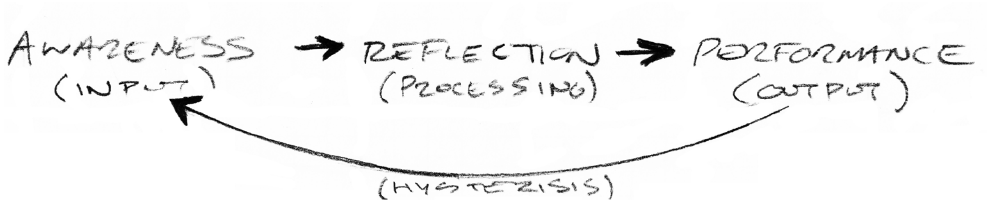

Figure 1.2: input – processing – output + hysteresis loop

1.1.3: HOW DO WE KNOW WHAT WE KNOW?

Jean Piaget, the founder of constructivism, described himself as a genetic epistemologist. For Piaget, the work was about understanding how humans fundamentally comprehend the world around them. Piaget's work was mostly conducted with children as he was interested in early development.[13] His work has subsequently been applied most frequently in the field of education and to pedagogical methods.[14] While this application makes sense, Piaget's ideas have broader application. Constructivism[15] was never about the development of teaching methodology, but rather it was a quest to better understand how knowledge generation occurs. Piaget's position is that humans form models of understanding, and through process of *assimilation* and *accommodation*[16] they modify, rebuild and articulate these models to generate and internalize knowledge.

Computers are excellent modeling tools. In the early 1980s Seymour Papert, contemporary and protégé of Piaget, combined Piaget's ideas with the then-new field of personal computing. Papert suggested that since humans create understanding through modeling and since computers are excellent modeling tools, computers could be used to help people model and explore complex ideas. Papert's primary contribution was the application of this idea to the field of mathematics where he developed a body-syntonic representation of geometry, the companion Logo programming language and "turtle" robot as proof of concept.[17]

Papert's seminal *Mindstorms*[18] covered this work and was published in 1981. What changed between 1981 and 2014? In short a return on the promise of ubiquitous computing or *ubicomp*: We now live in a society characterized by a global network of personal mobile devices which most of us carry on our person at all times. We use these devices for business and play, to stay in touch with our families and bond with tribes of common cause and understanding.[19] This, coupled with the social networking revolution of the early 2000's, has meant something significant in terms of epistemology. If we take Papert's notion of computers as modeling tools seriously and grant that computers can be used deliberately to change our mental model and acquire new knowledge, might be inverse also be true? Might it be true that by shifting our cultural exchange into the computational/modeled universe we have altered the way that we think? I suggest here that we have changed the way that we acquire and assimilate information. Furthermore, the impact of these shifts on the way that we consume and produce cultural artifacts is observable.

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[13] Piaget, Jean. *The Essential Piaget: An Interpretive Reference and Guide.* Edited by Howard E. Gruber and Jacques J. Voneche. Anv edition. Northvale, N.J: Jason Aronson, Inc., 1995.

[14] Duckworth, Eleanor. *"The Having of Wonderful Ideas" & Other Essays on Teaching & Learning.* 2 Sub. 0. Teachers College Press, 1996.

[15] Ackermann, E. "Constructivism: One or Many." *Learning Environments (IOS Press, Amsterdam. Series' The Future of Learning', Vol 2.)*, 2003.

[16] Atherton, J S. "Assimilation and Accommodation," 2013. http://www.learningandteaching.info/learning/assimacc.htm.

[17] Papert, Seymour. "The Turtle's Long Slow Trip: Macro-Educological Perspectives on Microworlds." *Journal of Educational Computing Research* 27 (January 2002): 7–27.

[18] Papert, Seymour A. *Mindstorms: Children, Computers, And Powerful Ideas.* 2 edition. New York: Basic Books, 1993.

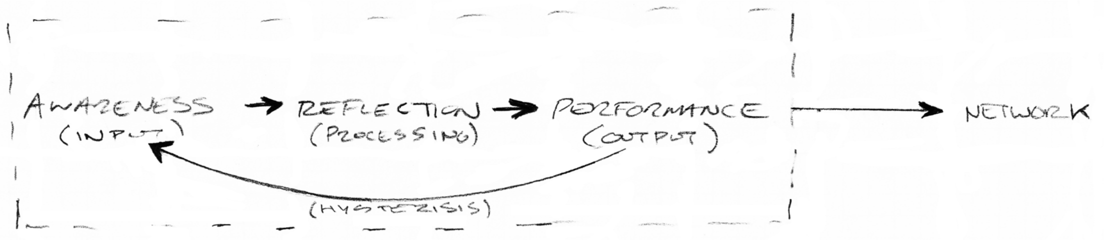

Figure 1.3: input – processing – output + hysteresis loop in a network

As proof of this I propose that we look for changes in aesthetic vocabulary. Ethnographic research tells us that the importance of personal narrative is not that it is somehow special or unique but rather that culture is conveyed through shared narrative. Atkinson et-al write: "We should not collect and document personal narratives because we believe them to have a privileged or special quality...Narratives do not convey "memory" as a psychological phenomenon. Experiences, memories, emotions, and other apparently personal or private states are constructed and enacted through culturally shared narrative types, formats and genres."[20] If we are indeed seeing a cultural shift, we should expect to see a shift in both the ways that we tell and consume stories. My investigation here is carried out by the application of technology to performance narrative.

1.1.4: PLACE IS THE SPACE

Human Geographer Yi-Fu Tuan writes in his 1977 *Space and Place: The Perspective of Experience*: "*Space* and *place* are familiar words denoting common experiences. We live in space. There is no space for another building on the lot. The Great Plains look spacious. Place is security, space is freedom: we are attached to the one and long for the other. There is no place like home. What is home? It is the old homestead, the old neighborhood, home-town, or motherland. Geographers study places. Planners would like to evoke "a sense of place." These are unexceptional ways of speaking. Space and place are basic components of the lived world; we take them for granted. When we think about them, however, they may assume unexpected meanings and raise questions we have not thought to ask."[21]

In geographic terms, *space* indicates a location whereas *place* indicates a particular space which has become imbued with value or meaning. Space exists physically, whereas place exists in our mind as a concept. Tuan allows that non-humans also carry a sense of place with them: “Recent ethological studies show that nonhuman animals also have a sense of territory and of place. Spaces are marked off and defended against intruders. Places are centers of felt value where biological needs, such as those for food, water, rest, and procreation, are satisfied.”[22]

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[19] McPherson, Miller, Lynn Smith-Lovin, and James M. Cook. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27 (January 1, 2001): 415–44.

[20] Atkinson, Paul, Sara Delamont, and William Housley. *Contours of Culture: Complex Ethnography and the Ethnography of Complexity.* Rowman Altamira, 2008., 38.

[21] Tuan, Yi-Fu. *The Perspective of Experience*. University of Minnesota, 1977. http://www.transart.org/wp-content/uploads/group-documents/69/1373295837-YiFuTuan_Space_Place.pdf.

Place is a sense, real or imagined, of safety and freedom. In 1975 Geographer Jay Appleton proposed *prospect-refuge theory*[23], to describe what he believed were two innate human drives for opportunity (prospect) and safety (refuge). For Appleton, these drives were encoded in the aesthetic values we attribute to our evaluation of landscape painting over time. A good landscape provides both: a vantage point from which we may safely rest and consider our prospects. This theory was effectively applied to an analysis of architecture and the built environment by John Jakle in 1987 in *The Visual Elements of Landscape*[24] and more recently by Grant Hilbrand, who used the theory to describe the appeal of architect Frank Lloyd Wright in *The Wright Space: Pattern and Meaning in Frank Lloyd Wright’s Houses.*[25]

We might say that these authors have described at least two characteristics which make a place into a space, but Tuan asks further what specifically grants and contains the sense of prospect and refuge necessary for creating a space: “What gives a place its identity, its aura?” [26] For Tuan, *aura* is that which makes a space into a place. But this same question, in particular its framing in terms of *aura,* has occupied a number of more contemporary artists and scholars with regards to the impact of contemporary technology on aesthetics.

A generation before Tuan, Walter Benjamin’s seminal 1936 essay *The Work of Art in the Age of Mechanical Reproduction*[27] used “aura” to describe that quality of an artwork which is inherent in the original but missing from subsequent reproductions. Benjamin’s intent was to situate the role of visual artwork in the then-newly emerging “mass media,” in particular against the backdrop of cheap and popular photographic reproduction techniques. What Benjamin never imagined was the type and fidelity of technology that we have today and the uses to which it has been put. I have written about this before in regard to contemporary artworks and virtual production.[28] Perhaps more convincingly, Bruno Latour and Adam Lowe write in *The Migration of the Aura*[29] about their project of replacing Veronese’s *Golgotha*, removed violently from Venice to Paris by Napoleon’s troops, with a replica painstakingly recreated by a complex laser scanning and 3D printing process. The replica *Veronese* is, in the estimate of Latour and many visitors, “more real than real” by virtue of its context. In Latour’s phrasing, the aura has been *migrated* away from the original object in the Louvre and back to the particular place of its birth. In point of fact, Latour shows us how technology can be used to move auras, to make and transport places into spaces at will. This is a key finding of the research presented here with respect to what computation allows us to do to our sense of place: it allows us to manipulate it, move it, send it and project it, treating reality as if it were digital.

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[22] Ibid, 4.

[23] Appleton, Jay. *The Experience of Landscape*. Revised Edition edition. Chichester ; New York: Wiley, 1996.

[24] Jakle, John A. *The Visual Elements of Landscape*. Univ of Massachusetts Press, 1987.

[25] Hildebrand, Grant. *The Wright Space: Pattern and Meaning in Frank Lloyd Wright’s Houses.* Seattle: University of Washington Press, 1991.

[26] Tuan, 5.

[27] Benjamin, Walter. *The Work of Art in the Age of Mechanical Reproduction*. Translated by Harry Zohn. Schocken/Random House. Accessed January 13, 2015. https://www.marxists.org/reference/subject/philosophy/works/ge/benjamin.htm.

[28] Sempere, Andrew. “The Work of Art in the Age of Virtual Production.” *Proceedings CHArt Computers and the History of Art*, 2009. www.chart.ac.uk.

[29] Latour, Bruno, and Adam Lowe. “The Migration of the Aura, or How to Explore the Original through Its Facsimiles.” *Switching Codes: Thinking Through New Technologies in the Humanities and Arts* University of Chicago Press (2011): 275–79.

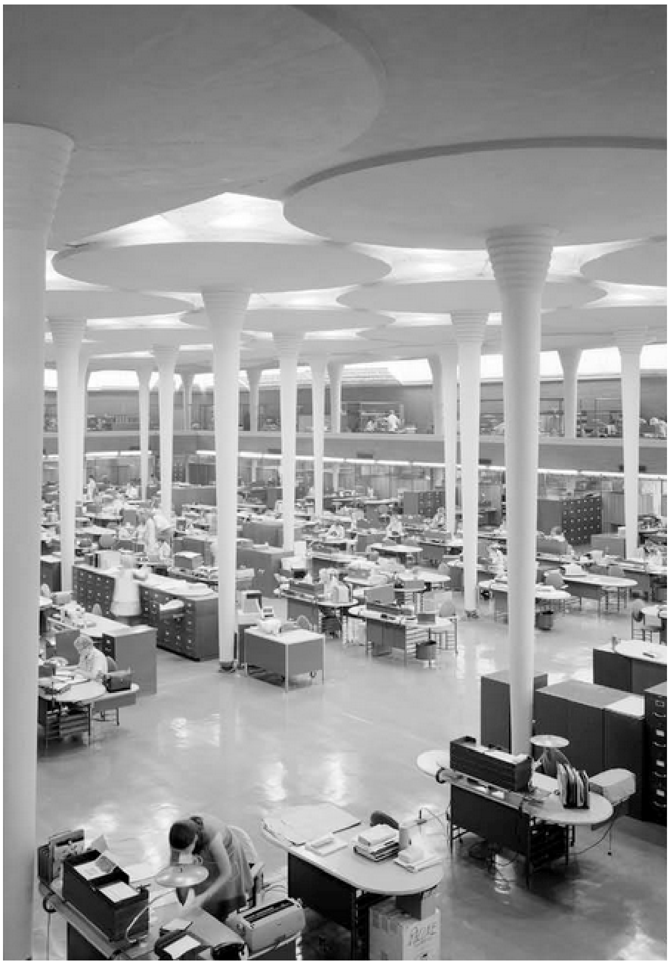

Figure 1.4: The Great Workroom, Johnson Wax Building

1.1.5: THE IMPACT OF UBICOMP ON ARCHITECTURE

If we are indeed treating space in a computational manner in order to control sense of place, how does mobile technology play into this? In the late 1980s, Xerox PARC researcher Mark Weiser coined the term *ubiquitous computing* or *ubicomp* and outlined its general principles,[30] suggesting that the computer act as a "quiet invisible servant" and that technology should "recede calmly into the background of our lives."[31] Since then, we have seen the rise of the ubiquitous GPS aware personal mobile device. As our relationship to these devices normalizes, ushering in the "quiet" phase of technology, it leaves in its wake a fundamental change in our relationships to each other, to our work and play, and to space itself.

Ubiquitous networked mobile personal computation allows us to efficiently decouple place from its intended function. The implications of this are reflected architecturally and historically in the design of office space tracing an arc from the birth of the cube farm to the general purpose workspaces of today.

In the late 1900s the trend towards *Taylorism* or *scientific management* emerged as an attempt to apply science and engineering to modernize the workforce and in particular factory labor. Proponents of scientific management promised "The whole field of natural science is at the disposal of industry so far as industry wishes to utilize it."[32] And promised "…maximum output, low cost, high wages, equitable distribution, reduction of unemployment, industrial Peace."[33]

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[30] Weiser, Mark. "The Computer for the 21st Century." *Scientific American*, September 1991.

[31] Weiser, Mark, and John Seely Brown. "The Coming Age of Calm Technology." In *Beyond Calculation*, edited by Peter J. Denning and Robert M. Metcalfe, 75–85. New York, NY, USA: Copernicus, 1997. http://dl.acm.org/citation.cfm?id=504928.504934.

[32] Thompson, Clarence Bertrand. *The Theory and Practice of Scientific Management*. Boston, Houghton, 1917.

There can be little doubt of the effectiveness of some of these efficiency techniques in terms of pure numbers: scientific management almost always makes a business more efficient by focusing on speed and profit margin. From the beginning, critics of this approach cite the resistance of certain types of labor to scientific analysis and question the morality of reducing people to fungible elements in a system.[34] For white collar workers of the West, the most visible battleground of this argument has been the architecture and design of the office.

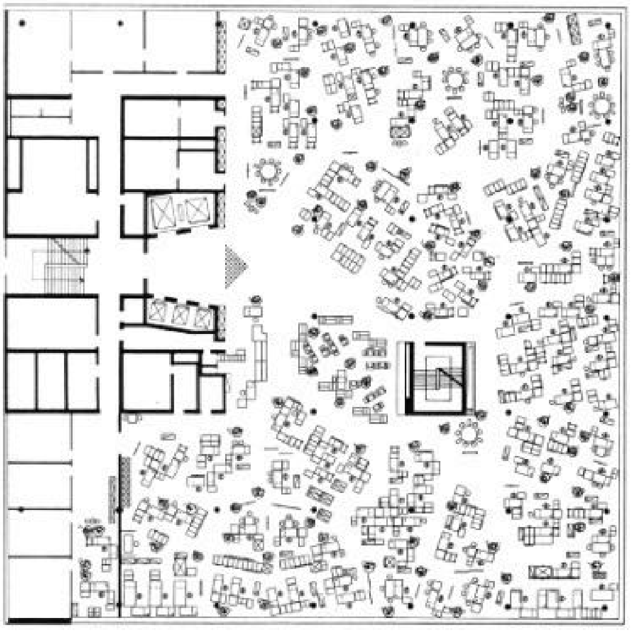

Figure 1.5: Office Landscape as envisioned by Quickborner

Initial open-plan office space came about largely as a result of the impact of scientific management on clerical work popularized in the late 1940s when the application of scientific method to all aspects of human endeavor saw the construction of large open "pits" for workers surrounded by closed offices for management. This model can be seen at work in the Frank Lloyd Wright designed Johnston Wax building, completed in 1939. The largest contiguous space in the entire complex, known as the "Great Workroom" features no internal walls, no direct sunlight and was originally intended for the secretarial pool.[35] Fed by efficiencies in construction and HVAC and complementary to the hierarchical organization favored by most businesses, this basic model of a large common climate-controlled work area surrounded by management offices is reflected today in the layout of most office spaces in the United States.

The application of a simplified version of the scientific method with heavy reliance on quantification to various other aspects of human endeavor brought us similarly unfortunate outcomes. In biology and medicine, the 1930s and 40s saw the rise in popularity of eugenics[36] which remained in fashion before the scientification of politics, known better as fascism, brought us a horrific object lesson in the misguided application of "scientific" systems to humanity.

In a deliberate and direct attempt to counter the specter of Nazism in 1950s post-war Germany, office consultants Quickborner proposed the scheme of *Bürolandschaft*, or office landscaping. This type of

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http://archive.org/details/theorypracticeof00thomuoft., 9.

[33] Ibid, 5.

[34] Drury, Horace Bookwalter. *Scientific Management; a History and Criticism, by Horace Bookwalter Drury ..* New York, Columbia university, 1918. http://archive.org/details/scientificmanag00druruoft.

[35] Lipman, Jonathan. *Frank Lloyd Wright and the Johnson Wax Buildings*. Dover Ed edition. Mineola, N.Y: Dover Publications, 2003.

[36] Currell, Susan, and Christina Cogdell, eds. *Popular Eugenics: National Efficiency and American Mass Culture in the 1930s*. 1 edition. Athens, Ohio: Ohio University Press, 2006.

open-plan layout featured no interior walls, but sought to organize work areas organically. "Unlike the American open plan, strategic use of partitions and large plants created some degree of differentiation and privacy. The use of carpets and ceiling absorbing panels tempered the noise of a large office to some degree. ... Derived from organizational theory, the rationale of bürolandschaft was based on a more complex scientific 'model' of 'human relations' rather than Taylorism."[37]

Influenced by Quickborner, Herman Miller research director Robert Probst set about addressing the woes of American office workers. Probst wrote in 1960: "Today's office is a wasteland. It saps vitality, blocks talent, frustrates accomplishment. It is the daily scene of unfulfilled intentions and failed effort."[38] Ironically, Probst's research efforts culminated in the development of the *Action Office*, better known to office workers as "the cubicle." Regardless of its original intent to inspire interaction and counter fascism, Action Office furniture is most often deployed in standard grid fashion, while offices with actual doors, walls and windows are as always reserved for management.

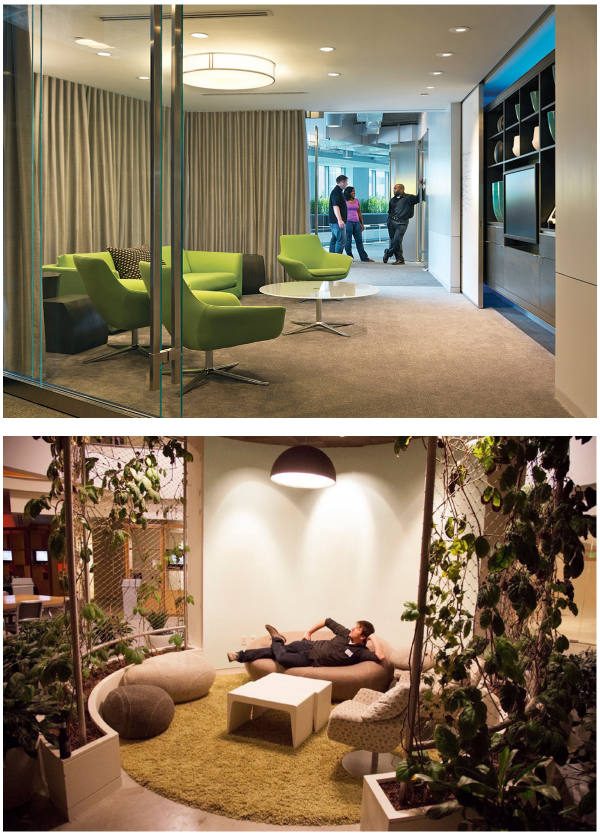

Figure 1.6: The Living Room and The Garden, two meeting spaces available to employees and visitors of the Microsoft NERD, which opened in 2009.

In part this unfortunate arrangement can be attributed to lack of imagination on behalf of office managers. Even allowing for the fact that most commercial office space currently available comes configured for cube farms (featuring as it does large open, climate controlled spaces with no natural light and no interior walls), there is nothing to prevent a more landscape-like distribution of Action Office style furniture. What is more interesting to note is that in spite of the fact that such layouts are universally hated by those forced to inhabit them, all are predicated on the notion of each worker (or function) occupying his or her assigned physical space.

Today the fundamental need to assign a location to each worker, at least in the field of so-called "knowledge work," has been nearly eliminated by the development of powerful mobile personal computing. There are other important psychological reasons such as vested interest in a working group, that might argue in favor of providing each worker with "ownership" over a space, but the labor activity itself no longer requires the infrastructure it once did. Office documents and communication also no longer require as much physical space for storage as in the past. It becomes increasingly less necessary to build the infrastructure of an office space with specific functions in mind.

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[37] Caruso St John Architects. "New National Office > History > Bürolandschaft." Accessed January 13, 2015. http://www.carusostjohn.com/media/artscouncil/history/burolandschaft/index.html.

[38] Herman Miller, Inc. "Designer Robert Propst - Herman Miller." Accessed January 13, 2015. http://www.hermanmiller.com/designers/propst.html.

Figure 1.7: "Hacking the Gibson," A still from 1995 film Hackers

Ubiquitous networked mobile personal computation allows us to efficiently decouple place from its intended function. It allows us to decouple space from place, and even more importantly to create a personal and portable sense of place - our own refuge and prospect - which we can bring with us regardless of surroundings. This technique, employed by office workers around the globe, is reflected in the strategy employed by workers in most cubical farms. Unless prohibited by management, workers tend to sit at their assigned cubicle with headphones plugged in, listening to a personal soundtrack and occasionally checking in and conversing with online friends via SMS or chat on their personal device while sending work related messages virtually over the company sponsored network. In this we see the everyday experience of mental layering and the performance of activity in the physical and the virtual simultaneously. This condition, once a particular practice[39] or site of strategic resistance,[40] is now as common as a location tagged photo or incoming text message.

It's not difficult to see how this kind of technology induced decoupling of place both ironically provides all of the benefits touted by the designers of the open-plan office (serendipity, casual interaction) while simultaneously decreasing commitment to the company itself. Enlightened contemporary office designers and managers have taken these lessons to heart and we can see the impact of mobility in the design of newer office spaces, particularly those designed by and for the tech industry. There, in addition to showing the impact of personal mobile communication, we also see that offices are increasingly employing the techniques of theater and scenography to indicate and perform their purpose. For example the Microsoft New England Research and Development center at 1 Broadway in Cambridge, MA includes a number of meeting areas which are described as "living rooms" (Figure 1.6). These spaces, intended for company meetings, resemble apartment living spaces including television and video game consoles. While undoubtedly most employees have their own much cozier living rooms at home, the intention of these spaces is to foster the type of relaxed interaction one would expect in a private home versus the type of interaction you might expect around a polished boardroom table. The effect is achieved through scenography: color and furniture choice, arrangement and the creation of an atmosphere which primes the occupants for a particular mindset.

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[39] Costa, Xavier, Internationale situationniste, and Museu d'Art Contemporani (Barcelona Spain). Theory of the Dérive and Other Situationist Writings on the City. Museu d'Art Contemporani de Barcelona, 1996.

[40] Certeau, Michel de. *The Practice of Everyday Life.* 1st ed. 0. University of California Press, 2002.

In spite of these examples there remain classes of activity which require specific infrastructure: bathrooms, kitchens, industrial factories, slaughterhouses and sports arenas, to name a few. Such places are likely to remain, but for a large swath of the activity we call "work," spaces need no longer be designated ahead of time for a particular use. This demonstrates that the ways in which we imbue space with meaning (that is, how we change space to place) owe a debt to the impact of computation on everyday life. As we digitize the world we internalize a particular way of thinking, becoming accustomed to rapid contextual changes and the ability to treat physical objects as if they were virtual. Seen this way, architecture becomes less about organizing space and more clearly an overlap of emergent practice somewhere between computer science, stagecraft, philosophy and world-building. This dissertation lives here: where space is in the process of becoming place with computation influencing this equation.

1.1.6: MERGING DIGITAL AND PHYSICAL

The notion that we have largely internalized the *layering* afforded by widespread use of mobile personal computational devices is a key finding of my research. Daily immersion in the computational has given us an internalized understanding of the world in flux. Online there is always *more*: more context, more data and more explanation. For a time this was obvious in particular settings. The world "online" when "logged-in" seemed boundless and expansive, a vision communicated visually by depictions of "cyberspace" which reveal endless vistas of clean, unnatural non-spaces stretching past the limits of our perception (Figure 1.7).

All prospect and no refuge, these depictions largely echo the emotional sensation of being "logged-in" and "surfing the web" while sitting at a desk and remaining in physical contact with a machine tethered to an outlet and a data port. These are illustrations of a sense of place-beyond-the-place we are in now, which at the peak of their popularity was most likely either a drab office or basement computer room.

The introduction of wireless communication and the miniaturization of technology allowed this idea to escape the bounds of the desk to travel with us throughout our lives. The resulting sensibility: that there is always information, data and another layer under the surface whether we can see it or not, has become a site of both joy and anxiety. We see attempts to both augment sites which are considered information poor[41] and to "deal with" sites of information overload.[42] Thus the increasing popularity of work on augmented reality,[43] projection mapping, responsive environments, tangible user interfaces[44] and even so called "smarter cities"[45] all of these seek to leverage the power of the digital to affect or to track changes in the physical. Most consist primarily of attempts to layer the digital on top of the "real world," using the existing physical environment as if it were a static display surface on which one can project more flexible digital information.

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[41] Dahley, Andrew, Craig Wisneski, and Hiroshi Ishii. "Water Lamp and Pinwheels: Ambient Projection of Digital Information into Architectural Space." In *CHI 98 Cconference Summary on Human Factors in Computing Systems*, 269–70. ACM, 1998. http://dl.acm.org/citation.cfm?id=286750.

[42] Toffler, Alvin. *Future Shock*. Reissue edition. New York: Bantam, 1984.

This preoccupation with treating the built environment as a projection screen makes sense for many reasons, not the least of which is that there are centuries of built environment that can not and should not displace without care. Perhaps more importantly this reflects a fundamental truth of digital information: digital information gains its power because it is immaterial and exempt from the laws of physicality which bind us. We will return to this notion repeatedly: computational thinking has shifted our understanding of the physical world, space, place, architecture and our selves by encouraging us to think of these solid, analog, physical things as if they were weightless, digital, and immaterial. Even in cases where this is impossible the model remains, encouraging us for better or worse to apply computational thinking to the real world.

As screens move from static positions on walls and desks and into pockets, cars and bodies, there is an observable impact on social and professional exchange.[46] We travel virtually while sitting in offices,[47] we work from home and the car or subway,[48] and we socialize from work. We occupy space in a vastly different way than previous generations. In particular we are now able to mentally occupy several spaces at once even while we may physically remain in one place. This is in fact no longer strange but is a characteristic of contemporary life.

We have seen also the way these ideas have changed the way that we organize work spaces. It seems pertinent to ask how this changes our architectural mindset: how we organize and respond to space, how it responds to us, and how we choose the layout and programming of our environment. How can we can treat the built environment as more than a display surface, and can digital elements serve an architectural purpose? Our limited attempts to do this have thus far been limited to projecting digital information over top of our built environment. Might we change the way we build? How do we design buildings and public spaces which serve a populace accustomed to wandering seamlessly between contexts? What would this allow us to do, and what environments can we consider to start answering these questions?

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[43] Sutherland, Ivan E. "A Head-Mounted Three Dimensional Display." In *Proceedings of the December 9-11, 1968, Fall Joint Computer Conference, Part I*, 757–64. ACM, 1968. http://dl.acm.org/citation.cfm?id=1476686.

[44] Gorbet, Matthew G., Maggie Orth, and Hiroshi Ishii. "Triangles: Tangible Interface for Manipulation and Exploration of Digital Information Topography." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 49–56. CHI '98. New York, NY, USA: ACM Press/Addison-Wesley Publishing Co., 1998. doi:10.1145/274644.274652.

[45] Batty, M., K. W. Axhausen, F. Giannotti, A. Pozdnoukhov, A. Bazzani, M. Wachowicz, G. Ouzounis, and Y. Portugali. "Smart Cities of the Future." *The European Physical Journal Special Topics* 214, no. 1 (November 1, 2012): 481–518. doi:10.1140/epjst/e2012-01703-3.

[46] Shami, N. Sadat, Li-Te Cheng, Steven Rohall, Andrew Sempere, and John Patterson. "Avatars Meet Meetings: Design Issues in Integrating Avatars in Distributed Corporate Meetings." In *Proceedings of the 16th ACM International Conference on Supporting Group Work*, 35–44. ACM, 2010. http://dl.acm.org/citation.cfm?id=1880078.

[47] Sempere, Andrew. "Architecture and Design for Virtual Conferences: A Case Study." *Future Internet* 3, no. 4 (July 6, 2011): 175–84. doi:10.3390/fi3030175.

[48] Shami, N. Sadat, Li-Te Cheng, Steven Rohall, Andrew Sempere, and John Patterson. "Enhancing Distributed Corporate Meetings with Lightweight Avatars." In *CHI '10 Extended Abstracts on Human Factors in Computing Systems*, 3829–34. CHI EA '10. New York, NY, USA: ACM, 2010. doi:10.1145/1753846.1754064.

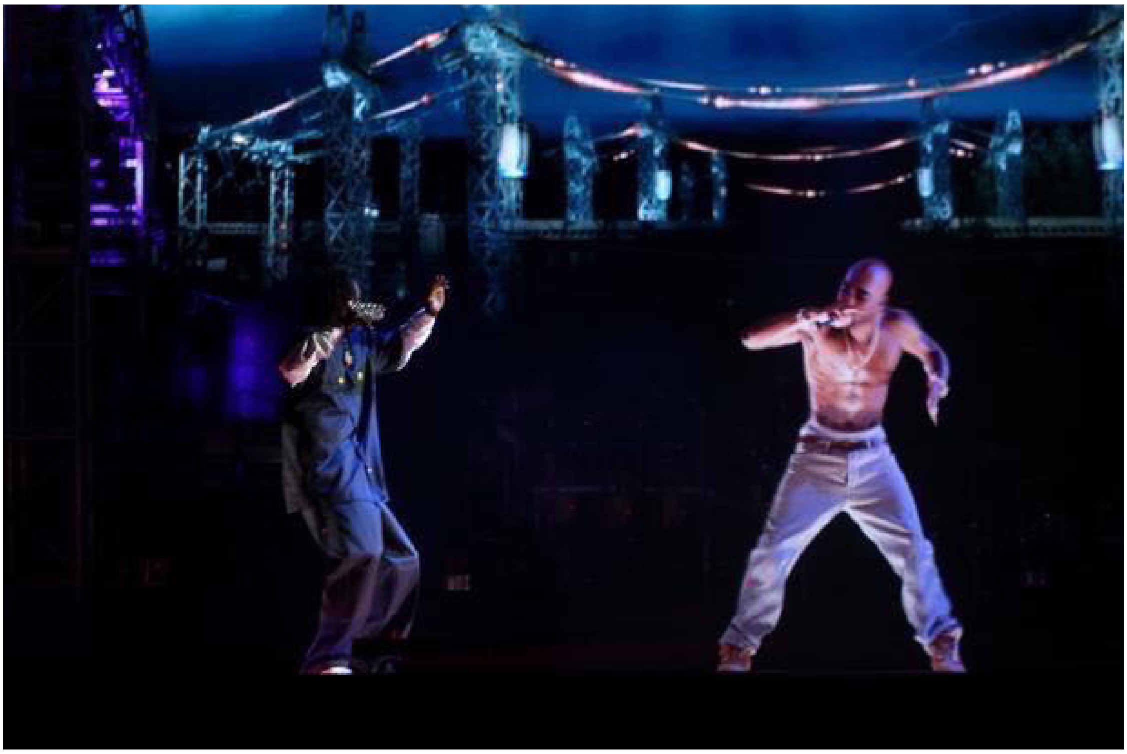

Figure 1.8: Lion (né Dogg), who is a real live human, performs alongside a computer generated animated hologram of the dead Tupac Shakur during the 2012 Coachella Valley Music & Arts Festival.

Questions like this one remain impractical to ask in the context of traditional building practices, correctly constrained as they are by practical matters. Building codes, financial, safety and structural concerns and construction time all conspire to make it unlikely we will be able to deeply explore the juncture of space and computation via traditional architectural means. Computation itself also resists us: advancements in computational technology out pace the fastest building techniques, making proposed integrations obsolete before they are complete. Theatrical space, on the other hand, may act as a rapid-prototyping environment for place, providing an ideal environment and opportunity to explore.

1.1.7: THEATER AS A GENERAL PURPOSE NARRATIVE MACHINE

Architected spaces are those which are deliberately organized or demarcated by human actors in a bid to create place. Most of the work described in this document exists in the context of *theatrical space,* a special category of architected space. The space of the theater is a unique case: theatrical space is an environment which has been architected specifically for the *simulation* of place.

While the audience in a theater production typically remain seated and immobile in a single space for the duration of a show they may be transported to any number of places as result of stagecraft and in particular scenography. The theater building may have its own sense of place - its own history, ghosts, smell or atmosphere, but as a machine for telling narratives the theater is intended to generate whatever place the production needs. In this way the theater is a tool for rapidly shifting context and perception very much like a general purpose computer.

1.1.8: CHANGES ON STAGE

As theatrical and architectural technology has improved we have seen a gradual move from purpose-built proscenium style stages to black-box theaters characterized by a lack of pre-set orientation. These theatrical spaces specify little in terms of the relationship between the audience and performer, allowing this to be defined at will by the actors and director of the play. The turn towards the flexible theater configuration can be traced to the early 1920s and the work of Swiss designer Adolph Appia, based on his argument for a flexible, simplified staging arrangement "…set only so far as is necessary for comprehension of the poetic text; a mere indication is enough to enlighten us to the nature of the visible environment."[49] Black box theater became more prominent in the 1960s and 1970s primarily as a way of overcoming the restrictions of both style and cost imposed by traditional theater architecture. In subsequent decades, the flexibility demonstrated by black-box has been integrated back into even the most traditional of theater buildings, which almost universally feature overhead grid, catwalk or tension-grid systems for rapid reconfiguration of lighting and sound.

Key to the function and popularity of the black-box theater is the ability to create a nearly infinite number of places in the minds of the audience. The practice of setting the scene is referred to as *scenography,* a term which was first used by Aristotle to describe perspective scene-painting[50] but which has come to encompass all aspects of scene-setting. The use of electric light in scenography, essential to all forms of contemporary theater, is perhaps Appia's best known contribution to theater studies. Appia has been credited with "…describing light as the soul of stage production, and in accurately predicting in detail its future evolution and use."[51] Appia categorized light as *diffused* and *formative* or active, which was the tool to be used to make objects appear and disappear, and to generally create the scenography through subtle hints. The use of pure light was in line with Appia's minimalist approach, and he called in particular for the abolition of painted scenery and "…the ridiculous incongruity between the moving, three-dimensional actor and the static two-dimensional trompe-l'oeil flats. …The scenic illusion [is] shattered the moment the actual performer intruded on to the stage."[52]

Appia was responding directly to what he saw as an over-elaborated style of staging opera popular during his lifetime. It is likely he would be intrigued by the technology we have available today, in particular the very special form of "active light" we have available in terms of computer generated projection. But what would Appia have made, for example, of the live performance on stage of a human musician alongside a computer generated and projected hologram (Figure 1.8)?

Regardless of how Appia may or may not feel about projection mapping the scenographic techniques we have at our disposal now take us far beyond anything available in previous centuries. Appia's call for movable lights which could be modulated at will is now possible but this development did not really emerge until the late 1990s (the blue LED, necessary for high quality stage lighting and video projection, was not invented until 1994). The change has shifted not only the way we make secenography but what scenography is. As Arnold Aronson writes: "For much of the history of theatre, scenography has functioned as a means of creating a material reality for the presentation of the immaterial: the mythical, allegorical, and fictional, or perhaps the illusion of an actual locale whose physical and temporal locality lay elsewhere… But in a world in which so much human interaction is mediated through electronic and digital technologies… it is increasingly difficult for the stage to exist meaningfully as a site of physical and tangible interaction.…new technologies are emphasizing the dematerialization of the stage: the stage as a permeable and ephemeral space that more accurately represents our perception of the experiential world."53

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[49] Beacham, Richard C. *Adolphe Appia: Texts on Theatre*. Reprint edition. London; New York: Routledge, 2011.

[50] Gullick, J., and J. Timbs. "Tempera and Encaustic in Antiquity and the Middle Ages." *The Crayon* 6, no. 8 (August 1, 1859): 249–51. doi:10.2307/25527934.

[51] Beacham, 5.

[52] Ibid, 4.

Because this shift is so recent, in looking for a way to consider the design of contemporary stage elements I will consider the history of theater and lighting design but draw most heavily on techniques employed by user experience designers. While the evolution of theatrical space occurred prior to the advent of the personal computer, what computation gives us is rarely fundamentally different from what we had before. What computation promises isn't the ability to do new things, but the ability to do things *faster*. Theatre has always been about transportation of place, but technology has been applied to make these changes occur more quickly at less cost and with greater ease than before, reducing the gap between the scene in the mind of the designer and the ability to render it physically.

We can follow an evolutionary arc in the development of our computational objects that tracks the same path we have seen in theatrical space. With advances in technology comes a trend towards generalization. Initial interaction with computation required a massive infrastructural investment. Computers were heavy and required purpose-built rooms, power supplies and cooling plants. As technology has progressed we have seen these devices shrink and become more general in their application. With the now ever-popular lightweight touch-screen based device we are approaching the computational ideal: information unconstrained by physical instantiation. The touch screen is a blank-slate, relying entirely on the scenography created by the user interface to indicate both context and function. In addition we have seen a shift from arcane modes of interaction towards natural-language and body-syntonic touch gestures requiring little to no special training. As space can become a place so can a screen become a stage, with technology driving both towards liminal place-less-ness whose context is set by design and changed parametrically at will. This spot between the physical and the digital serves as the site of my inquiry. What physical elements can be rendered virtual, and what virtual elements can be rendered physical? What does our understanding of the ease of applying layers, changing contexts and rapidly switching settings afford us as both authors and audience members? With these thoughts in mind, let us begin our exploration into the ways that computational ideas have altered our understanding of place.

1.2: THE CASE FOR HYBRID RESEARCH

1.2.1: METHODOLOGY PROVISIONAL AND CONTINGENT

Designer Bill Gaver, originator of the *design probe* concept and director of the Interaction Research Studio at Goldsmiths, writes: "…I suggest that we should moderate expectations of creating extensible and verifiable theory. Comparisons with accounts from the Philosophy of Science indicate both how provisional, contingent and aspirational design theories tend to be, but also how such conceptual work may nonetheless inspire thriving research programmes."[54] I agree with Gaver's analysis and in particular with the notion that theory which is provisional, contingent and aspirational may still be put to effective use. I would take it a step further and challenge the anxiety encoded in Gaver's use of the words *nonetheless* and *inspire*. What is it about qualitative work in an academic context which feels the need to justify itself in this way? Why is it not obvious that conceptual work can also constitute a research program rather than merely inspire one?

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53 Arnold Aronson *The Stage as Simulacrum of Reality* Passages 2014

54 Gaver, William. "What Should We Expect from Research through Design?" In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 937–46. ACM, 2012. http://dl.acm.org/citation.cfm?id=2208538.

Instead of looking for a way to "run the numbers" on what is essentially a phenomenon of experience or to present subjective experience as objective and universal, we ought to shift our focus to creating and using hybrid frameworks for analysis. The means of investigation and the techniques employed are as important as the outcome. This is especially true when dealing with a subject matter such as computational architecture where we manifest experiences using tools originally designed to calculate. To put it simply, I have chosen to hybridize my research methods for this work because only a hybrid approach allows for the proper interrogation of the research questions.

1.2.2: INSTRUMENTATION OF TRUTH

"the further a thing recedes from quantities, the more darkness and error inheres in it" -Kepler[55]

The notion of quantifying something as a method of approaching truth is an old one. The act of quantifying renders something open to analysis and discussion, allows us to feel as if we can rate and compare truthfulness and accuracy, and can be used to rationalize chaotic phenomena and to measure the world around us. We believe in the power of numbers and numeracy and lean heavily on the idea that these mean something fundamental, allowing us to make judgments that are not clouded by emotion or human weakness.

Furthermore computers, machines whose very name reveals their origins as machines for computing sums, have come to define contemporary culture. Computational thinking and computationally mediated exchanges define our daily vocabulary and our understanding of space and time. We owe these shifts to computational engines. More precisely, we owe them to our ability to transform the world into something which can be stored, transferred and manipulated by these machines. As media theorist Lev Manovich writes: "All existing media are translated into numerical data accessible for the computer. The result: graphics, moving images, sounds, shapes, spaces, and texts become computable, that is, simply sets of computer data. In short, media become new media. This meeting changes the identity of both media and the computer itself. No longer just a calculator, control mechanism, or communication device, the computer becomes a media processor."[56]

Precisely what it means once a computer "becomes a media processor" is at the subject of both Manovich's research and my own. For now I would like to point out that the ability to transmute our world into known quantities and then to perform calculations on it remains the most powerful tool we have in our arsenal for exploring the world around us. This ability is perhaps *the* defining characteristic of our age and has altered the ways in which we converse culturally and socially. That said, we ought to look with some suspicion on the notion that quantitative analysis is the best or the only method of accessing human truth and understanding. Why do we feel that converting something into numerical form makes it "better?" Is computation really always quantitative?

The answer to what is going on here lies at least in part with the "Western Folk Theory of Number." Anthropologist Nick Seaver explains: "Numbers in the West have a mixed reputation. On one side, we find the idea that numbers are transcendent entities: they are the language of the universe, their relations expressed mathematically are our purest, truest statements, and all of modern science and engineering owes its success to the fundamental truthfulness of numbers. On the other side, we find the idea that numbers fail to capture many of the qualitative phenomena that people find meaningful: to quantify something is to rationalize it, to deny its individuality, and to subjugate it to commensurative logics of control and exchange. These two positions constitute what Maurer (2006)[57] describes as the “Western folk theory of number.” They provide interpretive resources that people in a variety of situations draw on, often inconsistently, to make sense of quantities and quantification. They also attribute specific powers — reduction, abstraction, objectification, rationalization, and so on — to numbers themselves.”[58]

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[55] Mumford, Lewis, and Langdon Winner. *Technics and Civilization (1934)*. Reprint edition. Chicago ; London: University Of Chicago Press, 2010.

[56] Manovich.

From transcendence to subjugation, numbers are useful because they allow us to instrument the messy world around us. Numbers put a handle on abstraction and allow us to frame, shape, understand and grapple with reality. We rely on quantitive analysis because we believe it is immune to misunderstanding and somehow, inherently, closer to universal truth. In this we borrow heavily from our understanding of mathematics itself. Seaver writes: “Few human practices seem as resistant to anthropological inquiry as mathematics. Mathematical knowledge is generally considered to have precious little to do with the humans who produce it: the dominant view among mathematicians and the general public is that mathematics produces “statements of fact about some definite state of affairs, some objective reality, which exists independently of and prior to the mathematical act of investigating it” (Rotman 2000:6). This independence from human concerns is even greater than that typically imagined of the natural sciences: “mathematical objects are acausal, eternal, indestructible, and not part of space-time” (Shapiro 2000:27).59 In Gödel’s unsettling turn of phrase, mathematical facts seem to “force themselves on us as being true.”60 Kant grappled with this compulsion by granting mathematical knowledge an unusual synthetic a priori status. Can there be any doubt of a mathematical statement like 2 + 2 = 4? As Martin Gardner61 writes, “when two dinosaurs met two dinosaurs there were four dinosaurs. In this prehistoric tableau ‘2 + 2 = 4’ was accurately modeled by the beasts, even though they were too stupid to know it and even though no humans were there to observe it.”62

1.2.3: FROM LOGICAL POSITIVISM TO FACEBOOK

Logical Positivism was a late 1920s movement in western philosophy which sought to eliminate lack of clarity by merging philosophical discourse with empirical science, in particular by emphasizing reliance on only those statements which could be verified. The effort was to purge the quest for truth of elements of “meaningless” emotion, metaphysics and experiential phenomena. Some of the staunchest proponents of logical positivism were members of the Vienna Circle with Otto Neurath declaring: “Everything is measure and number. Kindness is number, sacrifice is number. Trust is number and mistrust is number. Woe to him who says that he teaches people action and cannot give the numbers.”[63]

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[57] Maurer, Bill. *Mutual Life, Limited: Islamic Banking, Alternative Currencies, Lateral Reason*. Princeton, N.J: Princeton University Press, 2005.

[58] Seaver, Nick. “Computing Taste:
The Making of Algorithmic Music Recommendation.” University of California, Irvine, 2013. (Unpublished Manuscript)

[59] Shapiro, Stewart. *Thinking about Mathematics: The Philosophy of Mathematics*. New York: Oxford University Press, 2000.

[60] Gödel, Kurt. “What Is Cantor’s Continuum Problem?” *The American Mathematical Monthly* 54, no. 9 (November 1, 1947): 515–25. doi:10.2307/2304666.

[61] Gardner, Martin. “Is Mathematics for Real?” *The New York Review of Books*, August 13, 1981. http://www.nybooks.com/articles/archives/1981/aug/13/is-mathematics-for-real/.

[62] Seaver.

[63] Neurath, Otto. *Empiricism and Sociology*. Edited by R.S. Cohen. Vol. 1. Vienna Circle Collection. Springer. Accessed January 13, 2015. http://www.springer.com/social+sciences/book/978-90-277-0258-6.

Ultimately Logical Positivism fell out of philosophical favor after collapsing under its own weight. As Laurence Smith writes: "The secondary and historical literature on logical positivism affords substantial grounds for concluding that logical positivism failed to solve many of the central problems it generated for itself. Prominent among the unsolved problems was the failure to find an acceptable statement of the verifiability (later confirmability) criterion of meaningfulness."[64] However the impact of this line of thinking on both philosophy and contemporary popular thought cannot be overemphasized. The notion that we can and should use quantitatively verifiable methods of inquiry over others "feels right." We use numbers to account for everything, to justify government and corporate action, to determine the correctness of behavior and to make decisions ranging from what to buy for lunch to who receives treatment for their fatal disease. That we often play fast and loose with numbers is also part of our cultural understanding, as evidenced by the joke that "99% of all statistics are made up on the spot."

The research arm of popular social media platform Facebook was recently widely attacked by both academics and in the popular press for publishing an unethical study of its users.[65] In that study, Facebook researchers claimed they could both manipulate and measure the emotional state of their users by altering the information displayed in activity feeds. The study is unethical for its lack of informed consent on behalf of its subjects and the criticism was justly deserved, but an interesting question remains: can emotion be measured using the technique the researchers employed? Facebook thinks the answer is yes. The researchers explained that the basis of this evaluation was the use of a particular algorithm: "Posts were determined to be positive or negative if they contained at least one positive or negative word, as defined by Linguistic Inquiry and Word Count software (LIWC2007) word counting system, which correlates with self-reported and physiological measures of well-being, and has been used in prior research on emotional expression."[66]

LIWC is a tool developed over nearly two decades by researchers who are interested in computational analysis of text for the coding of emotional content. This technique is particularly useful for very large datasets where hand-coding is impractical or impossible. The algorithm works by counting words which appear in a sentence and then analyzing those longer than six characters. "With each text file, approximately 80 output variables are written as one line of data to a designated output file. This data record includes the file name, 4 general descriptor categories (total word count, words per sentence, percentage of words captured by the dictionary, and percent of words longer than six letters), 22 standard linguistic dimensions (e.g., percentage of words in the text that are pronouns, articles, auxiliary verbs, etc.), 32 word categories tapping psychological constructs (e.g., affect, cognition, biological processes), 7 personal concern categories (e.g., work, home, leisure activities), 3 paralinguistic dimensions (assents, fillers, nonfluencies), and 12 punctuation categories (periods, commas, etc)."[67]

LIWC is indeed an algorithm which "has been used in prior research" and which has proven popular

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[64] Smith, Laurence D. *Behaviorism and Logical Positivism: A Reassessment of the Alliance*. Stanford, Calif: Stanford Univ Pr, 1988.

[65] Arthur, Charles. "Facebook Emotion Study Breached Ethical Guidelines, Researchers Say." *The Guardian*. Accessed January 2, 2015. http://www.theguardian.com/technology/2014/jun/30/facebook-emotion-study-breached-ethical-guidelines-researchers-say.

[66] Kramer, Adam D. I., Jamie E. Guillory, and Jeffrey T. Hancock. "Experimental Evidence of Massive-Scale Emotional Contagion through Social Networks." *Proceedings of the National Academy of Sciences* 111, no. 24 (June 17, 2014): 8788–90. doi:10.1073/pnas.1320040111.

[67] LIWC Inc. "The LIWC2007 Main Text Processing Module." Accessed January 13, 2015. http://liwc.net/liwcdescription.php.

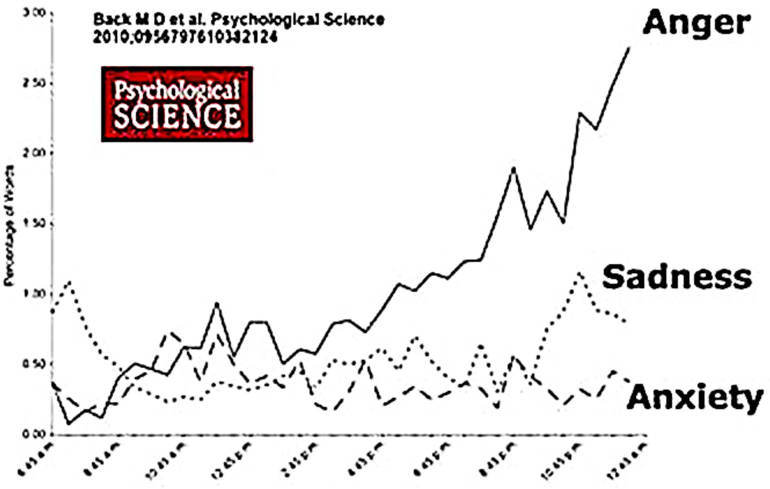

Figure 1.9: Graph from the original paper showing an uptick in "anger" over the course of the day

with the advent of big data research studies on large corpora. However it's important to understand the analysis that LIWC provides is not a simple one. Most notably, users of LIWC often make the assumption that context doesn't matter and that the algorithm has some magical ability to comprehend sarcasm, understand context and to differentiate between human and auto-generated text, repeats and spam. The problem here is not with LIWC itself, but with the way that it is used. The developers of LIWC acknowledge that text analysis is a "tricky business,"[68] and there is at least one clearly documented case where researchers understood and corrected the mistake they made with the algorithm in analyzing the emotional timeline of American's response to the terrorist attack of September 11th, 2001.

1.2.4: THE EMOTIONAL TIMELINE OF SEPTEMBER 11TH, 2001: A CASE STUDY IN MISINTERPRETING ALGORITHM

In *The Emotional Timeline of September 11, 2001.*[69] published in August of 2010, authors Back et-al made a surprising claim: based on LIWC analysis of pager messages the predominant emotion over the course of the day was not sadness or anxiety, but anger. Some authors used this study to draw political conclusions as in this article in *Psychology Today*: "This finding is consistent with decades of research on conflict and aggression in the laboratory: When you attack someone, it reliably elicits a counterattack. These findings also show the folly of terrorism: The most likely reaction is a desire to counterattack. In the case of those attacks, they have certainly cost more Arab than American lives over the long haul. … The bilateral support for Bush's decisions to start two wars in alleged response to those attacks, demonstrates that such wrath doesn't get replaced by a considered rational analysis too quickly."[70]

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[68] Ibid.

[69] Back, Mitja D., Albrecht C.P. Küfner, and Boris Egloff. "The Emotional Timeline of September 11, 2001." Psychological Science 21, no. 10 (October 1, 2010): 1417–19.

[70] Kenrick, Douglas T. "Sept. 11 Attacks Did NOT Elicit Terror, but Anger." *Psychology Today*, August 31, 2010. http://www.psychologytoday.com/blog/sex-murder-and-the-meaning-life/201008/sept-11-attacks-did-not-elicit-terror-anger.

The trouble with this finding is that it isn't true, or at least not demonstrably true given the dataset the researchers had at their disposal. In a letter to Psychological Science Journal titled *Automation Can Lead to Confounds in Text Analysis: Back, Künfer, and Egloff (2010) and the Not-So-Angry Americans*[71] Cynthia Pury of Clemson University pointed out that: "…[the researcher's] procedure did not exclude automatically generated messages. Consequently, LIWC words in such messages were counted, even if the words lacked emotional meaning in context. Furthermore, computers can send messages with superhuman frequency, turning an otherwise minor measurement error into a serious confound."[72] In particular Pury discovered a large number of automated messages arriving on pagers from servers which were disrupted. These messages included a message that read something like "Reboot machine in cabinet at location X. CRITICAL." Based on the fact that LIWC categorizes "critical" as an "angry' word, and the fact that nearly 6 thousand of these messages were sent, anger was shown to rise over the course of the day. Correcting for this mistake eliminated the dramatic rise in anger that the Back paper had reported.

In response, Back et-al issued a commentary to their original paper, acknowledging "As Pury intelligibly shows, this control routine was clearly insufficient. In particular, we did not anticipate that emotionally irrelevant, automatically generated messages… would be incorrectly classified by LIWC as anger related and at the same time show a nonrandom time course (I.E. A dramatic increase over time). …It did distort our findings for anger. …What can be learned from this scientific exchange? In a nutshell, automated text analysis of large digital data sets can lead to unforeseen confounds."[73]

Perhaps even more importantly: "As it turned out, there seemed to be no automatic way to unequivocally distinguish between automatic and social messages or to identify anger-related messages. Therefore, in addition to automatic algorithms, we used human judgment to generate a final data set that contained only social messages (two student assistants and the three authors classified 201,347 messages as automatic or social) and to determine the level of anger expressed in each of the 37,606 social messages identified (three independent student assistances rated anger on a scale from 0, no anger, to 2, strong anger)."[74]

This exchange conveys an important message about the limits of algorithmic analysis of large corpora. To do it right you need to spend time with the data and perhaps even classify it yourself. Minimally, you should have a sense of what is being said in order to conduct a "sniff test" to see if your conclusions make sense. All of this is at odds with the Facebook approach. In fact, to the extent that the Facebook researchers did attempt to address privacy concerns they argued these were satisfied by arranging the experiment such that the experimenters were prevented from seeing the source text at all: "LIWC was adapted to run on the Hadoop Map/Reduce system and in the News Feed filtering system, such that no text was seen by the researchers."[75] Based on this blind analysis, using LIWC to categorize words broadly as "negative" and "positive" the researchers made emotional conclusions, thus substituting the execution of an algorithm for actual research. Furthermore by using a system which generates numbers the researchers were able to "support" their arguments through statistically significant counts. This seems like a fundamental mistake of understanding, but why was it made? Why does the presence of a number, statistically significant or otherwise, trick researchers into believing they are accessing truth?

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[71] Pury, Cynthia L. S. "Automation Can Lead to Confounds in Text Analysis Back, Küfner, and Egloff (2010) and the Not-So-Angry Americans." Psychological Science, May 1, 2011. doi:10.1177/0956797611408735.

[72] Ibid.

[73] Back, Mitja D., Albrecht C. P. Küfner, and Boris Egloff. "'Automatic or the People?' Anger on September 11, 2001, and Lessons Learned for the Analysis of Large Digital Data Sets." *Psychological Science* 22, no. 6 (June 1, 2011): 837–38.

[74] Ibid.

[75] Kramer.

1.2.5: NUMBERS NEVER LIE EXCEPT WHEN THEY DO

Returning to our Facebook example in light of the Western Folk Theory of Number and our use of quantitative analysis as instrumentation: Can emotion be expressed numerically? Yes, almost certainly. Can emotion be expressed by an algorithm which relies on categorizing and counting "positive" and "negative" words? Almost certainly not.

Some people are firm believers in astrology. A common argument astrologers use to bolster their belief system is that it is "based in mathematics" by which they mean that things are being counted and that astronomy itself uses geometry to calculate movement. That math is involved in astrology is true. That this math is capable of transferring its own "acausal, eternal, indestructible" truth to astrological concepts is not true. Numbers cannot by their mere presence commute truth to an idea, although they are often employed in this way.

The Facebook study (and astrology) both rely on the conflation of two things: belief in the fundamental truth of mathematics itself and the mere existence of a quantity. Numbers are used to invoke the sense that one is being truthful or accessing something fundamental. In the end, however, what is important is not that numbers are involved but rather the use to which they are put. In the case of both astrology and Facebook, we need to examine the algorithm - the process by which the numbers are calculated. Careful examination of this in both cases reveals the mistake.

I do not doubt for a moment that Facebook is an emotional experience nor that emotion can be manipulated. Similarly, I don't doubt that belief in astrology affects one's life. Applying quantitative analysis (especially bad, over-reductive quantitative analysis) to either of these phenomena gets us nowhere. We need to stop using the wrong tool for the job.

1.2.6: DESIGN RESEARCH AND PHYSICS ENVY

In an op-ed in the New York Times, Primo and Clark, sociologists from the University of Rochester, articulate a problem that plagues political science and research design, namely *Physics Envy.* Primo and Clark write: "Economists, political scientists and sociologists have long suffered from an academic inferiority complex: physics envy. They often feel that their disciplines should be on a par with the "real" sciences and self-consciously model their work on them, using language ("theory," "experiment," "law") evocative of physics and chemistry."[76] Not only is this unproductive and silly, the phenomenon is fundamentally wrong-headed: "The ideal of hypothetico-deductivism is flawed for many reasons. For one thing, it's not even a good description of how the "hard" sciences work. It's a high school textbook version of science, with everything messy and chaotic about scientific inquiry safely ignored."[77] In an effort to justify work by adopting the guise of a practice which seems almost mystically attuned to the expression of truth, those with physics envy do double-violence to their own practice and to the science they wish to emulate. They don't just reduce their work to a series of numbers, they do it badly.

Design as a category of human endeavor began far before the introduction of the personal computer and yet, over the last two decades, has largely been eclipsed in practice by a special form of computer-based practice called Human Computer Interaction (HCI) or more recently User Experience (UX). This is mostly what we are talking about when we talk about design in 2015: not composition or contrast or typography or calligraphy or even information architecture but rather software and interaction, button size and placement, touch-screen gesture and mental model. What these practices have in common with each other is their origin in computer science and engineering. Steeped as it is in its own dual history, HCI research has largely defaulted to the more "truth-y" side of its nature, insisting that design concepts be described and accompanied by empirical research studies. This is in stark contrast to what we understand about design, architecture and art as inherently subjective disciplines.

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[76] Primo, Kevin A. Clarke And David M. "The Social Sciences' 'Physics Envy.'" *The New York Times*, March 30, 2012, sec. Opinion / Sunday Review. http://www.nytimes.com/2012/04/01/opinion/sunday/the-social-sciences-physics-envy.html.

[77] Ibid.

In HCI research, the struggle to publish papers evaluating the effectiveness of various interfaces has led to long ranging debate among participants regarding the role of analysis. In 2003 MIT Media Lab Professor Henry Liebermann published a comment on his website decrying the "Tyranny of Evaluation" declaring: "The truth of the matter is that pretty much all of our methodologies for quantitatively evaluating user interfaces suck. Nobody wants to admit it."[78] The trouble as Liebermann sees it is that design research is more art than science, but "the evaluationistas would have you believe that their user interface experiments are every bit as definitive as Galileo dropping balls from the Leaning Tower of Pisa. User interface research has a bad case of physics envy. First of all, for an experiment to yield a definitive result, all the variables need to be controlled. ...There are so many variables when presenting a user interface to someone that it is very difficult to make sure you've controlled all the relevant ones. There is no "ISO standard human".[79]

In response to this, IBM Almaden Researcher Shumin Zhai who is also Editor-in-Chief of *ACM Transactions on Computer-Human Interaction* and a member of the CHI Academy, responded with a similarly non-archival note entitled *Evaluation is the worst form of HCI research except all those other forms that have been tried*. Zhai's reasonable counter-argument is that most of the research studies submitted to CHI *do* suck, but that this is only an argument for more rigorously scientific user testing: "As the number of variables of interest increases, the experiment will be more complex, more difficult, and more expensive to conduct, but that does not mean the researcher or designer's subjective opinion is a better alternative."[80] Ultimately, Zhai writes, this is because "we need better and deeper, not fewer and shallower evaluations. HCI cannot be a faith based enterprise."[81]

Indeed I agree with Zhai that if one is going to conduct quantitative research that it should be done well and that we cannot design on faith, but this is not really how design is done. No designer worth their salt would design randomly, but almost every designer I know including myself does their work based on intuition honed by experience. In the face of this, commercial designers who know better are left with a choice to either sell "secret sauce" as design thinking justified with a portfolio of commercial successes or else bluster their way through faulty empirical study. We can do better.

1.2.7: A/B TESTING ISN'T DESIGN, BUT IT DOESN'T MATTER

While it is true that commercial design practice is rarely subject to HCI style evaluation, it is subject to the most ruthless quantitative analysis: units sold. A commercial design which fails to deliver by making its client money is a failure. In the face of this, HCI for the enterprise has developed a number of techniques for evaluation which require no design input whatsoever, the most effective of which is known as A/B testing. Under this method of evaluation, two versions of a given interface are released in the wild, and the results are tracked for desired outcome. If, for example, a company is unsure if a sign-up button should be red or blue, both versions are tried and the one with the most signups “wins.” The major advantage for its proponents is that “A/B allows seemingly subjective questions of design—color, layout, image selection, text—to become incontrovertible matters of data-driven social science.”[82]

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[78] Lieberman, Henry. "The Tyranny of Evaluation." *The Tyranny of Evaluation.* Accessed January 13, 2015. http://web.media.mit.edu/~lieber/Misc/Tyranny-Evaluation.html.

[79] Ibid.

[80] Zhai, Shuman. "Evaluation Is the Worst Form of HCI Research except All Those Other Forms That Have Been Tried." *Essay Published at CHI Place*, 2003. http://csi.ufs.ac.za/resres/files/Zhai.doc.

[81] Ibid.

Incontrovertible perhaps, but mostly if you exist in a world where the primary goal of design research is to make a website profitable. In the commercial realm this is largely true: the utility of design is directly proportional to its ability to boost sales. In the realm of research, however, this becomes a liability. As Cory Doctorow reports: “One consequence of this data-driven revolution is that the whole attitude toward writing software, or even imagining it, becomes subtly constrained. A number of developers told me that A/B has probably reduced the number of big, dramatic changes to their products. They now think of wholesale revisions as simply too risky.”[83]

The trouble with A/B testing is that it does not tell you if an experience is any good but only weather it satisfies a particular test case. As with the Facebook study, this may even provide you with statistically significant and publishable results, but it should not be confused with understanding. A/B does not help us suss out subtle changes, nor to contribute broadly to knowledge generation. In fact, it may greatly hinder research by encouraging designers to avoid exploring risky but potentially interesting areas or by forcing us to focus too long on minute details: “…just as a testing culture can make it hard to address the big problems, it can also make it hard to stop sweating the small stuff. “I had a recent debate over whether a border should be three, four, or five pixels wide, and was asked to prove my case,” wrote ex-Google designer Douglas Bowman on his blog the day he left the company. “I can’t operate in an environment like that.””[84]

We needn’t ask if quantitative evaluation is worthwhile, only if it is in fact the right tool for the job. There are questions in architectural practice which are closer to engineering than design (effectiveness of various materials, power usage, etc). These types of questions are handled well by quantitative analysis. Questions which are fundamentally qualitative, however, should be asked and answered qualitatively and subjectively.

1.2.8: A HYBRID APPROACH

It is tempting to want to use quantitative and scientific methods of evaluation because they feel more robust than subjective analysis and qualitative work. As we have seen, when misapplied they not only cause us to discard the most interesting part of our research but in fact lead us to embarrassingly incorrect conclusions.

There are aspects of architectural and design research which are undoubtedly closer to engineering than to design or art. HVAC systems, efficiency of windows, flows of people and air and traffic, power usage - all of these can all be measured and understood quantitatively. For the vast majority of architectural research questions, however, we should understand the field as subjective, situational, contingent and provisional. These are questions focused on what architecture means and does to society, the role of infrastructure in social justice and the long-term effects of altering the built environment. For these questions we should employ quantitative methods when they are useful but resist succumbing to what has been called "physics envy" to justify our work.

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[82] Christian, Brian. “The A/B Test: Inside the Technology That’s Changing the Rules of Business.” *WIRED*, April 26, 2012. http://www.wired.com/2012/04/ff_abtesting/all/1.

[83] Doctorow, Cory. “A/B Testing: The Secret Engine of Creation and Refinement for the 21st Century.” *Boing Boing*, April 26, 2012. http://boingboing.net/2012/04/26/ab-testing-the-secret-engine.html.

[84] Christian.

The process I am engaging in here is a hybrid of computer science, performance, philosophy, and architecture. Taken from each particular vantage point, recognizable methodologies are employed. In particular, I will draw from HCI and Design Research and practice. Readers familiar with these techniques will see evidence of Bill Gaver's *design probes*,[85] as well as the influence of social science approach: anthropology, participatory design,[86] and grounded theory.[87]

The work is perhaps most similar to Krzysztof Wodiczko's *Interrogative Design* practice. As with my own work, Wodiczko focuses on creating objects directly and in dialog with the stakeholders: "Designers must work *in* the world rather than "about" or "upon" it. ...The proposed design should not be conceived as a symbolic representation but as a performative articulation. It should not "represent" (frame iconically) the survivor or the vanquished, nor should it "stand in" or "speak for" them. It should be developed *with* them and it should be based on a critical inquiry into the conditions..."[88] Wodiczko's work privileges the first-person account and challenges the dominance of the authorial voice while seeking out "the hidden dimension of lived experience." My work shares these characteristics, however the focus of Wodiczko's work is on public space and real historical events whereas my work focuses primarily on fictional events in theatrical space.

In any case I am uncomfortable claiming any one of these techniques as "the methodology." In hybrid practice, I allow myself to draw from many methodologies as needed. This is unapologetically the approach of a *bricoleur*, the technique that anthropologist Claude Lévi-Strauss calls *mythical thought*: "The 'bricoleur' is adept at performing a large number of diverse tasks; but, unlike the engineer, he does not subordinate each of them to the availability of raw materials and tools conceived and procured for the purpose of the project. His universe of instruments is closed and the rules of his game are always to make do with 'whatever is at hand,' that is to say with a set of tools and materials which is always finite and is also heterogeneous because what it contains bears no relation to the current project, or indeed to any particular project, but is the contingent result of all the occasions there have been to renew or enrich the stock or to maintain it with the remains of previous constructions or destructions."[89]

This approach might be called *design research*, but in a bid to avoid the HCI debate over quantifiable user studies described above, I prefer the more neutral *hybrid* or *practice-based* research. Lastly I borrow heavily from *artistic research,* specifically because the term remains difficult to pin down: "The term 'artistic research' has many meanings, connotations and implications. It is characterized by its continuous search for a current and convincing definition. It is a search that is not problematic in itself but, on the contrary, the plain necessity of a fruitful, self-reflective and meaningful setup. At the same time as providing the researcher with intellectual challenges and learning experiences, artistic research also participates in the development of the theoretical basis of the field."[90]

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[85] Gaver, Bill, Tony Dunne, and Elena Pacenti. "Design: Cultural Probes." *Interactions* 6, no. 1 (1999): 21–29.

[86] Zimmerman, John, Erik Stolterman, and Jodi Forlizzi. "An Analysis and Critique of Research through Design: Towards a Formalization of a Research Approach." *Proceedings of the 8th ACM Conference on Designing Interactive Systems*, 2010. http://dl.acm.org/citation.cfm?id=1858171.

[87] Glaser, B. G. "The Future of Grounded Theory." *Qualitative Health Research* 9, no. 6 (November 1, 1999): 836–45. doi:10.1177/104973299129122199.

[88] Wodiczko, Krzysztof. Critical Vehicles: Writings, Projects, Interviews. MIT Press, 1999.

[89] Lévi-Strauss, Claude. *The Savage Mind*. The University Of Chicago Press, 1966.

[90] Hannula, Mika, Juha Suoranta, and Tere Vadén. *Artistic Research. Theories, Methods, Practices.* Academy of

1.2.9: BORROWING FROM ARTISTIC RESEARCH

The hybrid methodology I have employed here is not artistic research in the strictest sense, however artistic research shares a number of characteristics which make it a good place to begin in order to clarify both our approach and means of evaluation.

Artistic research does not dismiss the messy and chaotic but rather revels in it, using its status as a practice which is *not* science as a means to embrace creative and hybrid methods of inquiry. That said, there are seven characteristics of Artistic Research which are commonly agreed upon. I will use them here.

NB: This list has been adapted from the one which appears in Mika Hannula et-als *Artistic Research: Theories Methods and Practices*[91], edited for clarity. According to the authors it reflects "a consensus which many of the researchers and trend-setters approve of and endorse (see, for example, Slager 2004,[92] Biggs 2004,[93] Jones 2005,[94] Kiljunen & Hannula 2002)."[95]

- ***The artwork serves as the focal point. The work tops the list of the priorities.***
  Each of the five projects described in this dissertation have a strong technical computer-science component involving the creation of custom software, hardware or both. In all cases the artwork for which the technology was built served as the driver for design decisions. The technology is always in service of the artwork or the narrative of the play, never the other way around.

- ***Experience is at the very core of the research.***
  This is how work is transmitted and how it transmits meaning.
  This dissertation will introduce the idea of *experience catalyst* as a way of describing the phenomena encountered in an artwork.

- ***Artistic research must be self-reflective, self-critical***
  and focused an outwardly-directed communication.
  Each of the projects conducted included public performance. Each of the descriptions are written in first person and presented as a critical analysis.

- ***Artistic research should continuously locate the research in relation to its own actions and goals, and at the same time to be localized in relation to the more focused context of the field.***
  Each of the project descriptions below situates the work in regards to itself: its own actions and goals. This introductory chapter situates the work in a broader context, as does the conclusion and theoretical analysis at the end.

Fine Am, Helsinki, Finland and Universiry of Gothenburg I ArrMonitor, Gothenburg, Sweden, 2005. https://www.academia.edu/2396657/Artistic_Research._Theories_Methods_Practices.

[91] Ibid.

[92] Slager, Henk. "Discours de La Methode." In *Artistic Research*, by Annette W. Balkema, Vol. 18. Kenilworth: Rodopi, 2004.

[93] Biggs, Michael AR. "Learning from Experience: Approaches to the Experiential Component of Practice-Based Research." In *Forskning, Rejlektion, Utveckling*, by Torsten Kalvemark. Stockholm, 2004. http://r2p.herts.ac.uk/mb/2004a.pdf.

[94] Jones, Timothy. "A Method of Search for Reality: Research and Research Degrees in Art and Design." In *Thinking Through Art: Reflections on Art as Research*, by Katy Macleod and Lin Holdridge, 1 edition. London; New York: Routledge, 2009.

[95] Hannula, Mika, Juha Suoranta, and Tere Vadén. *Artistic Research. Theories, Methods, Practices.* Academy of Fine Am, Helsinki, Finland and Universiry of Gothenburg I ArrMonitor, Gothenburg, Sweden, 2005. https://www.academia.edu/2396657/Artistic_Research._Theories_Methods_Practices.

- ***Artistic research is characterized by a diversity of research methods, presentation methods and communication tools. Each demonstrates commitment to the needs and demands of each particular case.***
  As per this chapter, I will make use of many different methods of inquiry and presentation as the work demands. In each case I will provide an explanation for why the choice was made.

- ***Artistic research emphasizes the fruitfulness and necessity of the dynamic research group situation. Collective effort provides the closest critical environment, the protective realm for experimentation and the ability to share thoughts and emotions.***
  It is the nature of theater that the work is collaborative. All of the works presented in this dissertation were created in dialog with actors, directors, performers, technicians and the audience. This network is not merely convenient but essential to understanding the phenomena.

- ***Artistic research places emphasis on the hermeneutic, interpretative quality of research.***
  Artistic research is inherently subjective and interpreted. In order to convey this I have chosen to write the dissertation in first person and to articulate as much of my process as possible.

2

CHAPTER TWO COMPUTATIONAL AESTHETICS

Chapter 2 describes a stage play called *CYBORG[AME]* which was created with SINLAB artist in residence Gildas Milan. The scenography for CYBORG[AME] was performed computationally using tools which I created for this purpose.

This chapter answers the question "How Does computation occupy and transform space?" and in particular introduces the notion of dematerialization and use of the immaterial for architectural purposes.

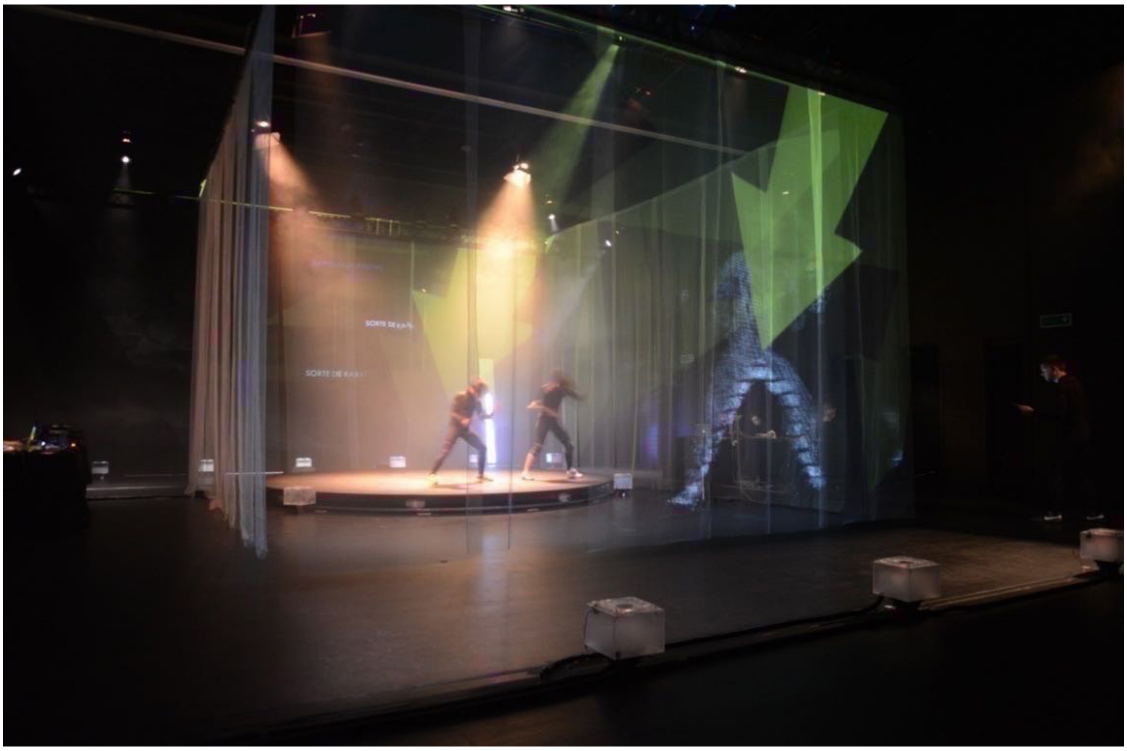

Figure 2.1: CYBORG[AME] stage showing teleprompter text projection (rear) and pointcloud and abstract text projection (front and rear)

2.1: HOW DOES COMPUTATION OCCUPY AND TRANSFORM SPACE?

The ideal projection surface is a flat, two-dimensional rectangle mimicking the proportions of a display screen. The surface should be free of wrinkles and defects and capable of reflecting light at the audience. Because of the nature of materials this usually means the surface will also appear solid and will be impermeable to the human body. By fixing the viewing angle of the audience and then drawing or projecting onto such a surface, a visual sense of place can be created. This effect has been used by theater for centuries in the shape of *trompe l'oeil* backdrops and scrims.[96] In scenographic terms, projection is often used in exactly this way: a kind of high-tech scene-painting. However, since projection is composed mainly of light traveling through space it has unique characteristics not shared by painting.

The challenge of *CYBORG[AME]* was to build a scenography on stage using only projection. In important ways the content of the play lent itself easily to this: the text describes a hard-edged digital "cyber" style that is complemented by the ethereal nature of projection. The script of CYBORG[AME] also reflects our basic computational model in terms of both narrative and form. *Input* consists of the actors and the text, which is *processed* by a computer and then *output* to create the atmosphere and place of the story. Central to both our computational model and the CYBORG[AME] narrative is the idea of the loop and in particular the aesthetic of the loop: visual multiplication and layering. This is especially apparent in the battle sequences where the main cast of two is multiplied and expanded into an army.

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[96] Gullick.

In spite of the compliment between the material and narrative aesthetic, a significant challenge remained: how to render two-dimensional representations of information into a physical environment that would impact the actors. In short, how to get computation to occupy physical space in a meaningful way. To accomplish this, I decided to play with the space between the digital and the physical to both emphasize and undercut notions of surface and screen. This development came with a major shift in my research focus: from concentrating on solving the technical challenges of tracking towards understanding and representing the computational ideas that tracking makes available to us.

For CYBORG[AME] the stage was surrounded by a cube of transparent material called *tulle*. This material was cut into long thin strips which created a projection surface the actors could also interact with, allowing characters on stage to play with their own digital ghosts. By employing multiple projectors and screens the play was able to treat a two-dimensional projection as if it were three-dimensional. While light itself is physical phenomena it is perceived as immaterial, as humans can move through it with no resistance, a fact which also allowed us to play significantly with notions of materiality.

2.1.1: NO CLEAR ENTRY. NO EXIT. NO WINDOWS. YOU ARE ALONE.

Remember : “If I get out of it, I will leave stronger.”

DARK
FAINT LIGHT

A dark room.

Shaped like a cube.
The ground is about two hundred meters square.
The ceiling isn’t visible.
No clear entry.
No exit.
No windows.

Cut in a faint light, we can make out the silhouette of the Character from the Book.

Some details stand out in him, a fresh femininity (once a man - but today a hybrid mix of a woman, part animal, and machine - when we speak of her, we call her “she.” When we think of her, we think of a Don Quixote).
We think at first that she is naked.

But with another glance, we notice that she is wearing an armor of some kind.
Delicate cybernetic skin.

She is alone.[97]

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[97] Milan, Gildas. “CYBORGAME or 33 Battles or The Fictional Character (A Hybrid Female Mutant Don Quioxte),” 2013.

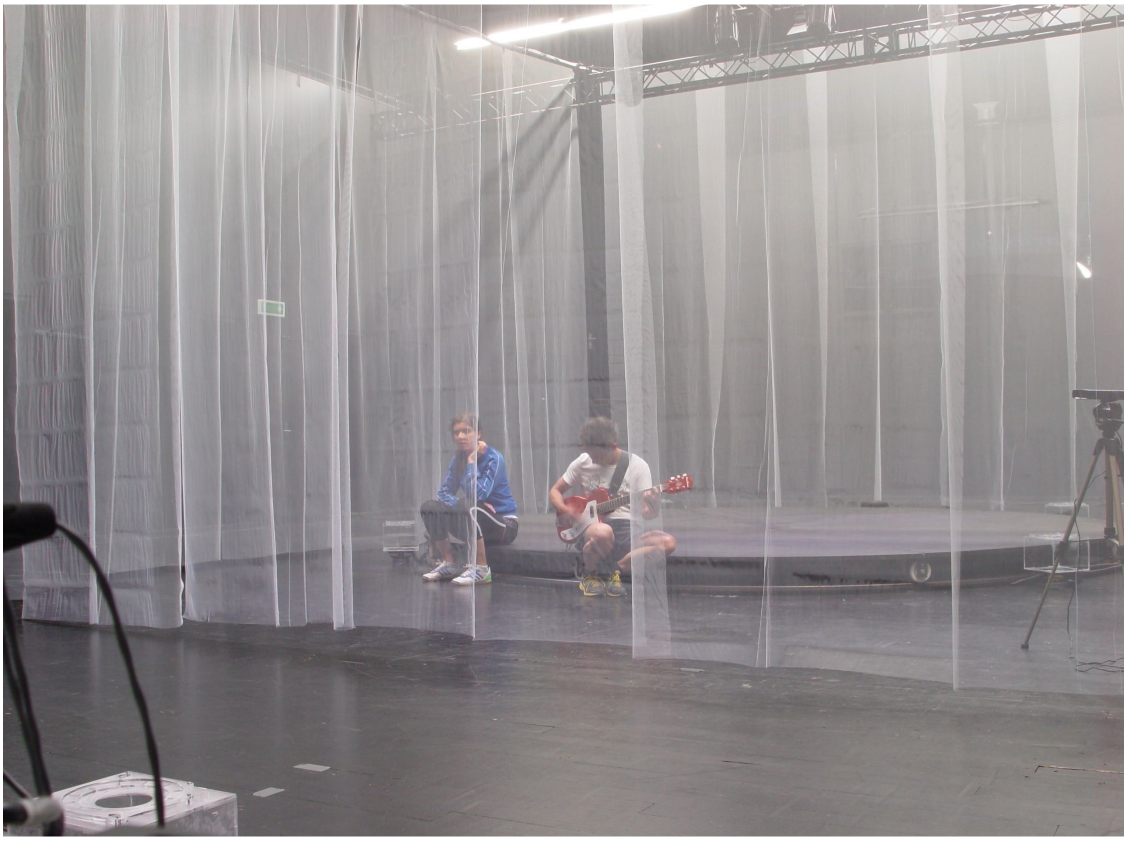

Figure 2.2: CYBORG[AME] stage with the lights on. An empty tulle cube.

In September 2013 after two weeks of intense rehearsals, French playwright and director Gildas Milan and his cast, including myself and research colleague Selena Savic, performed a portion of his work *CYBORG[AME] or 33 BATTLES or THE FICTIONAL CHARACTER (a Hybrid Female Mutant Don Quixote)*. The play follows the story of *The Fictional Character*, a male/female human/animal/cyborg mutant played by female actress Julie Pilod, who wakes up in an isolation cell confused and disoriented. *The Military*, an invisible force who have imprisoned The Fictional Character, are embodied on stage by the *The Colonel*, who is in turns a guide, tormentor, mentor, alter-ego and captor of The Fictional Character. The Colonel is played by Vassia Zagar, lead singer of the French rockabilly band *Sons of Nusku*. The Colonel performs *Nusku* songs live on stage and the play incorporates several layers of "play-within-a-play" storytelling, including a concert performance where we learn how the Fictional Character arrived in her present incarceration. The Character, a cyborg pop star, became increasingly paranoid and began carrying a sidearm to protect herself from attacks both real and imagined. One evening while performing a concert under the influence of psychotropic substances she took unwittingly, The Fictional Character mistook her audience for an invading army and opened fire on them. We learn this largely through our unreliable narrator The Colonel and it is not at all obvious that it is the truth. Nevertheless, in order to redeem herself and win her freedom, The Fictional Character engages in a series of 33 battles. These battles, conducted against an invisible enemy choreographed remotely by The Military, culminate in a victory-in-defeat monologue about truth, identity and sense of self and the individual.

Visually and conceptually the material of CYBORG[AME] is aggressive, hard-edged and "hyper" in the early 90s Internet sense. The content references the eponymous *Don Quixote* but more directly the work

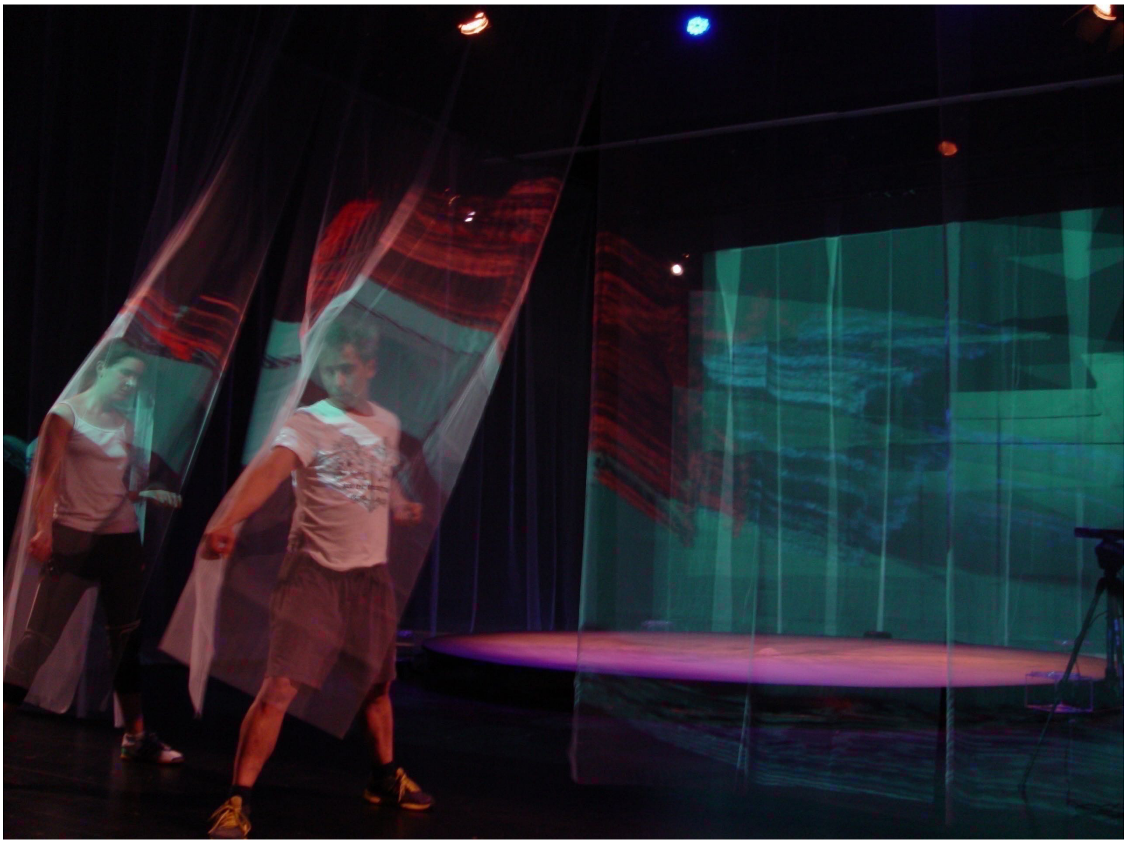

Figure 2.3: Julie and Vassia interact with the projection on top of the tulle during CYBORG[AME] rehearsal

of Japanese director Mamoru Oshii (most especially his films *Ghost in the Shell, Battle Royale* and *Avalon*). Spectacle, aggression, gender roles, power dynamics and heavy weaponry all collide. The atmosphere is one of oppression and technological assault from an unknown, remote power.

2.1.1.1: INVISIBLE SCENOGRAPHY

Formally the performance occurs in and around a *tournette* or rotating circular stage, centered in a cube of semi transparent fabric created by hanging large sheets of tulle. There are no additional visible props or physical set - the scenography and atmosphere of the performance are created entirely via video projection which I live-mixed using custom software written for the show. Four projectors and six screens are employed (four sides plus the floor of the main cube and a teleprompter-like arrangement purpose built by my colleague Selena Savic). Projection content consists of both text and image.

Images were created entirely though the layering and looping of pointcloud tracking data collected from the rehearsals as well as live during the performance. This data comes from from two Kinect depth cameras positioned around the stage fed into custom software I wrote called *Performance/Space. Pointclouds* are a type of visual imaging created by taking a number of measurements of points in space and then representing them in a three-dimensional projection in two-dimensional space (screen). The resulting output resembles a cloud and can appear quite ghostly, a visual effect which was emphasized and used extensively throughout the performance.

Text was also present both informationally and abstractly. An audience-readable teleprompter arrangement allowed us to display the script to the audience while the actors spoke, and included an animation effect which made the text appear as if it were being typed live during the performance. In addition, much of the atmosphere of the play was created by abstractly projecting symbols, glyphs, sentences and scraps of text which were colored, rotated and animated until rendered impressionistic and unreadable. Both of these types of textual output were created using a piece of software I wrote for this show, called *Textify!*.

Additional visual effects were made possible through the use of a video-sharing technology called *Syphon* and a tool I wrote to take advantage of this called *SyMix*. Combining all of these tools with support for a six-axis pointing device known as a *SpaceNavigator* and a general purpose MIDI mixer and pad (the Korg *Nanopad* and *NanoKontroller* respectively), I built a powerful system for generating and manipulating scenography live during performance.

2.1.1.2: DE-MATERIALIZED BODY / DE-MATERIALIZED SELF

Performance/Space, the tool which is used to create the disembodied ghosts of performers on stage, began its life as a system for collecting and stitching together pointcloud data from a number of live and networked depth cameras in order to create a large-scale 3D representation of the stage area. The intention was to solve a specific engineering problem: The Microsoft Kinect camera I was working with was designed to cover an area about the size of a living room, which is far too small to cover an entire theater. In order to overcome this limitation and to create an accurate tracking system, I had been working on creating tools for stitching the data from multiple pointcloud sources together into a single representation. Ultimately I would solve this problem, but CYBORG[AME] represents the moment where my engineering work on a tool for stitching pointcloud data evolved into an aesthetic tool for creating visual effects.

This was an important turning point in research. Prior to this point I had been concentrating primarily on engineering issues. I was operating under the assumption that if I could accurately track people and objects I would be able to create a tool that would allow me to treat the stage as a digital space freely manipulable in software. I believed this would allow me to explore the notions of computational epistemology I had set out to investigate, but by the end of this project I shifted my attention drastically from actual tracking to using the aesthetics of tracking as a tool to represent emotional and conceptual states.

One of the promises of digital technology is that it can remove or abstract away the problems of the physical world. Objects in digital space have no physical weight, dimension or mass. Digital objects can be multiplied infinitely, stored forever, never decompose, and are infinitely distributable. In most cases, we accomplish this through a deliberate loss of resolution. Even ”lossless” digitally encoded audio, for example, contains less data than the real world.[98] Whether or not this data comprises information in a Shannon-Hartley sense is a continued source of both technical debate and marketing confusion.[99] In general, however, we have collectively agreed that loss of resolution as compared to the real world as a worthwhile exchange in favor of the tremendous gains afforded by computational means of encoding and transport. Manovich writes: “....rather than being an aberration, a flaw in the otherwise pure and perfect world of the digital, where not even a single bit of information is ever lost, lossy compression is the very foundation of computer culture, at least for now.”[100]

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[98] Tocci, Ronald J. *Digital Systems: Principles and Applications.* TBS, 2006.

[99] Grotta, Sally Wiener. “How Many Megapixels Do You Really Need?” *Tom's Guide*, December 9, 2013. http://www.tomsguide.com/us/how-many-megapixels-you-need,review-1974.html.

[100] Manovich

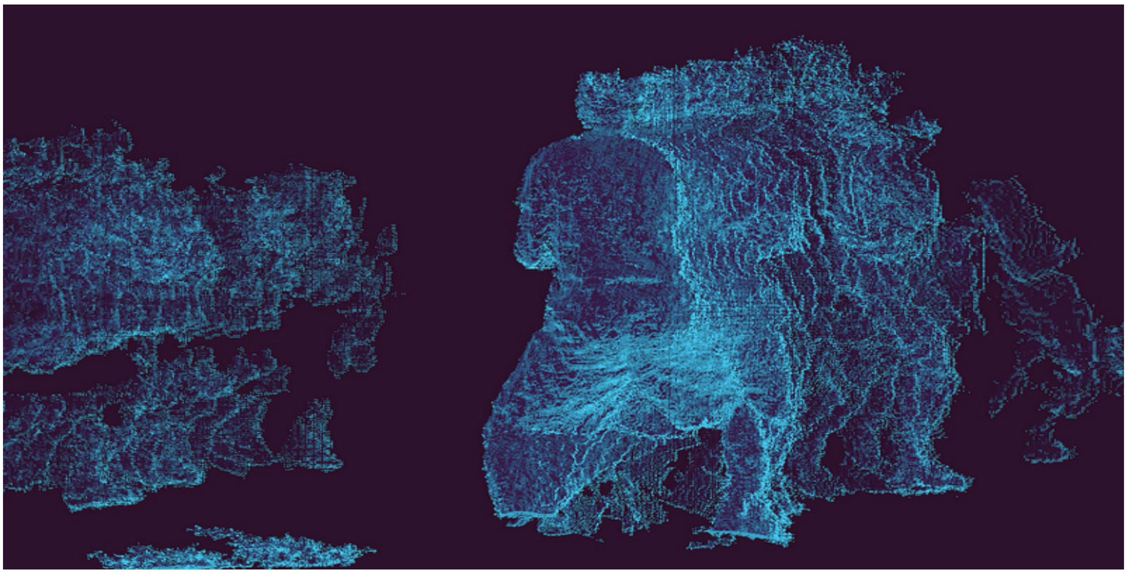

Figure 2.4: PERFORMANCE/SPACE generated visual

Rendered pointcloud data, at least that produced by my system, does not convey race, hair or eye color, any readily perceptible facial characteristics or even clearly recognizable clothing. Pointcloud representations of actors do not approach a high enough resolution to encompass the nuances of performance. Nevertheless they manage to distill and convey essential truths. My pointcloud does not look like your pointcloud. My digital ghost is both unique and recognizable in spite of the fact that it contains few "recognizable characteristics."

If digital technologies require us to reduce fidelity in order to efficiently access computational power then it should be relatively obvious to see how applying these principles to humanity might become problematic. We do, as a matter of course, frequently reduce humanity to statistics in order to make important decisions. This is a coping strategy for dealing with large amounts of data but can have a deliberate or accidentally dehumanizing effect. At the same time, this notion (that we are our perceived data and data can be controlled) can be deeply empowering, implying that a new identity and sense of self can be created at will.[101] As Sherry Turkle writes in her seminal book *Life on the Screen: Identity in the Age of The Internet*: "RL [Real Life] is just one more window, and it's usually not my best one." These are the words of a college student who considers the worlds he inhabits through his computer as real as RL--real life. He's talking about the time he spends "being" four different characters in three different MUDs--multi-user domains--as well as the time he spends doing his homework on the computer. As he sees it, he splits his mind and "turns on one part" and then another as he cycles from window to window on his screen. The computer and the Internet allow him to explore different aspects of himself. As another user puts it, "You are who you pretend to be."[102]

From the dawn of written history, humans have engaged in this kind of presentation of self, adjusting their presentation depending on social context. As Erving Goffman writes in 1959: "The issues dealt with by stagecraft and stage management are sometimes trivial but they are quite general; they seem to occur everywhere in social life, providing a clear-cut dimension for formal sociological analysis."[103] But if computational thinking has allowed us to approach the analog as if it were digital and to imagine that we can imbue digital characteristics into the world, this application to identity and sense of self has also activated a great anxiety.

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[101] Turkle, Sherry. *The Second Self: Computers and the Human Spirit*. First Edition edition. New York: Simon & Schuster, 1984.

[102] Turkle, Sherry. *Life on the Screen: Identity in the Age of the Internet*. Reprint edition. New York: Simon & Schuster, 1997.

Widespread adoption of ubiquitous networked mobile technologies have changed the speed and ease with which context-switching may take place. They also produce a new ur-context, a common public stage on which we can perform our lives or the lives we wish we had. The resulting availability of data, with and without appropriate context, has created a myriad of complexities requiring new vocabularies and means of understanding.[104] Humans are engaging in the same behavior Goffman identified more than 50 years ago (and which was likely occurring long before that) but we are doing it faster than ever before.

Proponents of a real or imagined pre-computational world insist that for an individual to project or inhabit more than one identity is a sign of criminal intent, degeneracy or mental illness. Proponents of digital identity argue that our ability to switch contexts and project different versions of ourself is not only healthy and acceptable but lies at the core of how we learn to interact socially as a species.

Researcher danah boyd explores the issue with more nuance in a speech given at the Supernova Conference in 2004. Boyd recognizes the power of social performance but articulates the "multiple profile" solution to privacy as tantamount to performance of mental illness: "Sociable technologies not only supported, but encouraged pseudonymous participation; even today, we talk about it as a protective tool against privacy invasion. People were encouraged to fragment their identity into different pseudonyms so that they could properly contextualize their online participation. They were encouraged to develop multiple selves." Boyd concludes: "Think about how asinine that is. Why on earth should we encourage people to perform a mental disorder in the digital world? We do so because we've built technology that does not take into consideration the subtle nuances of the identity faceting with which people are already accustomed."[105]

Inevitably, software models of social interaction are out of step with the complex reality of human interchange. Compounding this complexity is the notion that computation is as a branch of mathematics and engineering. This placement encourages us to consider data-driven representations of humanity to be somehow objective, measured and fair, or at least "cleaner" and more accurate than messy, emotional subjective view. So while what technology allows us to do (in this case apply digital notions of immateriality to previously static, material and non-digital concepts) is rarely debated, what that does to us as individuals, our culture and our species, remains a source of conflict.

This conflict, played out between the represented and the unrepresented, the visible and the invisible, the material and the immaterial, is the core conceptual idea behind both the narrative and the scenography for CYBORG[AME]. The story is one of overlapping fidelities and identities: an unreliable narrator, a shapeshifting protagonist, an army of two, capable of using technology to manifest thousands. It is a story of shifting power and epic battles reflecting contemporary anxiety that comes from thinking computationally about our sense of self.

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103 Goffman, Erving. *The Presentation of Self in Everyday Life*. 1 edition. New York N.Y.: Anchor, 1959.

104 Reid, Elizabeth M. "The Self and the Internet: Variations on the 'Illusion' of One Self." In *Psychology and the Internet : Intrapersonal, Interpersonal, and Transpersonal Implications, 2nd Edition*, edited by Jayne Gackenbach, 2nd edition. Amsterdam ; Boston: Academic Press, 2006.

105 boyd, danah. "Autistic Social Software." In *The Best Software Writing I: Selected and Introduced by Joel Spolsky*, by Avram Joel Spolsky, 1st ed. 2005. Corr. 2nd printing 2005 edition. Berkeley, CA: Apress, 2005. http://www.danah.org/papers/Supernova2004.html.

2.1.1.3: “DO WHATEVER YOU NORMALLY DO”

In June of 2013, director and writer Gildas Milan arrived at La Manufacture to work on the pre-production of CYBORG[AME]. As the third SINLAB artist in residence, Gildas was also invited to integrate the ongoing work of the SINLAB researchers into the production.

Gildas favors an intense and heavily process-oriented production style. Rather than traditionally direct performers and crew, Gildas creates a system for the cast and crew to be involved in every step of the production. The resulting performance emerges somewhat organically out of the process and people who are present. These people are not necessarily ideal for the roles as written, but they are always somehow the correct individuals, and whatever they bring to the role will ultimately describe what the role is.

This is something like method acting[106] for the entire crew - all hands participate from install to teardown. The cast and crew eat together, take breaks together, play games and when possible all live in the same space. A typical rehearsal day runs for twelve hours, and a typical rehearsal period is no shorter than a full week. In this way musicians become actors, actors become theater technicians, technicians become characters in the play and elements compose and re-compose themselves in unpredictable ways.

The two primary actors who had speaking roles (Julie Pilod and Vassia Zagar) engaged in a particular style of learning the material. The actors first watched original source material consisting of Kung-Fu films and anime which they were then asked to replicate while a reader (François-Xavier Rouyer, a student at La Manufacture who was Gildas’ assistant for the duration of the production) read their lines out loud. This process was periodically documented by Gildas using a video camera and the documentation was studied by the performers who were encouraged to repeat the performance later from memory, deliberately including any mistakes that were made. Later, the performers sat quietly, not moving at all while they rehearsed only text. Finally, at a later date they rehearsed the combination of text and physical performance. Throughout this process Gildas replaced and “edited” the performance freely, often incorporating chance occurrences or elements of previous rehearsals directly into the performance itself. Early on the most frequent answer to most of my questions, even concerning which character would be speaking a particular line or performing a certain action was “I don’t know yet.”

When I first encountered Gildas it was in the context of a meeting set up to discuss the project. I showed him the work I had to date including an early prototype of the *Performance/Space* software. It was unclear at this point exactly how I would contribute to the production, but Gildas encouraged me to participate in the rehearsals by “just showing up and working, doing whatever you normally would do.” At the time what I was normally doing was coding image and pointcloud processing routines. I hadn’t managed to collect much data for testing my system because it is difficult to both write software and perform physically in a space at the same time. I suggested I might continue my programming work in the rehearsal space with the depth-cameras pointed at the cast. Gildas, Julie and Vassia all agreed.

The conditions at the rehearsal space were terrible for software development. There was no workspace, no Internet and unreliable electricity. For a week I sat on the floor of the rehearsal space with my laptop balanced on my knees, rearranging cameras and computers and recording more than 10 gigabytes of raw pointcloud data from various angles. I focused mostly on the problem of data compression and transmission while thinking about calibration and alignment. While I was occupied with engineering thoughts, Gildas would periodically look over my shoulder and mention an effect or a visual he particularly liked. I was puzzled by this at first. I was so focused on coming up with a functional tracking system the rest seemed incidental. I didn’t quite understand for example why he would care about the more or less random color I had selected as the background of my interface.

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[106] Meisner, Sanford, Dennis Longwell, and Sydney Pollack. *Sanford Meisner on Acting*. 1 edition. New York: Vintage, 1987.

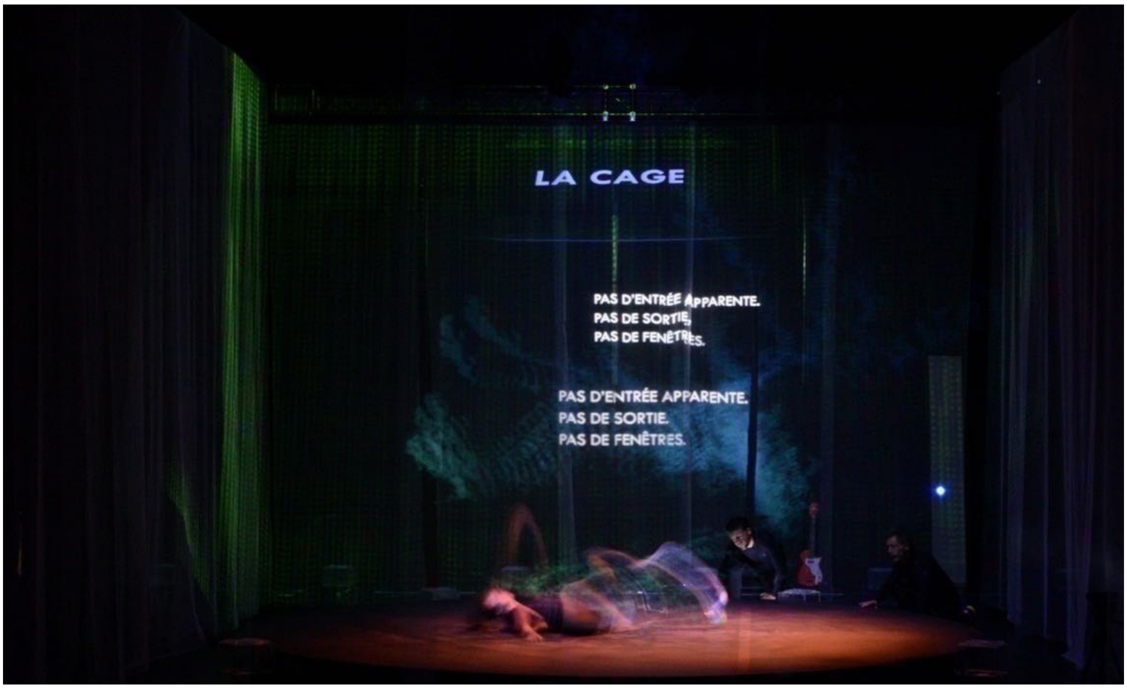

Figure 2.5: CYBORG[AME] stage showing the text projection. "LA CAGE" is on the teleprompter, The other text is projected directly on the tulle.

After rehearsals we took a break lasting several months during which I refined the software and made another major shift in my approach to tracking. In the meantime what I was to discover was that Gildas had, without my realizing it, cast and rehearsed me for the role of "The Military" in his play. My software would be the control system which would imprison Julie's character and the output would define the edges of the theatrical space, dematerializing the performers on stage and reconstituting them as pointclouds which formed the scenography of the play. During the final performance I sat along with Eric Dagaca, Ian Lecoultre, SINLAB colleague Selena Savic and Tomas Gonzalez, flanking the stage with our tables of equipment and sculpting the visual atmosphere in real time. My software had moved from tracking system to visual effects generator and my role had moved from technician to performer.

2.1.1.4: BUGS ARE FEATURES (IF THEY'RE PRETTY)

The process of adapting my tracking software into a visual performance tool included the conversion of several bugs into formal visual elements. For example, early on the tool would frequently crash during rehearsals. Each time I would restart the software, causing the screen to flash as the window expanded. Inevitably this would happen during the most dramatically and visually intense portions of the performance because of the stress on the computer's GPU and my OpenGL code. After one particularly hard crash, Gildas stopped the performance. I was expecting him to admonish me for the annoying flashes occurring during a crucial monologue. Instead he asked if it was possible to create the flashing effect on demand. That afternoon I modified the software to flash as needed in white, black and a random color.

Another example of this was a glitch caused by a bug in my rendering code, which under certain circumstances accidentally skipped the OpenGL "clear screen" command and left a ghost of the previous frame behind. This effect was to multiply the pointclouds on stage, an effect Gildas thought would be well used during one or more of the 33 battles. The original bug caused severe instability in the system, but with some modification I incorporated a deliberate “glitch” button into the software, allowing the operator to turn off screen clearing in order to create a semi-unpredictable layering effect.

This method of working also created a number of amusing misunderstandings and mis-communications, such as the time when Gildas proclaimed loudly “That was great! The blood! The blood was great!” I was baffled and tried in vain to replicate the effect he was talking about, made worse by the fact that my vantage point from the side of the stage didn’t allow me to see the same view that Gildas and most of the audience had from the front. It was nearly a week before I figured out the “blood” was a close zoom of pointcloud data, tinted orange/red with the glitch effect turned on.

2.1.1.5: ARCHITECTURE OF TEXT

Architecture is commonly taken to mean the design of buildings or the built environment. Architecture can also be applied to information, user interfaces and ideas.[107] At its heart architecture is the studied application of an organizing principle. Architecture is the framing which makes the space, information or interface work. As with most design practices, what the audience, client or end-user experiences is not the architecture itself, but the outcome of a process. What we often refer to as “architecture” is really “the architected.” The architecture of a building, information, or idea is deeply embedded in this outcome, but the details of the journey are often kept behind the scenes.

Similarly when an audience watches a play or performance they are usually invited to take part in the architect-ed, the end product of a process of organization and staging which hopes to create a gestalt in service of a particular narrative. Seen this way, text (or more accurately, the script) can be thought of as part of the architecture of performance which is rarely exposed in raw form. Text is typically performed, not read. The opposite was true with CYBORG[AME], where the script was used both informationally and abstractly to frame the story.

As we have seen, digital technologies can be used to de-materialize the material. We can use computers to turn actors into ghosts, and to expand and multiply a single body across an entire stage. We can also apply these tools to accomplish the reverse: to manifest the invisible, and to render an idea in physical form. In this case, throughout the staging of CYBORG[AME], software was used to transform text into an architectural element.

While I was working on the *Performance/Space* pointcloud software, my colleague Selena Savic began a project to create “disembodied text” in order to layer the actual text of the play into the performance space. The object itself was essentially a large-scale teleprompter aimed at the audience. Selena constructed a frame and researched materials to identify the right type of screen which would provide the desired effect without too much excess light or distortion. Selena also wrote a text-mining script written in Python in order to pull relevant strings out of the script of the play in realtime.

In parallel I worked on display software to support the teleprompter. Influenced by the transition from tracking to visual effects that was occurring with *Performance/Space*, the display software grew significantly in scope, eventually becoming a tool called *Textify!*, which allowed for broad support of colors, fonts and animation styles. Eventually I would incorporate the features of Selena’s Python script directly into the display software and add an important animation feature, creating a single tool which allowed us to treat the actual script of CYBORG[AME] as raw material for performance.

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[107] Wurman, Richard Saul. *Information Architects*. New York: Graphis Inc, 1997.

2.1.1.5.1: TEXT AS INFORMATION

CYBORG[AME] presents the audience with a large quantity of information: video projection, live performance, physical and projected movement, ambient sound, music, a rotating stage, lighting effects and spoken and written text. This information is often presented rapidly and in an overlapping manner that creates an aesthetic of overload. Although this is done deliberately, the shear quantity of sensory input challenges the audience to follow the story.

Textify! plus the teleprompter arrangement allowed us to display the text live during the performance. This functioned as an informational device to help the audience navigate the sometimes overwhelming number of layers used in the play. In the same way that subtitles are often employed during an opera to provide translation into the local language, this was a straightforward but necessary application of technology. The teleprompter provided the audience with a clear reference point and explanation for what they were seeing. Regardless of the action on stage or the place in the story, the text remained constant, clear and readable, allowing the audience a place to rest and return to as needed.

While functionally important, the teleprompter had a much more important role in the play which was to manifest "the author," a phantom character understood to be writing the play into existence in front of the audience. This had the effect of underscoring the notion of fiction versus non-fiction, performance versus reality and the overlapping narratives of unreliable narrators, all key thematic elements in the play. A similar technique was employed in the 2006 film *Stranger than Fiction*, starring Will Ferell (Figure 26). In this film the main character is the subject of a narrative voice that only he can hear. Ultimately the story folds in on itself as the character seeks to find the author of his life. The author (played by Emma Thompson) is eventually seen on screen, but prior to this is represented by text and graphics superimposed over live action.

Key to the creation of this effect in CYBORG[AME] was not the text itself but the way in which it was displayed. Text which appears on screen or stage an entire line at a time appears informational and authoritative. Text which appears character by character has a quality of becoming, appearing as if transcribed out of the mind of the author in realtime.

This was the effect that Gildas requested: the script should appear as if it were being typed as the characters spoke the words on stage. Although this could have been accomplished by hiring an accomplished typist, that route proved impractical for a number of reasons including cost and the need to repeat the same lines hundreds of times during rehearsals. Scripting the typing seemed an obvious choice as computers are designed to repeat things rapidly and accurately many times over without complaint, but unlike computers humans make mistakes, become distracted, hit slightly the wrong button or mispronounce or stutter their speech. These micro pauses and mistakes, perceived subconsciously, are cues that we use to understand "aliveness."[108]

In order to create the effect of a live person while taking advantage of the strength of computation, I created a "typing effect" in *Textify!* which created the illusion of words appearing on screen. This was accomplished by setting a timer to display one character after another at a set rate. Initial versions of this software appeared mechanical: the computer "typed" every letter with exactly the same amount of time between them. The solution was to create a semi-random system of variable pauses, and to pay particular attention to the character being typed. For example an experienced keyboard operator will develop motor memory equivalent to a complete word. The result is that while words appear rapidly, there are slightly longer pauses occurring at the spaces between them. Punctuation, special characters and upper case letters

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[108] Mori, Masahiro. "The Uncanny Valley." *IEEE Spectrum*, May 12, 2012. http://spectrum.ieee.org/automaton/robotics/humanoids/the-uncanny-valley.

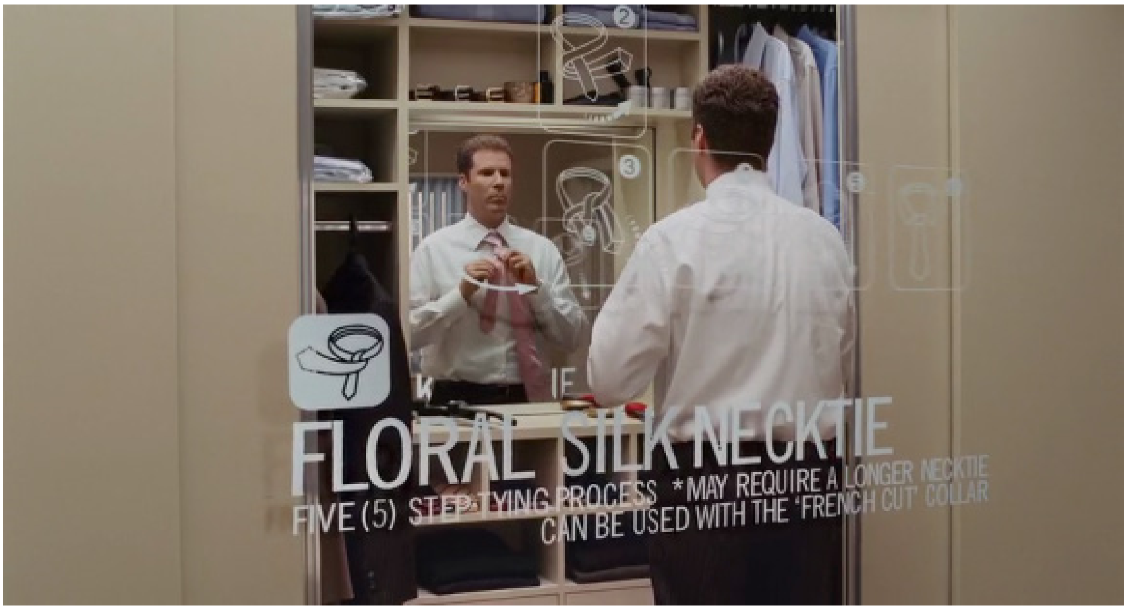
FLORAL SILK NECKTIE
FIVE (5) STEP TYING PROCESS
*MAY REQUIRE A LONGER NECKTIE
CAN BE USED WITH THE 'FRENCH CUT' COLLAR

Figure 2.6: Will Ferrel in the 2006 film Stranger than Fiction, showing the superimposed text and graphics that narrate his life.

also are usually the result of a gesture involving the coordination of more than one finger, which causes a slight delay. After implementing these semi-random delays the ghost-typist was not perfect but appeared far more "human" than before.

I highlight this specific problem because what is interesting is not the problem itself but the relationship that it describes between humans and their technology, as well as the effects we see at the edges of our perception and the need to create work in-context. When creating art with the aid of computation, one frequently has the need to "soften" the edges of the digital to appear more human or natural. In many ways the recent history of computation is about shifting the computational power from performing a specific mathematical or engineering task towards "extraneous" things like user interface: softening the edges of text or slowing down the computationally fast in order for humans to see and remain comfortable with progress. The degree to which this is both necessary and easy to overlook is difficult to anticipate in the abstract but becomes glaringly obvious in practice.

2.1.1.5.2: TEXT AS SURFACE

The same *Textify!* software used to drive the teleprompter was used in a far more abstract manner. The script itself as well as words, individual glyphs and even the source code of the software itself were processed through *Textify!* and projected onto the tulle screens to create a number of different patterns and surfaces of varying density.

Key to this aspect of the performance was the ability to rapidly create, save and reload a large number of font settings, especially as the performance was mostly improvised live on stage. During a concert scene, for example, I used an array of punctuation marks and rapidly cycled the colors, creating the impression of a rain of colored dots. During the fight scenes, I used a number of arrow-glyphs rapidly cycled to strobe in time with the pace of the battles. I also implemented a texture-sharing mechanism between *Textify!*

and *Performance/Space*, allowing me to treat the output of the text generation software as a visual texture for the three dimensional environment the point-clouds occupied.

In this sense I was able to architect space using text as a structural element. The text obviously does not hold up the walls, but it can be used to draw the “walls” in space and used as a spacial element. For example, using *Performance/Space*, text could be presented on the “floor” underneath the pointcloud representations of the actors. Subject to the same sort of three-dimensional visual effects as the digital ghosts, text could be treated as surface. By choosing to project the result onto long strips of tulle, actors were able to interact with the surface as if it were semi-solid, playing at the space between material and immaterial.

The text is also structural in a different sense: it provides the narrative backbone for the play. As described earlier this is presented in a straightforward way on stage. This presentation not only creates the phantom author, but also exposes the underpinnings of the story as a written fiction. By selecting elements of the “straightforward” display and manipulating them onto the surfaces of the set, we set up a narrative relationship between information and aesthetics and between representation and abstraction. We play between text and surface and between display and understanding.

2.2: THE DIGITAL, MANIFEST

How might computation occupy and transform space? The promise of the digital is that it de-materializes our world. Digitized objects, people, and ideas can travel an infinite distance, replicate indefinitely and be made to exist in more than one place at once. This idea can be effectively conveyed in space by using physical phenomena, in particular projected light and sound, which maintain some of these properties for the audience but with a number of tradeoffs.

Projection and sound are ideal for conveying computational ideas in space as they offer both material and immaterial properties. Light is transmitted through space, subject to refraction, reflection and interception by solid surfaces. This can be used to transform a blank surface through projection mapping, or to use a surface as a screen, or to switch between the two. Sound, while often considered immaterial, is one of the most physical of sensations in that it is created by sound waves physically manipulating your inner ear and can be located in space to create stereo or ambisonic effects.[109]

Performing the digital in space requires an infrastructure: a projector or speakers, electricity and wiring, all of which allow us to manifest aspects of the digital but introduce their own analog problems. A given projector has a finite amount of light and surface area over which it can produce a coherent image. Matching the colors and brightness between two projectors is difficult given the way filaments age and differences in manufacturing tolerance. Both projection and sound are subject to perceptual shifts caused by the position of the audience members.

Further, converting the analog world into the digital is most often accomplished by reduction in resolution. A high definition video of a person speaking is not the same as the person itself. This can be seen as a degradation of the “real” or it can be said that digital representations have their own unique qualities when re-manifest into the world.

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[109] NB: Sound is not explicitly discussed in this chapter as it was not used in the CYBORG[AME] performance. However, soundscapes served as the basis of the original prototypes I developed at SINLAB prior to *Performance/Space*. These prototypes are described in more detail in Appendix B.

Digital representations fall short of the fidelity of live performance every time. The best compromise for the introduction of the digital into performance is to make these limitations serve an aesthetic purpose. Ideally the technical limitations become aesthetic strengths (using the ghostlike appearance of pointcloud data to represent conceptual ghosts, for example). This works well although one needs to guard against relying too heavily on the aesthetic signature of the limitations of a given technology. While sometimes effective, relying on the novelty of a technology subjects a work to technological side effects which are likely to be eliminated as technology improves. It is also a sure way of making the work appear dated in the future.

3

CHAPTER THREE COMPUTATIONAL LAYERING

Chapter 3 describes two projects, a stage-based dance work with ATOU company called *SHinMu* and a public art project called *Lines of Desire*, produced during a residency at École Nationale Supérieure d'Architecture de Lyon (ENSAL). Both projects were presented to the public in Lyon, France.

This chapter answers the question "How can humans and computation co-exist in space?" And in particular introduces a framework for how computation can be used on stage to shift our attention, most effectively as a tool for amplification of performance either by magnification or resonance. This chapter also examines the notion of computers and humans as co-authors of experience, helping to explain the changes which computation has brought to our understanding of the world.

3.1: HOW CAN PERFORMERS AND COMPUTATION CO-EXIST IN SPACE?

Dance is an art form which is highly physical. This seems like an obvious statement but it has a particular consequence for performance technology. Many attempts to augment dance with interactivity claim to provide the dancer with performance capabilities beyond physical movement,[110] turning dancers into musicians or conductors. The stated aim of this research is often to increase the impact of the performance or to better convey emotional content as in this example: "We seek to explore the potential of using AR [Augmented Reality] in the context of a ballet dance show to better convey the choreographer's message and suggest innovative artistic situations."[111] These approaches are largely technocentric and carry with them two unspoken understandings: 1. That dancers have excess creative capability they are having difficulty expressing through movement alone and 2. That dance is somehow lacking or needing in improvement. Discussion with dancers reveals otherwise: dancers tell me they typically find such systems irritating and invasive unless they can find a way to ignore the technology while they concentrate completely on articulating movement.

It may be true that for some performers and for certain types of performance operating a technical system is the performance itself but for most traditionally trained performers looking to incorporating digital technologies into their work the need to operate something is seen as extra work or a nuisance. Technological augmentation of the stage is considered part of the engineering or scenographic work which performers ignore as part of their training. I found this to be the case with both dancers and stage actors. When working on *CYBORG[AME]*, for example, there were portions of projected scenography which included high contrast strobe-like flashing aimed directly at the face of Julie, the main actress. After rehearsal I asked Julie if the projected scenography bothered her. She thought about it a moment and then shook her head "No, I'm too busy concentrating on the text, I don't even really notice."

The same answer was echoed when I spoke to the dancers who were working with Pablo Ventura, the choreographer who was the first SINLAB artist in residence and who was developing a system that generated sound in response to the movements of dancers.[112] On two occasions I asked the dancers if they were aware of the sounds they were producing with their movement while they danced. Both times I received more or less the same answer: "No, I'm concentrating on the movement and I'm not thinking about much else. Maybe with a lot of practice, once the moments are muscle memory, then I could play the system. Maybe."

This has profound effect on the design of systems for performance interaction. As a primary consideration such systems must remain unobtrusive. For motion-capture or tracking systems it is both easier and more accurate to attach sensors or markers to the body you are tracking.[113] For a physical performance such as dance, these wearable objects need to be both lightweight and balanced. To allow for free movement active devices must also be wireless and battery powered and ideally shock and water resistant to withstand impact and sweat. In terms of placement on the body, they cannot be too far from the center of a dancers mass nor alter the weight of the body in any significant way. My own tracking work focused on creating system which required no wearable element at all. This reduces the accuracy and the type of information available to the system but seemed important in order to create a system which would adapt the space to the performers rather than requiring the performers to adjust to the technology.

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[110] Paradiso, Joseph A., and Eric Hu. "Expressive Footwear for Computer-Augmented Dance Performance." In *Wearable Computers, 1997. Digest of Papers., First International Symposium on*, 165–66. IEEE, 1997. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=629936.

[111] Clay, Alexis, Nadine Couture, Laurence Nigay, Jean-Baptiste De La Rivière, Jean-Claude Martin, Matthieu Courgeon, Myriam Desainte-Catherine, Emmanuel Orvain, Vincent Girondel, and Gaël Domengero. "Interactions and Systems for Augmenting a Live Dance Performance." In Mixed and Augmented Reality (ISMAR-AMH), 2012 IEEE International Symposium on, 29–38. IEEE, 2012. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6483986.

[112] Mazenauer, Beat. "Metamorphosis in the Source Code." Translated by Eileen Walliser-Schwarzbart. *Passages Prohelvetia*, n.d.

[113] Roetenberg, Daniel, Henk Luinge, and Per Slycke. "Xsens MVN: Full 6DOF Human Motion Tracking Using Miniature Inertial Sensors." *Xsens Motion Technologies BV, Tech. Rep*, 2009. http://www.xsens.com/wp-content/uploads/2013/12/MVN_white_paper1.pdf.

It seems unintuitive, but creating a situation where there is meaningful interaction between performers and technology seems to be about taking agency *away* from the performers. Actors on stage need to be able to interact-with, not operate, the technology. At the same time, there are particular cues, moments in time, which must be hit accurately. Stage performers are trained to hit their marks and most are quite good at this, but a computer has no real sense of space and at these moments direct input from the performer can be invaluable. How can this be accomplished? How can humans and computation co-exist in performance? In the case of stage performance is this level of interaction even meaningful?

3.1.1: TOO MUCH DATA LEADS TO DANCE

In between the *CYBORG[AME]* rehearsals in June of 2013 and the production of the same show in September I encountered a serious technical problem with my tracking system: the sheer size of pointcloud data. In the course of solving this problem I built several pieces of software in two different contexts: a dance performance and an art installation in public space. Each of these projects allowed me to explore the way computation can mediate between people and their environment and provided useful insight into the different types of meaning this creates.

A single Primesense depth-camera like the Kinect produces 30 frames per second of pointcloud data at a VGA resolution of 640 x 480, or 307,200 pixels. Each pixel contains an 11 bit number indicating depth. Although not every pixel of every frame contains data, a completely full frame presents a “worst case” maximum of 33,79,200 bits or approximately 0.4 megabits per frame. At 30 frames per second we need to accommodate roughly 12Mb/second of data per camera. I was looking to employ a minimum of four cameras so needed to account for a continuous flow of 48Mbs of data. This exceeds the capabilities of commercially available wireless networks. While the 802.11n specification indicates that a wireless network should be capable of supporting 300Mbs, this is highly dependent on environmental factors and is rarely seen. In terms of sustained throughput a far more typical rate for a wireless network would be somewhere between 10 and 100Mbs. Commercially available wireless was simply too unreliable for this application and so I opted for running Cat-6 cable between my cameras and base station, providing reliable data flow at the cost of installing physical infrastructure.

Switching from wireless to wired network went a long way towards making it possible to transmit pointcloud data. To help the situation further I also compressed the data using lz4,[114] a very fast lossless compression algorithm with several freely available open source implementations. With lz4 I was able to compress the data with roughly 50-75% size savings depending on the complexity of the scene and no observable impact on performance. This solution more or less solved the problem for four distributed cameras, but what if I wanted to use eight or eighty? In the Lausanne and Basel train stations at this time, there was an installation of more than sixty such cameras.[115] This installation was collecting information about passengers movements between stations in order to help guide future renovations. Coincidentally the technical work on this system was done by the EPFL LTS2 (Signal Processing) lab on the EPFL campus near my own lab. In order to figure out how this was being accomplished I contacted one of the lab's technicians, David Chanel, to discuss my project.

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[114] Collet, Yann. “RealTime Data Compression: LZ4 Explained.” Accessed January 11, 2015. http://fastcompression.blogspot.ch/2011/05/lz4-explained.html.

[115] Thiran, Jean-Philippe. “Sensors Study Pedestrian Flow in Lausanne Train Station.” Accessed January 11, 2015. http://sti.epfl.ch/page-87394-en.html.

David's approach to collating the train station data was far simpler than my solution of pushing the pointcloud data over the network. Rather than attempt this network-heavy operation, the LTS2 system consisted of distributed computers each paired with a single camera. The computers attached to each camera ran local analysis on the pointcloud data and then transmitted only minimal information over the network. This resulted in bandwidth usage so low that regular wifi could be used easily although for interference and security purposes it still made sense to use a closed wired network. With this system sixty cameras were easily supported. One of the major drawbacks of the train-station system was that while it allowed for the combination of data from many cameras it was never intended for realtime performance. That particular system has no output visible to the people in the space, it simply collects data which is analyzed later in a separate process. For a stage application you typically want to collect the data and then immediately produce an output.

By the time I completed my work on CYBORG[AME], David had left EPFL to become the principal of an interactive projection-mapping company called Theoriz Studio based in Lyon, France. David was interested in solving this realtime performance problem and as he and I were working on more or less the same thing we decided to combine our efforts. I spent a week working first with the LTS2 lab extending a piece of open source software called TSPS[116] which would form the data-gathering half of my tracking system. After this week David invited me to continue the work in Lyon as Artist in Residence at École Nationale Supérieure d'Architecture de Lyon (ENSAL). The ENSAL residency lead to a collaboration with the ATOU dance company and a performance of their piece SHiNMu, but the work began with an exercise in augmenting space.

3.1.2: ENSAL: LINES OF DESIRE

How can the introduction of computation to the built environment change our relationship to space? Desire paths are the marks that are created as a consequence of foot traffic over snow, grass or similar terrain where physical movement creates visible erosion. These paths indicate intentionality on behalf of the users of a space, and may indicate a sensibility which is contrary to the official intended use. Urban planners have studied such lines.[117] and some have famously used them to plan footpaths in public parks.[118]

In the interior of a building or across a hard surface desire paths are typically invisible. However, I suspect that the type of surface does not deter the occupants of a space from having a goal. Invisible intention is still intention and desire paths exist in interior spaces even if we can't see them. I wanted to make a system that would make this invisible intentionality visible.

The ENSAL building has a basilica layout, with a large central corridor ending in a multistory circular rotunda that houses the program offices. This main "street" connects all the labs and classrooms on the

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[116] TSPS is "Toolkit for Sensing People in Spaces" by Rockwell Group. For more information: http://www.tsps.cc/

[117] Myhill, Carl. "Commercial Success by Looking for Desire Lines." In *Computer Human Interaction*, 293–304. Springer, 2004. http://link.springer.com/chapter/10.1007/978-3-540-27795-8_30.

[118] Royal Borough of Kensington & Chelsea. *The 21st Century High Street*. Cultural Strategy. Royal Borough of Kensington & Chelsea, June 2011. http://www.rbkc.gov.uk/idoxWAM/doc/Other-777167.pdf?extension=.pdf&id=777167&location=VOLUME2&contentType=application/pdf&pageCount=1.

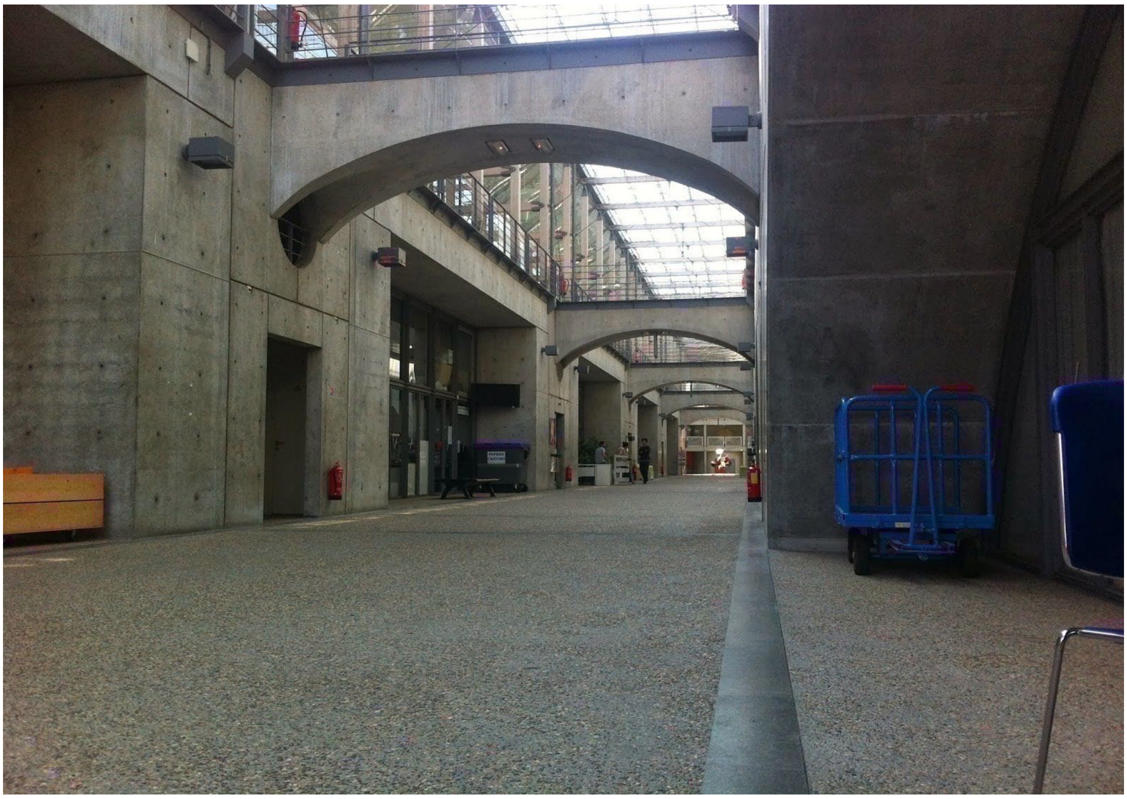

Figure 3.1: The main hallway of the ENSAL building where the residency took place.

ground floor and provides access to the exits and stairways to the upper level. It can be observed from a second story balcony and during the day is brightly lit by a glass ceiling that runs the length of the building. For my installation I proposed an overhead projection that would run the entire length of the corridor to augment the floor with the motion of bodies along the hallway.

Key to this idea was the notion of time-shifting over three different time scales: immediate, daily and for the duration of the install. I first created a system with a slight delay, showing the path of travel as a contrail behind people moving in space. This was done as both a cue to the people walking through space that they were being tracked as well as to provide a way to bring attention to the direction and rate of travel for both the mover and any incidental observers. This first pass was to create a situation where attention was drawn to an otherwise unremarkable activity, making visitors aware of their movements and relationship to the space.

In support of the longer timescales and for testing purposes I wrote software I called *ReOSC* to track and record movement data over time. While the immediate visualization indicated movement of a person in the space, collecting the data provided for the ability to create a daily visualization mimicking the use cycle of the building (occupied during the day / empty at night). While the space was closed to the public during non-business hours, the recorded data could be used to let the space “dream” of its occupants by playing back remembered activity. This self-haunting can activate the dormant architecture in order to bring attention to the life of the building even while it sleeps. Finally, this same data can be used over the duration of the install by creating the eponymous desire paths: a projected line increasing in brightness over the most frequently traveled areas in the corridor.

As time and budget were short I was only able to cover one segment of the hallway and implemented

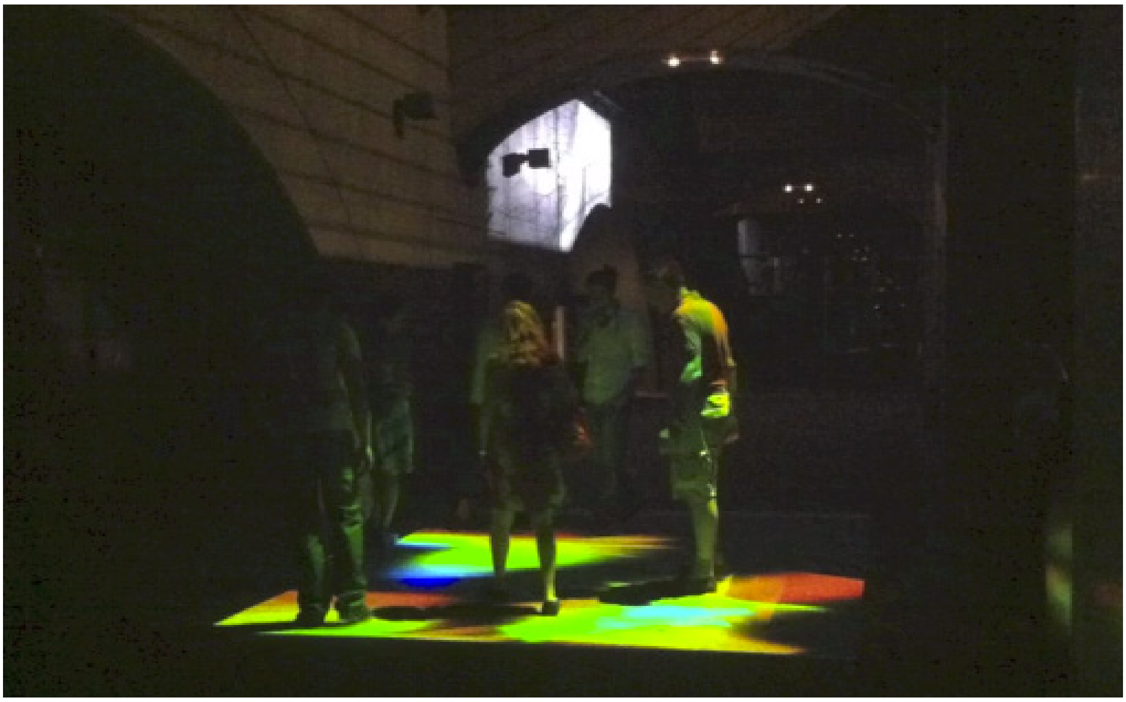

Figure 3.2: A group plays with the interaction between their contrails.

just the primary goal of an immediate, contrail-visualization. Data was collected for the duration of the event but was not used in the visualization seen by ENSAL audience. Nevertheless, this small sample of data revealed some curious patterns. According to my data, most people moving down the corridor had a tendency to stick to the edges rather than walk down the unimpeded middle. This tendency seemed unconscious. My conjecture is that people traversing the corridors are responding to the "street" cues the architecture has provided. In the ENSAL building the edges of the corridor are marked visibly with wide stripes of stone. There are benches placed strategically along the "sidewalks" and the double story mimics the sensation of two-story urban retail. I believe that most people traversing this "street" subconsciously follow these cues and remain at the edges for safety reasons in order to avoid imagined automobile traffic (Figure 3.1).

Instrumentalizing space to analyze movement was not the focus of this project nor of this dissertation. There is insufficient data to draw any significant conclusions from the ENSAL project, but as an anecdote I believe this hints at the possibility for inquiry offered by using the data gathered in a playful manner. This is a technique which has been employed successfully in "serious games"[119] and in social software contexts[120] as well as for gathering advertising and security data in commercial contexts[121] although not without receiving much-deserved criticism.[122]

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[119] Von Ahn, Luis. "Games with a Purpose." *Computer* 39, no. 6 (2006): 92–94.

[120] Kramer, Adam D. I., Jamie E. Guillory, and Jeffrey T. Hancock. "Experimental Evidence of Massive-Scale Emotional Contagion through Social Networks." *Proceedings of the National Academy of Sciences* 111, no. 24 (June 17, 2014): 8788–90. doi:10.1073/pnas.1320040111.

[121] Vazquez, Paloma. "Unilever's Smile-Activated Ice Cream Machine." *PSFK*, June 22, 2010. http://www.psfk.com/2010/06/unilevers-smile-activated-ice-cream-machine.html.

[122] Greenfield, Adam., Mark. Shepard, and Architectural League of New York. *Urban Computing and Its Discontents.*

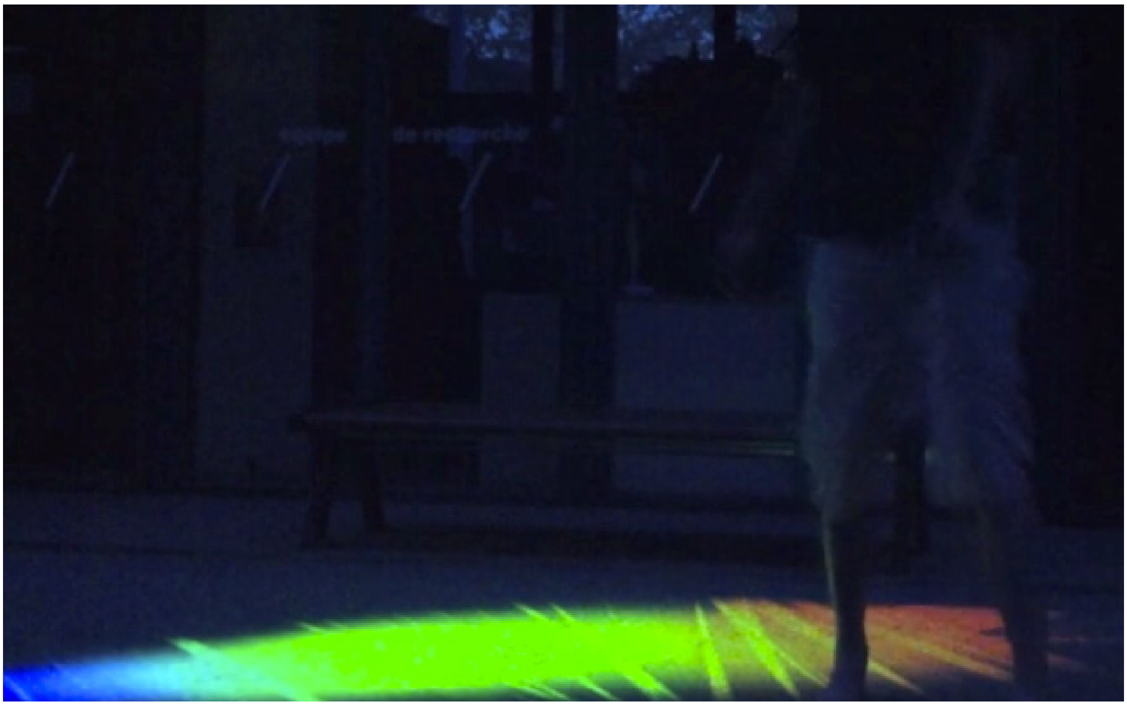


Figure 3.3: Single contrail as a person moves down the hallway.

3.1.2.1: DEFINING SPATIAL RELATIONSHIPS THROUGH ATTENTION

The visuals for the lines of desire installation were created using a commercial 3D game engine called Unity. Although the rainbow-contrail projection appears two dimensional it depended on affordances in the game engine offered by the inclusion of both 3D and a physics engine. This method of working proved powerful, allowing me to experiment with different effects in close to realtime directly in the space. This was close to the toolkit I had imagined when I first began my tracking work prior to the CYBORG[AME] project, but it still lacked the key ability to stitch multiple depth camera's together. Even so a single camera was sufficient to both demonstrate the concept and explore a research question: How did the installation of interactivity change perception of architectural space?

With the CYBORG[AME] project, the goal was to transform the virtual into the physical in order to impact the actors. Presented in theatrical space, the immaterial (projected light) was used to define a sense of place, to form the walls, and to construct an environment. In contrast, the ENSAL *Lines of Desire* project used the existing built environment as a screen in order to draw attention to the way the physical environment was invisibly impacting the people in the space.

By augmenting everyday movement with a lightweight visualization I was able to create a situation where the audience member was free to choose their own level of engagement with the project. In some cases individuals traversing the hallway ignored the installation completely. In this case, their data was still collected and their movement provided a small light show to incidental observers. In other cases, individuals spent a good deal of time playing with the light, making shapes and experimenting with interactions between each other. My favorite interaction was an older man who I was later told was a retired judge who spent 20 or 30 minutes dancing with the system on his own.

New York, N.Y.: Architectural League of New York, 2007.

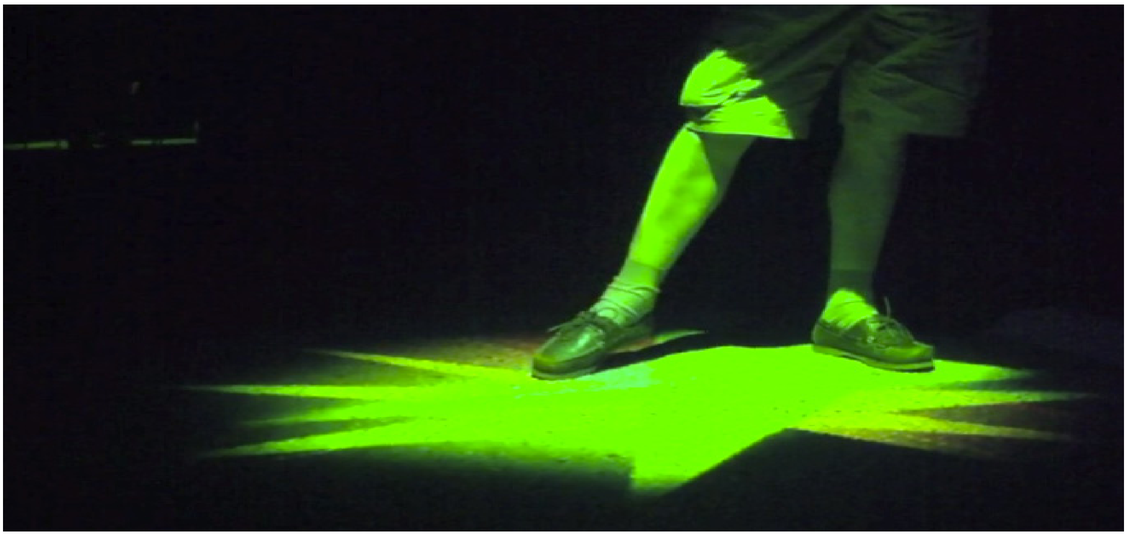


Figure 3.4: Dancing with your interaction.

Physical material which is impacted by humans does show wear and tear over a long timescale. Stone and metal can be ground down, concrete wears out, beams may sag. Over many years this impact is visible and and can even be dramatic, but the passage of a single individual is typically invisible and and thus we tend to treat the built environment as if it were static and immutable. Digital effects projected onto static architectural elements draw attention to them. By tying physical movement to visual feedback and using the body as a stylus or pointer we can connect our own innate sense of physicality with this focus of attention. The timeframe of the display is significant and changes the type of interaction: a very brief contrail drew attention to froward movement but provided little time for a person to contemplate or play with the movement. By increasing the fade delay a few seconds, individuals interacting with the system were able to consider their movements more carefully and often altered their own path or rate of movement to play with the system.

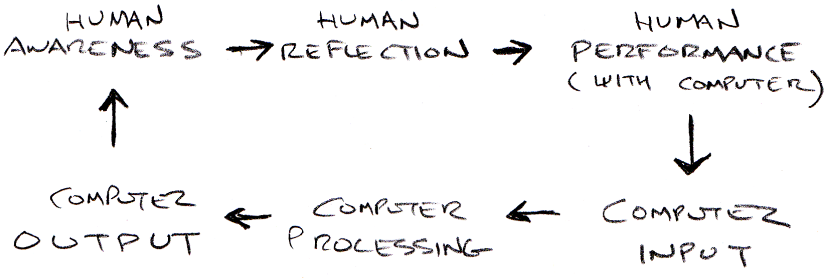
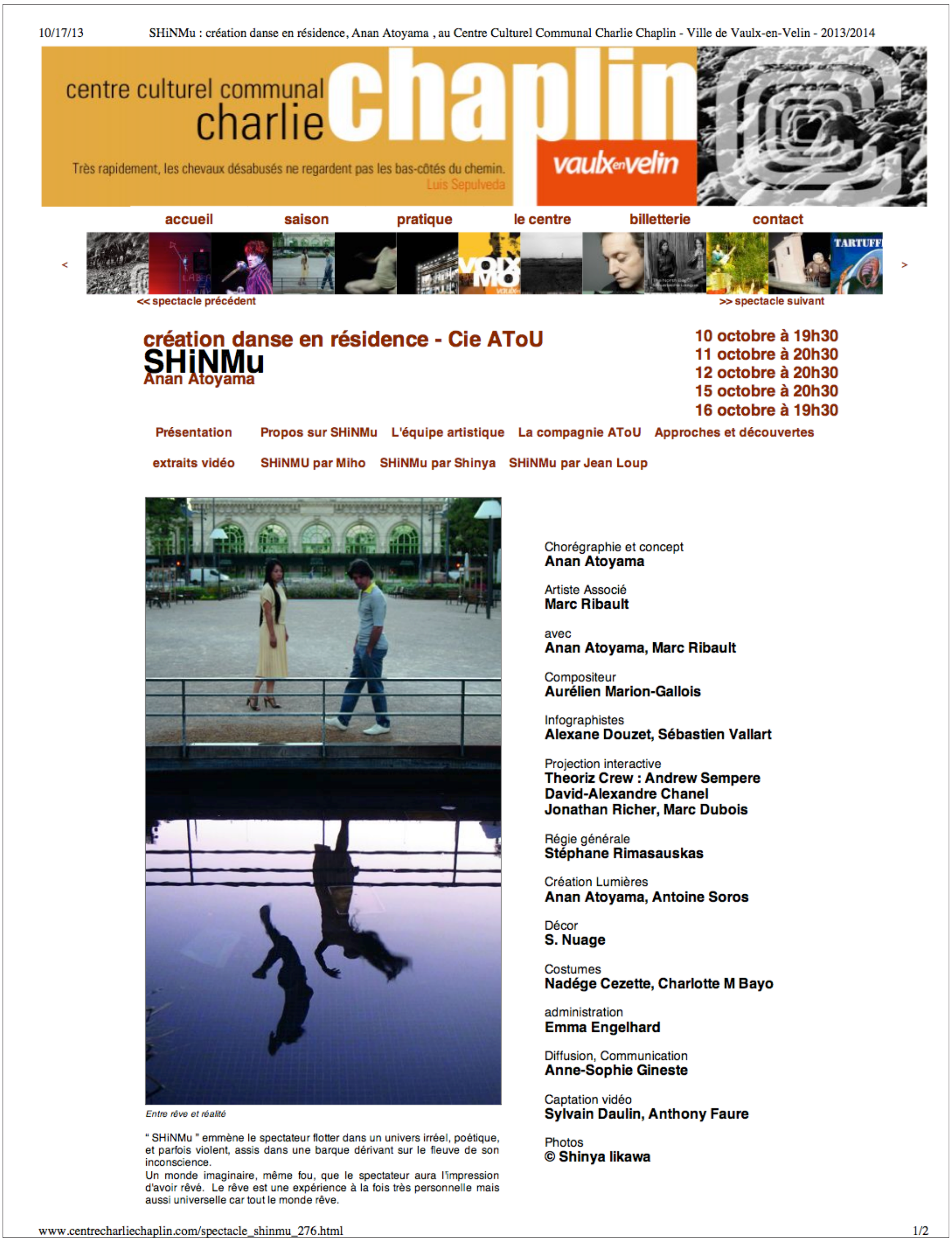


Figure 3.5: Basic model of computation with person in the loop

Light projected onto a surface does not impact the surface itself but can be used to make observers acutely aware of their own presence. Computation thus augments our perception by allowing us to speed up a natural process virtually. We can use computation to visualize the traces of our impact at a speed and



10/17/13 SHiNMu : création danse en résidence, Anan Atoyama , au Centre Culturel Communal Charlie Chaplin - Ville de Vaulx-en-Velin - 2013/2014

centre culturel communal
charlie **Chaplin**

Très rapidement, les chevaux désabusés ne regardent pas les bas-côtés du chemin.
Luis Sepulveda

vaulx en velin

accueil saison pratique le centre billetterie contact

< >

<< spectacle précédent >> spectacle suivant

création danse en résidence - Cie AToU

SHiNMu

Anan Atoyama

10 octobre à 19h30
11 octobre à 20h30
12 octobre à 20h30
15 octobre à 20h30
16 octobre à 19h30

Présentation Propos sur SHiNMu L'équipe artistique La compagnie AToU Approches et découvertes

extraits vidéo SHiNMU par Miho SHiNMu par Shinya SHiNMu par Jean Loup

Entre rêve et réalité

" SHiNMu " emmène le spectateur flotter dans un univers irréel, poétique, et parfois violent, assis dans une barque dérivant sur le fleuve de son inconscience.
Un monde imaginaire, même fou, que le spectateur aura l'impression d'avoir rêvé. Le rêve est une expérience à la fois très personnelle mais aussi universelle car tout le monde rêve.

Chorégraphie et concept
Anan Atoyama

Artiste Associé
Marc Ribault

avec
Anan Atoyama, Marc Ribault

Compositeur
Aurélien Marion-Gallois

Infographistes
Alexane Douzet, Sébastien Vallart

Projection interactive
Theoriz Crew : Andrew Sempere
David-Alexandre Chanel
Jonathan Richer, Marc Dubois

Régie générale
Stéphane Rimasauskas

Création Lumières
Anan Atoyama, Antoine Soros

Décor
S. Nuage

Costumes
Nadége Cezette, Charlotte M Bayo

administration
Emma Engelhard

Diffusion, Communication
Anne-Sophie Gineste

Captation vidéo
Sylvain Daulin, Anthony Faure

Photos
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www.centrecharliechaplin.com/spectacle_shinmu_276.html 1/2

Figure 3.6: Flyer advertising SHiNMu.

scale that we can see and relate to. Computation can be used to demonstrate and amplify impact in a bid to facilitate deeper relationships between humans and environment, most especially when we use it to link the physical and the visual.

Returning to our model of computation, we are inserting ourselves into the loop along the line of hysteresis (Figure 3.5). The system itself collects input and produces an output based on its own internal processing. In collaboration our brains use the output of the system to reflect on our own movement and awareness/feedback loop, potentially changing our understanding the space. Computation can be used to help us understand and alter our behavior by rendering it visible.

3.1.3: SHINMU: DREAMING WITH PROJECTION

What happens when we apply the same technology to theatrical space? At the end of the ENSAL residency a public opening was held to show the work. Two of the attendees were the principals of the AtOU dance company led by the Japanese choreographer Anan Atoyama. Anan was working on a show called *SHiNMu* (a Japanese portmanteau meaning "deep dreams"), a fifty minute nine part dance piece exploring dreaming, horror and solitude (Figure 3.6). The company was interested in applying projection mapping techniques to their work in order to convey these dream-ideas to the audience.

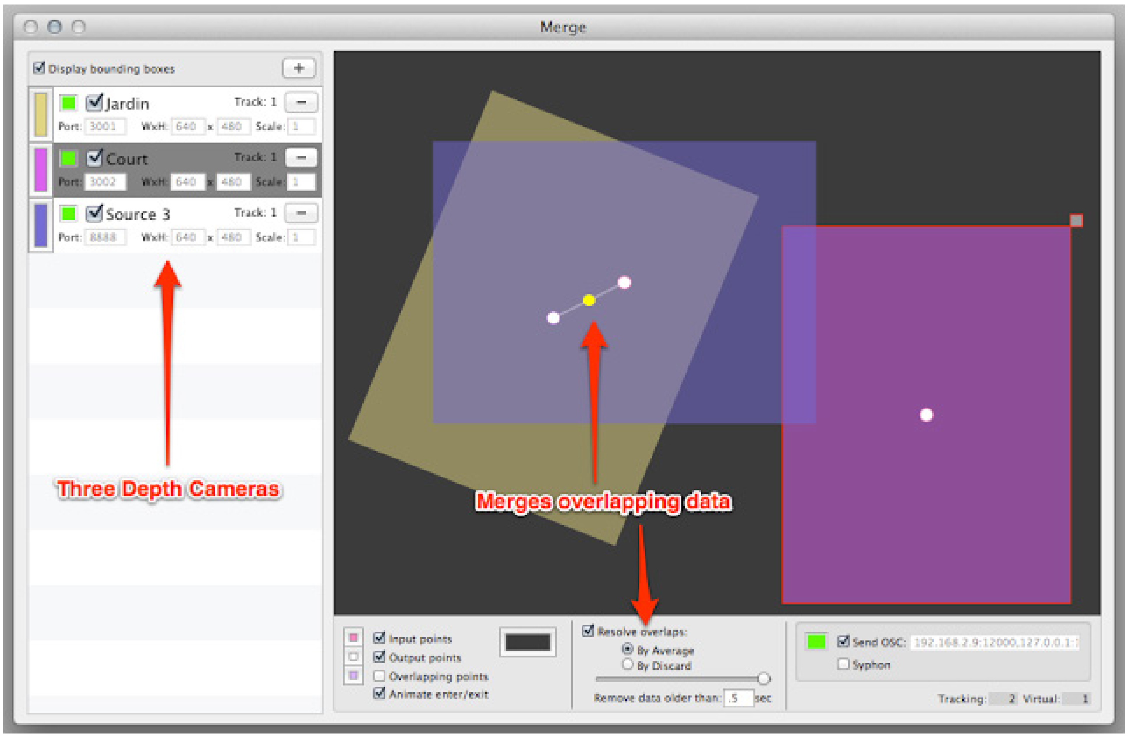
SHiNMu was already a work in progress which included a number of projected video elements, but none of these were interactive. Even working alongside David and his highly capable team it was not possible to completely re-engineer the show, although in practice this limitation proved to be extremely valuable. If you have the luxury, the best way to include technology into a performance is to develop the technology in parallel with the show itself. Remaining open to this way of working can push your technical development in interesting ways as with CYBOG[AME], or guide an understanding of the narrative itself as we will see with LIWYATAN/LEVIATHAN. Working in close parallel ensures a deep integration with the material. If this is not possible, it is best to forgo technical development until after the show has been significantly developed in a narrative and conceptual sense, as happened with SHiNMu. What this does is create a strong framework for aesthetic decision making that places the technology firmly in service of the story. This constrains technical movements and decisions to those which can be made in favor of the performance, strengthening both.

I began work on SHiNMu well after the dance itself had been choreographed and staged. The first challenge was technical: how to cover an area larger than I was able to cover with a single depth camera. This was the problem which had led me to engage with David and ENSAL in the first place and would culminate in the development of a piece of software called *Merge*, written for this purpose and deployed for the duration of the SHiNMu show.

3.1.3.1: MERGE

Merge is a piece of software created to collect and collate the data from multiple networked depth-camera sources. These sources can be any of the Primesense-based cameras. Previous work had been conducted using the Microsoft Kinect but for this show I decided to switch to the ASUS Xtion. The Xtion uses the exact same sensor as the Kinect but lacks a motor and visual camera. By removing the motor and additional sensors, the Xtion presents a significantly smaller and lighter-weight device than the Kinect and does not require an external power source, making it easier to work with in a theater environment.

Two Asus devices, each paired with a Mac Mini running a modified copy of TSPS, were mounted above the stage. A custom gigabit network carried the OSC data from these machines to the engineering booth, where a Macbook Pro running the Merge software collated the data and fed it into Unity3D. The output



☑ Display bounding boxes

☑ Jardin Track: 1
Port: 3001 WxH: 640 x 480 Scale: 1

☑ Court Track: 1
Port: 3002 WxH: 640 x 480 Scale: 1

☑ Source 3 Track: 1
Port: 8888 WxH: 640 x 480 Scale: 1

Three Depth Cameras

Merges overlapping data

☑ Input points
☑ Output points
☐ Overlapping points
☑ Animate enter/exit

☑ Resolve overlaps:
● By Average
○ By Discard
Remove data older than: .5 sec

☑ Send OSC: 192.168.2.9:12000,127.0.0.1:
☐ Syphon
Tracking: 2 Virtual: 1

Figure 3.7: Screenshot of Merge Software

of Unity was sent via Syphon into *Millumin*, a commercial software that was used to handle the mapping and stitching of three independent projectors which were used in the show.

Merge's main job is to collate the data from multiple independent networked data sources and handle rotation, scaling and positioning of the data. The interface provides a way to manually align the areas covered by each camera (represented by a colored rectangle). To get the best possible coverage on stage it is advisable to overlap the viewing areas of adjacent cameras slightly. This will ensure that there are no gaps in coverage, but creates a problem of overlapping data (a person visible to two cameras will appear twice). Merge resolves these overlaps by identifying points which occur simultaneously in an overlapping area and which are a certain user-adjustable distance apart. Once two points have been determined to indicate duplicate data, they are handled either by averaging the distance between them or discarding one of the points. The software speaks the TSPS protocol and can therefore be used directly with TSPS. For both ENSAL and SHiNMu, a slightly modified version of TSPS with better support for depth cameras was used. This setup required periodic manual calibration but performs well and was used without any major problem for rehearsals and one week of public performance.

The development of Merge allowed me to create an interactive system similar to that presented at ENSAL but over a much larger area. In both cases physical space was treated in a similar manner, using projection to turn the floor into a screen, although the purpose of the stage implementation was quite different. Deployed in the ENSAL space, this technology created a live-feedback loop between visitors to the space and the built environment, drawing attention to "ordinary" unscripted and un-choreographed movements in order to change a visitor's understanding of place.

Deployed on stage this same technology served not to change the dancer's relationship or understanding

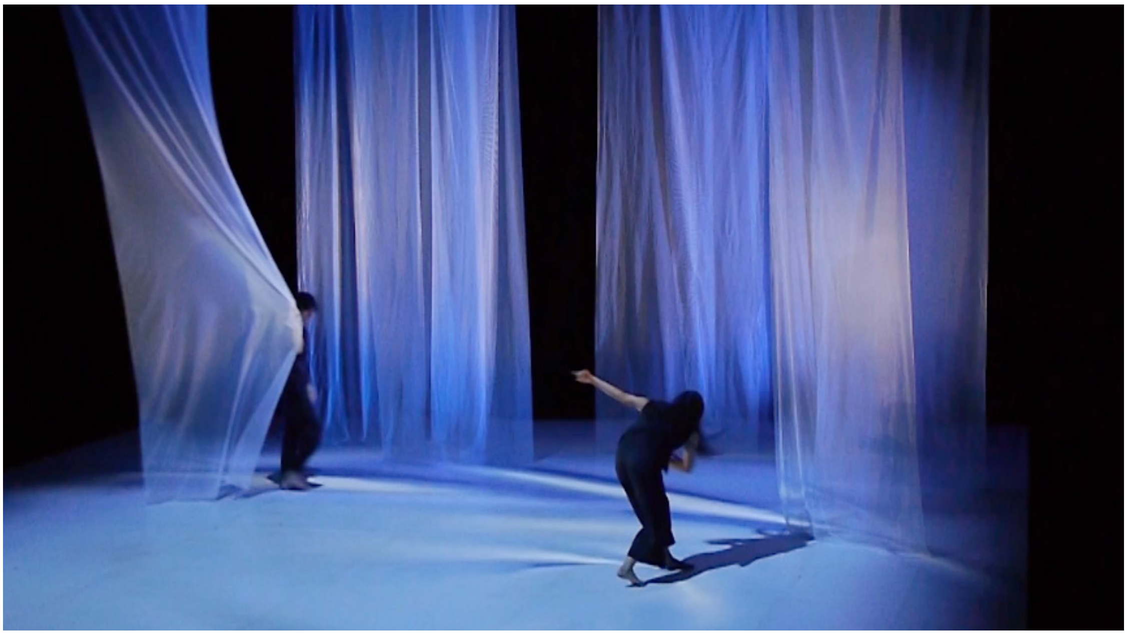


Figure 3.8: Scene 8, Duo. Note the interactive projection on the floor which is responding to both dancers and the fabric hanging from the ceiling.

of the space or their own movement but to *amplify* and *resonate* with the movement of the performers in order to emphasize and increase the impact of the performance on the audience. Since the technology was "touch-less" and required no wearable, little to nothing needed to change in terms of choreography or performance style and yet the aesthetic of the scenography and the sense of "place" could change at computational speed, the same technique as employed in CYBORG[AME].

The subtle but important distinction between these two types of audiences and environments can be understood by explaining a step in the calibration process. During installation the tracking system and the overhead projection system must be aligned so that the visuals occur at the spot where the tracked individual is standing. In the case of stage performance it is important that the visuals and the tracked position align almost exactly otherwise the illusion of the performer impacting the environment is spoiled. In the case of an installation, aligning the visuals with the tracked spot precisely makes it almost impossible for the audience to see their own visualization, as the projection appears on top of their head. Therefore it is preferable to introduce an offset in an installation environment.

3.1.3.2: DANCING WITH VIDEO

As with CYBORG[AME], the nature of the narrative and the aesthetic of the technology aligned well. Projection works well with the concept of fantasy and dreaming, although the two shows couldn't be more different visually. CYBORG[AME] is hard edged, sharp and stereotypically male and "gamer," characterized by high-contrast, sharp cuts and clearly "digital" visuals. SHiNMu is soft, stereotypically female and dreamlike, characterized by smooth movements, soft transitions and more analog visuals even during the horror sequences. Nevertheless, the same interplay between material/immaterial, physical/virtual is at work, allowing for an application of computation that makes strong narrative sense.

SHiNMu consists of nine consecutive dance pieces which are loosely linked in theme and content. All but one of the works contains video projection, although only three of the scenes are interactive in the sense

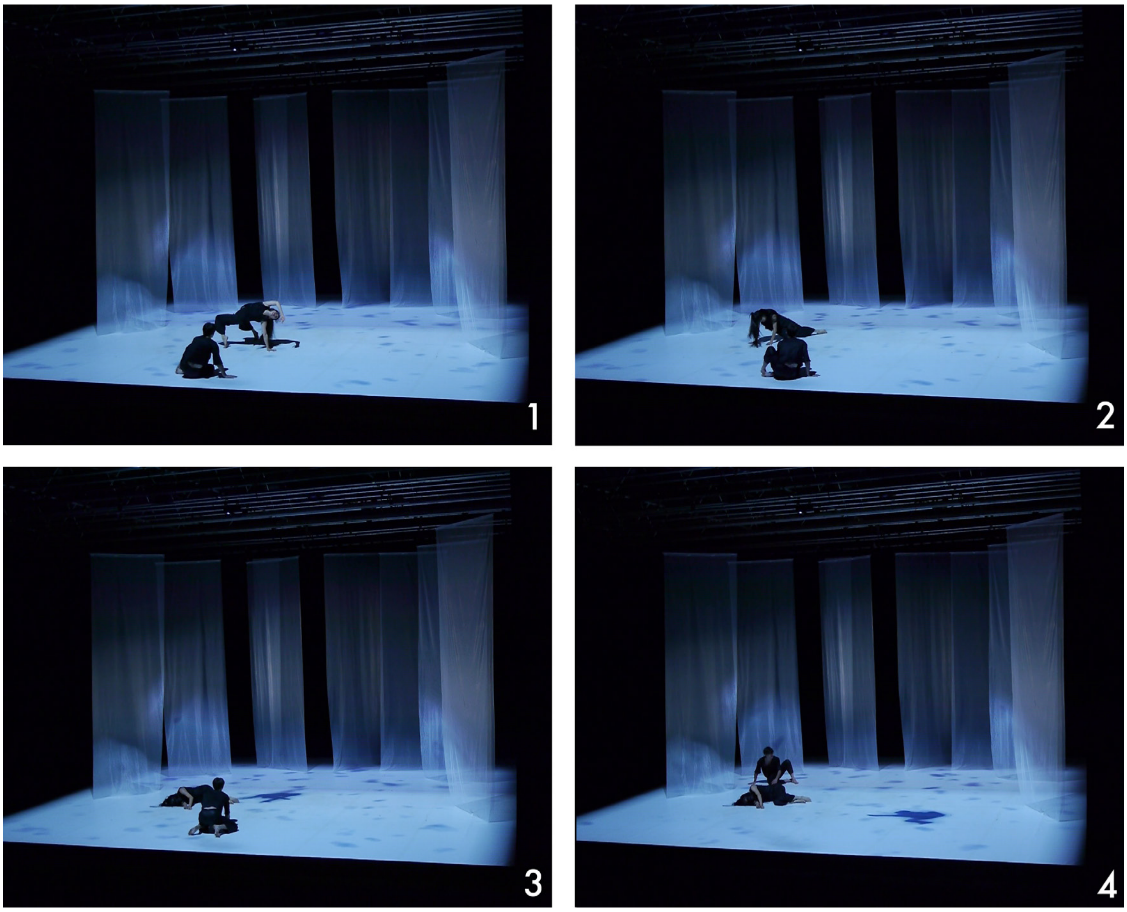


Figure 3.9: Visually this dance occurs on an evenly lit floor. The darker spots are static elements left over from a previous scene. 1.) Anan moves across a "normal" scene and 2.) Collapses. 3.) Her collapse triggers her shadow to disconnect from her body. 4.)The disembodied shadow moves by itself across the stage, occasionally interacting with Marc in a teasing manner before returning to Anan.

that the visuals are a result of real-time processing of movement on stage. The other scenes are either pre-rendered video or, in one case, pre-rendered video clips which were triggered manually to simulate complex interaction. Only one of the scenes is truly interactive in the sense that the dance and the computationally generated visuals might be considered equal participants. I will discuss each of these scenes below as we explore how computation and performers might co-exist on stage.

3.1.3.3: AMPLIFICATION BY MAGNIFICATION

Scene 8 of SHiNMu, called *Duo*, is a dance duet between Marc and Anan in which a sleepwalking Anan is "directed" by Marc to perform to a chopped and remixed version of Offenbach's can-can. In terms of narrative flow this number appears about halfway through the show. The scene is the fastest paced of all the choreography and includes several elements of physical comedy. Emotionally and aesthetically, the scene provides relief from the nightmare and introspective sequences which proceeded it. The scene is visually calm: monochromatic, bright and evenly lit. It is also the scene which most obviously features interactive projection mapping.

Using the overhead tracking system, the position of people and objects on stage are used to “push” against a fabric simulation generated by the Unity 3D game engine. The result is that the floor appears to be made of cloth over which the dance takes place. As a technical demonstration this scene is ideal for explaining the system and is similar to that implemented at ENSAL: low-latency overhead tracking via depth-camera is fed into a 3D engine. The subsequent output is mapped onto the position of bodies in space to create the illusion of normally static infrastructure reacting to the presence of actors on stage.

The primary difference between this and the ENSAL installation is that the impact of the generated floor is meant for the audience and not for the dancers. In a conversation with Marc after rehearsal I asked if he was aware of the interactive elements while he danced “I can tell if they’re working, but I don’t really see them. Anyway, they look different on stage.” Specifically, Marc was referring to the viewing angle and the fact that, on stage, the individual pixels were visible, making the graphics appear low-resolution. In the case of SHinMu, coverage of the entire stage was afforded by stitching together the image from two projectors. It is extremely difficult to match the color and brightness of two different projectors. These characteristics shift not only from model to model but also over the lifetime of the bulbs used in the projectors. Placement of the projectors is also a factor as most projectors have a “viewing angle” from which colors and image quality appear at their best. In addition to the alignment issue described earlier, when producing projection work on stage, compromises are made to ensure the audience view presents the best possible image. Frequently this comes at expense for the on-stage view, a fact which is actually of little concern given the role the technology is playing as a mechanism for aesthetic amplification. The one to one relationship between the movement on stage and the projected visuals are not meant to change the dancer’s perception of space but to convey a certain sensibility to those viewing the scene.

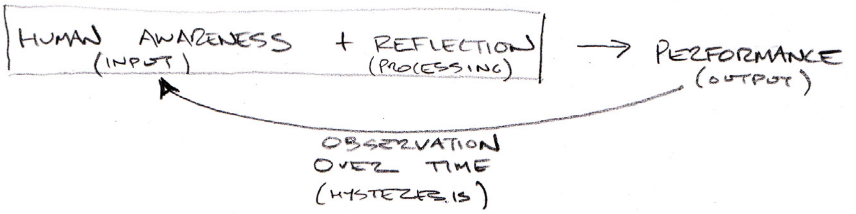


Figure 3.10: Computational Model + Human Awareness

In this particular case, the fabric content of the projection conveys the idea of a bed or sleep while also mimicking the hanging cloth that Marc moves during the dance. The notion of a responsive world evokes the dreamlike themes of the show, providing the illusion of elasticity and instability to the floor: an architectural element that we typically prize as being the most stable and level of surfaces. The quality of Anan’s choreography in this scene is also elastic like the fabric, and so the projection provides physical amplification of the dance movements by increasing the stage area that body movements can impact as well as emotional amplification by evoking a sense of place and by creating the impression that the building is echoing the dancer’s movements. This literal and figurative amplification through magnification is the first of two ways that computational technology can be used to amplify performance.

3.1.3.4: FAKE INTERACTIVITY / GENUINE AUTHORSHIP

Scene five of SHiNMu, *Shadow Play*, is one of the more recognizably dreamlike sequences of the show. This scene tells the story of a possessed Anan who dances until she collapses, each collapse freeing her shadow-self which is capable of independent movement until it returns to her body and motivates her to move again. In this scene Marc dances the part of a concerned observer who, along with the audience, witnesses the shadow's independent movement (Fig 3.9).

Technologically this scene was produced by projecting pre-recorded video of the shadow at specific times with the pacing of the dance arranged in such a way to complete the illusion. There is no "interactivity" in the scene at all. None of the graphics are generated by software and none of the tracking system is used. Instead, each shadow-clip is triggered by an operator in the technician's booth (usually me), watching for a physical cue from Anan who collapses at particular pre-determined locations on stage. At each collapse, a button is pressed in the booth to trigger playback of the next segment of the shadow video. Marc times his movements in response to these videos, but the pacing proceeds according to Anan's performance. This allows the dance segments to remain freeform in terms of length and movement around the stage, provided that Anan always "collapses" at the pre-determined location.

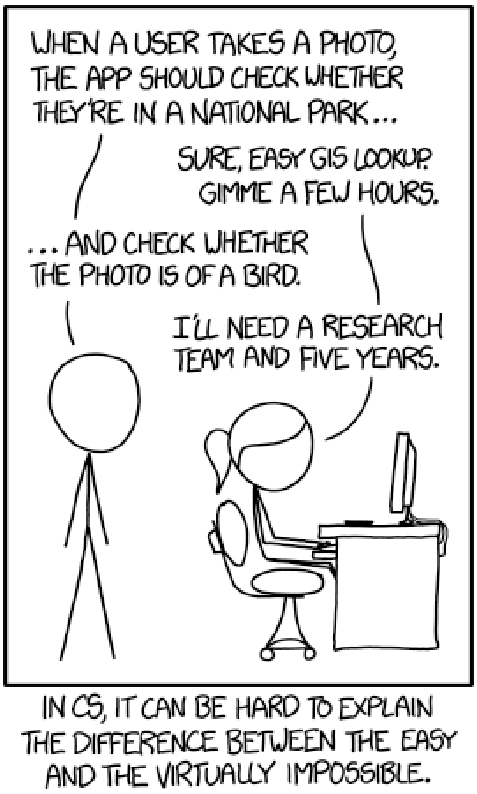

WHEN A USER TAKES A PHOTO, THE APP SHOULD CHECK WHETHER THEY'RE IN A NATIONAL PARK...
SURE, EASY GIS LOOKUP. GIMME A FEW HOURS.
...AND CHECK WHETHER THE PHOTO IS OF A BIRD.
I'LL NEED A RESEARCH TEAM AND FIVE YEARS.
IN CS, IT CAN BE HARD TO EXPLAIN THE DIFFERENCE BETWEEN THE EASY AND THE VIRTUALLY IMPOSSIBLE.

Figure 3.11: XKCD Tells it like it is.

Although nothing in this scene is computationally generative, it remains aesthetically consistent with the rest of the show. This is important to highlight because it clarifies the complex inter-relationship with technology that human performers and technicians play in creating a whole performance. As with the *Duo* scene discussed earlier, the primary goal here is not to change the understanding of the performer or the technicians involved in the production but to create an overall experience for the observers of the scene. Consequently from an audience perspective, the knowledge of which segments of the performance are generated versus pre-recorded, which use tracking software versus "human sensing," is irrelevant. What matters in the end is the *gestalt* of the performance, created not by isolating the roles of performer, technician and computer, but by creating a complex interplay in which all three are necessary co-authors of the experience.

The decision not to use "pure" computation for complex interactions like this one is a practical one. Programming computer vision software to follow subtle cues such as "human falls on ground and twitches left wrist" is one of many problems which are extremely difficult to model but easily handled by a human observer (Figure 3.11). But while this decision was driven by practical concerns it demonstrates an interesting fact: allowing for the inclusion of human decision making in the awareness->reflection->performance loop also allows us to access the aesthetic qualities and power of computation without needing to sacrifice human intelligence or aesthetic sensibility. This notion, that computation can be treated as a prosthesis to amplify human capability, is a hallmark of computational epistemology demonstrated throughout this piece both visually and in the way it was produced.

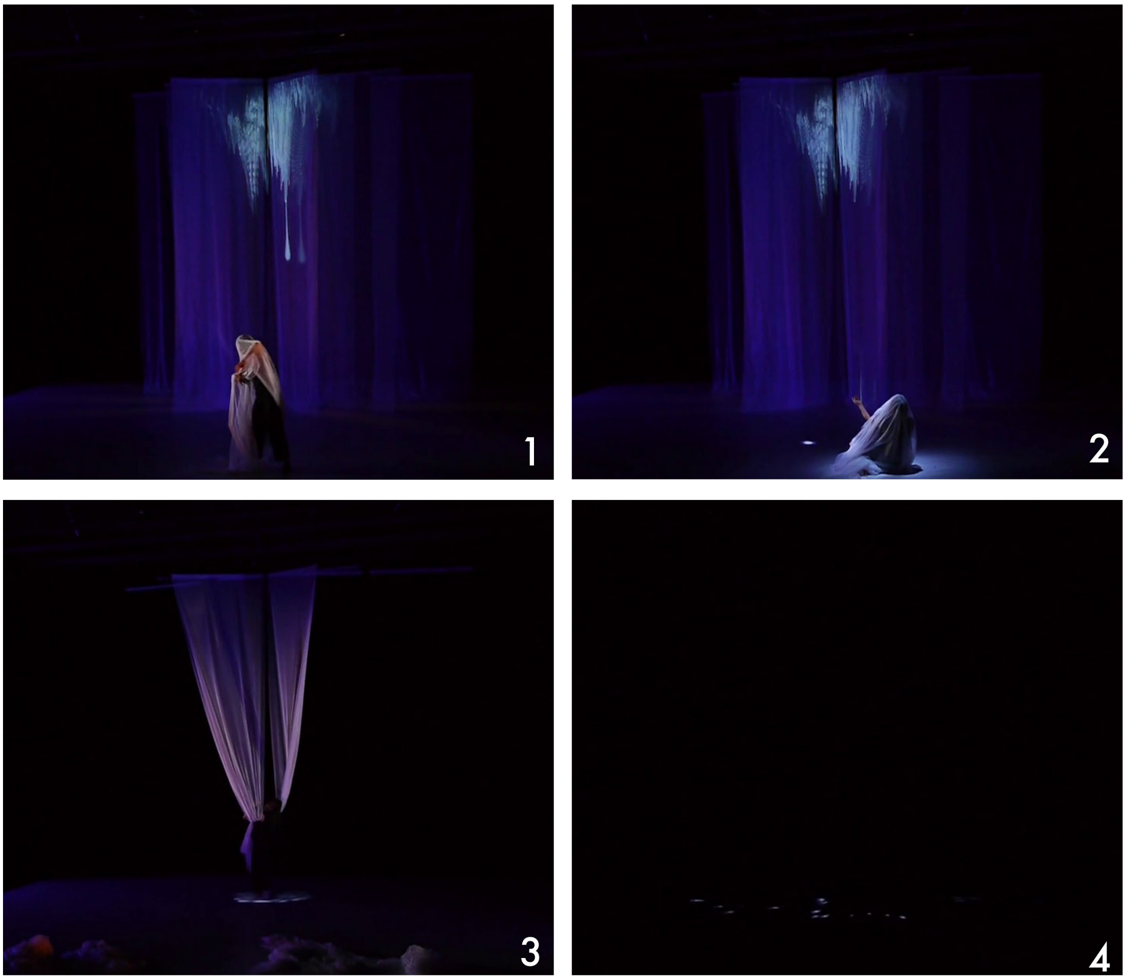


Figure 3.12: 1.)Reaching the heart of the labyrinth, Anan finds a cave populated by light-creatures which appear first as water droplets from the ceiling. 2.) When the droplets touch the ground they become independent entities which explore the space before 3.) Clinging to and circling around either Anan or to the cloth which is hanging from the ceiling. 4.) At the end of the piece, Anan pulls the cloth from the celling and the entities burst outward before fading from view.

3.1.3.5: AMPLIFICATION BY RESONANCE

Scene 9, *Labyrinthe*, immediately follows the *Duo* scene described earlier, and features an awake and alone Anan navigating a labyrinth on her own (Fig 3.12). In this scene, the “light-creatures” are computer-generated sprites given a few simple rules: when “born” each creature should find and circle the nearest physical mass as indicated by the tracking system. Creatures are born by pressing a button in the technician’s booth, an event which is triggered by the technician watching for the prerecorded video of the droplet to hit the bottom of the screen. Once created the entities operate independently and neither the dancer nor the technician has much control over whether or not they will circle Anan or another element in the space. Furthermore, if Anan moves quickly enough, it is possible to “dislodge” an entity, at which point it will circle for a bit, either re-joining her or settling in orbit around the hanging cloth. The “burst” at the end is created by hitting another button in the booth. The beginning and end of the life of each sprite is controlled manually, but the quality of their life is algorithmic and somewhat unpredictable.

As with *Shadow Play*, this scene demonstrates a certain sensibility towards the role of the projected scenography: the visuals are activated and dismissed manually. However, here computation is acting as a co-performer. The computational presence on stage is stochastic. While the behavior is programmed it is described to the computer as a ruleset. The actual performance on stage proceeds with input from the real world and thus the behavior is unpredictable and never exactly the same thing twice. Much like the microtones produced by a human musician[123], and like the delays introduced into the typing behavior in CYBORG[AME], this serves to provide a degree of "alive-ness" and changes the role that computation is playing on stage.

Computation here is not acting as a magnifier as in *Duo*, nor as a means to tirelessly reproduce a script as in *Shadow Play*, but as something approaching a collaborator. The action of computation in space in this case is a *resonant* one: the behavior of the system emphasizes the action of the performer by creating a proximal and supplemental aesthetic activity in concert with the dance. This begins to approach the idea of how we really use our mobile computation to experience space and demonstrates how computational epistemology has altered our view of the world around us. Computation encourages us to think of our environment as a collaborator. Our spaces are not only amplifiers capable of magnification nor are they simply machines for living[124], but actors in a network of authorship[125] whose activity in relation to our own creates a momentary sense of place and purpose. Not end points, but material in constant state of flux. This is amplification through *resonance*.

3.2: THE AESTHETICS OF INTERACTIVITY

The development of a tracking system coupled with video projection system over that same area allows us to demonstrate the ways in which computation can be used to make connections visually and conceptually between space and the people in it. The precise nature and outcome of these interactions depends heavily on the environment in which they are deployed, although both are dependent on our understanding of computation as a co-author in the development of a space into place.

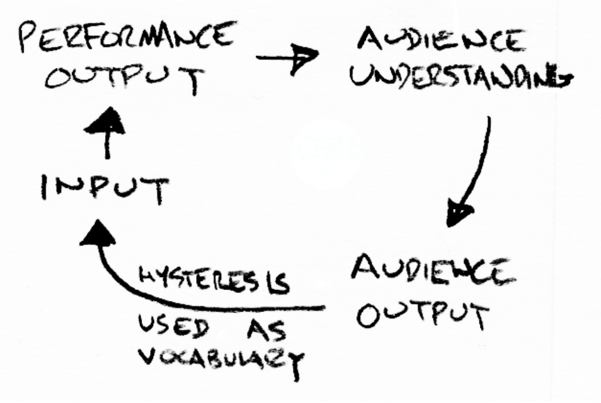


Figure 3.13: Human/computation model of co-authorship.

Theatrical space and stage provide a particular type of environment for exploring these ideas. Public space provides another. In both of the examples presented above (ENSAL and SHiNMu), we see the use of projection to connect sensory perception with physical movement and sense of time. Computation allows two types of amplification of perception: magnification and resonance, both created through the use of the loop. Looping also allows for sense of memory and understanding over time, and so we see that the impact of using computation to augment architecture can be a shift in perception of both time and space. Architecture is typically meant to be experienced as if it is timeless or else considered on a seasonal or even geologic scale. Using computation we can challenge this.

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[123] Sethares, William A. *Tuning, Timbre, Spectrum, Scale*. 2nd edition. London: Springer, 2004.

[124] Bacon, Mardges, Barry Bergdoll, and Le Corbusier. *Le Corbusier: An Atlas of Modern Landscapes*. Edited by Jean-Louis Cohen. New York: The Museum of Modern Art, New York, 2013.

[125] Latour, Bruno. *Reassembling the Social an Introduction to Actor-Network-Theory*. Oxford; New York: Oxford University Press, 2005. http://site.ebrary.com/id/10233636.

The primary distinction between the deployment of the same technology in theatrical versus public space is one of audience. In a public space the audience and the interactor are often one and the same. The system must be tuned so that the best perception of the interaction can be had by the person in direct dialog with the system. In a performance context, feedback to the performer is not as important as the overall experience as perceived by the audience. This opens up possibilities for incorporating humans into the computational loop in interesting ways, expanding the ability of both computation and human in a relationship of co-authorship.

3.3: HUMANITY, COMPUTATION AND CO-AUTHORSHIP

Taken as a whole the experience of a computationally mediated performance is not a matter of a activity undertaken by technicians, software systems, or the performers themselves but rather is a complex network of interactions between all such actors. There are narrative moments which are best communicated by software alone while others are best performed unmediated or in combination with technicians, or by traditional scenographic techniques such as music and lighting. In many cases it is a combination of all of these things that make it difficult to say exactly who or what is producing “the performance.”

In order to facilitate this further in almost all cases the audience is kept deliberately unaware of technical distinctions between puppetry and interactivity, scripted and emergent behaviors. This is of course done for the sake of the performance but often also in service of narrative and culture in a somewhat complex way. As we have seen with the Shadow Play scene in SHiNMu and will see even more clearly with *LIWYATAN/LEVIATHAN* and HeartCollector projects, performances which include technology in a central roll often rely on playing with audience understanding of that technology. Playing with the edge of that understanding (IE producing an unexpected or surprising result) is the site of both delight and of new knowledge-generation and understanding on the part of the audience and the performers alike.

Computational technology can be employed to shift attention and change spatial relationships in a way that both challenges and shapes our model of space: what it is used for and what it can do. These performances also challenge and shape our model of computation itself: what it is used for and what it is capable of. Thus our initial (INPUT->PROCESSING->OUTPUT) model of computation is repeated on a larger scale. With each performance, the output is fed back into the audience understanding of the world as it is and how it could be. In the best cases the audience subsequently behaves (or thinks) differently as a result of the shift (Figure 3.13). This change in behavior and/or understanding can be understood as an aesthetic, providing a vocabulary that can be used in future performances. Our understanding is therefore co-authored and in-relation-with technology, most especially when it is applied to culture.

In this way, computationally mediated stage performance mirrors the way that we use computation and increasingly computers in our everyday lives. Early on computers were slow calculators, used to “number crunch.” While even the earliest and slowest of these machines was faster than a human at solving mathematical problems they were not initially seen as co-problem-solvers but as tools used by humans solving the problems. Computation was something that was applied to a problem as needed and then turned off. As computers have increased in speed and in particular as we have made them smaller, networked and mobile, the notion of “turning off” is becoming meaningless. Computation is not a tool that we pick up and use occasionally, but a prosthesis for understanding and communication that has become inextricably linked to the way we live our lives.

3.3.1: ARTIFICIAL-ARTIFICIAL-INTELLIGENCE

This change in the way that we use computational objects also changes the way that we think of computation, a framing that can be seen clearly if we look at a curious conceptual shift that has occurred in the field of Artificial Intelligence research. The holy-grail of computer science, AI has traditionally set its sights on creating a sentient computer: an intelligence which is artificial in the sense that it was crafted by human hands out of manufactured parts but that otherwise behaves in a manner indistinguishable from a fellow person.

Early AI researchers set their sights on chess as a milestone to represent human reasoning. Chess is an easy game to model but a difficult game to play and, at least superficially, requires a large amount of that which we might call thoughtfulness or foresight in a human, or “processing power” in a computer. At its infancy, AI researchers were faced with computers which had limited capabilities and in some ways it was exactly this limitation that made the AI promise so tantalizing. We can see how much space mainframe computers take up. We understand these computers could not possibly fit inside our skulls, and yet humans are good at certain tasks and not at others. Aesthetically it seems a straightforward proposition: if large and visibly complex computers are good at certain “high level” tasks such as math, they are probably also good at “low level” tasks such as emotion and social interaction performed by our physically much smaller brains which appear visually far less complex. What is missing is merely the right language to teach them.

Pulling the thread on the reasoning surrounding early AI research reveals endless problems ranging from miscategorizations of human behavior to inherent and heavily gendered assumptions about goodness and technology. Nevertheless it is true that if we could solve such a problem it would solve the need for an increase in brute-force computational power, which has wide ranging implications for cost and energy savings. This early framing of the possibility of the work is echoed throughout the writing of the pioneers of AI. In *What is Artificial Intelligence*, updated as late as 2007, AI pioneer John McCarthy writes on the necessity of using faster computers to obtain AI: “Some people think much faster computers are required as well as new ideas. My own opinion is that the computers of 30 years ago were fast enough if only we knew how to program them.”

McCarthy goes on to explain his disappointment in the way the chess problem has been solved and in the general increase in computational power thrown at the problem: “Playing chess requires certain intellectual mechanisms and not others. Chess programs now play at grandmaster level, but they do it with limited intellectual mechanisms compared to those used by a human chess player, substituting large amounts of computation for understanding. Once we understand these mechanisms better, we can build human-level chess programs that do far less computation than do present programs. Unfortunately, the competitive and commercial aspects of making computers play chess have taken precedence over using chess as a scientific domain. It is as if the geneticists after 1910 had organized fruit fly races and concentrated their efforts on breeding fruit flies that could win these races.”[126]

Perhaps McCarthy is right and in the long run we will discover a language capable of teaching a computer from the late 1970s to think. This would indeed have profound implications and is worth researching, but in the meantime what early AI has missed is that by applying large amounts of computation as a “substitute” for understanding, we have in effect solved the practical problem that AI set out to solve in the first place.

Computers may not think the way you and I think, but the telephone in my pocket now has enough power to work in partnership with my own mind to solve everyday problems faster and more efficiently than I ever could before, and this device is likely to be obsolete in six months. I don't need my phone to play chess at a grandmaster level if it can play chess at a level enough to challenge me. Better yet, I don't need my computer to play chess at all if it can find me a good restaurant recommendation in short time.

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[126] McCarthy, John. *What Is Artificial Intelligence*?. Stanford University, 2007. http://www-formal.stanford.edu/jmc/whatisai/whatisai.html.

Since the 1970s, the target of much of the increase in processing power has not gone into simulating understanding or even performing calculations, but into user interface. The most computationally powerful piece of hardware in your average desktop, laptop or mobile telephone is the graphics processor. Advanced processing for processing sake remains at the heart of important research agendas in computational biology, economics and healthcare, but it says something that we have spent almost all of our computational efforts on increasing the ability of computers to render visuals. In short, we are spending most of our effort on getting computers to communicate with us aesthetically, socially and emotionally.

This shift in understanding of what computers and computation are good for: neither slaves nor masters but prosthetics and peers, is yet another example of the ways in which computational epistemology has changed our thinking. This shift is clearly reflected in everyday use of computers but it also is reflected in a shift in more contemporary AI research.

In 1990 Roboticist and AI Research Rodney Brooks argued in a paper called *Elephants Don't Play Chess*[127], that in order for robots to accomplish everyday tasks they would need to be able to develop abstract thinking based on hand-eye coordination. Brooks has argued successfully from a robotics perspective that in order for AI to become useful there needed to be a shift from emphasis on mathematical computation and processing power and towards *behavior*. Working with Brooks, Dr. Cynthia Breazeal received her Science Masters in 1993 from the MIT Artificial Intelligence Lab and subsequently obtained her Doctor of Science in 2000 in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology. Breazeal's current research work "…focuses on developing the principles, techniques, and technologies for personal robots that are socially intelligent, interact and communicate with people in human-centric terms, work with humans as peers, and learn from people as an apprentice. … Her recent work is investigates the impact of social robots on helping people of all ages to achieve personal goals that contribute to quality of life." [128] Breazeal's work is nothing at all like a mainframe computer playing chess but instead resembles emotionally evocative creatures with childlike characteristics, including a huggable owl and a robot which converses at the level of a toddler. The goal is not to create machines that think, but machines that can evoke an emotional response in the human collaborating with them.[129]

Even in research which emphasizes the use of serious computational power we have seen a shift away from imagining computation as an external intelligence that we consult with as an oracle and towards computation as a tool that works in dialog with our own thinking. IBM Research, famous for the development of the chess playing computer *Deep Blue* which beat world Champion Gary Kasparov in 1997, retired that project shortly after the competition and began looking for a new "Grand Challenge."

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[127] Brooks, Rodney A. "Elephants Don't Play Chess." *Robotics and Autonomous Systems* 6 (n.d.): 3–15. Accessed January 13, 2015.

[128] Breazeal, Cynthia. "Biography." Accessed January 13, 2015. http://web.media.mit.edu/~cynthiab/bio/bio.html.

[129] Breazeal, C. "Role of Expressive Behaviour for Robots That Learn from People." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364, no. 1535 (December 12, 2009): 3527–38. doi:10.1098/rstb.2009.0157.

Breazeal, Cynthia. "Emotion and Sociable Humanoid Robots." *International Journal of Human-Computer Studies* 59, no. 1–2 (July 2003): 119–55. doi:10.1016/S1071-5819(03)00018-1.

Breazeal, Cynthia. "Toward Sociable Robots." *Robotics and Autonomous Systems*, Socially Interactive Robots, 42, no. 3–4 (March 31, 2003): 167–75. doi:10.1016/S0921-8890(02)00373-1.

Breazeal, Cynthia, and Brian Scassellati. "Robots That Imitate Humans." *Trends in Cognitive Sciences* 6, no. 11 (2002): 481–87.

As a followup to *Deep Blue*, IBM unveiled *Watson* in 2011, a data-mining software built on massively parallel computational backend capable of natural language processing and deep search on a large number of databases. The challenge that the IBM team set for themselves was to enter Watson as a contestant in the trivia game show *Jeopardy!*. Watson won the competition, but while superficially the two projects (Deep Blue and Watson) are both game-playing computers, the philosophy in terms of how they arrived at their wins couldn't be more different.

Deep Blue owes its legacy to the older model of AI: computer as an expert problem-solving machine. The intention is to process a large number of possibilities but ultimately to arrive at a single "best move" in order to win the game. While Watson did indeed compete in a game show, the output of Watson consists of a weighted average of a number of possible solutions. Watson is a powerful "solution suggester" intended to return a range of possibilities to help humans make a decision. As a researcher at IBM I was struck when one of the senior scientists who working on the project made a point of remarking that Watson would run quite happily on a standard laptop "only really slowly." The "magic" wasn't in any assumption or implication that the computer was thinking, only that through shear processing power, computation can *behave* intelligently. In a sense, Watson really isn't all that different than *Siri*, the natural-language personal assistant available on all current iPhone devices, and this role of computer as peer is reflected in IBMs marketing material which describes Watson as ushering in an era of cognitive computing to "… enables a new partnership between people and computers that enhances and scales human expertise."[130] Current work on Watson seeks to integrate the machine into medical practice, but not as a robot diagnostician that one might imagine. Watson isn't meant to be a doctor replacement, but rather to help a human doctor arrive at a diagnosis by, for example, analyzing a patient's records alongside all known medical literature. In this way the software might suggest weighted correlations between symptoms and possible causes, leaving the doctor to determine if these correlations make sense or bear further investigation. There may be cases where these correlations are extremely useful, drawn as they are from data and not clouded by the doctor's own expectations. In the end the doctor makes the decision. While the marketing myth of Watson is one in a line of intelligent machines, the reality is that we have come to see the "dumbness" of technology as an asset when used correctly. Robots are not our overlords although they may yet become powerful prosthetics.

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[130] IBM. "IBM Watson." CT004. Accessed January 13, 2015. http://www.ibm.com/smarterplanet/us/en/ibmwatson/.

4

CHAPTER FOUR COMPUTATIONAL SHIFTS

Chapter 4 describes the production of Paul Auster's book *Leviathan* as a stage play by the theater group MOTUS working with students at La Manufacture in Lausanne, Switzerland. The play was produced using video mixing software which I wrote and which allowed the story to be told in a uniquely contemporary manner.

The staging of Leviathan provides a way to answer the question "How does computation shift perception of place?" and ultimately allows us a basis for comparing the changes which technology brought to our understanding of video surveillance.

Of particular interest is the treatment of photography in Auster's original text (1992) versus treatment of the same material in the stage production (2014). **This comparison allows us to answer the question "How does computation shift perception of self?"**

Finally, this chapter examines the same question from a data-centric perspective, using the project *Heart-Collector* to see how the "quantified self" movement has re-framed the way that we see ourselves and our bodies.

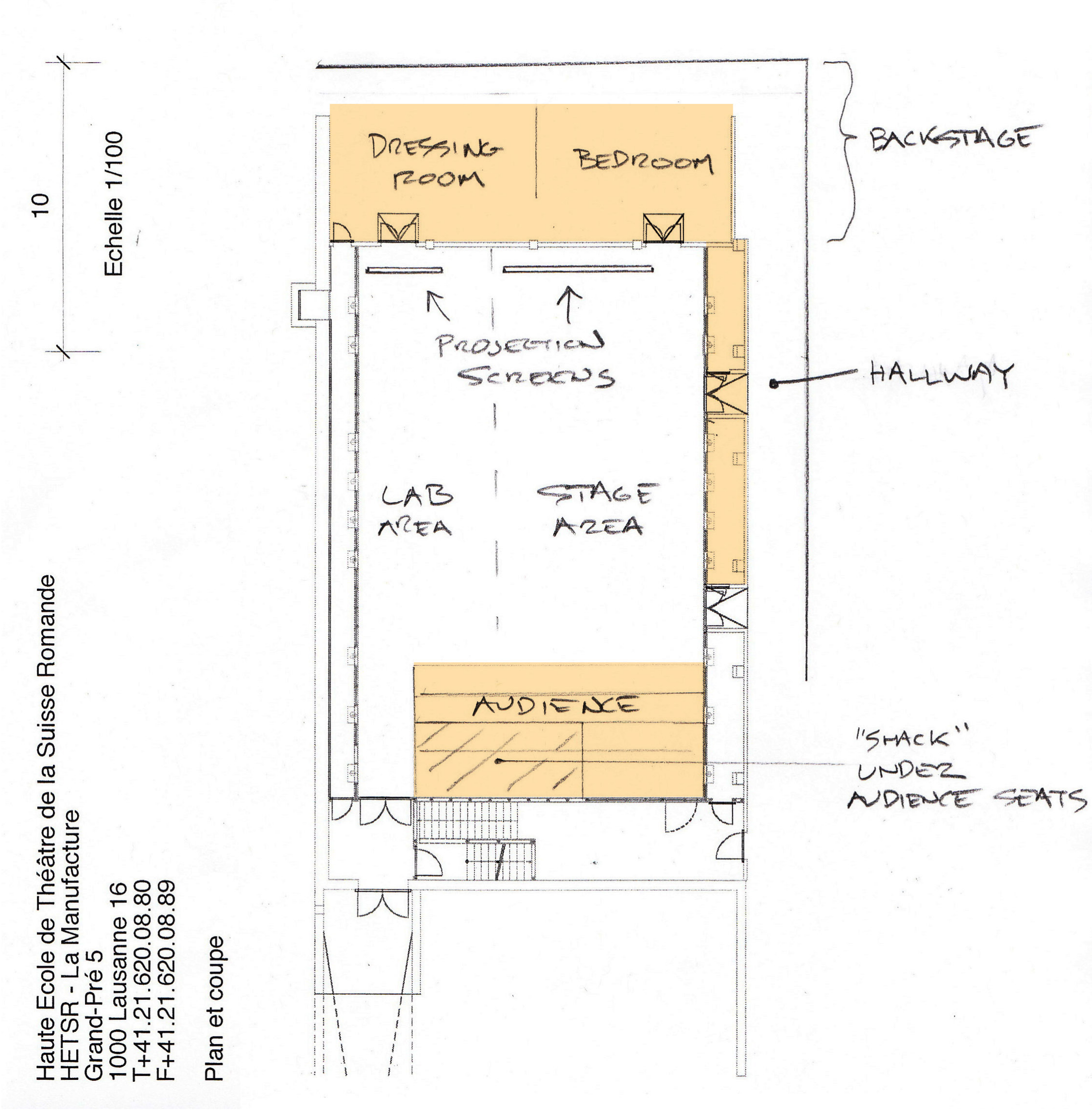
10
Echelle 1/100
DRESSING ROOM
BEDROOM
BACKSTAGE
PROJECTION SCREENS
HALLWAY
LAB AREA
STAGE AREA
AUDIENCE
"SHACK" UNDER AUDIENCE SEATS
Haute Ecole de Théâtre de la Suisse Romande
HETSR - La Manufacture
Grand-Pré 5
1000 Lausanne 16
T+41.21.620.08.80
F+41.21.620.08.89
Plan et coupe

Figure 4.1: The stage layout for LIWYATAN/LEVIATHAN showing the various locations where the action takes place, including the hallway and writing shack under the audience seats.

4.1: A VISUAL LANGUAGE OF RE-LOCATION

4.1.1: HOW DOES COMPUTATION SHIFT PERCEPTION OF PLACE?

We have seen the ways in which computation can be used as an authoring tool to make perceptual shifts, but do these shifts also occur “naturally?” The last decade has been marked by an uptake in personal computing devices which are equipped with cameras and are always online, presenting a situation where the whole world really is a stage. The world and its architecture becomes a backdrop on which we act out events real and imagined, documented and presented on social media platforms in a real-time performance of life. Has this social behavior, enabled by our application of computational ideas to social interaction, changed the way that we think about space? If so, is this change sufficient to allow a theatrical production to take advantage of the relationship? How can computation shift audience perception of place?

In geographic terms, *space* indicates a location, whereas *place* indicates a particular space which has become imbued with value or meaning.[131] One of the key characteristics of theatrical space is that it is designed to be manipulated through the use of lighting, sound design, scenography and the audience’s own willing suspension of disbelief.[132] This process allows theatrical space to serve as whatever place a narrative needs. This is a fundamental technique of stagecraft and is as old as theater itself, although as we have seen contemporary technologies have given it a new twist by allowing us to de-materialize the physical or create architecture from text as with *CYBORG[AME]*, amplify a traditional performance as with *SHiNMu*, or change our relationship to the built environment as with the ENSAL *Desire Paths* installation.

In each of these cases we have relied primarily on non-representational visuals. CYBORG[AME] used glyphs and patterns. ENSAL and SHiNMu used sprites and colors. Portions of CYBORG[AME] used recognizable body shapes, but these pointclouds were characterized by an abstraction of form. What has computation done to our understanding of *representational* information?

Computational epistemology is characterized by an understanding of the world brought about through internalization of computational ideas. In this case the key idea is an increased sensitivity to layering both literal and metaphorical. By thinking computationally we become attuned to the idea that what we see is one of many: there is always *more*: more context, more data and more explanation. In particular, the use of networked mobile cameras allows us to both consume and perform a narrative layer on space. By performing our lives in public or private space we use and transform the places around us as a stage and a framing device. The world becomes scenography for our performance of self and each of us becomes both performer and author. This activity carries with it a particular aesthetic: visual cues that signal to our audience the type and validity of our performance. “Selfies,” or photographs taken of oneself using a handheld smartphone, provide a good example of this. In terms of content, these images are mostly pictures of people, but selfies share a particular point of view. Such images tend to be roughly the same distance between camera and subject (an arms length) and tend to frame the subject in more or less the same way. Images from these devices also have a particular visual signature caused by the fact that the cameras used in their manufacture feature pinhole-type apertures with wide-angle lenses, providing infinite depth of field and similar resolution, color and light response. These images are shared en-masse daily in a ritual of self-documentation, and taken as a whole form a very specific aesthetic vocabulary.

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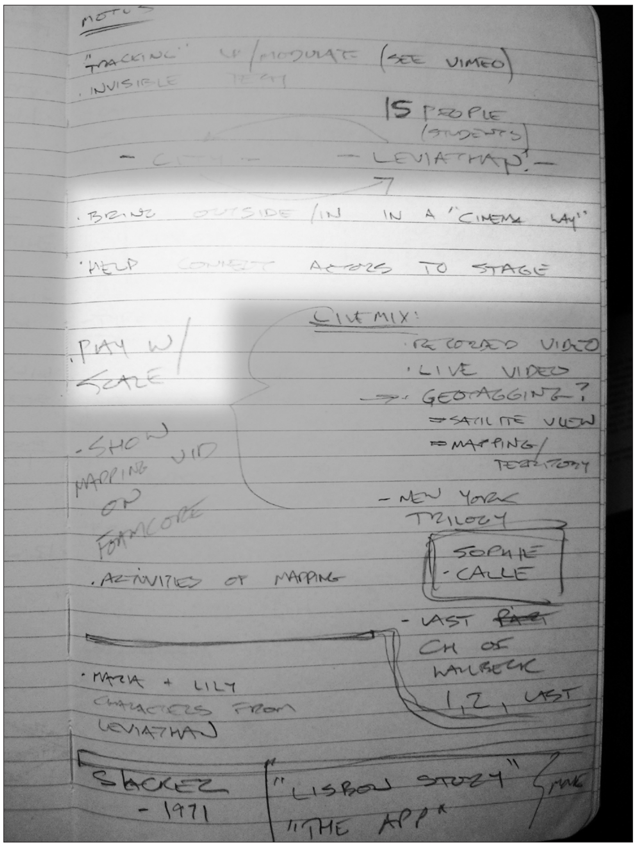
[131] Tuan.

[132] Coleridge, Samuel Taylor. Biographia Literaria - Or Biographical Sketches of My Literary Life and Opinions (1817). Pomona Press, 2006.

Can we deploy this aesthetic vocabulary explicitly to tell a story? This was the challenge of LIWYATAN/LEVIATHAN, an adaptation of Paul Auster's 1994 novel staged by the Italian theater group MOTUS. For this project I created a tool which allowed for realtime layering of photographic images: still, pre-recorded and live-streamed from mobile cameras. Actors in the play were given iPhones and asked to shoot the scenes they were playing in, allowing us to move freely between theatrical and cinematic storytelling vocabularies. Although staged traditionally with the audience seated for the duration of the performance, the action of LIWYATAN/LEVIATHAN took place around the building and across the city: on the main stage, but also in the hallways, backstage, under the audience and in the streets and forests of Lausanne. The play accomplished this through extensive use of distributed video, relying on the audience's understanding of "selfie culture" and Internet video and photography in order to shift the story in time and space.



MOTUS

"TRACKING" UP/MODULATE (SEE VIMEO)

. INVISIBLE TECH

15 PEOPLE (STUDENTS)

– CITY – – LEVIATHAN! –

. BRING OUTSIDE/IN IN A "CINEMA WAY"

. HELP CONNECT ACTORS TO STAGE

. PLAY W/ SCALE

LIVE MIX:
. RECORDED VIDEO
. LIVE VIDEO
→ . GEOTAGGING?
⇒ SATELLITE VIEW
⇒ MAPPING/ TERRITORY

. SHOW MAPPING VID ON FOAMCORE

– NEW YORK TRILOGY

SOPHIE - CALLE

. ACTIVITIES OF MAPPING

– LAST ~~PART~~ CH OF WALLBECK 1, 2, LAST

. MARIA + LILY CHARACTERS FROM LEVIATHAN

SACKER - 1971

"LISBON STORY" "THE APP" MAKE

Figure 4.2: Notes from the initial meeting: "Play w/ Scale" / "Bring outside/in in a 'cinema way'" / "Help connect actors to the stage."

4.1.2: WHOSE MAP? WHOSE TERRITORY?

In March of 2014 I met with Enrico Casagrande and Daniela Nicolò, the principles of MOTUS theater company. Daniela and Enrico had arrived to participate in the SINLAB artist in residence program and had just completed the first week of working with HETSR acting students using Paul Auster's novel *Leviathan* as source material. Their intention was to stage a play around that text that also layered in local geographic elements from nearby Lausanne. The novel is by an American author and set quite specifically in New York and New England, so this by itself seemed challenging, but they also told me they would also be using video and photography, live and pre-recorded, alongside live performances on stage. Furthermore the production was intended to occur in many physical locations in and around the main stage. The story, Daniela told me, would only be clear if you sat still and watched the video unfold, otherwise each small play and location would be related but not contain the whole narrative.

As usual when approaching a working relationship with strangers, the initial meeting is about establishing roles and sorting out who participates and in what ways. My role in this project, and in most of the projects presented throughout this document, was not to act as the primary artist. My initial approach resembled most closely the approach I follow in design practice. As a designer I treat the initial encounter as a fact-finding mission. I ask questions and take notes. I try and see how I can help. I work to form in my mind the production as the client sees it.

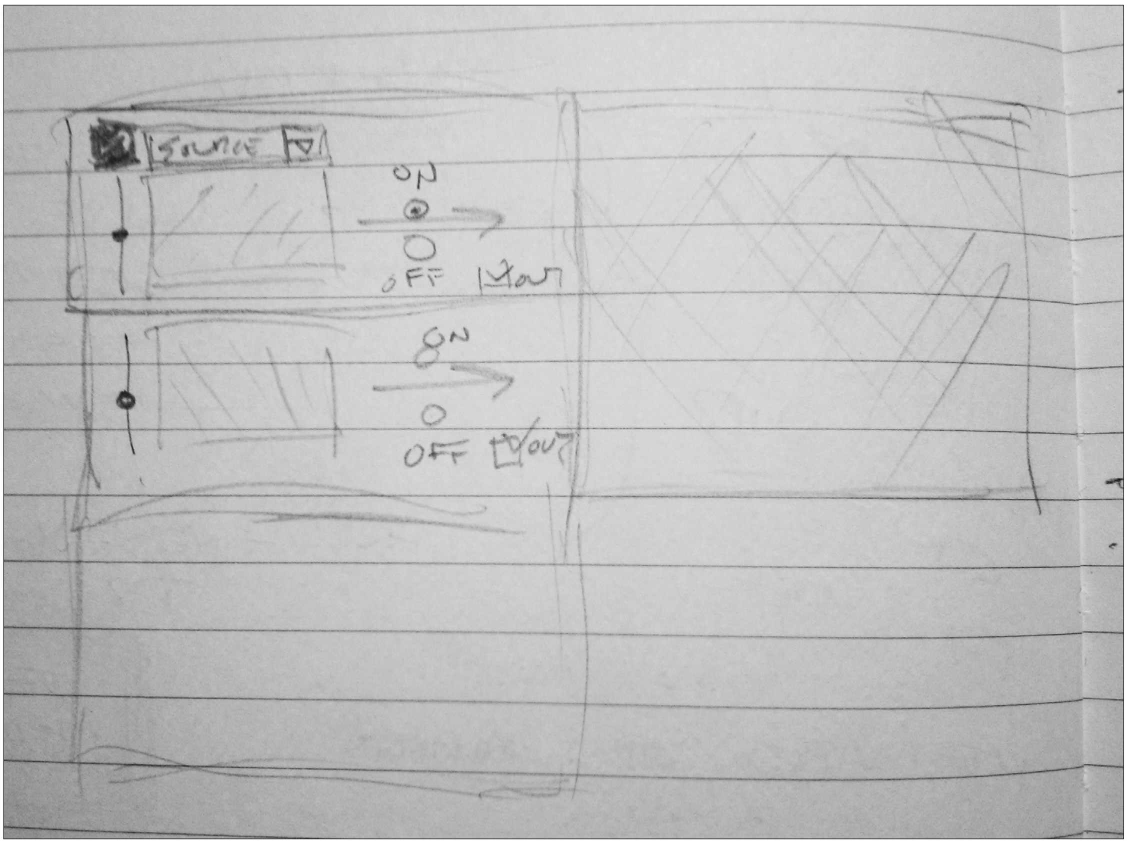
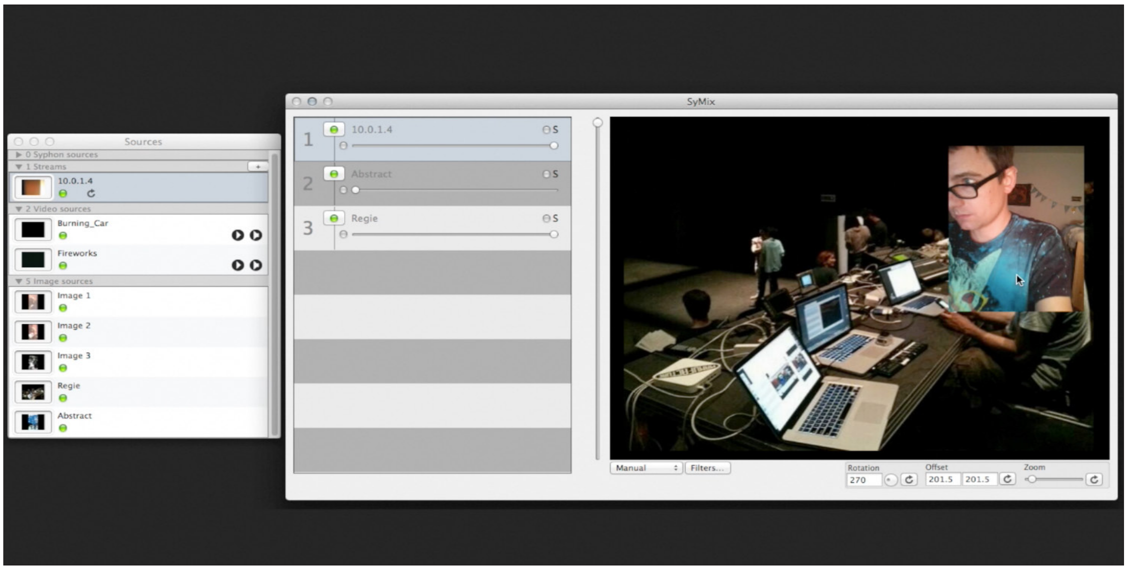

Source
ON
OFF
Out
ON
OFF
Out

Figure 4.3: Initial sketch of a possible interface for layering video.


Sources
0 Syphon sources
1 Streams
10.0.1.4
2 Video sources
Burning_Car
Fireworks
5 Image sources
Image 1
Image 2
Image 3
Regie
Abstract
SyMix
1
10.0.1.4
S
2
Abstract
S
3
Regie
S
Manual
Filters...

Rotation 270

Offset 201.5 201.5

Zoom

Figure 4.4: Screenshot of SyMix, short for Syphon Mixer,
named after the OpenGL frame sharing technology called Syphon.

For me, *who poses the question* is the key distinction between art and design. As an artist working by myself or on a team with another artist, the problem space is mine to define as I see fit. As a designer, my job is to take the problems posed by my client and help them find a solution. To their credit Enrico and Daniela are excellent collaborators: they are quick to listen, slow to impose their own will on the project, and very open to hearing interpretations of their work. This is one of the reasons they work so well with students and across languages and disciplines: their practice allows plenty of space for work to breathe and find its own level. At the same time they possess a strong vision and are professional theater workers: they are not operating in a haphazard manner, but have a crafted product in mind. It was clear to from the outset that MOTUS had something specific in mind with this text, but that they were not yet willing to reveal it.

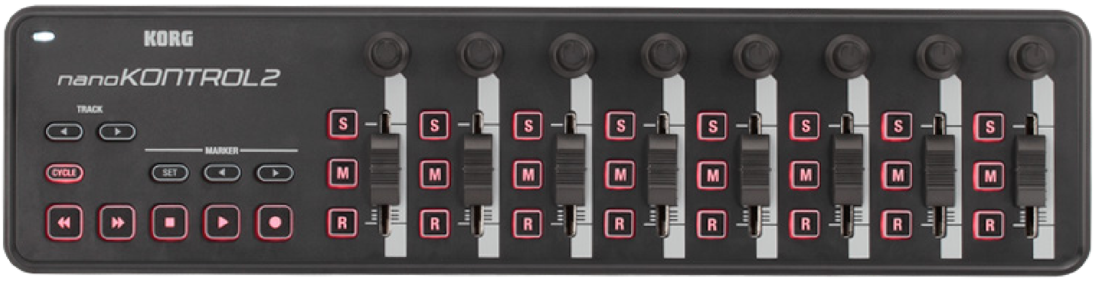


Figure 4.5: Korg NanoKontrol2 MIDI Mixer.

For this initial meeting I applied the design approach. Seen this way, Enrico and Daniella's reluctance to impose their will became a classic problem of the design trade: how to coax a client to articulate their intent. However it's important to note that although almost everyone has preferences and can express them, when working as a hired designer one frequently collaborates with individuals who lack the vocabulary to describe or critique aesthetic choices. The reality when working with artists is quite different. Negotiation of vocabulary is almost always part of the process, in particular where the "clients" and the "designer" do not share a native language, and where the "clients" are a couple who have worked closely together for many years. Nevertheless artists and professional artists who frequently collaborate are adept at describing what they want.

Several of my questions during this initial meeting were designed to probe what they had in mind and to get behind the reluctance to articulate. For example, MOTUS stated that they wanted to conduct the play in several physical locations but it was initially unclear to me that they wanted the audience stationary. When I asked the first time if it was to be staged classically (by which I meant an audience sitting for the duration, facing forward into the theater space), Daniela said no, but I wasn't sure I'd made my question clear. I told a story about *Punchdrunk*, a London-based theater company whose work I enjoy. Punchdrunk conduct their "plays" as immersive experiences that the audience is allowed to freely wander through with little to no guidance. Based on their reaction to this I was able to clarify that the intent for this show was to have the audience remain stationary for the duration while the work unfolded in front of them. We would need to find a way to use technology to mentally space-shift the audience.

I left this meeting with very few specifics: a small page of notes (Figure 4.2), a broad directive to consider ways in which we might handle video and an assignment to read Paul Auster's *Leviathan*[133] and Michael

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[133] Auster, Paul. Leviathan. New York: Penguin Books, 1993.

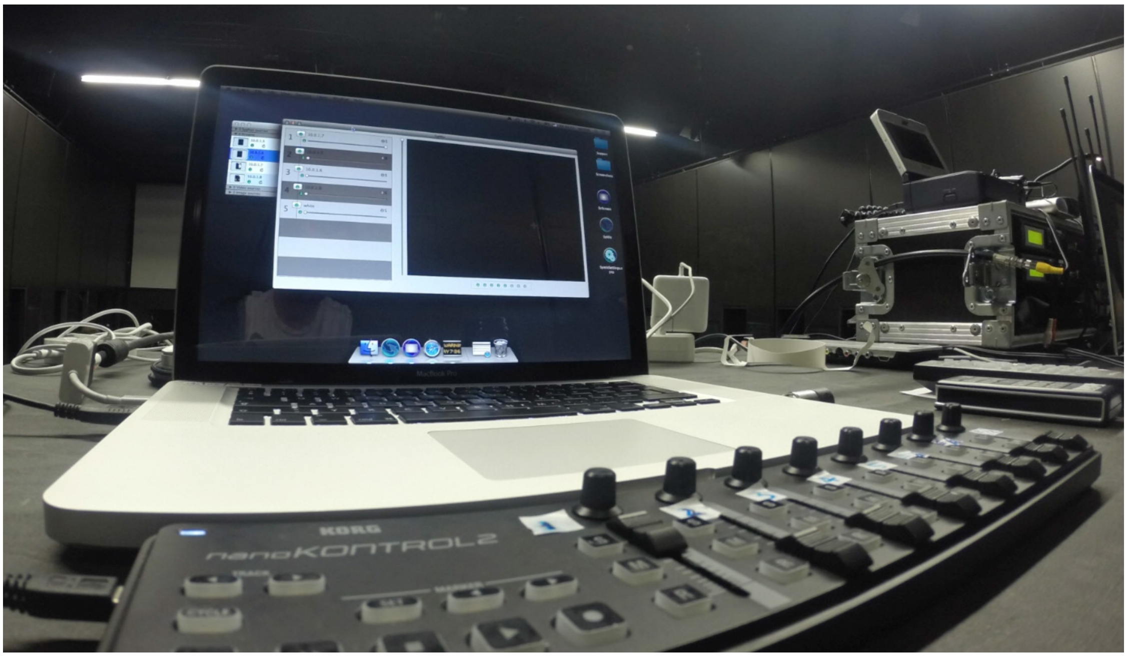

Figure 4.6: SyMix + Mixer as used during production.

Houllebecq's *The Map and the Territory*,[134] neither of which I had read before. As a designer this meeting would have frustrated me, primarily because we were scheduled to have just one more meeting before the entire cast reconvened for the final rehearsals before the public presentation of the work. The information I had was intriguing but seemed too little too late. Enrico and Daniella had sketched out a problem space but fallen short of articulating an actual problem. The most concrete thing I had to go on were two novels, written by different authors in two different countries, in two different languages and nearly two decades apart. MOTUS had already been in rehearsal with the students for a week (none of which I'd seen) and the production was only a month away. I asked to see some photographs, video or material from rehearsals but none were available at the time. What should I build? What would be useful? How would we evaluate it? How could I help?

Had I been operating in full designer mode I would have pressed harder for answers, perhaps insisted the second meeting be dedicated to design or brainstorming and/or politely declined the opportunity for lack of time. As an artist I was fascinated by the source material and the story they were trying to tell, and, had my designer-self declined the gig I would have used the new-found time to read the books on my own. A hybrid approach presented itself. I treated the initial design meeting as a scouting mission, kept my notes in mind but set them aside. I jotted down some ideas about technical problems I'd been facing with my own work. I picked up the Auster text and read, weaving the ideas in the novel together with my own research. As an engineer I was interested in image processing. As an artist I was interested in displacement, time/space shift and layering. As a designer I had the directive to make some sort of video tool for live play. I made it a game to build something that hit on all three (Figure 4.3).

I knew early on that I would be creating software that would incorporate layers, so almost immediately began working on how to accomplish this efficiently. I built a general purpose OpenGL based custom view that supports a large number of layers whose geometry (size, scale, screen placement) can be easily and efficiently manipulated. I then created a UI around this view which allowed for fast swapping of various sources. Lastly, I incorporated an image filtering mechanism (OSX Core Image filters) to add visual effects, along with a cropping tool and full screen mode for projection onto stage.

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[134] Houellebecq, Michel. The Map and the Territory. Translated by Gavin Bowd. Reprint edition. New York: Vintage, 2012.

My initial intent was for this tool to be used live on stage by the student actors. I assumed a basic level of computer literacy but not much else: I relied as much as possible on drag and drop UX and gestures familiar from cellphones (for example, to rotate a layer, you use a two-finger rotation gesture on the trackpad. To resize a layer, you use a pinch gesture.) Layers are reordered by dragging, and new sources are added either automatically (in the case of Syphon) or by drag-and-drop in the case of image or movie files.

In addition to gesture control and careful UI design I integrated a hardware mixer, the *KORG Nanokontrol 2* MIDI controller, which I had used previously on the CYBORG[AME] project (Figure 4.5). All of the features of the software are accessible using on-screen controls and the keyboard and the mouse. However, including this "mixing board" style hardware controller makes the notion of fading and mixing relatively intuitive as you can use actual physical sliders and knobs to manipulate the material. *SyMix* is therefore a general purpose mixing software that allows you to take input from a number of sources: a built-in live webcam, pre-recorded video in various formats, still images in various formats, live video streams in M3U8 and MJPEG format and frames shared via Syphon (the video sharing technology which gives the software its name).

My emphasis while creating this tool was on computational efficiency and UI. I wanted potential users to be able to quickly swap and layer a large number of sources, mixing them in real time as fluidly as possible. My initial intention was for the student actors to use the tool live on-stage. Although in the end the mixing was done primarily in the engineering booth, emphasis on careful UI made it possible to switch operators with very little technical training. For many of the rehearsals I operated the software, but for several of the rehearsals Enrico ran the board, and during the final rehearsals and both performances a MOTUS colleague operated the system (Figure 4.6).

After the initial MOTUS meeting I read the entirety of *Leviathan* but didn't have time to complete *The Map and the Territory* which I was told was "background material." Late in the process, well after the software was complete, I did finish the text and was delighted to encounter a small bit of synchronicity. Hollobeq, explaining the late-work process of an artist who is one of the main characters in his story, describes a piece of software commissioned from an engineer which enables the artist to make his signature work:

"They struck a deal, and a few months later Jed Martin had exclusive use of a quite extraordinary tool, that had no equivalent on the market. Based on a principle quite similar to that of Photoshop layers, it allowed you to superimpose up to ninety-six videotapes, by setting for each of them the brightness, saturation and contrast; by making them, also, progressively pass to the foreground, or disappear in the depth of the image. It was this software that allowed him to obtain those long hypnotic shots where the industrial objects seem to drown, progressively submerged by the proliferation of layers of vegetation."[135] (Figure 4.7).

4.1.2.1: LESS IS MORE

Early on it was understood that the play was going to take place in multiple physical locations. At our second meeting Enrico and Daniella asked about the possibility of streaming live video. I was curious about how to integrate this into the layering system I was building and so I investigated various streaming

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[135] Ibid.

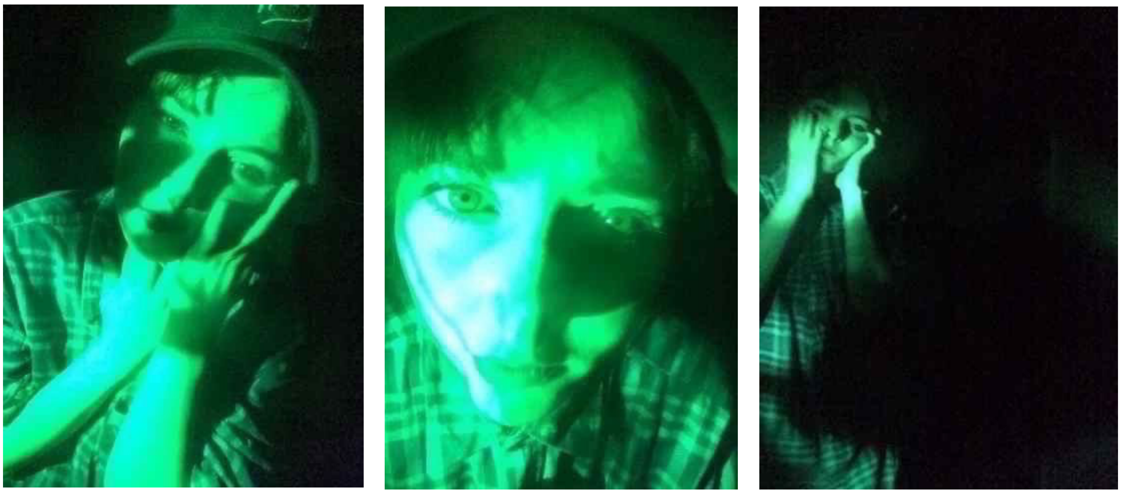

Figure 4.7: Three stills from the "forest" scene, shot via smartphone and projected via SyMix. In keeping with the production's lo-fi aesthetic and revealing all aspects of production, the green color is accomplished with a lighting gel taped over the camera lens, the shadow is a tree branch and the fingers of another actor. During the production the audience can see both actors performing with the camera and the results on the screen behind them.

technologies, ultimately implementing M3U8 and MJPEG streaming support. Initially the idea was to use streaming video simply as a way to transmit an image using the camera's the theater had on hand. As it turned out, none of the available cameras had built in streaming but I identified a piece of hardware, the Teradek *Vidiu*, that would allow us to stream video and audio live over wifi. We also discussed the possibility of shooting using the *GoPro* camera, a lightweight, waterproof, shockproof, wearable and mountable wide angle HD camera.

The GoPro is important to discuss here because it is a wide-angle pinhole camera with a very particular aesthetic signature. The wide-angle causes lens distortion at the edges, and the pinhole provides an infinite depth of field. The sensor used also has particular color and contrast characteristics. As these camera's are largely responsible for the proliferation of homemade FPV (First Person View) stunt videos on the Internet, the "GoPro Look" signals something to the audience. Understanding the nature of this aesthetic signaling would prove key to the way LIWYATAN/LEVIATHAN worked on stage. Streaming support on the GoPro is extremely limited, however, and after spending some time attempting to modify it for live-streaming use I decided it was not usable for this purpose.

The Teradek hardware seemed the best solution to the problem but costs 600USD per camera. This is one of the least expensive full-HD streaming options currently available, but we intended to use at least five. I decided to consider less expensive approaches. As I had already implemented M3U8 video streaming, intending it for use with Internet based videos, It seemed worthwhile to explore the possibility of using ubiquitous mobile devices as video streaming platforms. To save time and effort I looked first for existing solutions and found several applications (one free on the Android platform, and another available for a few dollars on the iPhone) that offered to turn these devices into IP cameras.

The format offered by these and similar types of devices, such as the AXIS IPCam, is known as MJPEG (Motion JPEG) and is one of the oldest types of "video streaming" available. MJPEG does not stream any audio at all and rather than rely on a complex compression algorithm or efficient transport method as with most modern video streaming protocols, MJPEG is typically implemented on top of the relatively heavy HTTP protocol used by the web. After an initial GET request to the serving device, the client receives a continuous stream of JPEG encoded frames, with a simple boundary marker indicating the end of each frame. Essentially the device is taking still pictures as quickly as possible and blindly shoving them out into the world. Motion JPG can generously be described as a useful hack. There is no published specification, no standard boundary marker or packet length. In fact the only commonality between MJPEG implementations is that which I described in the previous paragraph: The software needed to be re-written for each of the possible client apps we were considering. In spite of this, MJPEG is durable and relatively easy to implement. Once running on a private wireless network I had no problem with five simultaneous streams serving two clients and could probably have supported more of both.

The decision to use what was on hand rather than invest heavily in a better technological solution is in keeping with the sensibility of Enrico and Daniella, who have a marked tendency towards a "less is more" approach to technology. What this decision ultimately accomplished was not only money-savings but also drove us towards an aesthetic which lined up better with the narrative than high definition video would have.

TERADEK
Vidiu
Live
ustream.tv/CES
Teradek CES'13
1080P High
H.264
READERS' CHOICE AWARDS 2013 FINALIST

Figure 4.8: Teradek Vidiu wireless HD streaming box.

HERO3+
00:01
GoPro

Figure 4.9: GoPro Hero3+ camera.

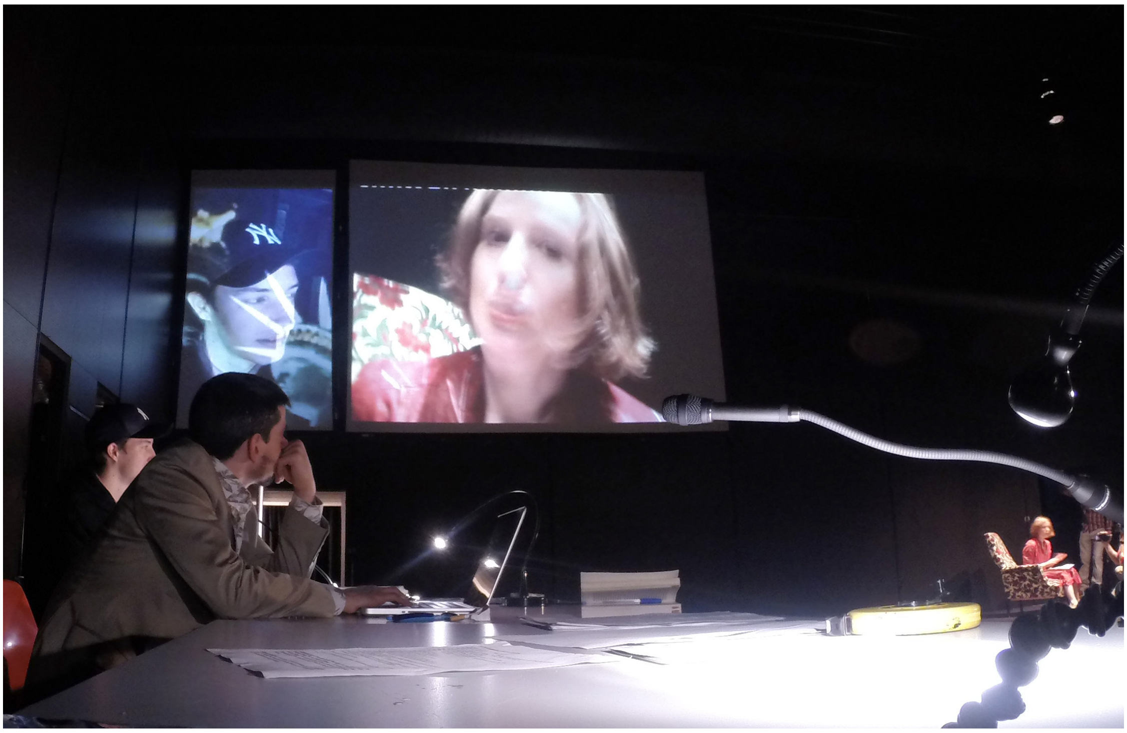

Figure 4.10: Mobile video screen on the left, constructed so that the aspect ratio matches that of a smartphone, and the "main screen" which projects the video from the cameraman just visible in the lower right corner of this image.

4.1.2.2: NECESSARY FRICTION

Friction is colloquially understood as a negative. It is used to describe trouble between individuals or to describe that which is causing problems and preventing the desired outcome. In art, as in physics, friction is understood as a necessary component of work. In a true frictionless environment, nothing works properly. You need friction to push against in order to drive yourself forward.

The decision to use an "old" streaming technology that did not transport synchronized audio, for example, created a problem for the production. While the lower frame rate of the streamed video was a considered aesthetic choice, and while I could have implemented a method for transporting audio from the smartphones along with the images, delayed and out-of-synch audio would have created an uncomfortable and undesirable experience for the audience. This was especially true given the fact that key moments of the production hinged on the audience understanding or becoming aware of the fact that what they were seeing on the screen and in front of them were in fact simultaneous events at different visual scales. In these cases the audio was often the bridge between the two. Good audio was necessary.

To solve this problem, HETSR technician Ian Lecoultre arranged microphones strategically around the theater, choreographing the soundboard so that the correct areas of the stage were amplified at the right moments. The production team discussed the possibility of using wireless microphones including "halo rigs" which involve hiding the microphones nearly invisibly in the hair of the actors. This was a more ideal solution but would have involved the expensive purchasing or renting of fifteen or more microphones and associated hardware. It also would have required more costuming work since the microphones would need to be "installed" on each actor.

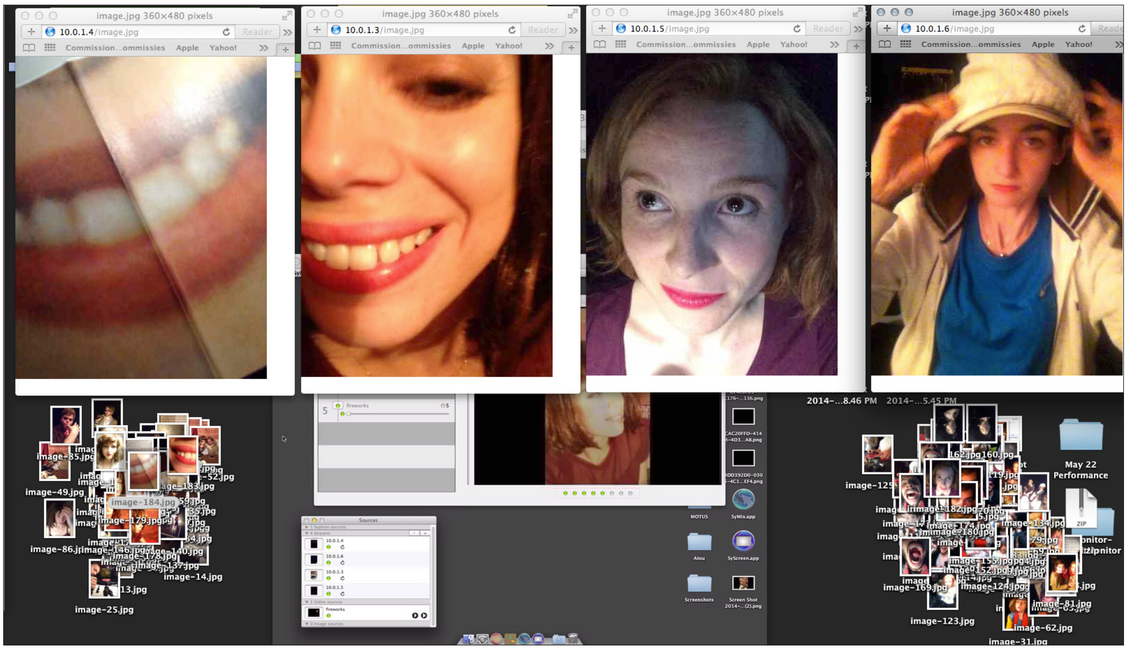
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image-86.jpg
image-25.jpg
image-14.jpg
image-123.jpg
image-62.jpg
May 22 Performance
MOTUS
SyMix.app
Screenshots

Figure 4.11: Desktop showing preview from all four cameras at once, plus piles of screenshots. The SyMix interface is visible in the background.

Enrico and Daniella declined the use of the halo mics, arguing that while this approach was technically correct it was not appropriate to the educational setting. As Daniella said: "Of course, if it was our professional play, we would have wireless microphones on everyone and perhaps also use high quality streaming cameras, but this is a school." This is a comment which needs to be considered carefully in light of the notion of friction. What MOTUS was saying was *not* that the students deserved less. This statement should also not be seen as a comment on the school's willingness to purchase equipment. On the contrary, a generous budget was available, the expertise was at hand, and both Enrico and Daniella demonstrated the utmost respect for those they work with. Instead, what they were articulating here was that friction is a necessary part of art practice. Without the right kind of pushback, the right constraints and rules, the work cannot go forward. In the case of *Leviathan*, MOTUS had been pushing the cast of fifteen students firmly out of their comfort zone and directly into the path of a powerful computational aesthetic characterized by "cheap" mobile video. What would become a defining aesthetic tool of this play was initially arrived at by avoiding the "best" technical solution during the devising phase.

As both Enrico and Daniella and members of the cast all told me independently, theater, especially French theater, is heavily text centric. The actors were accustomed to memorizing and performing text, emphasizing all of the emotion and work represented in the words. This particular show was far more demanding physically and mentally, requiring them to re-think their placement on stage when addressing the camera rather than the audience, for example, or to concentrate on the scene they were filming with a phone while remaining conscious of the figure they presented to the audience. Replacing the microphones with higher quality body-mics arguably would have made the show better for the audience and perhaps even lessened the cognitive load on the performers, but this reduction was seen as a net loss for the learning experience.

While not limited to artistic practice this type of thinking is a hallmark of art making. Scientific, design and engineering practice often maintain a notion of "best practices" for technical applications and then looks for close approximations, artistic practice considers first what is the best conceptually, experientially and aesthetically. Therefore technical “best practices” for an art piece are almost always nonstandard and negotiated - a given artist can tell you what works best for them and for a particular audience or situation, but this is rarely broadly applicable.

The choice to take the more challenging road for the sake of the experience is a characteristic of gameplay, in which deliberate action is often taken to make a situation more rather than less difficult. To illustrate this point Jane McGonigal discusses the game of golf: If the actual goal of golf was to get a ball into a hole you would pick up the ball, walk over to the hole and drop it in. As it turns out the game is all about making this task artificially difficult. You are supposed to get the ball into the hole, but using only a stick, from very far away. In this way a simple task is deliberately complicated and becomes more entertaining and more enjoyable, “forcing” the player to encounter friction and changing the experience in the process.[136]

“There are at least two kinds of games. One could be finite, the other infinite. A finite game is played for the purpose of winning, an infinite game for the purpose of continuing the play.”

“The rules of the finite game may not change; the rules of an infinite game must change.”

“Finite players play within boundaries, infinite players play with boundaries.”

“Finite players are serious; infinite games are playful.”

“A finite player plays to be powerful; an infinite player plays with strength.”

“A finite player consumes time; an infinite player generates time.”

From Finite and Infinite Games : A Vision of Life as Play and Possibility, James Carse[137]

4.1.2.3: THE AESTHETIC CUES OF LO-FI TECH

Humans use contextual information to develop an understanding of the information they are reading or seeing.[138] Theater makes extensive use of “context clues” to indicate the place and setting of a story. The same technique is employed by participants of social networking sites who often stage images of themselves and their surroundings to create a particular context for social interaction.

As Bellingham and Vasconcelos write: “online environments provide their users with the potential to perform and present different identities. The distance between performer and audience that physical detachment provides makes it easy to conceal aspects of the offline self and embellish the online.”[139] An up and coming businessman, for example, might post only photographs of himself at fundraisers and with clients and always dressed in the best suits. A young adult who wishes to appear popular and exciting might post photos of parties and party paraphernalia, or emphasize their taste and demographic by posting photos of luxury goods. In both cases it is tacitly understood that these people are individuals who move freely through different contexts (the businessman probably doesn't wear his suit to bed, and the popular young adult cannot possibly exclusively drink expensive champagne, in spite of the mountain of evidence to the contrary). We use these clues to adapt our own behavior and to understand the origin and nature of the story we are being told.

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[136] McGonigal, Jane. Reality Is Broken: Why Games Make Us Better and How They Can Change the World. Penguin, 2011.

[137] Carse, James. Finite and Infinite Games. New York: Free Press, 2013.

[138] Yngve, Victor H. “On Getting a Word in Edgewise,” 1970, 567–77.

[139] Bullingham, Liam, and Ana C. Vasconcelos. “‘The Presentation of Self in the Online World’: Goffman and the Study of Online Identities.” Journal of Information Science 39, no. 1 (February 1, 2013): 101–12. doi:10.1177/0165551512470051.

In addition to the context offered by the content of the images we see, we also use the quality of the images themselves as a clue to their origin and veracity. Surveillance footage is understood best as "surveillance footage" when it appears in black and white, low-fidelity and grainy. Professional photographs are understood to be professional when they appear in high resolution with lots of detail, simple backgrounds and in full color. In addition to characterizing the experience of the play for the performers, the decision to rely on "lo-fi" methods serve as storytelling cues to the audience to explain the source of what they were seeing.

This type of context information is not limited to photography or to photographic images. As an example I previously described the decision not to use a hidden microphone system, instead forcing the performers and the audience to encounter the microphone system physically. During several scenes of the play, a character known as *the cameraman* films actors on stage, and the closed-circuit footage is displayed on the back wall of the theater alongside the video produced by the iPhones and SyMix. For these scenes, a boom-mic was employed to capture the audio of the actors that were speaking. The boom-mic featured on stage is a functional prop, used to amplify the dialog in those scenes. This fact not only makes the play more realistic (the actors playing *sound man* need to know how to properly position and handle such a mic in order for the play to be heard) but it also serves to strongly signal the audience that a layering is taking place. Hidden microphones and amplification systems in theater are intended to make the infrastructure of performance invisible. Here we make the means of production visible to the audience: the boom mic functions technically as an amplification device but also serves aesthetically and conceptually as a signifier indicating "filming." This emphasizes the framing of the scene being played out in front of the audience and strengthens the connection between the live performance and the simultaneous projected video.

This deliberate choice to emphasize the lo-fi for aesthetic purposes was repeated several times throughout the rehearsal period. In addition to the four iPhones used by the cast, included in the production was a live closed-circuit video loop produced by a wired camera operated by a character in the play (the cameraman). This video was fed to the video board in the engineering booth by means of a very long analog composite video cable. Analog video signals do not travel well and the consequence was an irritating flickering and some speckling artifacts in the high-brightness range of the image. In a bid to mitigate that, theater technician Ian Lecoture replaced the cable with a digital HDMI run. Daniella described the result as "a better image, but hard and cold, not good. We hated it." Ultimately the analog video and its artifacts were deemed *aesthetically* better and the higher quality digital cable was removed.

Similarly, during the production four different iPhones were used: two brand-new models and two older models. The oldest phone, which happened to belonged to Daniella, featured a slower processor and was equipped with a less capable camera than the others. This introduced a bit of digital "grain" and also a slight delay in the video feed. Of all four phones, this was the image stream that MOTUS directors preferred, with Daniella declaring: "Ha! I like my phone the best!"

The quality of the image, as well as the image itself, became a storytelling device the play relied on to convey the narrative. To further emphasize the source of the video for the audience, a projection screen was constructed in the same aspect ratio of the iPhone. This ratio is as different from a traditional 35mm or digital SLR camera as it is identifiable and the choice was made deliberately to emphasize to the audience

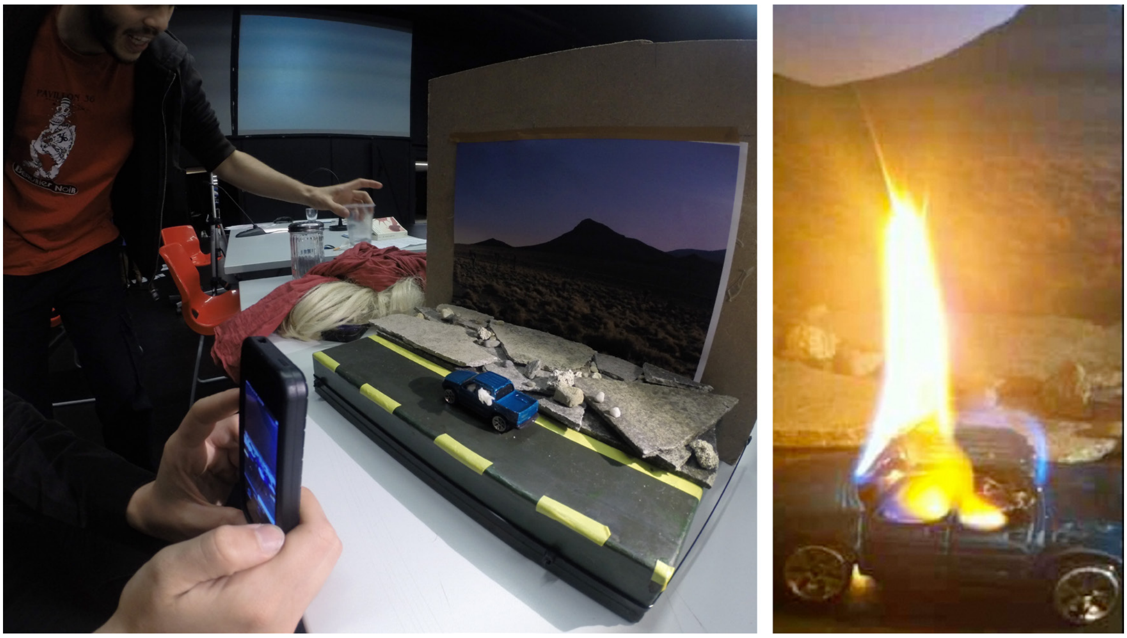

Figure 4.12: The Car Fire "Special Effect" created with a model + SyMix. On the left is the model, on the right the image created by the smartphone and projected on stage.

that what they were seeing was "smartphone video."

4.1.3: SHIFTING PLACE

During the performance of LIWYATAN/LEVIATHAN, live action occurred on the main stage area in front of the audience, but also in the hallway, backstage and even in a specially constructed room located underneath the risers where the audience was seated. Most of these areas were directly viewable to the audience but in obstructed ways: the backstage areas were visible through doorways at a far distance from the audience, the space under the seats was visible if the audience looked down between their legs, and the hallway was completely out of view although actors could be seen entering and exiting at various points during the show.

Video, both pre-recorded and live, was used throughout the show to focus audience attention and to shift the place where the narrative took place. Pre-recorded video was used in a fairly straightforward film-like manner, to show several scenes performed in and around the city of Lausanne. Live video mixed with the SyMix system was used in a more computational way: to shift the context of a scene, to create or ease transition between scenes and to convey emotional interaction between events that were physically or temporally separate.

4.1.3.1: REVEALING THE MEANS OF PRODUCTION

One of the major themes in both Auster's original text and the MOTUS adaptation is the notion of authorship and layered narrative. Auster's book accomplishes this by telling us a story in which the narrator claims to have authored the text we have in our hands, a book with Auster's name on the cover, about a relationships between a number of authors and artists who make performance and identity play their lives and deaths. The MOTUS stage adaptation makes the layering explicit by revealing all aspects of the performance directly to the audience: While the play is being performed the audience can also see, in front of them and via video, the actors changing costumes, re-arranging the set and filming their own performance. This is underscored further through moments in the play where the actors provide meta-commentary, for example one scene where an actress addresses the audience directly and discusses with them the content of video in which she is playing a role (a play within a film within a play within a play).

Conveying such a complex staging without confusion relies heavily on the audience having internalized a complex storytelling vocabulary. LIWYATAN/LEVIATHAN uses the language of theater and performance, but also makes use of cinematic vocabulary. In 2014 audiences can be expected to be fluent in these languages but the show goes further by introducing new aesthetic practices, such as the use of computationally mediated live video, and adding this to the mix requires a bit of pedagogical work.

The opening scene of LIWYATAN/LEVIATHAN features a dramatic car explosion on a lonely road. Initially this was to be portrayed by stock footage projected on the wall of the theater. This footage, of an actual car on fire, was better than any that could have been created safely on stage and yet it was decided to produce the effect by filming a model car that one of the actors would douse in alcohol and light on fire live on stage (Figure 4.12). To dramatize the event further, the live footage of the burning model was combined with the sound of an actual explosion and the audio from the real car fire film to create a sensory experience far larger than the comically small model.

While accomplishing the effect necessary for telling the story, this scene also played an extremely important role in the play by introducing the audience to the technology that was going to be used for the duration of the show while simultaneously emphasizing the thematic elements of authorship and layering. By clearly revealing the way the car-fire video was being created the audience was led to understand that the video they were seeing was being shot live (and not pre-recorded) and that the means of production, the telling-of-the-story, was in fact part of the story itself. This “pedagogical moment” is an important part of nearly any stage production that incorporates new technology and is always best implemented when integrated into the story itself.

In live-action role play (LARP) scenarios, the integration of signals which change or indicate the nature of play into the story itself is known as *steering* and is considered a critical player skill. For example: “The player of a tyrant might choose to play in a more benevolent style when interacting with beginners, or a vampire character might leave an interesting scene because the player needs to find the restroom.” A player who is steering their character performs actions which are motivated by the world outside the circle of play while simultaniously making an attempt to maintain the illusion. “Specifically, players attempt to ensure that characters maintain the outward appearance of coherence

Figure 4.14: Mobile photos from the Fourth of July party scene.

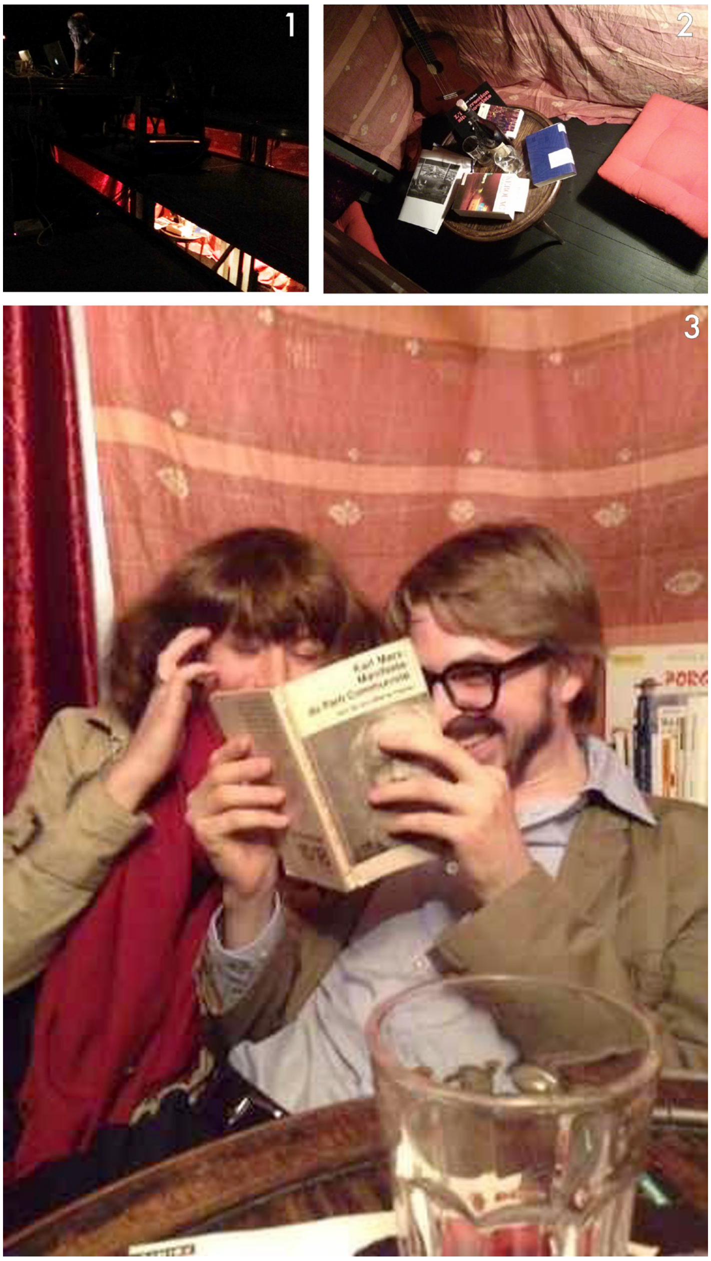

Figure 4.13: The "remote cabin" located under the risers. 1. The audience view if looking directly. 2. The view if you were to put your head through the gap in the stairs. 3. The view as seen via smartphone video projected on stage.

for the character's actions, from the perspective of other characters first and other players second. In other words, a player who is steering strives to maintain the illusion that the actions of her character make sense as a whole."[140]

Epistemologist Gregory Bateson identifies this type of activity as the meta-communication of play. Indeed Bateson's definition of play *requires* the addition of meta-communication, or an act which "stands outside the current level of communication and comments upon it. ...These actions, in which we now engage, do not denote what would be denoted by these actions which these actions denote. The playful nip denotes the bite, but it does not denote what would be denoted by the bite."[141]

In the case of the car fire in LIWYATAN/LEVIATHAN, this meta-communication served a pedagogical purpose, educating the audience as to the nature of the way a new technology would be used in the telling of the story. As a second example we will look at the way that mobile video allowed the actors to transition between physical locations.

4.1.3.2: TRANSITIONING BETWEEN SPACES

Throughout LIWYATAN/LEVIATHAN, mobile smartphone video and the perspective it afforded was used to convey a transition between scenes, characters or elements of the play, as well as actual physical locations of performance. One such location was a "remote cabin" staged physically underneath the risers on which the audience was seated (Figure 4.13). The space was visible to audience members who looked down through their feet, but short of lying down and putting their heads through the holes on the floor there was no way to really see what was occurring there.

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[140] Montola, Markus, Jaakko. Stenros, and Eleanor Saitta. "The Art of Steering: Bringing the Player and the Character Back Together." In The Knudepunkt 2015 Companion Book, edited by Charles Bo Nielsen and Claus Raasted, 108–17, n.d.

[141] Bateson, Gregory. Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology. University of Chicago Press, 1972.

Rather than observe them directly, scenes performed under the audience were revealed via smartphone video. However, it was important that the audience understood the performance was happing live but out of view. This idea of observation by mediation was crucial to the central concept of the story, and so it became important to show the audience explicitly that computational mediation was taking place.

The opening scene of LIWYATAN/LEVIATHAN introduces the audience to the technology the play makes use of via a *pedagogical moment*. By showing an actor creating the special effect of the burning car live on stage, a link is made between the projected video, the smartphones being used and the activity occurring on stage. Similarly, the first time that action takes place in the space under the stage it is preceded by one of the actresses removing the smartphone that was used for the car fire scene from the tripod that it was on. This actress then follows two other characters off stage and into the hidden space, allowing the audience to directly witness the transition between spaces.

In addition to teaching the audience the language the play, this pedagogical moment serves another purpose by emphasizing the viewpoint of the photographer. It is a curious fact of all forms of photography that the viewpoint of a camera explicitly hides both the person making the documentation and the act of documentation itself. As Barthes says, "a photograph is always invisible: it is not what we see."[142] Photography is often felt as objective largely because it occludes the

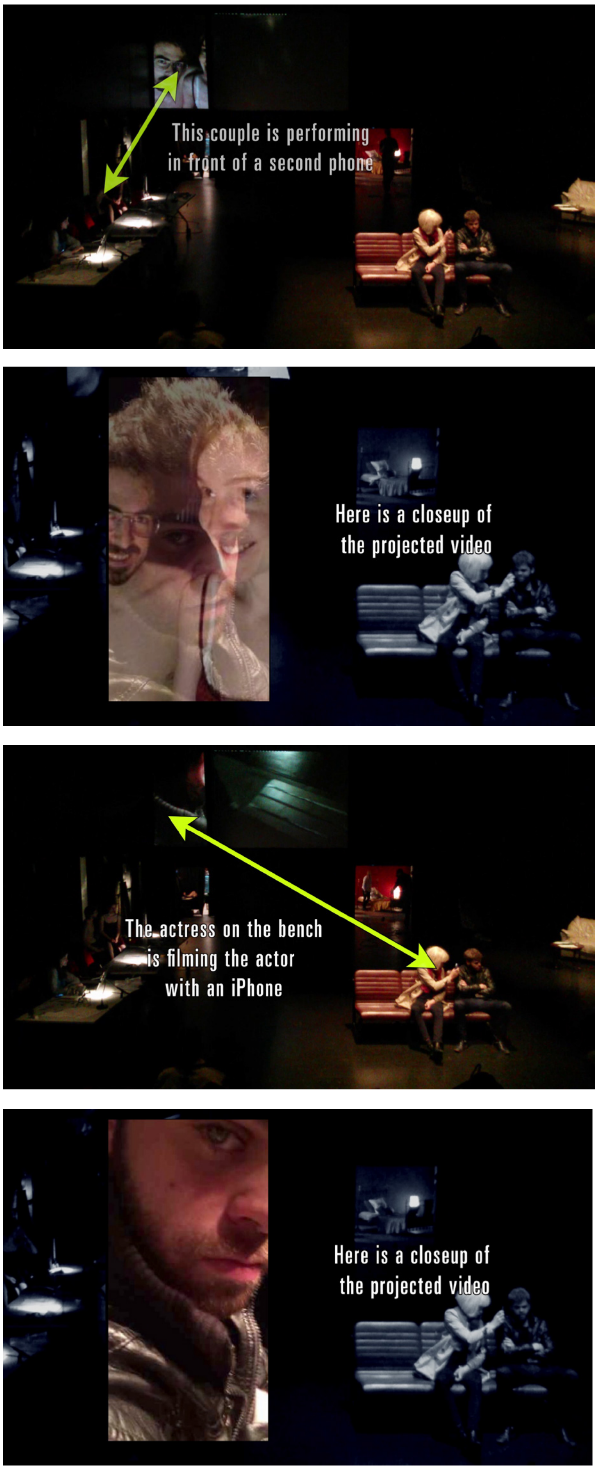
This couple is performing in front of a second phone
Here is a closeup of the projected video
The actress on the bench is filming the actor with an iPhone
Here is a closeup of the projected video

Figure 4.16: Jerome and the lovers, cross-mixed video. Stills from a short video documenting the SyMix project.

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[142] Barthes, Roland. Camera Lucida: Reflections on Photography. Macmillan, 1981., 6.

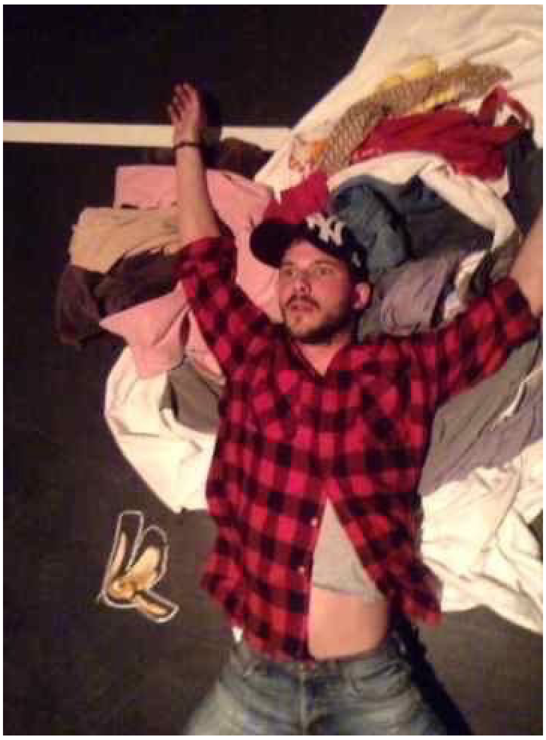

Figure 4.15: "The Fall," overhead shot with smartphone camera.

original observer from view, giving us a sense that we are observing the scene ourselves. This is of course not true: as with any method of image production, photography is highly subjective and can be easily manipulated to tell any story a creator wishes. Auster's text and the MOTUS adaptation both call the role of authorship into question and revel in this confusion of observer and observed. We encounter this first by showing the audience explicitly both the film and the filmmakers, revealing clearly that all imagery is a performance and a fiction created by human hand. Barthes: "In this (after all) conventional debate between science and subjectivity, I had arrived at this curious notion: why mightn't there be, somehow, a new science for each object? A *mathesis singularis (*and no longer *universals)."*[143]

4.1.3.3: PERSONAL VIEWPOINT

Photography's designation as an unemotional and accurate repository of truth makes it an ideal candidate for performance. If we cannot show things as they are, we can at least stage and document a scene indicating the way we wish things to be. Intriguingly, the greater the subjectivity of the cameras viewpoint, IE the closer the camera-eye is to the eye of the imagined observer, the more intimate and emotionally true we feel an image to be. Thus we tend to react more strongly to candid first-person photographs than photos taken at a distance by a surveillance camera.

A hyper-personal viewpoint gives us emotional access to a scene or event in a way that external observation does not. By virtue of the technology employed, LIWYATAN/LEVIATHAN was curious in that it often gave the audience both: for example presenting a scene on stage that the audience could watch from the outside while simultaneously presenting them with live video shot by actors participating in the same scene. In this way the audience was allowed to mentally occupy the same scene from several different locations at once. The intimate nature of the cameras-eye-view was conveyed by the fact that the audience could see the photography taking place as well as by the aesthetic quality of the video itself - The "selfie" style and smartphone feel the chosen hardware imposed on the images.

Actors carrying the phones with them during the Fourth of July party scene, for example, produced a number of shots that would not appear out of place on Facebook (Figure 4.14). The quality of the live video from these scenes is obviously handheld, jittery and prone to blurring caused by rapid shifts in the contrast of the scene. This image quality telegraphed both the reality of the source of the images and the emotional sense of the narrative.

In this particular scene, the party is interrupted when one of the main characters, previously balanced on the edge of a fire escape, is accidentally bumped by another party guest and nearly dies in a four story fall. The fall here was conveyed to the audience by an abrupt change in both the audio and video on stage:

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[143] Ibid, 8.

music and general party sounds are silenced by a loud scream. More interestingly, the shaky hand-held video of the party goers is replaced by a still, steady shot taken from overhead. The perspective of the view changed at this moment from intimate and personal to distant and documentary, from horizontal to vertical, but still with the same overall visual quality telling us that the view was being shot by smartphone (Figure 4.15). What the audience is meant to understand is that they are seeing the party and the tragedy as performed and documented by the participants.

This particular scene is also intriguing for the physical way in which it conveys a spatial shift usually accomplished cinematically. Audience watching the live video of the scene will see an abrupt change in location of a character (from the raucous party onto the ground four stories below). In terms of stagecraft this transition is accomplished by moving one of the iPhone cameras from the main stage to the technicians loft, while the actor who "fell" merely lies down on the ground. The actor who fell hasn't really moved, but a four-story fall has taken place through the use of the video's perspective on the scene. In cinematic terms this might be called a jump-cut, but in this case it is accomplished live through the physical movement of the actors rather than via editing or post-production. Lighting and timing are used so that the emotional impact of the scene remains and the fall is "felt" by the audience, but here none of the mechanisms are hidden: every element of the production is on display. The audience can see the actor on the ground but also the actress holding the smartphone. They can see the video's perspective of objective observation, but they can also see the person holding the camera, a tactic which conveys Auster's themes of layering and authorship with a contemporary computationally-mediated twist.

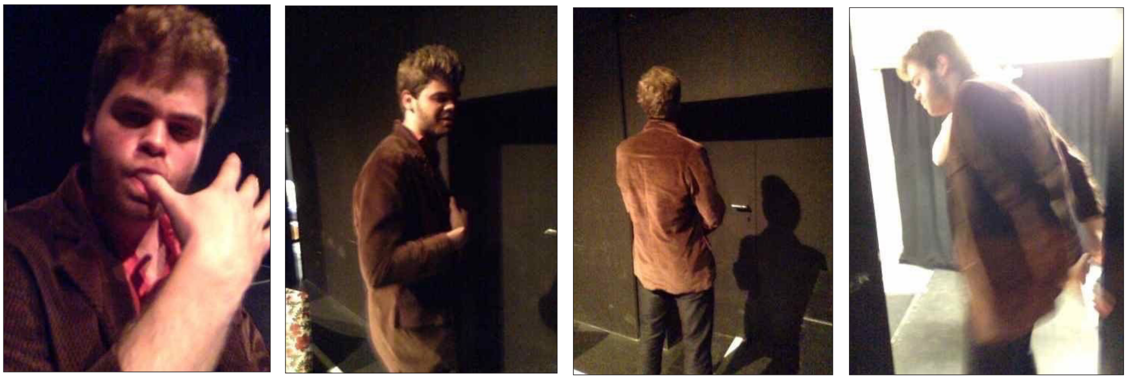

Figure 4.17: Jerome goes to see Maria as Lillian the prostitute. The camera follows him as he knocks on and enters a door at the back of the stage, allowing the audience to follow the transition.

4.1.3.4: CONNECTING REMOTE LOCATIONS

The use of distributed video in LIWYATAN/LEVIATHAN also allowed the play to convey intimate emotional interactions between events that were separated by time, space or both. While the wireless cameras could be positioned anywhere in the theater, the mixing nature of the software allowed for images to be combined, layered and cross-faded. Theatrical space itself, with the willing participation of the audience, allows us to indicate nearly any place that can be imagined. Similarly this tool allowed for the compression of two or more events into the same physical space by allowing images of both to occupy a screen at the same time.

Overlaying two images creates a relationship between them. The nature of this relationship can be friendly or antagonistic, beautiful or frightening, depending on the nature of the images and the way they are mixed. In one transitional scene, a pair of lovers shares an intimate moment while the audience is introduced to the character of Jerome, a sullen and angry man who will later badly beat a woman in a key event in the play (Figure 4.16).

Here the camera feed was initially used to allow the audience to feel a sense of intimacy with the lovers, whose scene began in the bedroom area located backstage. This space, only just visible to the audience, was brought closer to the audience via video. The playful and vulnerable chat that we see between them after their scene creates a strong tension to the action on stage, where a woman appears to be aggressively documenting her companion on a park bench. The sullen anger of this man, and our inclusion in both scenes via the camera view, foreshadows the violence to come. At the end of this scene the smartphone cameras is used to define another key transitional moment - the woman on the bench follows Jerome as he leaves, providing a close up view of his back as he makes his way to an appointment with a prostitute (Fig 4.17), a scene we will discuss in depth in the next section.

4.2: PHOTOGRAPHY, SURVEILLANCE AND THE COMPUTATIONAL SELF

4.2.1 HOW DOES COMPUTATION SHIFT PERCEPTION OF SELF?

We have now seen the ways in which computational epistemology impacts an audience's understanding of space and the way in which performers can make use of this understanding in the service of narrative. Particular aspects of social media interaction, specifically the aesthetic markers of the video and pictures that we use to tell our personal stories, can be pressed into scenographic service to great effect. Can these same tools be used to explore the ways in which computational technology has changed our perception of society and self?

Paul Auster's *Leviathan* was released in September of 1992, just five months after the fires had cooled from the Los Angels riots. Those riots were sparked famously by footage of motorist Rodney King being beaten by the LAPD, an event captured on home video equipment by George Holliday from the balcony of his nearby apartment (Figure 4,18). "The simple existence of the video was something unusual in itself. Relatively few people then had video cameras, Holliday did — and had the wherewithal to turn it on. "It was just coincidence," Holliday reflected in an interview a decade ago. "Or luck."[144] Scarcely one year later, in April of 1993, the Irish Republican Army detonated a truck bomb in the financial heart of London. This action ushered in the *Ring of Steel* and launched an era of coordinated CCTV surveillance. There are now 1.8 million CCTV cameras in operation in London, or one camera for every individual in the entire United Kingdom.[145] These events are connected only in time, but in an our current era characterized by ubiquitous computational surveillance coupled with ubiquitous networked video, it is perhaps difficult to understand the massive shift they represent. When *Leviathan* was released, use of photography by law-enforcement and the populous alike was not unheard of but was uncommon and the explosion

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[144] Rubin, Joel. "Twenty Years after the Beating of Rodney King, the LAPD Is a Changed Operation." Los Angeles Times, March 3, 2011. http://articles.latimes.com/2011/mar/03/local/la-me-king-video-20110301.

[145] Lewis, Paul. "You're Being Watched: There's One CCTV Camera for Every 32 People in UK." The Guardian, March 2, 2011, sec. World news. http://www.theguardian.com/uk/2011/mar/02/cctv-cameras-watching-surveillance.

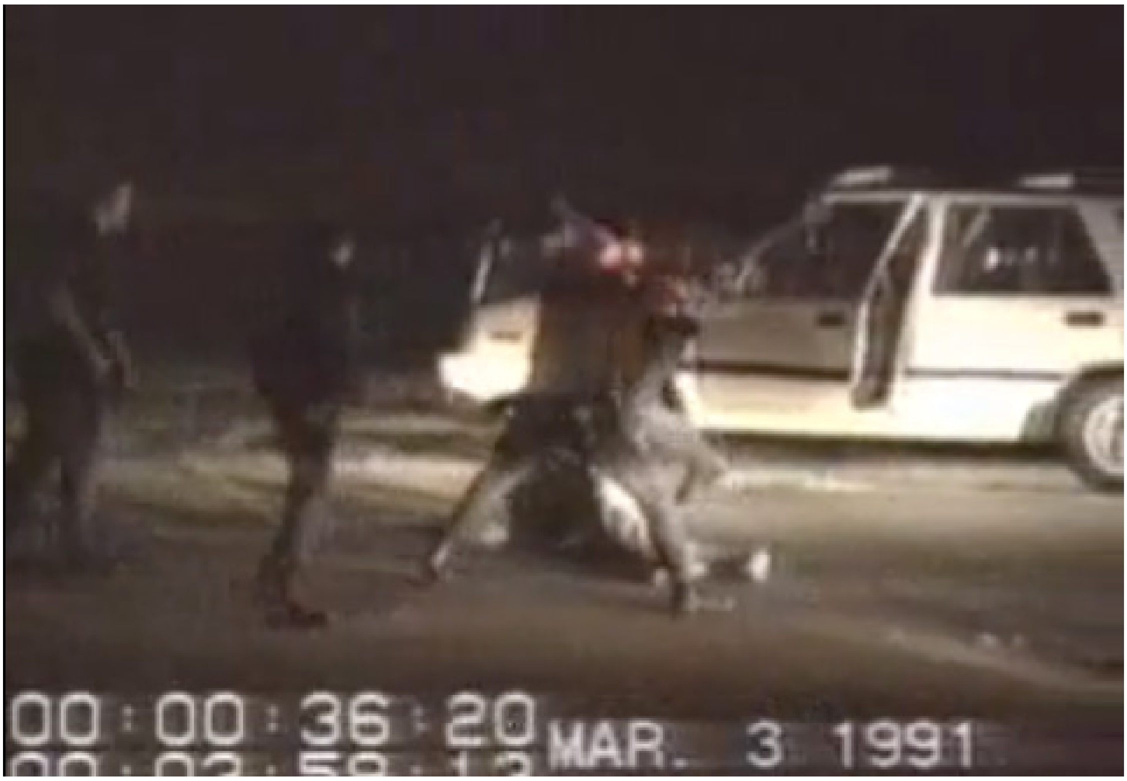

Figure 4.18: Still from the home movie footage LAPD beating motorist Rodney King, shot on VHS.

of ubiquitous high definition digital photography was still several years away. Auster's novel contains complex explorations of power relationships, pornography, law-enforcement and spying as mediated by photography and image, but it contains nothing of the computational shifts which occurred in the decade after it was published.

The MOTUS staging of Leviathan does not represent a major alteration of the original text, but in terms of the *manner* in which the play was staged it elegantly encodes a computational understanding of photography and its impact on both society and self. Staging the play through the application of computational aesthetic (layering, time and place shift, along with a particular image vocabulary drawn from social networking practice) allows us to explore a different, richer and more complex relationship to image than is explored in the original story, a shift which is both a hallmark of and a result of computational epistemology.

4.2.2: VIOLENCE AND SURVEILLANCE IN 1992

When discussing the use of video and tracking technology in art it is necessary to address the widespread application of these technologies for surveillance purposes. As an artist one can make the choice to deliberately ignore the connection but the link is always there for the audience: power, sex, pornography, law-enforcement, spying, advertising, exploitation, voyeurism, entertainment, extortion and performance are deeply intertwined.

In Paul Auster's *Leviathan*, there is a key scene where the character of Maria, based on the real-life artist

Sofie Calle, creates an artwork in which she trades places with her best friend Lillian. Lillian is working as a prostitute and it is Maria's intention to sleep with Lillian's clients and document the process as an artwork. Her first client, a "fat furry salesman" named Jerome, is described as diminutive and physically repulsive, making it difficult for Maria to "go through with it." Nevertheless she is determined to complete her project:

"I'd hidden my camera in the bathroom, and I figured if I was going to get any pictures out of this fiasco, I'd have to act now. So I excused myself and trotted off to the potty, leaving the door open just a crack. I turned on both faucets in the sink, took out my loaded camera, and started snapping shots of the bedroom. I had a perfect angle. I could see Jerome sprawled out on the bed. He was looking up at the ceiling and wiggling his dick in his hand, trying to get a hardon. It was disgusting, but also comical in some way, and I was glad to be getting it on film."[146]

Maria's project is nearly complete, but her decision to film the proceedings proves nearly fatal.

"I guessed there'd be time for ten or twelve pictures, but after I'd taken six or seven of them, Jerome suddenly bounced up from the bed, walked over to the bathroom, and yanked open the door before I had a chance to shut it. When he saw me standing there with the camera in my hands, he went crazy. I mean really crazy, out of his mind. He started yelling, accusing me of taking pictures so I could blackmail him and ruin his marriage, and before I knew it he'd snatched the camera from me and was smashing it against the bathtub. I tried to run away, but he grabbed hold of my arm before I could get out, and then he started pounding me with his fists. It was a nightmare. Two naked strangers, slugging it out in a pink tiled bathroom. He kept grunting and shouting as he hit me, yelling at the top of his lungs, and then he landed one that knocked me out. It broke my jaw, if you can believe it. But that was only part of the damage. I also had a broken wrist, a couple of cracked ribs, and bruises all over my body. I spent ten days in the hospital, and afterward my jaw was wired shut for six weeks. Little Jerome beat me to a pulp. He kicked the living shit out of me."[147]

Taken at face value this story is depressingly common: we can read it as one of many in a long line of cautionary narratives about "loose women" and the dangers they face for transgressing the lines of traditional marriage. Maria naively thinks that it would be fun to play the whore and is punished for it. What is curious, however, is the twist that Auster brings to the story through the voice of his narrator Ben, who explains that while she was nearly killed, it wasn't the physical attack that had the biggest impact on Maria, rather:

"…the incident with Jerome had been a spiritual defeat. For the first time in her life, Maria had been chastened. She had stepped over the boundaries of herself, and the brutality of that experience had altered her sense of who she was . Until then, she had imagined herself capable of anything: any adventure, any transgression, any dare. She had felt stronger than other people, immunized against the ravages and failures that afflict the rest of humanity. After the switch with Lillian , she learned how badly she had deceived herself. She was weak, she discovered, a person hemmed in by her own fears and inner constraints, as mortal and confused as anyone else."[148]

In *Leviathan* it is not the decision to become a prostitute that is the primary sin, it is the notion that one might dare to alter their self at will and change who they are through performance. In short, the artist Maria "goes too far" not because she is having or selling sex, but because she's not doing it seriously enough. Photography In this case serves as a stand in for the audience, allowing us to understand that Maria is "merely playacting." This performance of a different self is the specific transgression that brings about her punishment. "…For the first time in her life… [Maria] stepped over the boundaries of herself, and the brutality of that experience had altered her sense of who she was." Seen from this perspective, Auster's entire text can be read as a cautionary tale about the dangers of performance.

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[146] Auster.

[147] Ibid.

[148] Ibid.

4.2.2.1: PERFORMANCE COLLAPSE

Computational epistemology can be understood as a sensitivity to certain computational concepts such as layering, as well as an ability to follow and undertake operations such as context-switching at computational speed. We have seen how this can be a valuable tool for setting the scene of a story, or for drawing attention to the architecture around us. In the world of *Leviathan,* performance and performance layering is conveyed as a valuable but dangerous tool for self exploration and is the defining characteristic of the book itself.

When reading Auster's novel it quickly becomes difficult to tease apart where the storytelling begins and ends, which narrators are reliable and indeed whether or not we are to understand the narrative voice as the character of Peter or as Auster himself. From the opening scene we are introduced to this deliberate confusion: the text tells us that the object we are holding in our hands is a book being written in real time by Peter Aaron, an author who has just received a visit from the FBI investigating a recent death and related series of terrorist bombings. Peter, our narrator, stonewalls the police specifically to find the time to retreat and record the true events leading up to the bombing. His account, the manuscript we are holding in our hands (with Auster's name on the cover), is the book *Leviathan.*

Leviathan can perhaps be best understood as a love story between the narrator and his friends: a recording of the lives of good people whose experiments in self went astray but who deserve better then they are about to receive from the establishment. Nevertheless every instance of performance and border-crossing portrayed in the text ends in disaster and violence. By the end of the book the women are all beaten and alone, the men have mostly been killed, and the people around them are dead, injured and left to pick up the shattered pieces. Our narrator Peter remains enamored with the courage of the performances around him, but as each meets the edges of the establishment (the eponymous Leviathan) he documents their collapse.

As fascinated as I am with the capability of theater, narrative, fiction and technology to perform and reinvent, I find *Leviathan* the novel frustrating for its steadfast refusal to allow any performance to end well. Nevertheless the exploration of performance and the cautious admiration of the narrator makes the text valuable for exploring our current reality with regards to computer mediated social performance. *Performance collapse*, the point at which our fictions fray and the mechanisms of personal theater become visible, is a phenomena we now encountered daily. Ubiquitous photography means that every sin can be accounted for, but such a case also reveals the veneer of "real" to a degree that requires us to re-evaluate the role of performance in our lives and in the construction of self. Whether this ends in tragedy or not seems largely based on our ability to accept a layering of realities and a multitude of potentially conflicting truths as equally true depending on framing and context. This notion, having at its heart the idea of valid multiples and context-switching, is a powerful example of how computational thinking has changed the way we see our selves.

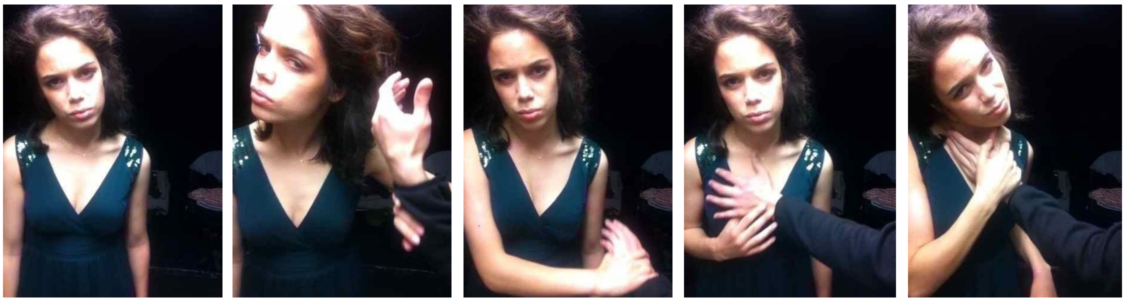

Figure 4.19: The offscreen hand interrupting performance.

4.2.3: STAGING LEVIATHAN IN 2014

Mobile video technology and the aesthetic created by contemporary social performance with these devices helped form the narrative quality of the MOTUS staging of Leviathan. What other characteristics of the play indicate a computational sensibility and how does this help us understand the changes technologies have brought us since the book's initial publication in 1992?

In order to understand the changes that computation has made to our understanding of surveillance and photography in the decade or so since Leviathan was first published, we can look at how MOTUS staged the Maria-as-prostitute scene described above. The stage adaptation does not deviate widely from the original in terms of content, but through the use of mobile video technology it demonstrates a very different sensibility than Auster's original.

We have already seen the ways in which the play makes the notion of authorship explicit. LIWYATAN/ LEVIATHAN constantly reveals the hand that creates the scene. In the play, Peter Aaron, the narrator of the original text, remains present as a character but his role as narrator is greatly diminished. Peter's narration has largely been replaced by the cast and theater environment itself. Rather than receive the text as a finished document, in the stage adaptation we clearly have the sense of both the story and the play about the story unfolding live in front of us. Consequently, in the stage adaptation Jerome's assault on Maria is observed directly rather than as a recollection told from Peter's perspective. The result is both more immediate and more disturbing. Rather than receive the scene wrapped in Peter's explanation of Maria's chastisement, we are left to experience the violence ourselves and draw our own conclusions. This framing is both more generous to Maria's role as performer and artist and more accessible to the audience than Auster's text.

Curiously this sense of immediacy is accomplished using photography, the same mechanism that signaled Maria's performance to Jerome. During the scene in question, the action takes place in one of the backstage rooms. This space is visible to the audience but at a great distance, a close-up is provided by a live feed from the camera hidden in the bathroom by Maria. We are thus provided with the camera's-eye-view of the scene. Technically and historically the camera view is treated as objective, but but here it is physically both more intimate and subjective. As observers of the play we are also the observers of Maria's performance of alternate self and if, as Auster claims, Maria's altering of her sense of self was a brutal and damaging act, here we are made complicit.

Complicity in performance through photography is a hallmark of contemporary social media interaction. Photos may be taken for one's own pleasure, but they are posted in public as performance. Every performance needs an audience. In Auster's world performance outside the "boundaries of oneself" is dangerous. Today it is not the performance itself but the shifting contexts which are potentially dangerous, and a performance out-of-context may not be recognized as such. The camera in the bathroom serves as a witness to Maria's acting, providing us as the audience of the play a way to see the scene. Jerome does not recognize Maria as a performer, nor does he recognize the play or the playacting. Jerome does not understand the camera is a witness, the eye of the audience, and for him the mere suggestion of parallel selves is enough to engender violence. In terms of contemporary culture it seems that we are more willing to accept the performative nature of social interaction, but not everyone is willing to play the game. Some people, like Jerome, will fight aggressively against what they see as a leak a fictionalization into reality.

Auster's characters and perhaps Auster himself struggle with performance and performance collapse, while the cast and contemporary audiences of LIWYATAN/LEVIATHAN revel in it. Transgressions of context occur throughout the play and were even explored actively during early devising sessions. As an example, one of the actresses who was particularly enamored by the text and the connection between the character of Maria and the real-life performance artist Sofia Calle took it upon herself to perform a version of one of Sophie's artworks. Dressing the part in a wig and trench coat, the actress selected a homeless man at random in downtown Lausanne. Over the course of an afternoon the actress stalked this man, photographing his movements and later narrating a fictional account of his life story. This activity was documented by another actor who followed the pair around the city, and the footage and description of the project were both incorporated into the play itself.

As an artist I admired the actresses engagement with the text and willingness to push the ideas in terms of craft. As a human I was uncomfortable with her choice to follow and surveil another human without his consent, even if the story she was telling was fictional. The problematic issues at play here are deeply contemporary. While Auster's text needed to imagine a fairly complex scenario in order to try and come to terms with power dynamics and photography, for us these issues are everyday events. Who is holding the camera? Who is telling the story? What is the context of the image and where are the boundaries between public and private?

While I found the stalking of the homeless man to be uncomfortably problematic, another scene in the play dealt well with almost exactly the same questions. In this scene a woman is preparing for a party. The camera is positioned as if it were behind a mirror so that we see the woman getting dressed, applying her makeup, and fixing her hair. We are invited to witness the dressing-up, the application of costume for performance. Periodically during the scene a man's hand enters the frame, awkwardly caressing and eventually grabbing at the woman (Figure 4.19). The scene is in some ways comical - the hand is always repelled, and clearly is more annoying than damaging. However when seen in the light of the previous scene and in light of the violence that many women experience daily it becomes a brilliantly disturbing series of images. This is not a major scene in the play, but is one of my favorite set pieces for the way it captures all of the anxiety of contemporary performance of self online. Who owns the image? Who is telling the story?[149] Who is holding the camera, in what context, and who or what is present just off stage?

Computation can shift our understanding of place and can change the way that we treat a space. It can shift us in time and be used to stage a scene. Some of these techniques have been employed for centuries by theater but the widespread adoption of computation into everyday life changes the equation. We are both more familiar with and struggling with our newfound ability to generate and switch context at will. We use this to supercharge our understanding of the world and to treat that world and ourselves as data. In doing so we are beginning to encounter large existential questions that are beyond the reach of a single design probe or line of academic inquiry. This however is exactly where we should be: Art is exceedingly good at asking questions. Coupled with contemporary technology, performances can help us model and understand the world. Computational models created for practical reasons have given us a vocabulary for understanding, and we can use that same vocabulary to help us understand ourselves.

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[149] Turkle, Sherry, and Seymour Papert. "Epistemological Pluralism and the Revaluation of the Concrete." Journal of Mathematical Behavior 11, no. 1 (January 1992): 3–33.

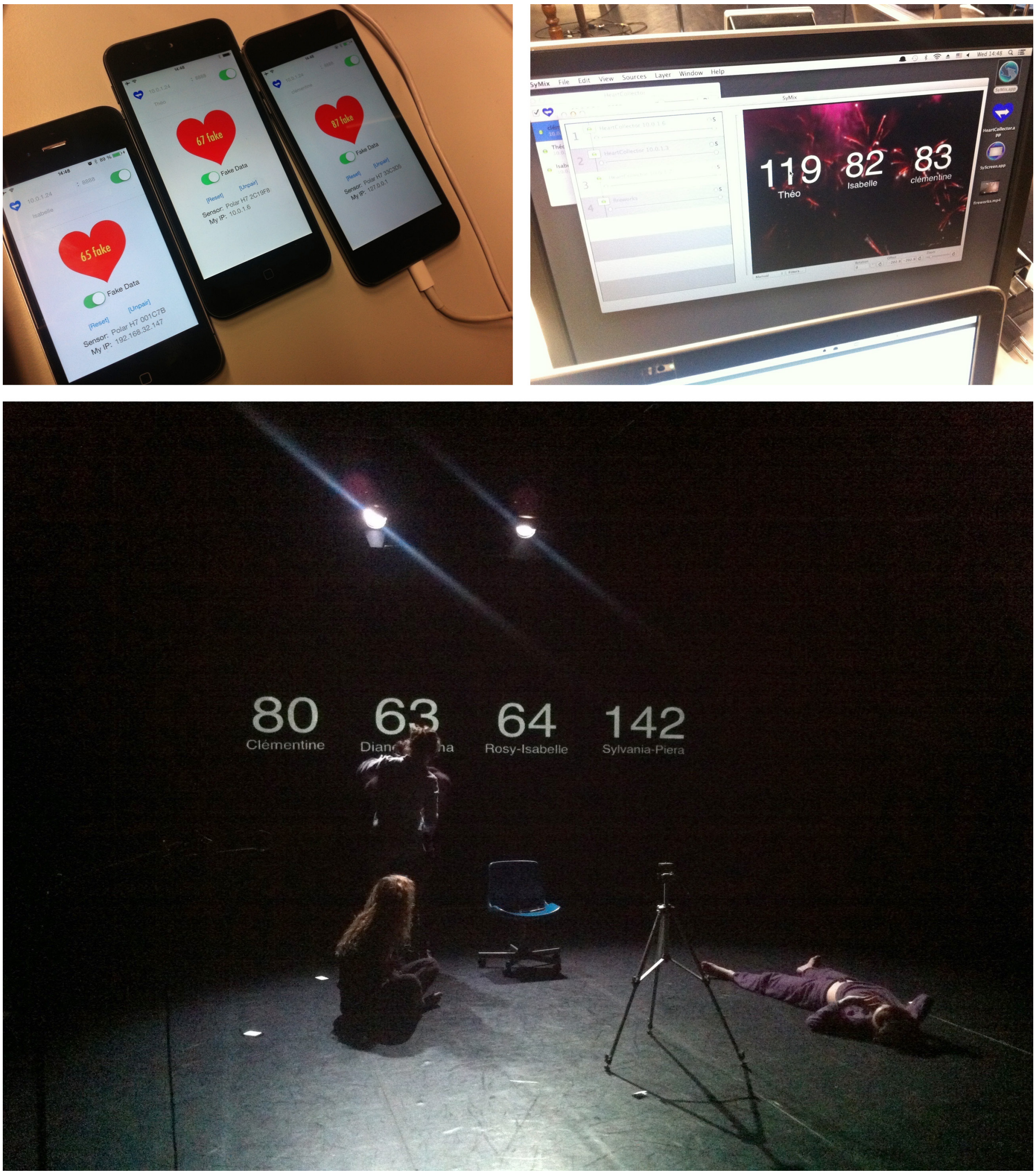
65 fake
Fake Data
[Reset] [Unpair]
Sensor: Polar H7 001C7B
My IP: 192.168.32.147
67 fake
Fake Data
[Reset] [Unpair]
Sensor: Polar H7 2C19F8
My IP: 10.0.1.6
87 fake
Fake Data
[Reset] [Unpair]
SyMix File Edit View Sources Layer Window Help
119
Théo
82
Isabelle
83
clémentine
80
Clémentine
63
64
Rosy-Isabelle
142
Sylvania-Piera

Figure 4.20: HeartMonitor and HeartCollector software on iPhone and desktop respectively, and the data projected during rehearsal. Note the rates: the two women on the ground have been relaxing and their heart rates are in the 60s. The person moving rapidly over them is 142, and Clementine the director (80) was sitting and speaking to me.

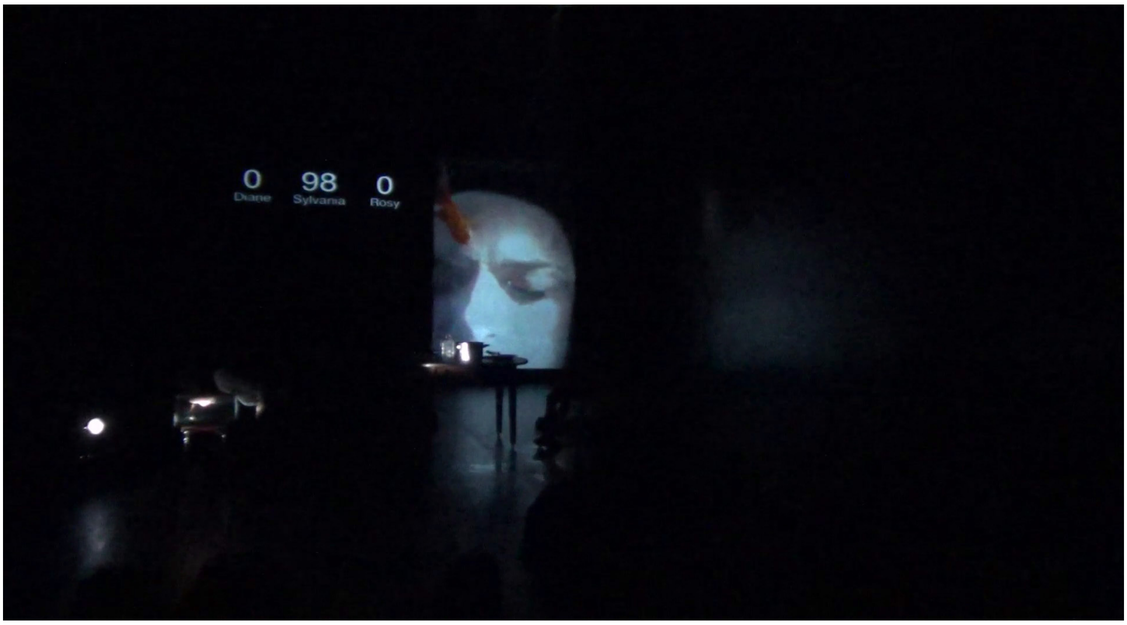

Figure 4.21: Stage setup for L'auteur dans la mise en scène by Clémentine Colpin, featuring HeartCollector. At this point two of the three performers are "dead" as indicated by their heart rates of zero on the screen. One of them has just drowned face-first in a fish tank. Video shot from inside the tank is projected on screen via SyMix.

4.2.4: THE QUANTIFIED SELF

Following the LIWYATAN/LEVIATHAN project, I was approached by one of the directorial masters students of La Manufacture with a challenge: could the heart rate of an actor be tracked live on stage? The student, Clémentine Colpin, wanted to use the data as both the scenography for her play and as a storytelling device. I was curious about the project for reasons both technical and conceptual. From a technical perspective this project was a challenge: gathering heart rate data reliably on stage for one person is often difficult, but the play required that we track four or more individuals. Also, this data needed to be transmitted wirelessly and displayed simultaneously for the duration of the show.

The technical challenge here was met using low-power Bluetooth (BLE) modules designed for use by athletes engaged in heart-rate training. Each of four actors wore one of these modules around her chest. These devices communicated wirelessly to an iPhone application I wrote called *HeartMonitor.* Each actor carried a phone with her in her pocket or strapped to her body. The phone was responsible for collecting the local heart rate data and transmitting it via OSC over wifi to a computer which then rendered the data in text via using another piece of custom software also called *HeartCollector* (Figure 2.0). The result of this was fed into the SyMix tool originally developed for LIWYATAN/LEVIATHAN, allowing for a single simultaneous projection of all four heart rates along with a video overlay used later in the play.

Conceptually what was most interesting for me was the use of biometric data as a narrative device. We have seen the way in which we perform computationally using film and video and how this can change our sense of place, space and self. This has largely been expressed through our use of photography and image, but perhaps even more tightly linked to computation is the so-called "quantified self" movement. A large number of software and hardware devices are currently on the market to help individuals collect data about themselves. *FitBit, Nike Fuel, Zeo*, applications like *RunKeeper* and *Daytum* all target the health and athletic market. There are data collection devices and software to help you identify patterns in your eating, your workout, in the behavior of your children and even your pets. The promise of all of these tools is that computation can be used to find actionable patterns in data which is otherwise difficult to understand or even see. As Wired magazine author Mark McCluskey wrote in 2007: “We tend to think of our physical selves as a system that’s simply too complex to comprehend. But what we’ve learned from companies like Google is that if you can collect enough data, there’s no need for a grand theory to explain a phenomenon. You can observe it all through the numbers. Everything is data. You are your data, and once you understand that data, you can act on it.”[150] This is computation as prosthetic superpower augmenting the body as a source of data.

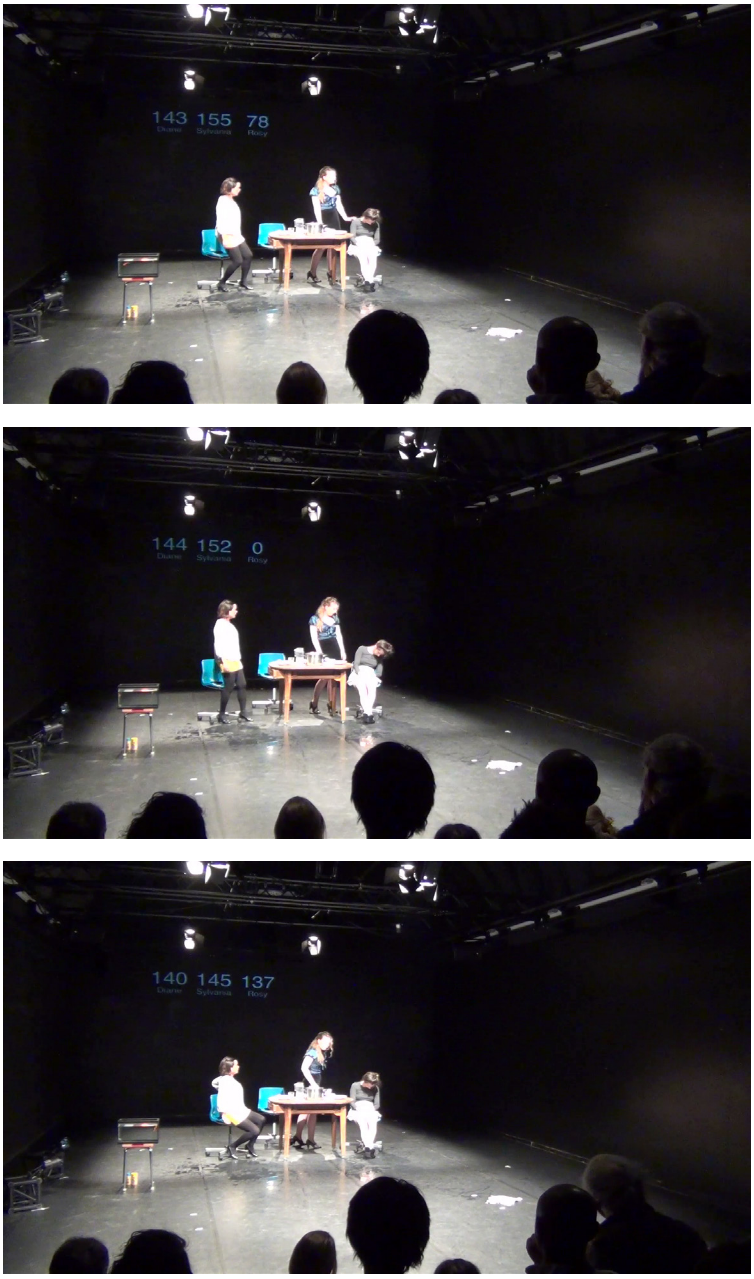

Figure 4.22: Ruth, the character on the right, “dies” on stage, as reflected by her heart rate dropping to zero (visible in the background).

Clémentine’s play was not explicitly about quantified self but allowed us to explore these ideas. Just as LIWYATAN/LEVIATHAN allowed us to explore the way that our relationship to performance has changed as a result of ubiquitous networked photography, what I appreciated most was in L’auteur dans la mise en scène was the inherent criticism of data-as-self present in using health technology as a narrative device. The heart rates displayed behind the actors (a number underlined with their name) served as surrogate representations of individuals, or at least their bodies.

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[150] McClusky, Mark. “The Nike Experiment: How the Shoe Giant Unleashed the Power of Personal Metrics.” WIRED. Accessed January 12, 2015. http://archive.wired.com/medtech/health/magazine/17-07/lbnp_nike?currentPage=all.

A key narrative element of this production was that each of the characters, including Clementine herself, were "killed" during the show (Figure 4.22). Early on this was a design consideration for the software: Clementine wanted to track the heart rates on stage but also wanted a way to turn them off in a manner which implied the actors hearts had stopped. For this purpose I implemented a "kill" button which made the display go from current reading to zero over an adjustable period of time. During the introduction to the play, Clementine showed the audience her own heart-rate tracking device and explained that each of the actors was also wearing one. This is the pedagogical moment, echoing the function of the car-explosion seen in LIWYATAN/LEVIATHAN (introducing the audience to the technology). It also solidified the audience understanding of the projected numbers as representing the actors. The audience was made to understand the numbers were not only representing individuals but also impassively, scientifically and objectively tracking them. The heart rates were the people, showing their true state independent of the roles they were performing in the play. The tension between this understanding and the understanding of the performance as fiction was exploited for dramatic and comedic effect with each "death."

Killing the characters in this way seemed a perfect critique of the quantified self moment, as did all of the myriad jokes and bugs that we encountered along the way ("Maybe she's dead!" / "No, she just doesn't have a heart!"). We are not our data, but we have been experimenting socially with the idea that we might be. The promise inherent in the marketing that surrounds the quantified self movement is that we might divine a deeper understanding of ourselves and our species by studying the numbers. Artworks, long vehicles for this type of introspection by proxy, can make use of this same technology in a playful way to help us explore the gaps in our thinking and perhaps to come full circle to arrive at what we were looking for in the first place: a more nuanced understanding of our selves.

4.3: EXPERIENCING COMPUTATIONAL SHIFTS

Space becomes place by virtue of the fact that humans invest meaning into location. This investment is aesthetic, emotional, and intellectual. Space becoming place is also a matter performance: we perform our meaning and we attach this meaning to context and staging. Ubiquitous computing, in particular smartphones equipped with cameras, allow us to turn every moment and every place into a site of performance. Thus computation has fundamentally shifted the way that we think about and the way that we behave towards space. Cinematic, photographic, and computational vocabularies are no longer limited to the technical or authorial, but have become part of the way we tell stories in our everyday lives.

5

CHAPTER FIVE THE TERRITORY OF THE MAP

Chapter 5 asks how computation has changed our relationship to the notion of experience and modeling and presents the concept of experience catalyst as both an example and a framing for considering interactive artworks and performances as parametric models of ideas.

The work centers around an interactive game engine and installation called *CinemaMutation* which was used to present the film *HotelCity*.

5.1 THE TERRITORY OF THE MAP

5.1.1: HOW DOES COMPUTATION CONVEY EXPERIENCE?

Computation has created the opportunity for us to shift our understanding of space, place, self and society. Comprehension and creation of these mediated experiences rely on computational epistemology: a core understanding and sensitivity to certain computational ideas that make this type of communication possible. Computational epistemology is characterized by the basic computational loop which, when applied to the world around us, carries with us the ability to amplify and augment our perception of time, place and each other. Aesthetic characteristics of this awareness include a fundamental affinity to layering, an understanding and ability to follow fast context changes, and an internalized understanding of performance and modeling.

Key to understanding this relationship as it manifests now is the nature of the feedback loop. Computation allows us to do the same sort of things we've always done but much faster than before. This speed of iteration allows the feedback loop between audience and performance and operator and tool to collapse in on itself, thus becoming a site for knowledge generation.

In the 1980s Seymour Papert imagined computational modeling as a site for learning, an idea which defined his *constructionism* concept as an extension of Piaget's *constructivism*. In particular, Papert positioned modeling as the creation of an "object to think with" in public, an activity that facilitates learning: "Constructionism is the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe."[151]

While Papert's idea extends to non-computational models such as sand castles and theories, many fields of practice have adopted computers for this purpose: to create models in order to collectively learn and explore ideas that might otherwise be too difficult, complicated, expensive or impractical to explore directly. But just as we have seen an increase in performance collapse and both a general anxiety and increasing tolerance towards the same, we have also seen a kind of "model collapse."

The slight difference here is that models in this sense are not external objects which mimic some part of the real world (as they originally were) but are themselves now fully realized and complete entities. This collapse does not run counter to constructionist ideas but underscores their usefulness: With the introduction of computation models are not only simulations of real-world phenomena but are themselves complex enough that they become sites of their own understanding and knowledge generation. Models are not "just tools," but places that we can visit and dwell in. These type of models, simulations or situations for understanding I call *experience catalysts*, a term borrowed from SINLAB philosopher Jens Badura.

An *experience catalyst* is a situation, a technology or an environment (usually a combination of all three) which enable the person who encounters it to directly experience a particular idea or set of ideas. An experience catalyst is therefore not a substitute for a concept but a way of facilitating direct engagement although its form may resemble a model. Experience catalysts are not fake experiences. Although they are mediated by a staged environment, experience catalysts are as real as the emotional impact of a book or film, or the reaction we have on hearing a friend tell a particularly sad or joyful story.

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[151] Papert, Seymour, and Idit Harel. "Situating Constructionism." *Constructionism* 36 (1991): 1–11.

Figure 5.1: Ben Stiller is confused about a model in the 2001 film Zoolander.

> **Derek Zoolander:** *What is this? A center for ants? How can we be expected to teach children to learn how to read... if they can't even fit inside the building?*
>
> **Mugatu:** *Derek, this is just a small...*
>
> **Derek Zoolander:** *I don't wanna hear your excuses!*
> *The building has to be at least... three times bigger than this!*

5.1.2: MODELS OF REALITY

Modeling is a practice whereby a simulacra or simulation of a place or experience is instantiated, physically or virtually, so that it can be explored. Modeling is typically employed as a strategy for encounter when encountering the actual place or event is impossible or difficult. Often this is due to complexity, expense or danger to the observer. We create models of skyscrapers before we build them so that we can visualize their impact on the environment and sell their grandeur to investors before spending the time and resources to build them. We create models of the battlefield so that we can plan attacks without needlessly endangering our own side or expose our strategy to the enemy. We create dioramas of events which occurred eons ago so we can see what dinosaurs looked like without a time machine. We create models of ideas in our own heads so that others can engage them without needing to read our minds.

In constructivist epistemology we create models of the world in order to express and discuss our own understanding of the world with others. These models are "objects to think with:"[152] temporary externalized instantiations of ideas which are normally fluid and kept internal. By rendering our ideas "out loud" for others, we create sites of discussion and knowledge generation. This notion is fundamental to art practice[153] and constructivist epistemology both.[154]

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[152] Ibid.

These sorts of models are perhaps the easiest to understand examples of what Constructivism calls an "object to think with."[155] We understand inherently that an architectural model helps us visualize the impact of the building on a space. We can understand also how a computational model of the same space might be used to model change over time: for example airflow or light conditions. We understand how a computational or parametric model of the same system[156] might allow us to play with parameters to look at many of these things at once. In all cases we recognize models as models and not the actual thing: the model is a stand-in, and we are not confused or upset by missing information or incorrect scale.

5.1.3: REALITY COLLAPSE

Computation allows us to apply shifts in space, time and concept to models by looping quickly through variations and contexts. We model weather, epidemics and forest fires in order to get a low-risk sense of how these phenomena occur. Often we combine this data with real-world data, allowing us to "zoom out" to treat unpredictable or difficult to observe systems mathematically. We use this analysis to reconsider historical precedents.[157] plan political campaigns,[158] make sense of the ocean[159] and determine who gets medical treatment.[160] Computation allows us to make our models easily shareable and also fluid, capable of being modified at speeds which begin to approach the speed of thought.

In the film *Zoolander* the main character Derek Zoolander, played by comedian Ben Stiller, is presented with a model of a center for children that he hopes to fund. Derek, angrily misunderstanding the idea of model, smashes the building to the ground while demanding to know how it could possibly function as a community center when it's obvious that people can't even fit inside (Figure 5.1). This is obviously played for comedic effect: we the audience understand a model is a model and not real, and to propose otherwise is silly. Part of this understanding of model-ness comes from cues that tell us the object "isn't real." The model is the wrong size, it is made of the wrong materials, it is non-functional or is in the wrong context.

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[153] Ibid.

[154] Papert, Seymour. "The Turtle's Long Slow Trip: Macro-Educological Perspectives on Microworlds." *Journal of Educational Computing Research* 27 (January 2002): 7–27.

[155] Ibid.

[156] Ishii, Hiroshi. "Illuminating Clay: A Tangible Interface with Potential GRASS Applications," 2002. http://senseable.mit.edu/papers/pdf/2002_Piper_et_al_GRASS.pdf.

[157] Distant Readings: *Topologies of German Culture in the Long Nineteenth Century*. NED - New edition. Camden House, an imprint of Boydell & Brewer, 2014.

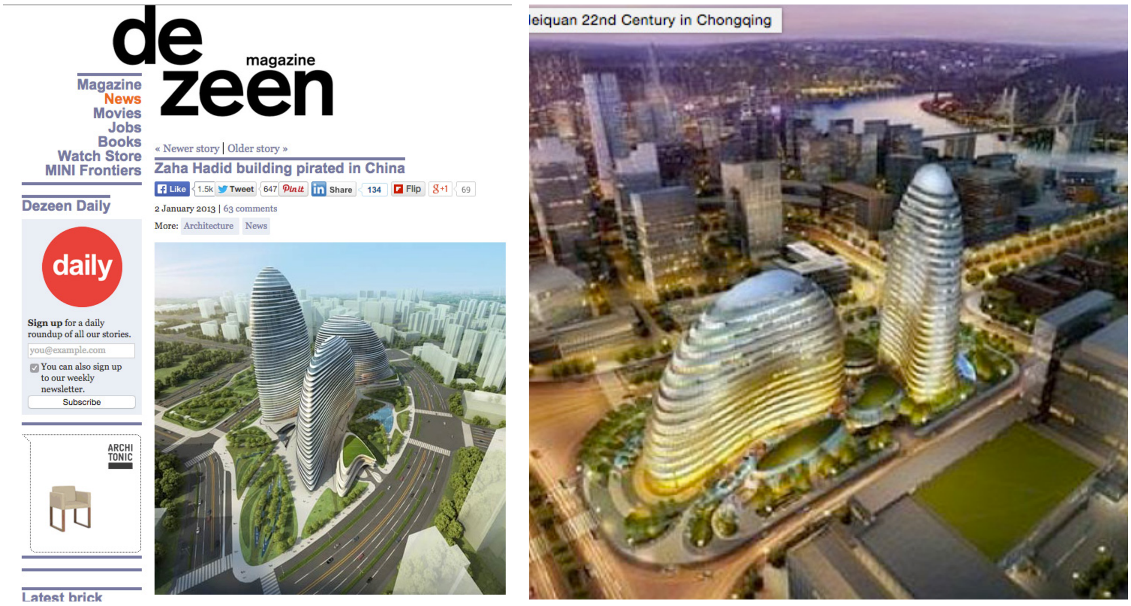
Guldi, Jo. Roads to Power: *Britain Invents the Infrastructure State*. Cambridge, Mass: Harvard University Press, 2012.

Onion, Rebecca. "Historians: Go Big or Go Home!" The Boston Globe, December 14, 2014. https://www.bostonglobe.com/ideas/2014/12/14/historians-big-home/6WFFq3tanP7nMdru0kzfVK/story.html.

[158] Nickerson, David W., and Todd Rogers. "Political Campaigns and Big Data." *The Journal of Economic Perspectives* 28, no. 2 (April 1, 2014): 51–73.

[159] III, Isaac R. Porche, Bradley Wilson, Erin-Elizabeth Johnson, Shane Tierney, and Evan Saltzman. *Data Flood: Helping the Navy Address the Rising Tide of Sensor Information*. RAND Corporation, 2014. http://www.jstor.org/stable/10.7249/j.ctt6wq8rr.

[160] Lissovoy, Greg de. "Big Data Meets the Electronic Medical Record: A Commentary on 'Identifying Patients at Increased Risk for Unplanned Readmission.'" *Medical Care* 51, no. 9 (September 1, 2013): 759–60.



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Subscribe
ARCHI TONIC
Latest brick
leiquan 22nd Century in Chongqing

Zaha Hadid building pirated in China

2 January 2013 | 63 comments

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Figure 5.2: DeZeen Magazine Coverage of the Chinese "piracy" of Zaha Hadid's Wangjing Soho Complex (left) by a developer building Meiquan 22nd Century (right) in Chongqing.

What happens when we move our models into computational space where, as we have seen, context can be rapidly shifted, materials and size don't matter and virtually any space can become the right place? What if we began to understand models as not merely as external artifacts, but as sites in their own right? In order for this to work our models would need to be able to change rapidly, at or near the speed of thought, and this is what computation has given us. Computational epistemology comes about in part because we have models which are flexible enough that we no longer recognize them as models. Models become ideas and experiences in their own right, sites for exploration, knowledge generation and understanding with their own histories and aesthetic vocabularies. The map has become the territory.

The degree to which computational modeling has become "the thing" and not merely "the model of the thing" can be seen in a curious anecdote about the rise of parametric architecture[161] and the new anxieties this has brought to the field. Computer modeling for architecture began as a way to help visualize traditional materials and means of construction. Early computer modeling merely reproduced the work that could be done by hand in a render or with cardboard or wood. Over time, however, computational notions infected aesthetic sensibility to became its own aesthetic. Both Zaha Hadid and Frank Gehry propose and build structures which are impossible to construct without computer aided design.[162] Much is made of the result but in terms of computational aesthetics what is more important is that their structures could not have been *imagined* prior to the widespread adoption of computation.

New techniques may be necessary to make construction efficient, but it is possible to build a Hadid or Gehry structure out of stone, glass and concrete. It is also possible to model one out of paper or foam core. What is impossible is to imagine that such design be proposed, let alone built, in an urban neighborhood in 1870 or even 1970 - the aesthetic understanding necessary for their presence simply did not exist.

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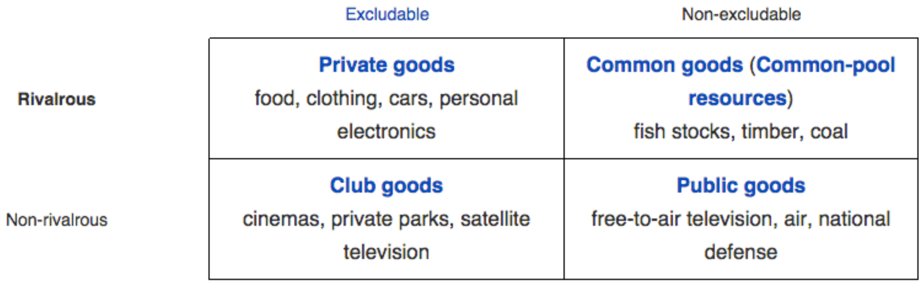
[161] Mitchell, William J. "Beyond the Ivory Tower: Constructing Complexity in the Digital Age." *Science* 303, no. 5663 (March 5, 2004): 1472–73. doi:10.1126/science.1091973.

[162] Russall, Jamas S. "A San Gimignano for Science, Gehry Partners' STATA CENTER Nurtures a Research Culture Ready to Cross the Fast-Dissolving boundaries of Knowledge." *Architectural Record*, August 2004.

The aesthetic style of Hadid and Gehry owes so much to computational aesthetics it should come as no surprise that these structures serve the same particular cultural roles shared by computation: they define place, they set context, they change our relationship to space, and they do it by overlaying a strong vocabulary of their own. Iconic structures by Hadid and Gehry are as advertised: they are self-contained icons. These structures do not speak to the environment or seek to provide a dwelling for genius loci but rather they define a sense of place by force of will.

In 2013 Hadid's *Wangjing Soho Complex* was built by a developer in Chongqing without credit or permission. This copy, called *Meiquan 22nd Century*, is being built concurrent to the original project. Beijing and Chongqing are 2000km apart, and yet we now supposed to understand that there are two of the same places in the world. Coverage of this event freely used the words "piracy" and emphasized the weakness of China's intellectual property law as a problem for architecture, a discourse usually reserved for ideas rather than things (Figure 5.2). It is extremely strange to think of place as something that is rivalrous and excludable (Figure 5.3)[163] and yet this type of architecture does exactly that: it privileges the notion of spacial organization as an idea so strongly that it overrides the very notion of place. It seems irrelevant that these places are miles apart, unlikely to be visited or occupied by the same individuals and unlikely to be seen in the same light literally and figuratively. Our only recourse seems to be to describe the real world in computational terms.[164] The boundary between model and place is collapsing. Further, models are not static and they are not end-points: they are fluid and malleable as is our thought. Rather than use computation to model the real world, computational epistemology positions the real world as a space in which we print our models. The computational world is real, and the real world becomes a place to hold our renders. In this way the relationship between physical reality and virtual fiction has been flipped.



	Excludable	Non-excludable
Rivalrous	**Private goods** food, clothing, cars, personal electronics	**Common goods (Common-pool resources)** fish stocks, timber, coal
Non-rivalrous	**Club goods** cinemas, private parks, satellite television	**Public goods** free-to-air television, air, national defense

Figure 5.3: Rivalrous and Excludable (chart from Wikipedia)

This notion is not unfamiliar to those that practice art, nor to those who have spent any significant time immersed in the computational worlds created by games like *World of Warcraft* or *SecondLife*. Although considered by many to be "more real" the same can be said about media-performance sites like Facebook and Twitter. In all such cases, the residents of the virtual and the author of the content are the same. The narrative takes center stage and the tools of objective documentation (usually photography) are used not to convey an experience of the real into the virtual, but rather to record evidence of the online-narrative's impact on reality. We don't post photos of a party on Facebook in order to report that the party has hap-

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[163] Leach, John. "A Course in Public Economics | Public Economics and Public Policy." *Cambridge University Press*. Accessed January 13, 2015. http://www.cambridge.org/hn/academic/subjects/economics/public-economics-and-public-policy/course-public-economics.

[164] Gillespie, Tarleton. *Wired Shut: Copyright and the Shape of Digital Culture*. Reprint edition. Cambridge, Mass.: The MIT Press, 2009.

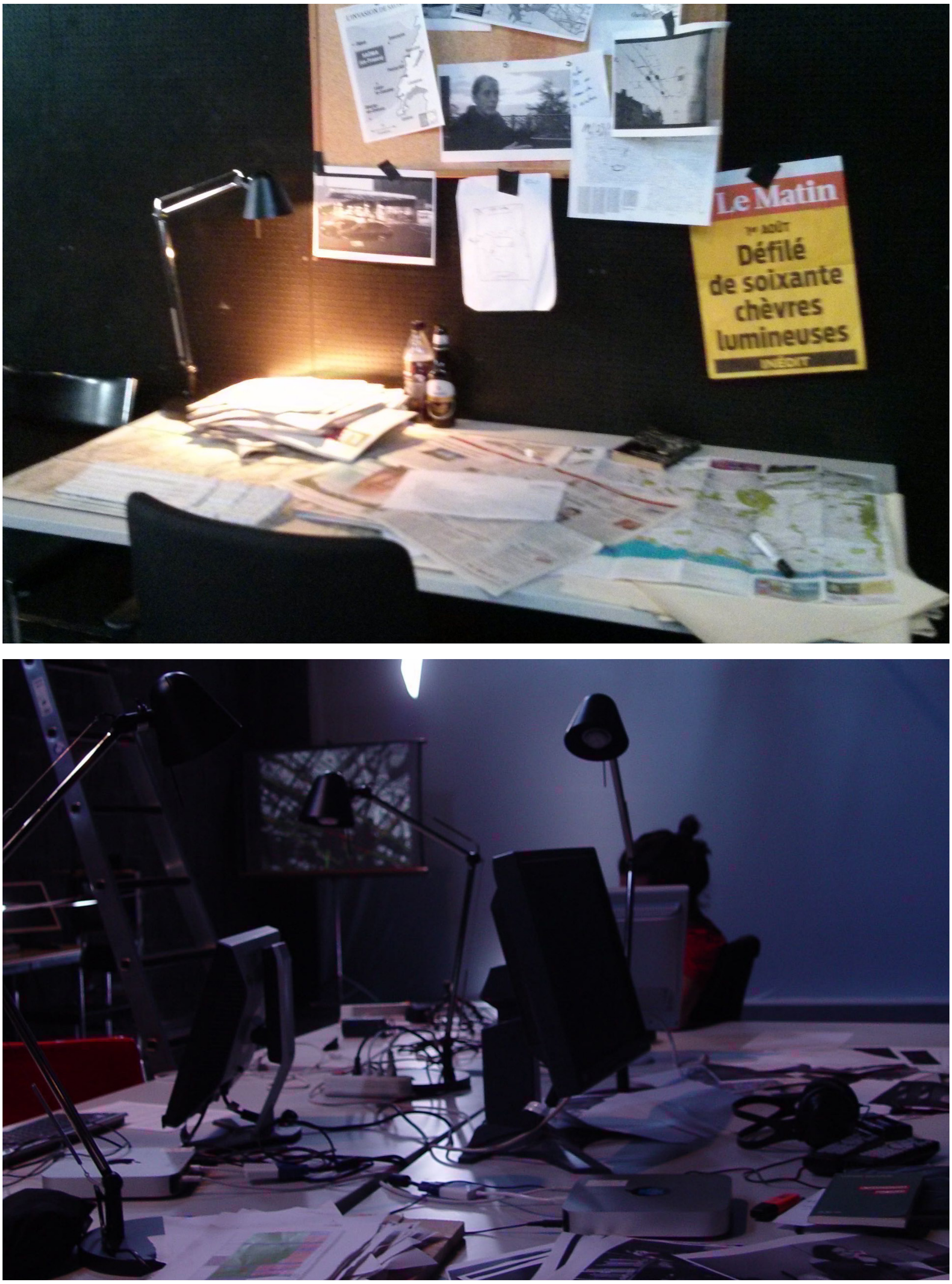
Le Matin
1er AOÛT
Défilé de soixante chèvres lumineuses
INÉDIT

Figure 5.4: Two scenes from the "Abandoned production office" installation of Hotel City as seen at the La Manufacture 10 Year Anniversary celebration.

pened, we post photos as proof that our virtual Facebook-self actually exists. Similarly, screenshots and fan-art of video games don't exist to support the game, they exist as artifacts which manifest the fictional into the real in order to validate the virtual experience.

5.1.4: HOTELCITY

Shortly after completing the LIWYATAN/LEVIATHAN and HeartCollector projects, I was approached by François-Xavier Rouyer, a student at La Manufacture who is studying both film and theater. François-Xavier (who goes by FX) was shooting a film called HotelCity. The actors in the film were all recent graduates of the La Manufacture acting program and the work in progress was going to be shown at the La Manufacture 10 year anniversary celebration.

HotelCity is an exercise in psychogeographic cinema. Originally called *46°31'26.4'' N 6° 38'9.6'' E* (the GPS coordinates for Switzerland), the film mixes elements of genre narrative, film-noir and spy films in particular, to tell the story of a secret society and their machinations in and around the city of Lausanne. The film is shot as a series of vignettes which can be watched independently or in one of several orders, chronologically or thematically. The initial intention during filming was to include every graduate of the La Manufacture acting program making for a cast in the hundreds. Not every graduate is featured in the film but the cast contains fifty to sixty different characters and as many story lines, all shot in different locations around Lausanne. Due to the large number of characters the film can be watched by following the action of one character throughout the story or by remaining in one location and watching the various stories which take place in that location. The film is like the city itself: many stories overlapping each other, occasionally crossing, influencing each other even when the influence is invisible or seems incidental.

The tenth year anniversary celebration took place on September 15, 2014, midway through the production of the film. The intention for that event was to show the work in progress while emphasizing the production as an ongoing event. The initial idea was to present the public with an editing room. Called "Rush Room," this installation was imagined as an editing suite which visitors would be allowed to enter in order to create their own version of the film which would be presented alongside the most recent "directors cut" of a linear version of the film.

Early on it became obvious that a real editing room was not the appropriate way to present the material, especially for an opening party where it was expected that a large number of visitors would encounter the film in a short period of time. Editing is a special skill that takes a great deal of time. As most of the visitors were not expected to be film editors it seemed unlikely that they would be willing or able to spend time editing footage. Instead I decided to try to create an environment that would conveyed the idea and experience of editing. While presenting the footage I wanted to give the audience some sense of what it was like to make a film like Hotel City. I wanted to create an immersive model. Not a dumbed-down editing tool, but a situation in which people would directly experience mental processes similar to those encountered when editing footage and mentally connecting locations, themes and people across space and time. It also seemed important to convey directly a sense of distributed place. Initial brainstorming included an idea of an actual physical dérive165 around the city of Lausanne, perhaps culminating in a clandestine meeting where participants would receive a physical key to an apartment somewhere in the city where the film was being screened, but unfortunately this seemed impractical to execute.

In a bid to capture all of these ideas FX and I settled on a game-like approach. I developed a storytelling engine called *CinemaMutation*, which allows the audience to explore locations, footage and related documentation fluidly. In addition we began to discuss the role that computation was playing in the story.

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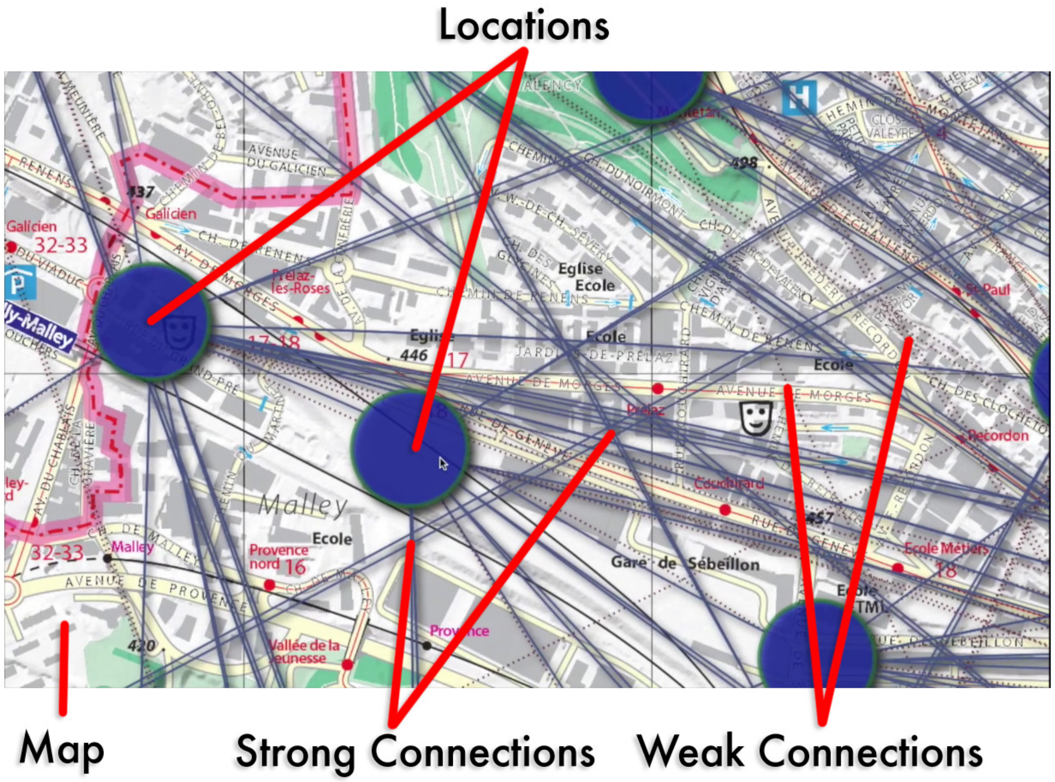

Figure 5.5: CinemaMutation / HotelCity Map

A kind of meta-character emerged through our discussions and the development of the CinemaMutation software. In a manner similar to "the author" in CYBORG[AME], the film was making itself known and requesting that we present the content in a certain way. Playing with this idea, FX and I discussed a fantasy scenario in which all of the footage and a computer would be locked into a cinema for 100 years to be discovered by an unknown audience in the future. In this version of the story, the future discovery would reveal that the computer had spent a century trying to complete the work the human authors had left behind. The computer had been making films, running through every possible iteration in a desperate bid to understand the story encoded in the data that it had been given. This idea evolved into the scenography for the 10 year anniversary presentation. *Rush Room* became an abandoned editing suite, filled with equipment for surveillance and film making. The filmmakers were nowhere to be seen, but visitors were allowed to sift through the artifacts they had left behind. Computer terminals provided access to actual surveillance cameras mounted around the room as well as allowing visitors to watch Hollywood blockbusters which had influenced various scenes in Hotel City. The script of the film and related documents were scattered around as well, encouraging visitors to encounter elements of the film and its production at their own pace. In effect the room itself became the experience of making the film as the visitors put together their own story from the information at hand.

By staging a situation where the audience was able to explore the material of both the film and the filmmaking process we created a situation that was similar to the process of making the film itself. We hoped to catalyze an experience and convey a particular understanding of film and the city that was in the heads of the filmmakers.

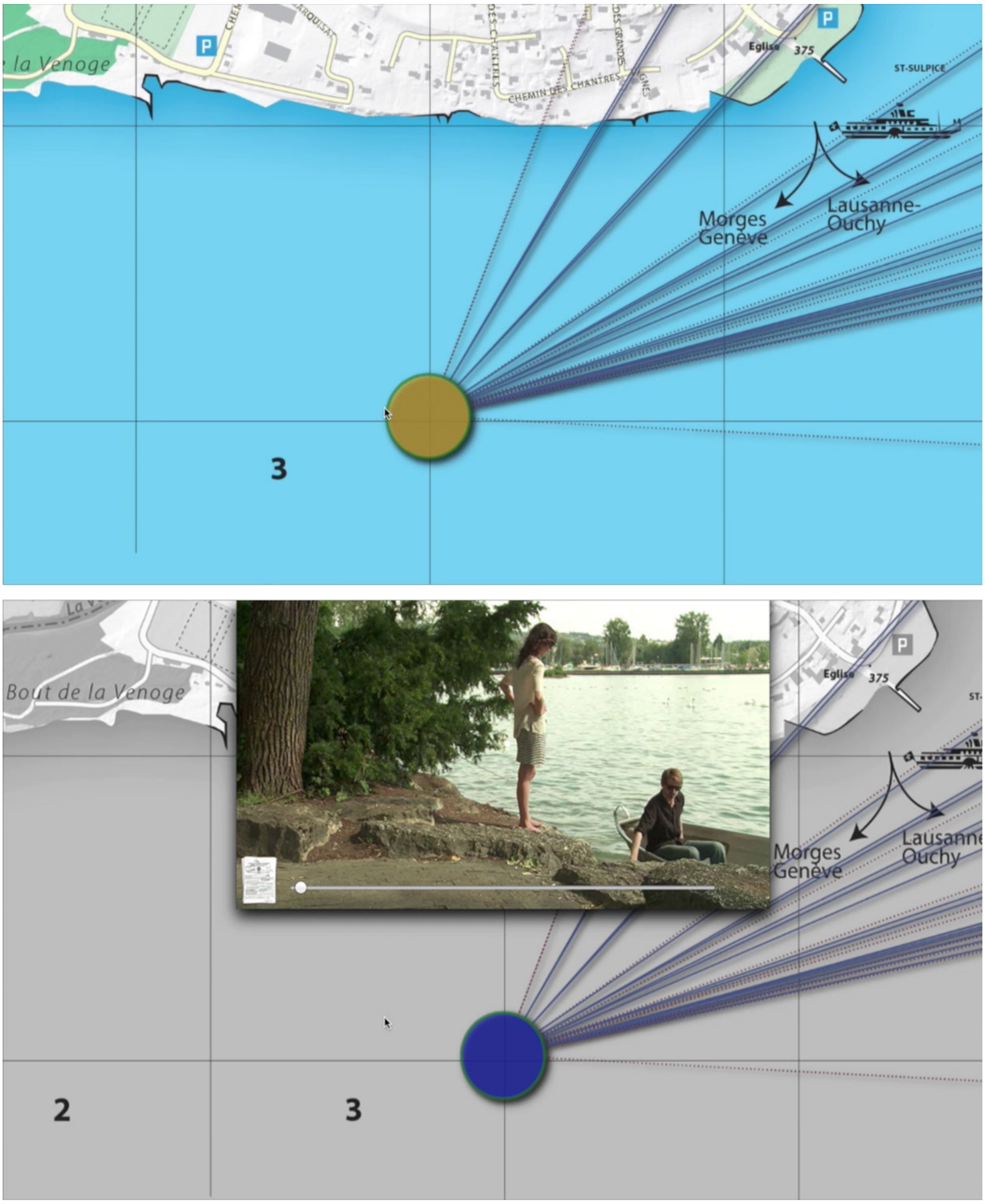
la Venoge
CHEMIN DES CHANTRES
Eglise
375
ST-SULPICE
Morges
Genève
Lausanne-
Ouchy
3
Bout de la Venoge
Eglise
375
Morges
Genève
Lausanne
Ouchy
2
3

Figure 5.6: Clicking on a location shows footage of events which occurred at that site.

5.1.4.1: CINEMAMUTATION - INTERACTIVE MODE

Key to the creation of this experience catalyst was *CinemaMutation,* a game engine I designed for this project. Cinema Mutation is a general purpose tool for psychogeographic storytelling which was used in two very particular ways for this installation: as a display of the film itself and as a means for interactive exploration of the film and related materials. Both modes were built on the same architecture: film, images and documents were grouped together and presented as locations on a map. Thematic links between these elements were represented by lines drawn between the locations.

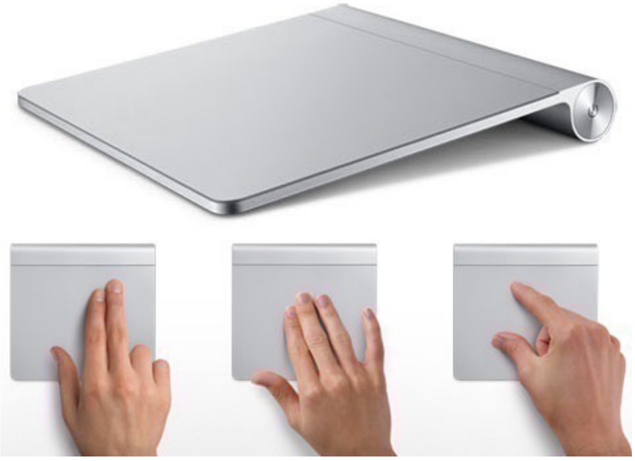

Figure 5.7: Apple Magic Pad with gesture support.

The basic unit of the interaction in *CinemaMutation* is the "map" which may be any image or PDF document. The map is presented in an endless tiled view, so that a user can scroll and zoom at will. This interaction is familiar to anyone who has used Google maps or similar mapping software, although it is important to note that the map need not be an actual map: the software supports any information capable of being displayed in two dimensions. Thus the "map" might be a document, a portrait, a painting or picture of an object.

For the *HotelCity* project, the map used was an actual map of the city of Lausanne. Overlaid on the map was a network of locations, each representing one or more film segments. Clicking on a location navigated a user to that spot and presented the user with footage that was either shot on that location, or which was supposed to have taken place at that location within the frame of the narrative (Figure 5.6). These two things (story-location and actual-location) were often but not always the same. Discrepancies were deliberate and helped add another layer of spacial-shift to those familiar with the geography of Lausanne.

In addition to film clips, many of the locations featured documents that were related to the vignette being displayed. These documents added yet another layer of information about the story and the making of the film. Users were able to explore the map, the locations, and the documents freely in any order and without additional guidance. Thematic connections between locations were indicated by color-coded lines. Strong thematic connections or those involving storyline of the single character were indicated by solid lines. Dotted lines indicated weak thematic connections between scenes (Figure 5.5).

The software is designed so that the only control necessary is a single Apple "magic pad," a large trackpad that supports multitouch gestures such as pinch and scroll (Figure 1.7). In this way I was able to present a

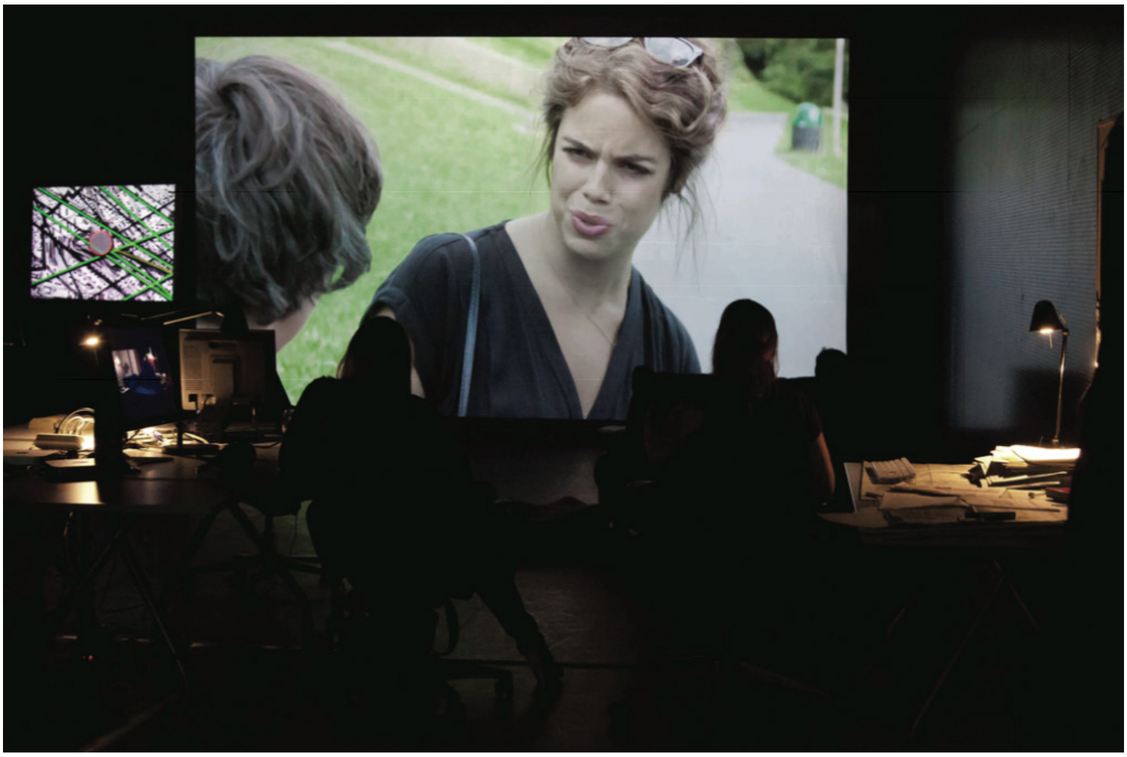

Figure 5.8: HotelCity *presented in generative mode by* CinemaMutation. *The map at the left indicates the site of the current scene. The green line shows the entire sequence and the dotted red line indicates the scenes which have been played already.*

visually minimal interface based primarily on physical gesture, which does not need to account for more than one user at a time and allows us to leverage the interface vocabulary the audience understands from their use of smartphones.

5.1.4.2: CINEMAMUTATION - GENERATIVE MODE

In generative mode, the system is capable of showing a film to an audience in much the same way one might watch a traditional film with the exception that the film has no set sequence. To generate a film *CinemaMutation* follows a set of simple rules to create a path through film segments. The path is shown via animation, "flying" the viewers to each location before displaying the relevant video clip. In order to generate the path, the system follows simple rules for display and branch choice: the first of which is that any given clip cannot be played more than once for the duration of a single run. The film begins at a randomly selected location. The next location is selected by following a strong link. If more than one strong link is available, the system selects randomly between them, discarding paths that lead to a clips we have already seen. If all of the strong link options are exhausted for a given location, weak links are used following the same pattern. If all strong and weak link options are exhausted, the film ends. During this particular installation, the end of each run resulted in the system generating another film, so that the room replayed a continual series of vignettes infinitely walking through all possible story combinations.

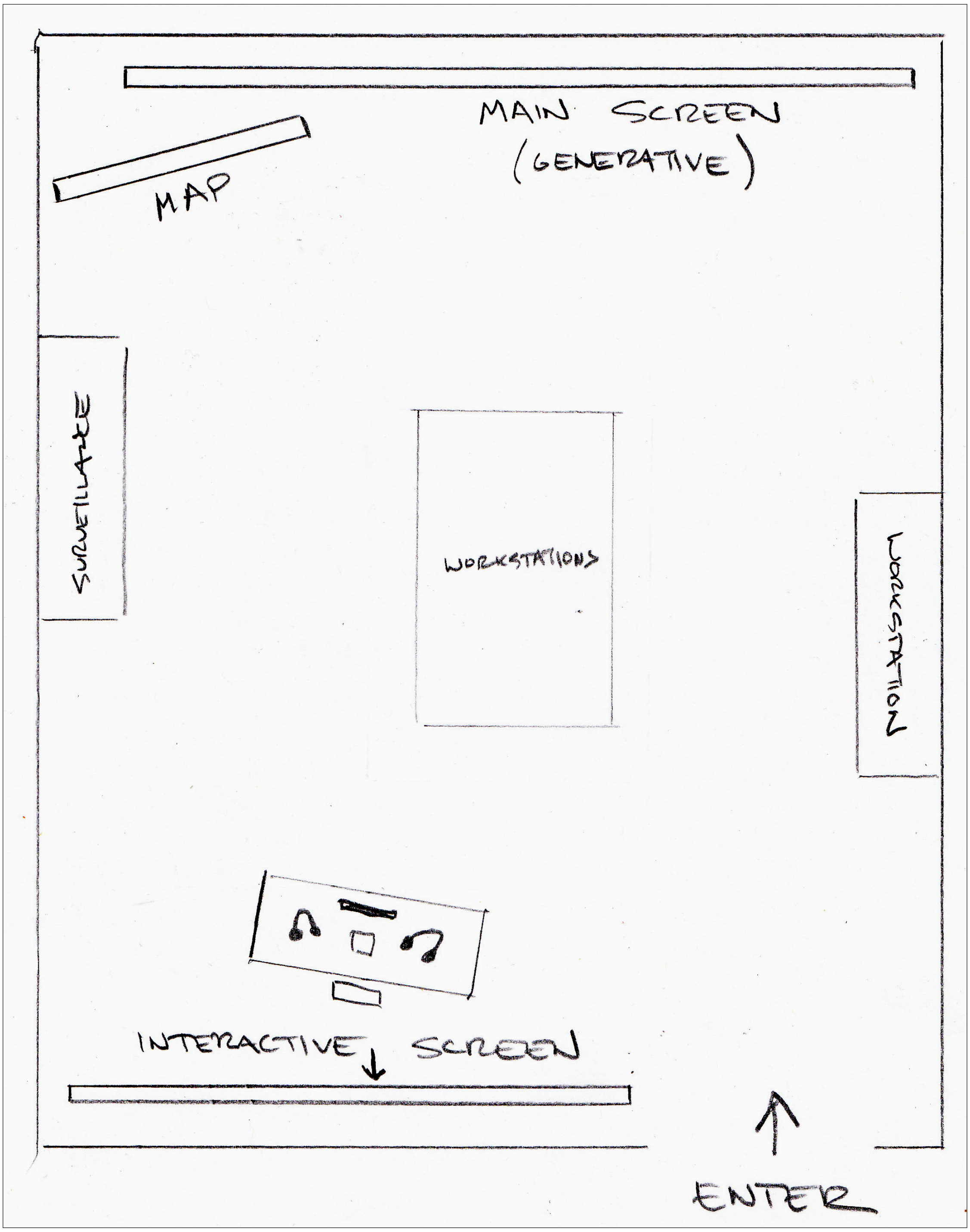
MAIN SCREEN
(GENERATIVE)
MAP
SURVEILLANCE
WORKSTATIONS
WORKSTATION
INTERACTIVE SCREEN
ENTER

Figure 5.9: Layout of the Installation

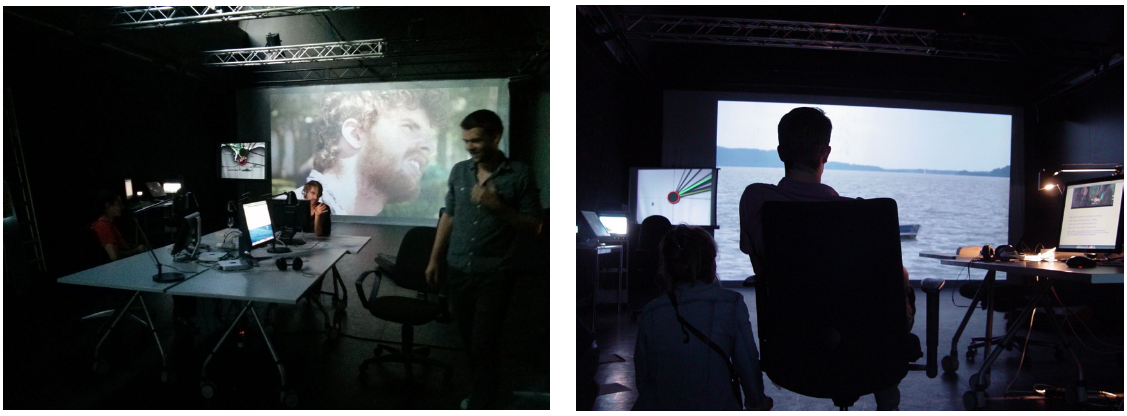

Figure 5.10: Two angles of the generative film, showing the map screen on the left and scenographic "work stations" in the middle of the room.

5.1.4.3: THE EXPERIENCE CATALYST

CinemaMutation software was central to the HotelCity installation, but it was the combination of software, staging and film that comprised the experience catalyst. Software alone would not have conveyed the idea properly, nor would static scenography or even an edited version of the film itself. Together the elements created an immersive experience and the relationship between them helped to guide and explain the tools to the audience.
The installation consisted of three major components: the interactive film, the generative film and ambient scenography. The latter also included some interactive elements, such as computers which displayed HTML versions of the film's script, but the interactive desk and generative film anchored each side of the room. The audience entering the room from one end first encounters the generative film projected across the entire back wall, just beyond a series of workstations which display elements of the production in progress: related films, the script of the film and some general background information (Figure 5.9). A secondary screen, positioned to the left and slightly in front, displays the map indicating the current location of the clip being played. At the end of each clip the map animates, showing the path to the next location and then flying the user into position, animating the destination as the clip plays to re-enforce the locative nature of the narrative. This projection also provides the ambient audio for the room: the other stations are all provided with headphones to isolate their sound from the room.

In addition to providing a practical viewing experience and a dramatic element that immediately declares the purpose of the room, the placement of the generative film also serves a pedagogical purpose. This is similar to the pedagogical moment as we saw with LIWYATAN/LEVIATHAN or HeartCollector, but repeats regularly because the duration and pace of the exhibition context is open-ended and the audience is free to enter and exit at will. The position of the map and the film physically connects the information displayed on different screens, as does the animation between clips. Audience members can see how the map moves when a clip fades as well as the animation between locations before the next clip fades into view. This creates a conceptual link between potentially disconnected screens in the space, inviting the audience to begin making connections of their own both literal and figurative.

On the wall opposite the generative projection is the interactive version of *CinemaMutation*, presented at a desk with two pairs of headphones, a monitor and a track pad which audience members can use to explore the map, scenes and related documentation (Figure 5.11). When seated behind the monitor, audience members are positioned so that they are facing the generative film and map display. The smaller monitor displays the same map, thus informing the connection between the two. This also serves a secondary pedagogical purpose: It is likely that the specific types of links between nodes (the dotted versus solid

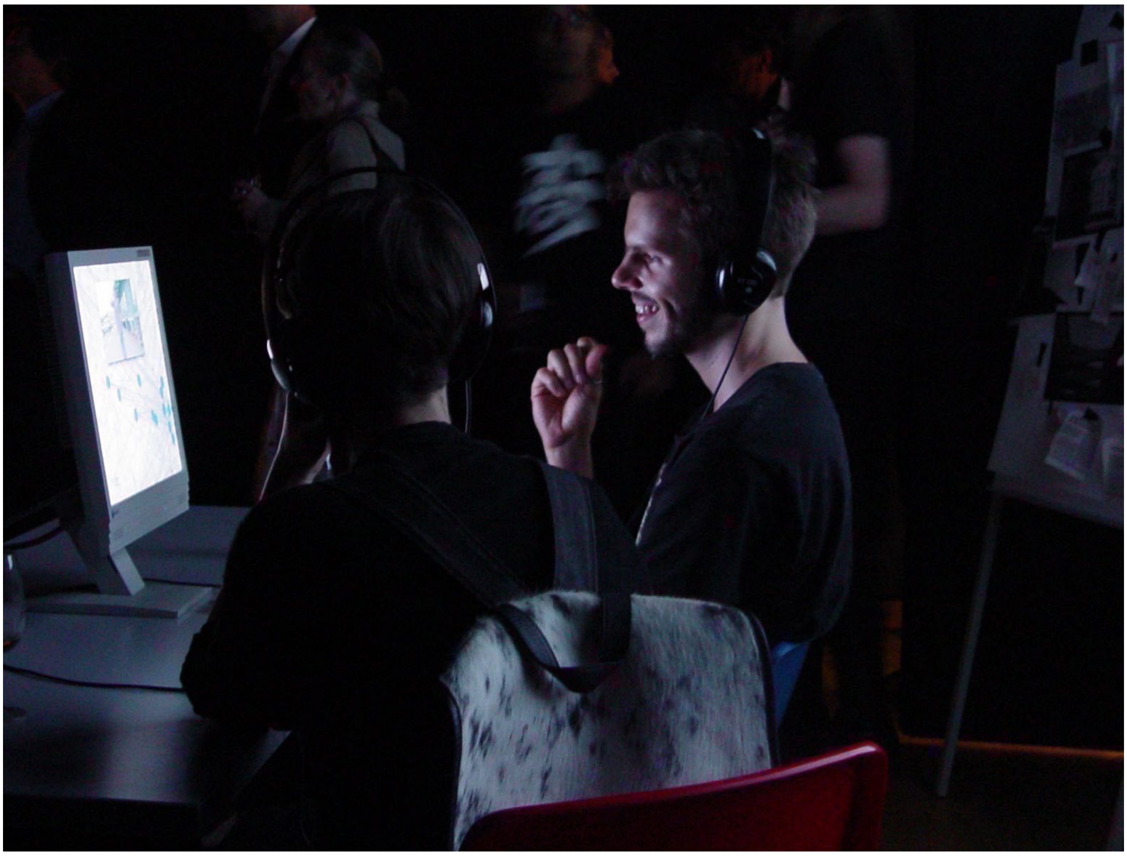

Figure 5.11: Two audience members using the interactive installation

lines) are not obvious unless one knows the material well. Initially, these visual connections signal only that there is a connection and that the positions on the map are not random. By presenting the interactive installation in the same context as the generative installation, however, audience members have a better chance of understanding the nature of these connections. The interactive installation can be used to navigate through scenes the audience may have just seen on the large generative screen. The physical juxtaposition of the two installations play off each other, inviting deeper engagement with both.

5.1.4.3.1: AUDIENCE AS ACTORS

This interactive experience is also immersive in a different sense: when seated with the headphones on audience members focus on immediate and local interaction with the computer under their control and are likely not aware of their impact on the space around them. This fact is exploited for both pedagogic and scenographic purposes. While users of the interactive system are focused on their exploration of the map, the screen they are observing is projected behind them. This provides an opportunity for audience members who are not using the interactive system to learn what the system is for and how it operates. In addition, this framing is designed so that the people operating the interaction serve as part of the scenography in a manner consistent with the narrative. The users of the system are simply exploring the map, but to observers wandering around the room they appear to be editing a film, inadvertently performing the role of editors in the abandoned film production studio (Figure 5.12).

5.2: COMPUTATIONAL EPISTEMOLOGY AND EXPERIENCE

Computational epistemology is a shift in our thinking: a fundamental difference in the way that we treat our environment and ourselves categorized by a strong influence of computational ideas onto the world we traditionally treat as static. Computation allows us to rapidly shift contexts, move ideas around the world at lightning speed and reconfigure the architecture of a place. Computation provides us a sensitivity to layering, visual and conceptual, allowing us to use different vocabularies for image generation and consumption and opening up new patterns for thinking about self and performance.

Computational ideas certainly effect our thinking and our virtual lives, but while it may be possible to create a fully immersive environment entirely within a computer, the power of computational epistemology is made obvious when we apply the ideas to the physical world. The most compelling of these applications result in *experience catalysts*: combinations of architecture, theater, computation and careful staging in the service of a narrative. These types of installations allow us to get to the heart of what it means to treat the world and our culture computationally.

One of the features of the *HotelCity* installation that demonstrates this best is a printer which automatically dispenses documents related to the scene currently being displayed by the generative film. By positioning the printer in the rafters of the space I created a situation where a physical instantiation of information literally falls from the sky. As audience members watched the film, related information periodically drifts down onto their heads (Figure 5.13).

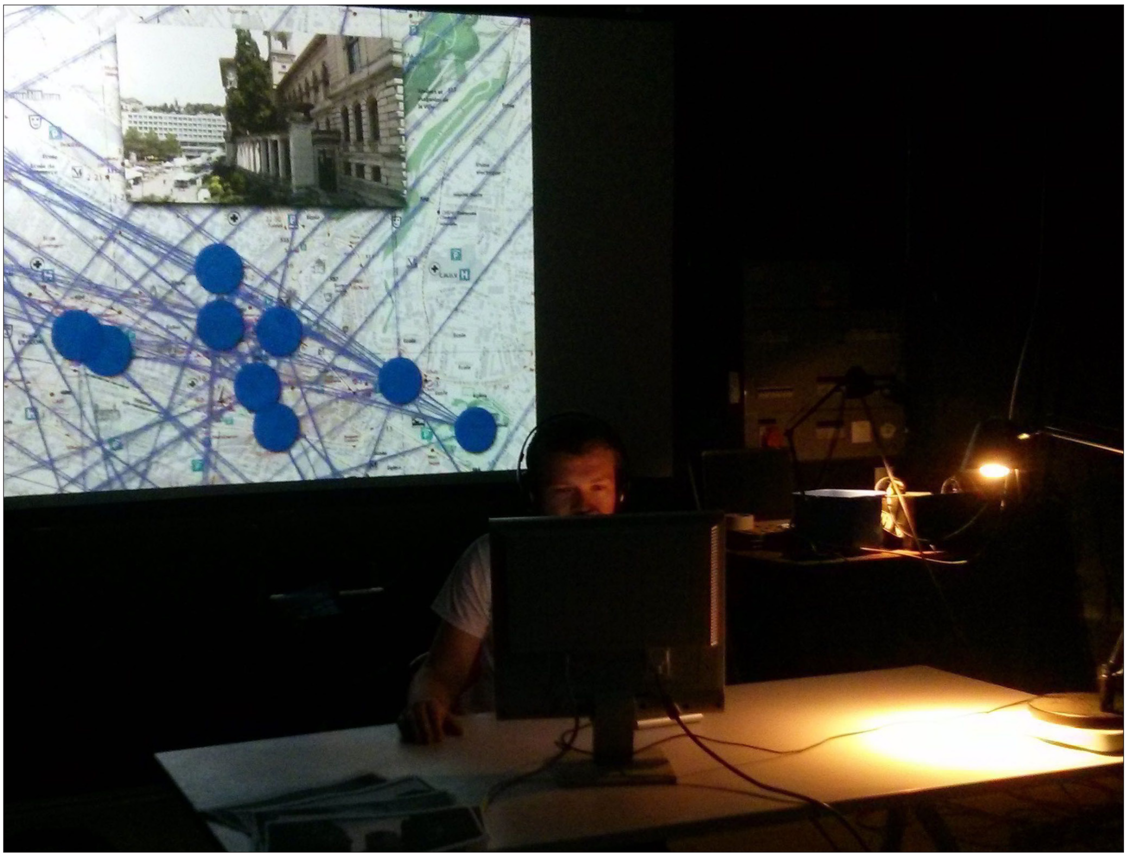

Figure 5.12: Exploring the interactive installation casts visitors in a role.

This playful and unexpected physical manifestation of the digital is one example of how computation can be used to explore our shifting relationship to the world around us. By locating the printer in the ceiling making the source of the documents somewhat mysterious, agency can be attributed to the space itself. This embodies the digital but more importantly helps us explore the fascinating, anxiety ridden and powerful places-between-places that computational epistemology has revealed in our shifting relationship to architecture.

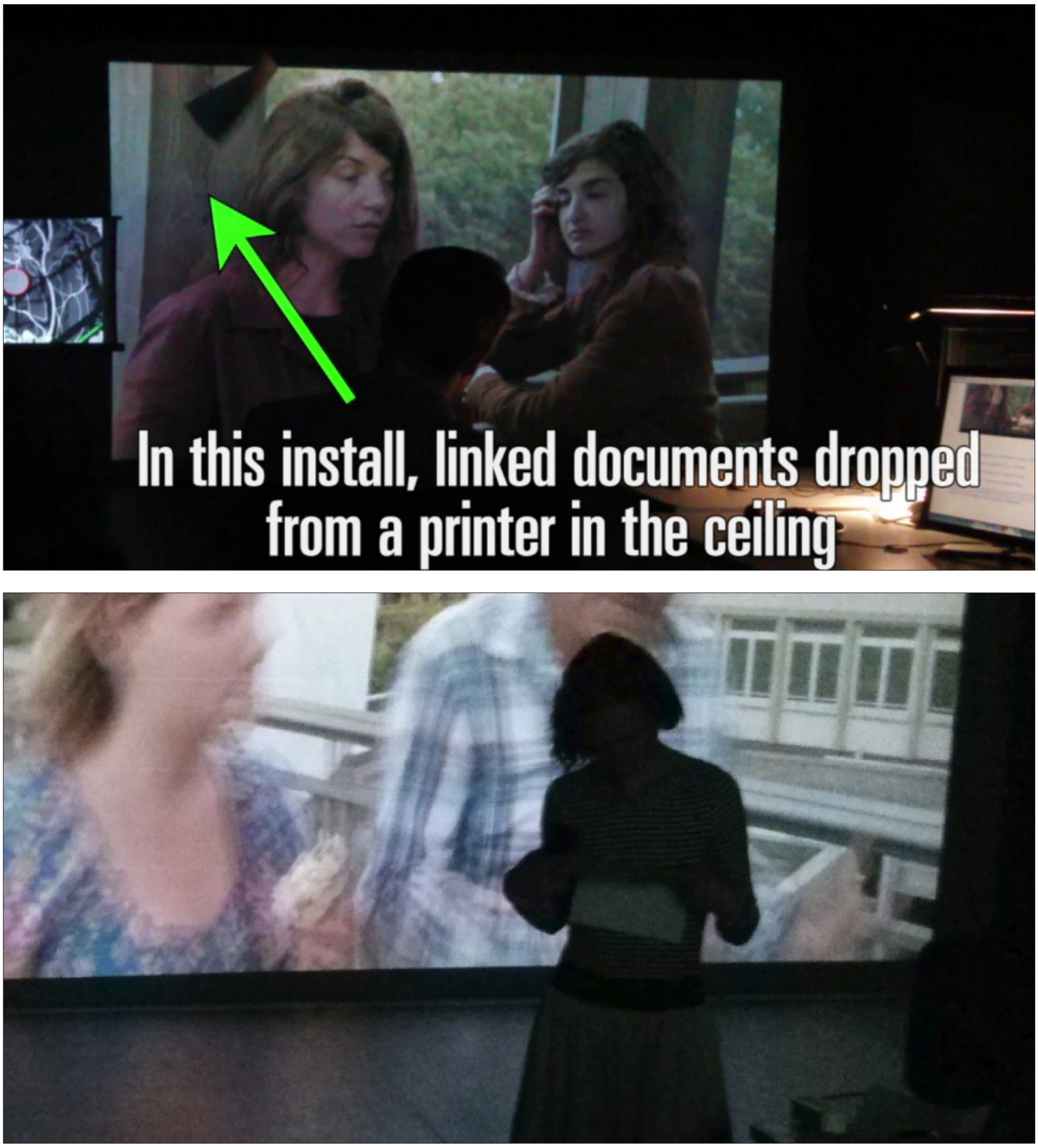
In this install, linked documents dropped
from a printer in the ceiling

Figure 5.13: Two stills from a video documenting the CinemaMutation project, showing a printed page falling from the ceiling and an audience member reading the paper with the film in the background.

6

CHAPTER SIX CONCLUSION

This chapter pulls together the ideas presented in each of the previous chapters by proposing a theory of computational epistemology, or a way of understanding the world as shaped by the internalization of computational thinking. This work draws on notions of pervasive ubicomp (ubiquitous mobile personal computing), media theory, art practice and on the constructivist/constructionist knowledge theories of Jean Piaget and Seymour Papert.

6: CONCLUSION

6.1: SUMMARY OF FINDINGS

I began this dissertation with an argument in favor of practice-based research and a promise to use *bricoleur* technique as a way to hybridize various methods of inquiry. The goal was to ensure I could adequately answer the research question: *how do computational ideas alter our perception of place?* I answered this question through engineering practice (the creation of custom technology) in the context of art practice (the development of various stage productions). Following a technique borrowed from artistic research I kept the narrative of each production central to the decision making process. All technology was developed in service of the artwork. Analysis and theoretical development was conduced via critical analysis techniques borrowed from design and the humanities. The result was conveyed via a first-person account of the development of each project.

Initially I proposed the creation of a computer vision tracking system which would allow me to digitize people and objects on stage in order to subject them to computational manipulation. At the beginning I believed that this approach would allow me to answer my research question completely. I successfully built the tracking system but discovered over the course of the research that while this approach allowed me to clarify the notion of *computational ideas* and *perception* it fell short of answering how computation had changed our relationship to *space and place*. In order to fully answer the question I developed three additional projects. These final projects represent a decided turn away from the use of tracking on stage but better embody key computational concepts of l*ayering, looping, and scale, time and place-shift*.

In chapter two I covered the production of a stage play called *CYBOR[GAME]*. Work on this production began while I was developing *Performance/Space*, the second iteration of my tracking system. The software I developed at this time began as a tool for position tracking on stage, but ended up as a tool for generating visuals. From a purely computer-science perspective the tracking problem offered a bigger challenge, but in terms of the research question it offered only shallow answers. Ultimately by following my own guideline to allow the artwork to shape the technical work I uncovered a deeper understanding of the role computation plays in perception, in particular the way in which it allows us to consider the space between the material and the immaterial. This experience also provided an object lesson in the way that practice based research guides its own development.

In chapter three I covered two projects, a dance piece called *SHiNMu* and a public installation called *Lines of Desire*. Both of these projects make use of the tracking system I developed to reveal the way that performers, audience and computation may occupy space simultaneously. The finding here is that via co-occupation, computation can be used to shift our perception of time and place by drawing attention to our own physicality and impact on the environment. Specifically computation can be used to *amplify* the activity of the performer or the audience, either through *magnification* or through a more complex *resonance* with activity occurring in space. Here a key finding was that the emotional and experiential phenomena encountered by mediating an event with technology is of more significance than the technology itself. Practically speaking for a stage production: in many cases it makes sense to include human operators in the loop to “puppet” the experience for the audience. The question of *audiencing* remains the main distinction here. In both public space and stage performance the audience’s perception remains paramount, but in a stage production the audience and the performers are different groups and physically separate whereas in public space they are often one in the same. This has consequences both for the role the technology plays in the experience and the way it appears visually.

Chapter four describes a stage production called LEWAYATAN/LEVIATHAN, the first project I developed which did not use tracking technology. This project used mobile digital video to physically distribute the staging of the play. The audience remained seated and stationary, facing the stage as in a traditional production. Mobile video was used to incorporate physical areas not immediately visible to the audience. The play occurred on the main stage but also under the seats, behind the stage and in the hallways of the theatre. This type of staging had significant conceptual and narrative consequences. Using video in this way created spacial and temporal shifts, allowing the story to occur in several physical locations simultaneously. By using the language of film and video and cross mixing video feeds from different locations it was also possible to compress one or more physical or emotional spaces into a single location. Finally, and most significantly, by creating a play in which the means of production was presented to the audience along with the play itself the audience became complicit in the story. This is most readily understood by the significant change in meaning in some of the key events in the play. The original Paul Auster text was not changed, but the narrative result was vastly different as a result of the mediating technology. Key to this is the notion of moving the audience from passive to active observers while making the mechanism clear. This chapter also includes the description of a project called *HeartCollector*, which uses the biometric data of actors on stage as avatars for physical bodies. The resulting interplay between what is real and what is fictional drives the play itself. Taken together these two projects most directly engage the research question by incorporating mobile ubicomp devices into performance. They also reveal the ways in which computational technologies have shifted the role of both audience and performer.

Chapter five describes an installation which collapses the separation of audience from the performance space and incorporates intent directly into space itself by means of computational augmentation. The tool developed for this is a psychogeographic storytelling tool called *CinemaMutation*, which was used to present a film called *HotelCity*. The presentation of a “film” in this way attempts to remove the boundaries between audience and scenography and between observation and experience. This introduces us to the concept of *experience catalyst* and shows how, through careful staging, computation can drastically change the audience/performer relationship.

Across all of this work I have looked for the ways in which contemporary cultural artifacts which use computational technology show evidence of computational ideas in the way they convey narrative. I have come to the conclusion that computational ideas alter our perception of what is possible by changing our understanding of what we consider fixed. These ideas mediate and layer our relationship to our environment by transforming what we formerly considered concrete, material and still into malleable, immaterial and active performance. *Place* is the meaning that we imbue in space to mark it as significant and this construction of meaning is not a single event but a cycle of feedback. Place is not an endpoint but an event. The computational loop which we historically encountered as a tool for occasional use is now the model on which we stand.

This shift in the way that we produce and consume narratives is a profound and permanent one which bears future investigation. I have demonstrated that to understand this shift requires an approach that crosses disciplines, incorporating computer science, art, philosophy, and architecture. Going forward I will continue to look for the gaps and overlaps between these practices while building both a vocabulary and community of practice around them.

6.2: WHERE DO WE GO FROM HERE?

6.2.1: COMPUTATIONAL EPISTEMOLOGY: TOWARDS A THEORY OF COMPUTATIONAL KNOWING

Throughout this text I have referred to *computational epistemology* as shorthand for the shifts which have occurred as a result of our immersion in a culture of mediation. This is the model and the vocabulary which I find most compelling, but it is important to make clear that I do not consider computational epistemology to be an overarching theory of everything. The goal is not to create a universal law but to explore the phenomena. This exercise is part of the commitment to practice-based work. As Nelson Goodman writes: "Perceiving motion, we have seen, often consists in producing it. Discovering laws involves drafting them. Recognizing patterns is very much a matter of inventing and imposing them. Comprehension and creation go on together."[166]

Even if it proves useful to others, computational epistemology is not the only way to frame the shifts which have occurred, nor is it the best or most complete. In fact what we know from other applications of constructivist thinking, from Howard Gardner's theory of Multiple Intelligences[167] to the curriculum of the Reggio Emilia[168] school system, is that it doesn't much matter if the theory here is true so much as it is useful. Nelson Goodman continues: "Much of knowing aims at something other than true… An increase in acuity of insight or in range of comprehension, rather than a change in belief… Such growth in knowledge is not by formation or fixation of belief but by the advancement of understanding"[169]

None of the ideas discussed in this thesis rely explicitly on the framework I call computational epistemology, but the framing may yet prove useful for helping to understand the juncture and overlap of trans-disciplinary work. In outlining this theory I borrow freely from many fields but lean most heavily on the traditions of *genetic epistemology*, *art practice* and *media theory*.

6.2.1.1: PART ONE - GENETIC EPISTEMOLOGY AND MODELING

Genetic epistemology is the name that Jean Piaget gave to his theory of knowledge acquisition. Most relevant to my work is the notion that all of human knowledge is constructed and that the result of this is that we think in terms of models. Our models may be incorrect, but they are never incomplete.

Piaget's description of this process, called *constructivism*, does not suggest that humans engage in this process voluntarily, but rather that it is simply the way we learn and think. In the 1980s, building on these ideas, Seymour Papert suggested that modeling could be used deliberately as a site for learning. Papert's *constructionism* identifies computers in particular as powerful modeling tools, ideal for creating micro-worlds for deliberate engagement with ideas.

The period of time between when Papert's *Mindstorms* text first came out in 1981 and now can be characterized by an exponential increase in the capability of computational devices accompanied by a similar exponential decrease in their size and therefore portability. The ubicomp future that Mark Weiser imagined has come to be. We are surrounded by computational devices and this has changed the way we think. This shift is visible in the way that we produce and consume cultural narrative artifacts.

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[166] Goodman, Nelson. Ways of Worldmaking. Hackett Publishing, 1978., p 22.

[167] Gardner, Howard. Frames of Mind: The Theory of Multiple Intelligences. Third Edition edition. New York: Basic Books, 2011.

[168] Edwards, Carolyn, Lella Gandini, and George Forman, eds. The Hundred Languages of Children: The Reggio Emilia Experience in Transformation. 3 edition. Santa Barbrara, Calif: Praeger, 2011.

[169] Goodman, p 22.

I offer the following as an explanation for the shift that we see in the way that narrative is composed and performed, as evidenced by the shifts I have demonstrated in my own work: the proliferation of cheap ubicomp devices plus the internet has created a situation in which computational modeling informs and occasionally defines the most fundamental of human activities: the listening and telling of stories and the performance of self and identity. The model is the way that we think (Piaget) and can be used as a site of engagement (Papert) but it is now no longer a separate activity we engage in, but the place we live daily.

The idea that the world is capable of being digitized and subject to digital manipulation has sunk deeply into our collective understanding of that which is possible. In much the same way that early computational thinking changed the way that we describe the brain and its capability, contemporary technology has changed the way we describe the world and its capability. We have in effect flipped our understanding of the world: the computational is not a model of the real world, but the real world is a container for our computation. These are not micro-worlds which we encounter occasionally, but a macro-world composed of micro-contexts that we live in, and we have developed the ability to move between them effortlessly.

Built on the knowledge theories of constructivism and constructionism I have proposed the notion of computational epistemology as a theoretical framework for further exploration. Computational epistemology suggests that prolonged cultural exchange via computationally mediated communication has fundamentally shifted the way that both audiences and authors understand and communicate various ideas, including our notions of place and space, time and self.

6.2.1.2: ROBOTS AND PLAY: PHYSICALITY MATTERS

The biggest trap that one can fall into when discussing computational ideas is to ascribe the power of the ideas to the computational devices themselves. This technocentrism confuses the object of power for the power itself and misses the opportunity to explore the changes that have been wrought. Technocentrism has also lead to dozens if not hundreds of misguided educational projects which involve the purchasing of computers (or tablets or smartphones) without consideration for context or content. You cannot lock people in a room with a computer and expect it to make a difference. You cannot put a projection on stage and expect it to change narrative structure.

The second biggest trap is to ascribe the power of computation strictly to the disembodiment of the physical. It is true that by digitizing the world we provide ourselves a version of it which is far more easily manipulable than the physical world. This serves as encouragement to think of the physical as an impediment, and to give the digital a kind of place of pride above the messy material. This approach is similar to the Cartesian notion of duality of body and spirit[170] which ascribes the mind sacred characteristics while relegating the physical body to the profane. The body here becomes something to overcome, a notion that finds its contemporary secular expression in the "singularity" of the post-humanists. As Ian Bogost writes: "…software and neuroscience enjoy a metaphorical collaboration thanks to artificial intelligence's idea that computing describes or mimics the brain. Computing-as-thought reaches the rank of religious fervor when we choose to believe, as some do, that we can simulate cognition through computation and achieve the singularity."[171]

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[170] Descartes, Rene, Karl Ameriks, Desmond M. Clarke, and John Cottingham. *Descartes: Meditations on First Philosophy: With Selections from the Objections and Replies (Cambridge Texts in the History of Philosophy)*. Revised. 0. Cambridge University Press, 1996.

While digitization does remove us from the physical world in order to give us super powers, the way this impacts our thinking does not stop at the edges of our devices. In fact despite centuries of trying through religion and technology to forsake our corporeal selves, far more interesting are the edges where the ideas begin to fold back in on themselves. The self-reflective loop that this creates is where the power lies: not in the split between physical and digital but in the recursive relationship between them that informs both.

A good example of this are Kiva Systems fulfillment robots, which treat a physical warehouse as if it were random access memory (RAM) in a computer. This robotic system applies memory caching algorithms, parallel processing optimization methods and distributed computation techniques to physical order fulfillment. This is a direct back-application of the digital to the physical. Digital design required the development of certain techniques. What Kiva has done is take these computationally ideal solutions and embodied them in the real world. Raffaello D'Andrea, founder of Kiva systems, explains that the most important factor in their design "…was the emergence of powerful but inexpensive electronics--wireless systems, guidance sensors, embedded processors--and the recent development of novel algorithms in the fields of multiagent systems and control theory."[172]

Another more performance-oriented example can be seen in Live Action Role Play, or LARP173. LARP provides a performance-centric example of how we use models to change our minds and also demonstrates that this is a spectrum, not a dichotomy. Writing on the Turku School of LARP, Mike Pohjola explains: "Role-playing is immersion ("*eläytyminen*") to an outside consciousness ("a character") and interacting with its surroundings. Most traditional mediums are either active (the part of the creator; writing, singing, acting etc.) or passive (the part of the audience; reading, listening, watching). Role-playing, however, is a truly interactive medium - and the best and most useful of such media - because there the creative side and the receptive side are no longer separate. The experience of role-playing is born through contributing. No one can predict the events of a session beforehand, or recreate them afterwards. "174

In LARP, humans use models of the physical and simulated physical experience in a deliberate way to literally "change their minds." This same exercise forms the core of theater and the theatrical experience. In the history of gaming, this specially designated space of play has been called the *magic circle*, an idea that originated with historian Johan Huizinga in the 1930s: " [Play] has its being within a play-ground marked off beforehand …Just as there is no formal difference between play and ritual, so the 'consecrated spot' cannot be formally distinguished from the playground. The arena, the cardtable, the magic circle, the temple, the stage, the screen, the tennis court, the court of justice, etc, are all in form and function play-grounds, i.e. forbidden spots, isolated, hedged round, hallowed, within which special rules obtain. All are temporary worlds within the ordinary world, dedicated to the performance of an act apart."[175]

To anyone who has ever enjoyed a game or a roleplay, the appeal of this is not hard to understand. Perfor-

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171 Bogost, Ian. "The Cathedral of Computation." The Atlantic, January 15, 2015.

172 Guizzo, Erico. "Three Engineers, Hundreds of Robots, One Warehouse." *IEEE Spectrum*, June 2, 2012. http://spectrum.ieee.org/robotics/robotics-software/three-engineers-hundreds-of-robots-one-warehouse.

173 Gade, Morten, Line Thorup, and Mikkel Sander. *As Larp Grows up: Theory and Methods in Larp.* Frederiksberg: Projektgruppen KP03, 2003.

174 Pohjola, Mike.*The Manifesto of the Turku School.* Published in *As Larp Grows up: Theory and Methods in Larp.* Frederiksberg: Projektgruppen KP03, 2003., 34.

175 Huizinga, Johan. *Homo Ludens (book)*. Routledge & Kegan Paul, 1949., 10.

mances spaces can be intense but are enjoyable because they are controllable. Again Huizinga: ”Inside the play-ground an absolute and peculiar order reigns. Here we come across another, very positive feature of play: it creates order, is order. Into an imperfect world and into the confusion of life it brings a temporary, a limited perfection.”[176] This idea has been extended to virtual worlds by researcher Edward Castronova[177] and applies also to the experience of reading fiction. In all cases the goal is to describe and frame a space which is, in some way, different and unique from other spaces so that a mental shift can occur. This is what computation allows us to do, but at a pace which is so rapid that the loop closes and the feedback becomes its own magic circle of order.

6.2.1.3: COMPUTATIONAL EPISTEMOLOGY

Computational epistemology is an extension of knowledge-theory in the tradition of Piaget’s Genetic Epistemology and can be defined as:

1. A way of knowing and interacting with the world
   which supposes the internalization of computational ideas.

2. The study of the same.

In terms of the production of theatrical or artistic events, or *experience catalysts,* this idea describes both the creation and consumption of media and experience, but means slightly different things from the author/creator and the audience/consumer perspective. For example a tool which enables an author to treat a physical space as if it were digital does so because the end goal is for the *audience* to experience the digital as if it were physical. The experience of the author, who is acting as game-master of the magic circle, is different than the audience who occupies the world the author is building.

Modeling tools provide a good example of this: an architect uses a computer model of building which will eventually be expressed in “immutable” form. The experience of the model-builder and the experience of the residence of the building are not the same. Linearly, you could say that the audience receives a performance. The audience does not experience a model or an architecture, but the model*ed* or architect*ed*. This is an “endpoint” in a process, although in reality it turns out to be merely a juncture which launches another process, the dialog which ultimately transforms a work of art into a cultural artifact.

Architectural modeling tools begin as digital equivalent of *maquette*: architects have been modeling with pen and paper and cardboard and wood for as long as these tools have been available and the core idea is pre-computer. Digital technology allows the application of computational ideas to this process, in particular decreasing the differences in time, property and scale between the model and the real. Whereas previous models required many hours to produce, exhibited clear signs of artificiality and were often physically smaller than the real thing, current models are becoming increasingly less so to the extent that we have nearly flipped the role of model and real, or at least blurred the edges.

In 2001 the MIT Media Lab Tangible User Interface group created CAD CAST, an interface for modeling the lighting in architectural site plans[178]. CAD CAST remains a fascinating parametric tool nearly fifteen years after its invention but is clearly a simulation of an experience. By applying theatrical techniques, researchers at Rensselaer Polytech are closing the gap between simulation and experience by working on a human-scale daylight simulator that allows you to model more or less the same thing, but by re-positioning full-scale physical walls to observe the effect in realtime and at human scale: "The visualized design environment being created by Rensselaer Architecture faculty members Anna Dyson and Jonas Braasch would be projected on movable partition video screens—acting as four walls surrounding the architect—and the makeshift "room" would be furnished. Ambient noise would be projected through hidden speakers, giving the architect the luxury of being fully immersed in the room he or she is designing. The architect could then interactively make design adjustments in real time. The ability to accurately simulate sunlight at different times of day, and in different months throughout the year, will allow the architect to optimize the amount of natural light that enters the room." [179]

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[176] Ibid.

[177] Castronova, Edward. *Synthetic Worlds the Business and Culture of Online Games*. Chicago: University of Chicago Press, 2005. http://public.eblib.com/choice/publicfullrecord.aspx?p=432203.

[178] Piper, Ben, and Hiroshi Ishii. *CADcast: A Method for Projecting Spatially Referenced Procedural Instructions*. Tech. rep., MIT Media Lab, 2001. https://pubs.media.mit.edu/pubs/papers/CADcast_technical_notes.pdf.

So where do we situate these ideas of time and space shift? We are closing the gap between the map and the territory by virtue of the powers afforded us by computation, but these are not "computer ideas," although computers serve as a kind of rocket fuel that propels them from interesting thoughts to highly effective methods of interacting and understanding the world.

It is similarly not accurate to call these ideas "digital" because they are also pre-digital ideas, but digitization makes some of them expressible in ways which were not previously possible.
It's not sufficient to call artistic expression of these ideas "new media" because they are not so new after all, nor are they media, although they are mediated and the notion of "new media" is useful in identifying the ongoing cultural work done as we transition from a mechanical to computational worldview.

"Computers" "digital" and "new media" thus all constitute an existence proof and a distillation of computational ideas. They embody them in concentration, but do not describe the limits. This interstitial work is largely an aesthetic and relational idea: a sensitivity to particular patterns of layering, flux, transition, context-switching and unfolding possibility.

6.2.2: PART TWO: ART PRACTICE

6.2.2.1: EXPERIENCE CATALYSTS AS A LABORATORY FOR EXPLORATION

If our focus is on physical it is worth understanding that physical can mean everything that can be experienced with the sensorium. Thus sound, light, a breeze across skin; all of these sensations are "physical." Aesthetically this allows us to create *experience catalysts*, or sensual experiences which convey ideas.

In a sense experience catalyst can be thought of as a synonym to "artwork" but that word fails to include experiences created by practitioners not typically identified as artists, which nevertheless share many of the same characteristics. For example, architects, designers, scenographers and performers all might construct mediated experiences, but for various reasons personal and practical may not wish to identify their work as art. I propose the term *experience catalyst* to encompass all such aesthetic experiences. In addition, e*xperience catalyst* has the benefit of calling explicit attention to the purpose of these events: to catalyze a thought in the mind of the audience member by virtue of mediation.

Although there is value in pluralizing the practice it is important to acknowledge that art itself has a rich history of exploring the ideas I am calling computational epistemology, even before the notion of computers really existed in popular thought. This is particularly true of the body of work commonly called "art and technology."

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[179] Rensselaer Polytechnic. "Modeling Natural Light - Rensselaer Polytechnic Institute (RPI)," December 17, 2010. http://afsws.rpi.edu/research/media/report/modelinglight.html.

6.2.2.2: ART AS EXPERIENCE

Recalling his telephone paintings, artist and Bauhaus professor Laszlo Moholy-Nagy wrote: “In 1922 I ordered by telephone from a sign factory five paintings in porcelain enamel. I had the factory’s color chart before me and I sketched my paintings on graph paper. At the other end of the telephone, the factory supervisor had the same kind of paper divided in to squares. He took down the dictated shapes in the correct position. (It was like playing chess by correspondence.)”[180]

While it is difficult to pinpoint precisely the origins of an idea, art and technology historian and artist Eduardo Kac identifies this as a key moment in the beginning of that which we now call art and technology. The important idea is that Laszlo’s creative process was mediated and not merely by the telephone but by the entirety of the industrial supply chain. Furthermore, what Moholy-Nagy produced with his graph paper sketches was not an artwork so much as an algorithm, the result being a performance of technology with the painting as an endpoint.

Historian Maud Lavin identifies the collages of dada artist Hannah Höch as another expression of the impact of contemporary technologies on art making.[181] During Höch’s lifetime, the popularity of “photo dailies” exploded as a result of advancements in photo reproduction technique. Höch’s application of aleatoric cut-up technique to these magazines pre-dates the now better known work of William S. Burroughs[182] and certainly the much later *rip-mix-burn* slogan used by Apple advertisements in the early 2000s.

In the 1960s and 70s, art reflects a widespread fascination with the way in which systems operate and how these systems can be revealed, concealed and manipulated. Political revolution was in the air in North America and Western Europe, technology was tapped both for command and control and for artistic intervention. Newfound pre-occupation with the occult and systems of magic (both literally and metaphorically) can be seen in everything from the founding of Anton LaVey’s Church of Satan in San Francisco in 1966 to the Industrial music scene of occultist Genesis P-Orridge (Throbbing Gristle 1975) and *Thee Temple ov Psychick Youth* in the early 1980s.

The *Op-art* movement of the 1960s, characterized by paintings which make use of optical-illusion techniques, owes something to both Bauhaus and dada-era ideas of color perception and chance operation and a contemporary culture of consciousness-expansion and encoding of occult knowledge through physical and mental manipulation (often through chemical means). The paintings are made active through a dialogue with the audience. While all two dimensional drawings and paintings are on some level optical illusions, op-art engages this process directly, drawing attention to the way in which art is not contained in any given object but produced by means of an event of exchange which occurs between the artist and the audience, mediated by the art object and our own sensory apparatus. Work on manipulation of the sensory apparatus for artistic purposes can also be seen in the work of “artist traveler writer and alchemist” Brion Gysin who is credited with re-discovering dada cut-up technique independently. As a contemporary of author and occultist William S. Burroughs, Gysin produced *Dream Machine* in the late 1950s, an apparatus for inducing art as experience. Sometimes called the first artwork intended to be viewed with your eyes closed, *Dream Machine* is nonetheless similar to Maholy-Nagy’s *Light-Space Modulator* sculpture from 1930.

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[180] Kac, Eduardo. “Aspects of the Aesthetics of Telecommunications.” In ACM SIGGRAPH 92 Visual Proceedings, 47–57. SIGGRAPH ’92. New York, NY, USA: ACM, 1992. doi:10.1145/131340.260550.

[181] Lavin, Maud, and Hannah Hoch. Cut With the Kitchen Knife: The Weimar Photomontages of Hannah Hoch. First Edition edition. New Haven: Yale University Pres, 1993.

[182] Skerl, Jennie. William S. Burroughs. First Edition edition. Boston: Twayne, 1986, 1986.

In the 1960s and 70s a fascination with mass media and in particular television drove much of the art world. Andy Warhol's engagement with the tools of mass production reflects this and presages much of the fascination of the late 1990s with the internet as a platform for mass distribution. Warhol engaged the tools of industrial production for art production, from his use of screen printing technique and Polaroid instant photos to filmmaking, to the founding of *Interview* magazine and the notion of art production as an ongoing event. It is no mistake that Warhol's live/work space was called the Factory.

Korean-American artist Nam Jun Paik is largely considered the "father of video art" and has used television both literally and figuratively in his work. Creating sculptures out of actual televisions and using television parts as sculptural elements, Paik also engaged the ideas of what television had done to our relationship to each other and to narrative. Paik's objects are immediately recognizable, but it is his performance work (*Becoming a Robot*, 1982) that best captures the way in which mass media altered our perception of each other and of space. Paik may also have been responsible for a defining phrase of the dot-com era, writing about the "electronic super highway" in his 1974 proposal *Media Planning for the Postindustrial Society – The 21st Century is now only 26 years away.*[183]

A contemporary of Paik, Bruce Nauman's early video pieces most directly engage the ideas I've described in this thesis as computational. Nauman's *Live-Taped Video Corridor* work creates a relationship between architecture and the audience by means of television loop.
In the mid 1970s, sculptor Dan Graham began creating glass installations whose surfaces reflect the audience and the environment. Graham's glass work produces a reflective loop without the use of electronic technology, although in 1974 Graham exhibited *Presence Continuous Past(s)* incorporating a video-delay monitor in a mirrored room with a hidden camera. The visitor is confronted with the ghost of their own presence reflected infinitely in a mirror-loop.

There are many more examples: William Wegman, known mostly for his comical dog portraits, began working as a video artist. Bill Viola's haunting and beautiful video installations fill the gap between contemporary technology and the techniques of medieval painting. Stan Vanderbeek, nominally a filmmaker, left a lifetime of work which plays freely between technology, art, music, and the relationship created by mediating experience with technology. As Lev Manovich writes: "All classical, and even mores modern, art is "interactive" in a number of ways. Ellipses in literary narration, missing details of objects in visual art, and representational "shortcuts" require the user to fill in missing information. Theatre and painting also rely on techniques of staging and composition to orchestrate the viewer's attention over time, requiring her to focus on different parts of the display. With sculpture and architecture, the viewer has to move her whole body to experience the spatial structure."[184]

6.2.2.3: ART COLLAPSE

As we have seen, art practice from the 1920s through the late 1980s reflects a fascination with technology as a tool for mediation and reflection. The ideas that I have identified as computational can be seen in work involving telephones and video cameras, but also reflective surfaces and in painting. The notions have been there for a long time, so what has changed?

The arc through art history that can be traced follows the same trajectory I proposed for epistemology

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183 Paik, Nam June. "Media Planning for the Postindustrial Society – The 21st Century Is Now Only 26 Years Away." Media Planning for the Postindustrial Society – The 21st Century Is Now Only 26 Years Away, 1976. http://www.medienkunstnetz.de/source-text/33/.

184 Manovich, Lev. The Language of New Media. Reprint edition. Cambridge, Mass.: The MIT Press, 2002.

from Piaget through Papert. Artworks prior to the 1990s addressed the same ideas of layering, looping and experience that I propose characterize our contemporary state, but ubicomp and computation closed the gap between simulated experience and reality significantly. This is in keeping with what we know computation does: not something new, but something *faster*.

The speed of iteration is what causes the collapse of metaphor into reality and this has also significantly altered our notion of what art is and where it comes from, leaving traditional guardians of the art world at a bit of a loss. In response we see new methods of collecting, such as the Victoria and Albert's Rapid Response Collection Gallery "conceived as a topical foil to the sluggish pace of the South Kensington institution, with its [normally] three-year lead times for large-scale exhibitions"[185], as well as the application of computational business models to art practice, such as the New Museum's NEW INC "…[an] incubator as a future-leaning platform for new, hybrid art projects, innovative applications, and the next inspired online start-up."[186] We can see this transition occurring at the way that we perceive what art museums are for (*MoMA and the Collapse of Things*[187]) and in the way that we present exhibitions, as evidenced by the recent reopening of the Cooper Hewitt design museum as an interactive experience and the way the curatorial process is described as a "lab" releasing "betas" for "testing".[188]

It is becoming increasingly difficult to locate clearly the distinction between dot-com startup and gallery, artist and millionaire entrepreneur, performance and reality. Ondi Timoner's 2009 documentary *We Live In Public* documents the rise and fall of internet pioneer Josh Harris and his *Quiet: We Live In Public* project. Harris' experiments are deeply problematic, pathologically megalomaniacal and at times cruel (Ondi's documentation features scenes where the lines between play and mental illness, sexual expression and rape, and brutal honesty and domestic abuse are decidedly and uncomfortably unclear). Underlying this Harris' aspirations and motivations owe more to dot-com capitalism based on the "attention economy" and the exploitation of "the weird" than they do any impetus to art. Nevertheless and in spite of itself, no other project captured the hopes, fears and terror of the early social internet the way *Quiet* does.

In the past artists have employed industrial and technical material and mechanisms of production while maintaining allegiance to the art world. Today artists are equally of both worlds. Warhol predicted this by blurring the line between commercial and fine art, but today we see no blur. Sign making and art making have collapsed into the same practice. We identify art from advertising mostly by subtle cues of intention and theatre from artwork mostly from the sign on the door. We have dissolved the boundaries between practice and this, in turn, requires artists to step into a new role not as *auteur* but as facilitator and guide.

6.2.2.4: CONTEMPORARY WORK

There are a number of theater companies, particularly in the UK and Germany, who are creating new types of immersive theater experiences using computational technologies. *Rimini Protokall* (http://www.rimini-protokoll.de/) from Germany uses contemporary video technology to change perception of space and play directly with the role of audience and performer. Audience members become characters in the production which they are also watching unfold around them. To accomplish this, Rimini relies heavily on direct audience interaction with technology by outfitting the performer/audience members with wearable headphones, screens and other media equipment.

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[185] Wainwright, Oliver. "The V&A Looks Outwards: Its Rapid Response Collecting Gallery Is Unveiled." The Guardian. Accessed March 5, 2015. http://www.theguardian.com/artanddesign/2014/jul/02/victoria-and-albert-rapid-response-gallery-unveiled.

[186] Halperin, Julia. "New Museum Gets into the Startup Business." The Art Newspaper. Accessed March 5, 2015. http://www.theartnewspaper.com/articles/New-Museum-gets-into-the-startup-business/30809.

[187] Domínguez Rubio, F. *MoMA and the Collapse of Things.* (Unpublished in preparation, Under contract with University of Chicago Press)

[188] Cooper Hewitt Labs. "'B' Is for Beta | Cooper Hewitt Labs." Accessed March 5, 2015. http://labs.cooperhewitt.org/2013/b-is-for-beta/.

Punchdrunk (http://punchdrunk.com/) is a UK based theater company which produces large-scale immersive theatrical events. Audience members purchase a ticket and are admitted for a period of time ranging from 2 to 6 hours. After a simple introduction (a pedagogical moment in which the audience is told to never speak, always wear their masks and explore freely), the experience begins. Although Punchdrunk does not make visible use of contemporary technology the way that Rimini does, they are known for providing their audiences with genuine agency within the bounds of play, a hallmark of micro-world notion of modeling. Audience members are free to wander around very large spaces, sit in one place, have a drink, and in general to choose to engage the production as they see fit.

Fine art has been following the lead of theatre in staging and scenography. In 2013 I attended the Lyon Biennale and was struck by the number of works directly referencing theatrical tropes by making the means of production visible to the audience. Also of note was a tendency towards the creation of immersive environments capable of exerting their own intention. Laure Prouvost's *Before Before / After After* consists of a loose collection of found objects (bad drawings, a broken mirror, spilled paint) that give the impression of a particularly dirty corner of an undergraduate painting studio. The walls are unfinished plywood and there's an odd green light over everything. At the end of this haphazard arrangement of objects is a curtained room which contains an elaborate computer-driven animatronic cinema linking various objects in the room. The audience sits on a bench and a disembodied female voice begins speaking: "all happened in this room, this very room." At various moments the room itself illuminates objects related to the story being told. The room also includes theatrical effects: fog, a fan, disco lights. Eventually the disembodied narrative voice inhabits the room itself like a ghost. By the end the room is pitch dark and the voice implores you not to leave, begging to remain occupied: *"I asked everyone to leave the room but you. Stay. Don't go, the room doesn't want to be empty. It's scared to be left alone."*

Elmgreen & Dragset's 2013 work *Tomorrow*, was a theatrical staging of items from the V&A museum's collection. Items were arraged as if the gallery were the personal apartment of a fictional character. The character's life was revealed through the juxtaposition of objects and also through the script of a play (copies of the play were free for the taking outside the gallery). The staging extended to the role of the museum guards who, for the purposes of this exhibit, were dressed in tuxedos as if they were servants. The story also extends throughout the museum, including a billboard hung on a construction site outside the museum which advertises condos for sale at this "new luxury address." On leaving the final room of the apartment, visitors find themselves on the opposite side of a theatrical wall whose support structure is clearly visible.

Ryoji Ikeda is a video and sound artist from Japan whose artwork consists of black and white patterns projected and displayed on various digital screens. Ikeda's work is best described not as digital work but work *made of* the digital. The imagery isn't recognizable as anything than pixels and patterns and in fact his 2014 NYC show was entitled *Test Patterns*. Ikeda's work has been presented in galleries and museums around the world but his most recent piece will be displayed in Times Square via the massive advertising video screens. The material and the presentation is indistinguishable from the texture of the technology it exists on except for the lack of obvious intent.

Lastly, a number of contemporary art groups create work with ubicomp devices with the notion of computational layering at their core. Blast Theory's 2015 work *Karen* is a downloadable life improvement software that can be purchased from the Apple ap store. This artwork is installed on your mobile device and requires you to grant permissions. *Karen* plays the role of personal assistant and coach, initially appearing friendly and helpful and eventually becoming increasingly creepy and invasive as she combs through the information you have stored on your personal device.

6.2.3: PART THREE: MEDIA THEORY

In our recent decade, *media studies* or *media theory* has emerged as one of the ways in which we examine and critique mediated artworks and the experiences they create. Computational epistemology is not meant to be seen in the same tradition as media studies, however it borrows freely from it in the sense that it uses both anthropological and literary criticism as means of inquiry and is related to the study of cultural artifacts created and distributed using contemporary technology.

As a final exercise it is appropriate to look at some of the core texts and authors, namely Marshall McLuhan, Friedrich Kittler and Lev Manovich. Notably missing from the discussion and suggested as a site for future work are more contemporary players, especially the transmedia work of Henry Jenkins and the work which emerged from the Comparative Media Studies department at MIT in the late 1990s.

6.2.3.1: CONTROL AND FEEDBACK LOOPS

"If "control" or, as engineers say, negative feedback, is the key to power in this century, then fighting that power requires positive feedback. Create endless feedback loops until…the whole array of world war army equipment produces wild oscillations of the Farnborough type. Play to the power their own melody."[189]

In 1986, Friedrich Kittler published *Gramophone, Film, Typewriter*[190], written in his native German. The text was published when Kittler was well into his academic career but did not appear in English until ten years later. In terms of worldwide academic discourse, this book is considered one of the fundamental texts in "new media," although in North America at least, Marshall McLuhan is more widely known. In part this is due both to language and the fact that McLuhan was nearly a generation ahead of Kittler (McLuhan was 30 years old when Kittler was born. McLuhan's final text *The Global Village: Transformation in World LIfe and Media*[191] was published in 1989, posthumously, nearly at the same time as *Gramophone, Film and Typewriter* was published in German.)

Gramophone, Film and Typewriter is a delight to read, equal parts playful and intelligent, but it does embody a certain amount of technological determinism in its arguments. As a standalone text this approach is unsatisfying: it is internally consistent but fails to adequately address local variations, global change and gives more agency to objects that should probably be given. On the other hand, insisting that the "medium is the message" is equally unsatisfying as it leaves no real room for a discussion of aesthetics or embodiment.

This latter point I believe accounts in part for the decline in popularity of McLuhan-ism prior to the creation of the world wide web (a global phenomenon that emerged around 1994). A more satisfying approach to understanding our relationship to technology would be to split the difference, and so I think we can read Kittler as providing a necessary bridge between the end of the mechanical era and the beginning of the computational in spite of the fact that McLuhan's work pre-dates Kittler's chronologically.

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[189] Kittler, Friedrich. *Gramophone, Film, Typewriter.* Translated by Geoffrey Winthrop-Young and Michael Wutz. 1st ed. Stanford University Press, 1999.

[190] Ibid.

[191] McLuhan, Marshall, and Bruce R. Powers. *The Global Village: Transformations in World Life and Media in the 21st Century.* New Ed edition. New York: Oxford University Press, 1992.

As we move towards an attempt to understand global phenomena, a task required by the emergence of the Internet, a more serious critique of *Gramophone* would be Kittler's reliance on the western media and cultural cannon. While it is not wrong to do so in-context it would be a mistake to assign these technologies universally impact. For example, while the Gutenberg press and the typewriter are often credited with changing the way media works in our culture, it is not the case that this carries the same weight among cultures with more complicated alphabets. The Chinese developed movable type long before Gutenberg[192], but it was simply impractical within the framework of a pictorial language and so rather than radically changing the culture it remained a curiosity. To use Kittler's own formulation of observation in practice, the reality of this is obvious upon observing someone operate a Chinese typewriter: it is simply too cumbersome to have ever become a universal technology. Similarly, while Kittler and Manovich ascribe much to the filmic language and vocabulary that emerged out of cinema this language is not the same across cultures. Japanese film and visual storytelling show very different sensibility of time and place than their western counterparts[193], to say nothing of the tropes of India's *Bollywood* cinema.

An example closer to home for my research, the use of personal mobile networked devices such as smartphones have fundamentally changed the way our culture operates. This is observably true, but in the details we must ask what we mean by "culture." European and North American culture have largely adopted smartphones as cultural prosthetics. Mostkoff cites Tenner: "When we use simple devices to move, position, extend, or protect our bodies,our techniques change both objects and bodies. And by adopting devices we do more. We change our social selves. In other species, natural selection and social selection shape the appearance of the animal. In humanity, technology helps shape identity" (Tenner, p. 37). In this sense, the information systems that allow us to search for, manipulate, and author information, serve as a prosthesis for our memory, designed for recall."[194] But is this universally true?

Cellphones are extensions of our everyday lives, additions to to the actions we perform in "real life" and on our primary devices: desktop or laptop computers. While this "feels right" it should be contrasted with what we know about the way in which mobile devices are used in the developing world and among poor and minority populations in the west. According to Pew Internet for example, in the United States "Half (51%) of African-American cell internet users do most of their online browsing on their phone, double the proportion for whites (24%). Two in five Latino cell internet users (42%) also fall into the "cell-mostly" category."[195] While culturally the smartphone might serve the same sort of mental prosthetic role, it is not an extension of the primary computing experience it *is* the experience. This has significant implications for our understanding of the way the technology impacts narrative culture. For this dissertation, I confine my conclusions to a North American and Western European context and assume a population which is well connected. The ideas presented here may have broader implications, but the only way to determine this would be to try them in those contexts.

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[192] Tsien, Tsuen-hsuin. "Part 1, Paper and Printing." In *Science and Civilisation in China: Volume 5, Chemistry and Chemical Technology*, by Joseph Needham, 201–17. Cambridge University Press, 1985.

[193] Wee, Valerie. *Japanese Horror Films and Their American Remakes*. Routledge, 2013.

[194] Mostkoff, Ariella S. "Memory Prosthesis Design." North Carolina State University, 2012. http://ariella-mostkoff.com/wp-content/uploads/2012/05/ASM-Thesis-fin.pdf.

[195] Smith, Aaron. "Cell Internet Use 2012." *Pew Research Center's Internet & American Life Project*. Accessed January 12, 2015. http://www.pewinternet.org/2012/06/26/cell-internet-use-2012/.

6.2.3.2: WHAT IS MEDIA?

The question remains whether we ought to hang our understanding on particular media at all. McLuhan's definition of *medium* is all-encompassing and has been criticized extensively. Raymond Williams, one of the founders of Cultural Studies, writes from a Marxist perspective that "The crucial slippage McLuhan exploits is the overlap between the arts/skill-based usages of "medium" and "technology/technique." This enables the further conflation of "technology" with usage (iii) of "medium."[196] In any case McLuhan's "medium" is almost certainly too broad. Kittler is less imprecise than McLuhan but takes a similar approach in conflating technology and medium. Does a transport technology really constitute the atoms on which our universe of storytelling and understanding are built? Certainly they are important, providing both the language and the ability to transmit ideas, but the ideas themselves must exist in some other place closer to our experience.

Critics have also pointed out Kittler's particular technology choices privilege the pre digital (he curiously does not include radio, the keyboard, or the Internet, for example). This perhaps has something to with his apocolypitic worldview: "As a kind of media theory of History, a requiem and good-riddance for the era of so-called Man, *Gramophone, Film, Typewriter* transmits the tenor of its own historical moment. The German edition appeared in 1986, the year after the opening of MIT's Media Lab and the release of Talking Heads' post-hermeneutic concert film and album *Stop Making Sense*. Other resonant events in American culture include the publication of William Gibson's *Neuromancer* (1984), Donna Haraway's *Manifesto for Cyborgs* (1985), and Octavia Butler's *Xenogenesis* trilogy (1987-89). Memories and premonitions of mushroom clouds loomed over these three speculative and/or scholarly scenarios published during the final decade of the Cold War; each text imagines the form of a posthuman or post-nuclear world."[197] In any case, it would seem that having survived the cold war, our newer medium-melting technologies would demonstrate some of the problems with his underlying approach.

Indeed in the updated introduction to his own work, Kittler begins with the phrase "Fiber optic networks..." and subsequently argues more or less that contemporary distribution networks are disassembling media into a single distribution network which is rendering the notion of "medium" a bit quaint. Kittler writes: "Sound and image, voice and text are reduce to surface effects... sense and the senses turn into eyewash... inside the computers themselves, everything becomes a number: quantity without image, sound or voice."[198] Nevertheless Kittler goes on to argue that there are still differences in media, since we can perceive a difference between types of information, and therefore these differences must matter.

While I fundamentally agree with Kittler that there *are* differences in media, this madding slight-of-hand is typical of his style. Rather than acknowledge that reliance on technology itself poses a problem to his theory, Kittler simply states that there is no difference between formats, only a perceptible one, and before we can catch our breath he moves on. We need additional work to put this text in context. I've already suggested McLuhan might be worth pairing, but while McLuhan has found a comfortable home with scholars of Internet ideas his focus was on television and mass broadcast media. How can we fill in the gap?

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[196] Jones, Paul. "The Technology Is Not the Cultural Form?: Raymond Williams's Sociological Critique of Marshall McLuhan." *Canadian Journal of Communication* 23, no. 4 (April 1, 1998).

[197] Clarke, Bruce. "Friedrich Kittler's Technosublime." *Electronic Book Review*, December 30, 1999.

[198] Kittler.

6.2.3.3: BUILDING ON “NEW MEDIA”

Lev Manovich’s *The Language of New Media* (2001) is a systematic approach towards understanding what “New Media” is in an attempt to build discourse from the ground up. The work references historical and contemporary work (most notably the history of cinema) but does not privilege existing theory without consideration. Manovich writes: “Rather than imposing some a priori theory from above, I build a theory of new media from the ground up. I scrutinize the principles of computer hardware and software and the operations involved in creating cultural objects on a computer to uncover a new cultural logic at work.”[199]

Contemporary new media theory provides the closest possible framework to what we need in order to discuss the impact of contemporary and art with technology, but there is something missing in its insistence on physical media as a metaphor. Experiences are mediated but it is not quite true that art and technology experiences are themselves a media type any more than “theater” is.

Neither Kittler, McLuhan nor Manovich were artists. None created media objects other than their own writings and so largely treat media *after* it comes into being. The process of becoming: of creating media and the life these “objects” have in relation to both creator and audience is a space which is mostly ignored. What is missing technically from the work is the impact of the Internet, but what is more important is what the Internet facilitates: a network of relationships between computation, audience and performer.[200] In this space, a new kind of meta performance emerges and new types of vocabularies become available for production.

What I propose here is a blend of all of these ideas into a theory which takes into account shifting ideas of the artist and the audience, filling in the gaps to explain some of the phenomena we are seeing now. This theory is based around the notion of computation as an organizing principle whose characteristics establish a kind of framework for understanding: a way of seeing the world or *epistemology* in the most basic sense of the word.

6.3: A THEORY IN MOTION: AUTHOR AS LENS

What I have sketched above represents a nascent idea which expands on art practice, media theory and genetic epistemology in order to come to terms with what has occurred over the last decade: namely the emergence of both technology and a global network which has changed the way we relate to both media and mediums. McLuhan’s “medium is the message” promise has already been delivered on, and now we are living in a kind of post-medium state. Using medium as an organizing principle only makes sense historically. Going forward we need something more relational.

If there is a cue that we can take from Kittler’s work it is that our answer will not lie in any of the existing technologies or organizational systems. Rather, understanding will come from a careful blending of sources both “high” and “low:” the inclusion of academic texts, songs, plays and science fiction. Each of these alone fail to accurately explain the situation but together form a focal-point of understanding. Unlike the notion of a singularity, this focal point will depend on the role of the practitioner acting as a lens. The lens focuses attention and energy and makes certain ideas visible, but the phenomena exists in front of and behind the lens. The lens can be moved, it is temporary, and by itself it does very little. It is only in the interplay between all elements that meaning and understanding emerge: not the architecture but the architected. Not the performance but the performed. Not an artwork as object but artwork as event.

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[199] Manovich.

[200] Jenkins, Henry. *Convergence Culture: Where Old and New Media Collide*. New York University Press, 2006.

In this, Gramophone, Film, Typewriter exemplifies a final key notion of computational epistemology with regards to the role of the author. Out of a sea of data, art comes from the individual as a momentary organizing principle. This is a different notion of authorship and authorial aesthetics than we are historically familiar with. The author is not omnipotent or an endpoint, but offers focus for a brief moment in time in order to collect ideas into a new meaning. The text itself weaves a world in which it make the most sense and, in this, demonstrates its own value.

As James Carse writes: “There are at least two kinds of games. One could be finite, the other infinite. A finite game is played for the purpose of winning, an infinite game for the purpose of continuing the play.” 201 Consider this work an infinite game. Future work will seek to expand the theory by continuing the play.

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201 Carse, James. *Finite and Infinite Games*. New York: Free Press, 2013.

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APPENDIX A

A

APPENDIX A PROJECT TIMELINE

2012	April	Proof of Concept (AniMOOG + Existing Tools)
	April	*Sink I* developed
	October	Tsinghua Media Lab Workshop w/*Sink I*
	November	*Inter-Actor* (Sink I + Processing)
		Les Urbaines in Lausanne *Aroroa, Sonous, Solinophone*
		Stage Digtial I in Zürich Lightbox and *Sonous*
	December	SINLAB AiR Mark Coniglio *Sink II* developed
2013	June	*CYBORG[AME]* w/SINLAB AiR Gildas Milan *Performance/Space* developed *SyMix Beta* developed *Textify!* developed
	August	*Lines of Desire* ENSAL Residency Lyon, France Work on TSPS, Unity *ReOSC* developed
	September	*SHiNMu* production in Lyon, France *Merge* developed
2013	November	*Stage Digitial II* ZhDK Residency Zürich
		Lines of Desire developed
		Dodecahedron integration
2014	May	*LIWYATAN/LEVIATHAN* w/SINLAB AiR MOTUS *SyMix* developed
	June	*HeartCollector* + *HeartMonitor* developed
	July	*CinemaMutation* developed La Manufacture 10year Anniversary Celebration

B

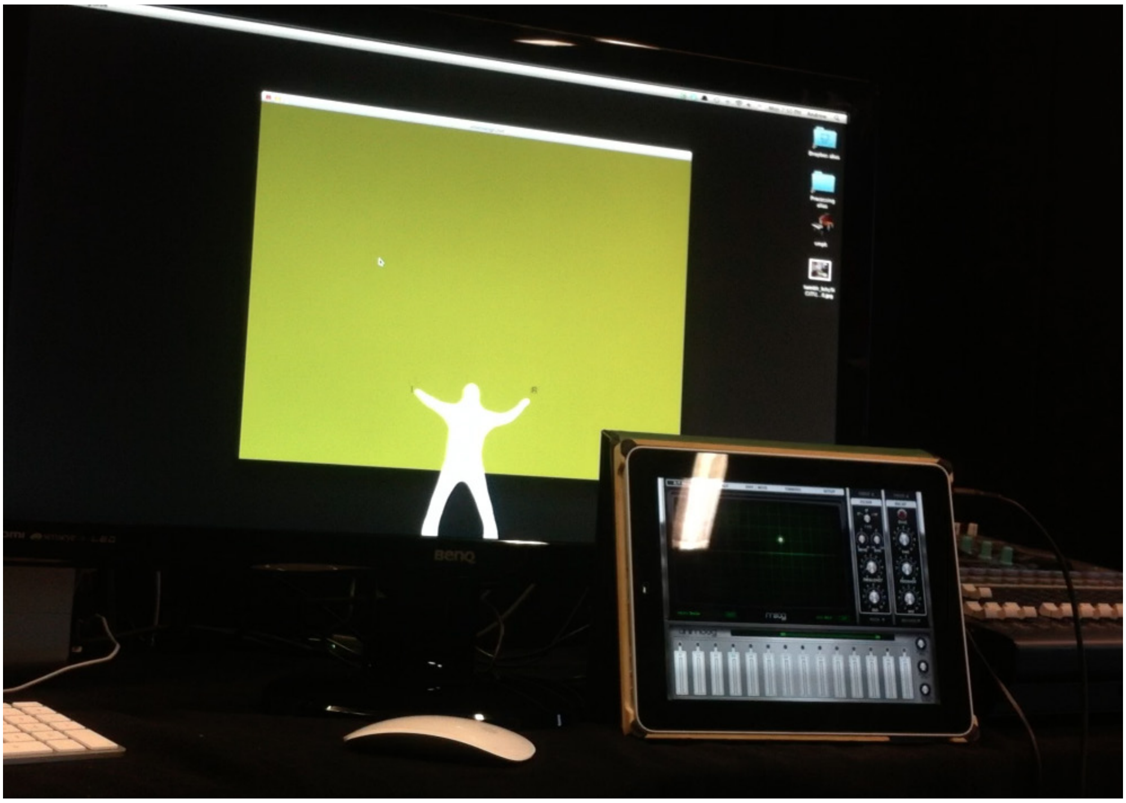
APPENDIX B SOFTWARE DEVELOPED

PROTOTYPE / ANIMOOG - APRIL 2012

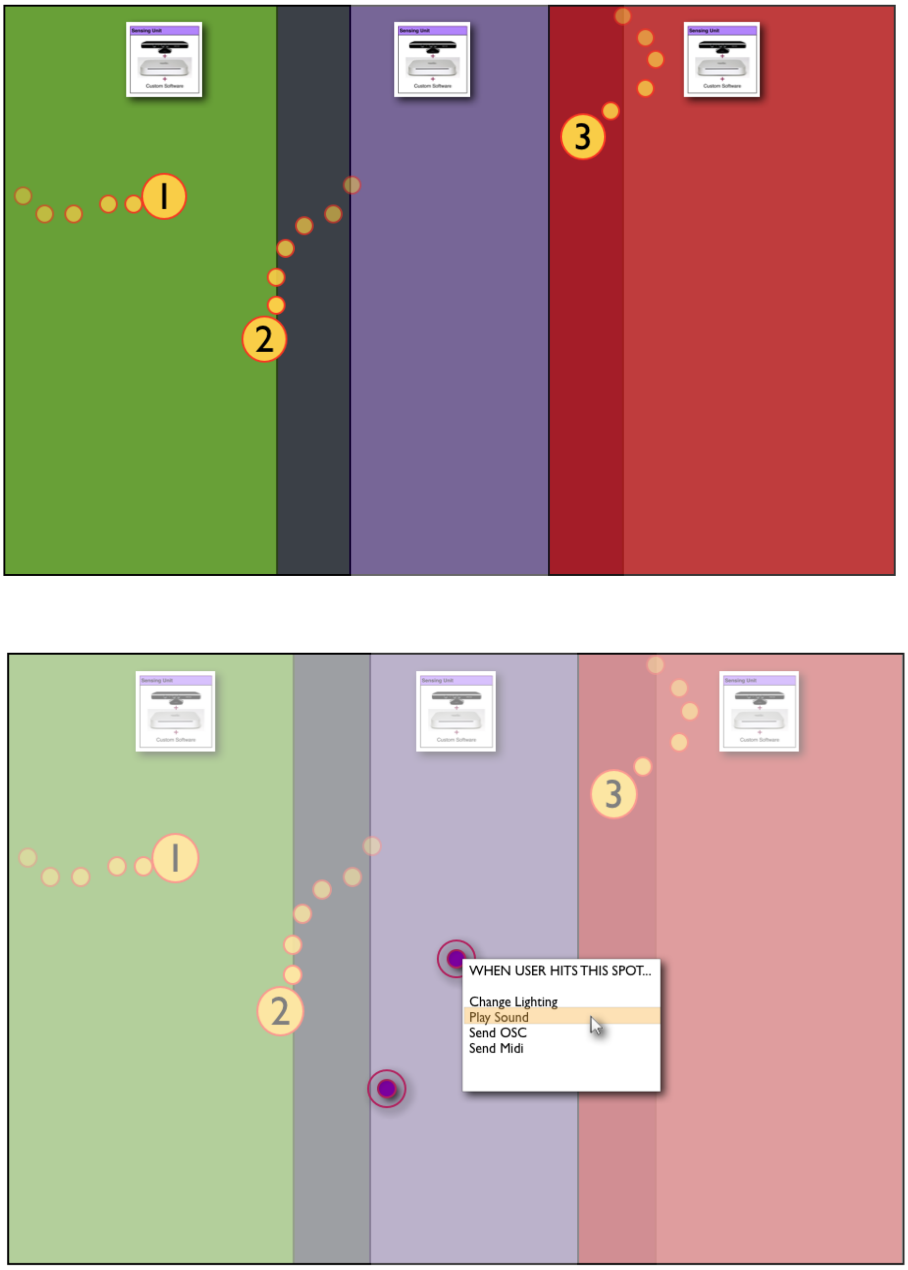
As early as possible I wanted to arrive at a system I could use to demonstrate control of stage technology using the Kinect as input. This prototype, shown informally to staff and visitors of HETSR, consisted of a combination off the shelf tools which allowed a single user to step on stage and play a MIDI Instrument with their body.

Commercial beta NI-Mate software was used to interface with the Kinect and collect and process the data from the camera. This was sent via OSC to a sketch written in Processing which was responsible for a simple visualization showing the path traveled over the stage with a background color indicating status (green for on stage and white for off). The Processing sketch also played short melody via MIDI indicating a performer's presence on or off stage.

The intrument controlled was the MOOG Animoog, a synthesizer that runs on the iPad. The MIDI was controlled wirelessly. The interaction was straightforward: move towards the camera and the system would play a note increasing in pitch, move away and the pitch would decrease. Moving from stage left to right changed the characteristic of the sound. The processing sketch was also capable of tracking the number of people on stage. Control over sound remained an integral part of the work through June 2012 when I switched away from DMX, MIDI and sound control and towards scenography created with projection.



Prototype setup shows the NI-MATE output superimposed over a custom Processing sketch on the screen. The output is sent via wireles MIDI to the Animoog synthesizer running on the ipad, whose output is fed out through the PA system at the right.


Sensing Unit
Custom Software
1
2
3
WHEN USER HITS THIS SPOT...
Change Lighting
Play Sound
Send OSC
Send Midi

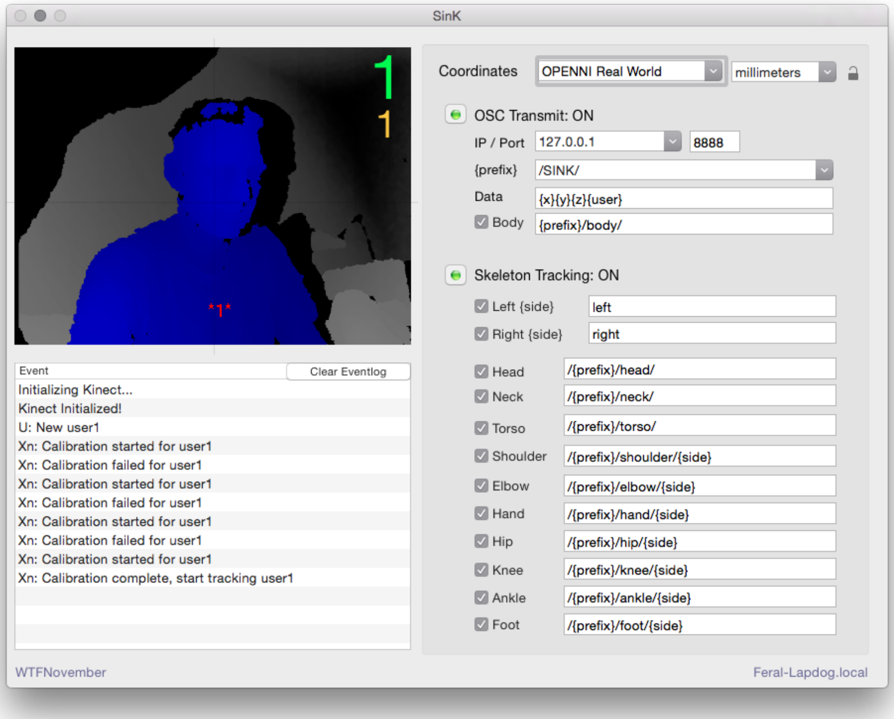
Conceptual sketches of the proposed system. Each colored rectangle represents the area covered by a single Kinect camera, the yellow dots represent users, the purple dots represent virtual "hotspots" which trigger events on stage.

SINK I SINK II - OCTOBER 2012

SinK (Sinlab Kinnect-or) I and II were developed as general purpose tools to provide a basic interface to the Microsoft Kinect depth camera and as a replacement for the commercial NI-MATE software used in my initial prototype.

Using the OpenNI 1 library and NITE, this tool collects scene and skeleton information and distributes it over the network via OSC. OSC data may be consumed by any client capable of handling OSC input, but was used in this case primarily with Processing.

The SinK tool allows you to remap OSC address data on the fly, which provides a simple method of reconfiguring the interface of any existing processing sketch. For example, a drawing tool might be configured to use the left hand as a color selector. In order to change this to the foot, one needs simply type in a change of address, reconfiguring /left/hand to /left/foot. While not suitable for a production environment (remapping in this way can be confusing), this tool allows you to very quickly test variations of physical interface, exploring full body interaction with as little code as possible. Data can be provided using Real World or Projected coordinates and converted automatically to millimeters, centimeters or meters. It is possible to save and reload configurations on the fly to facilitate custom configurations for each client.



SinK
1
1
1
Clear Eventlog

Coordinates: OPENNI Real World, millimeters

● OSC Transmit: ON

IP / Port: 127.0.0.1 8888

{prefix}: /SINK/

Data: {x}{y}{z}{user}

☑ Body: {prefix}/body/

● Skeleton Tracking: ON

☑ Left {side}: left

☑ Right {side}: right

☑ Head: /{prefix}/head/

☑ Neck: /{prefix}/neck/

☑ Torso: /{prefix}/torso/

☑ Shoulder: /{prefix}/shoulder/{side}

☑ Elbow: /{prefix}/elbow/{side}

☑ Hand: /{prefix}/hand/{side}

☑ Hip: /{prefix}/hip/{side}

☑ Knee: /{prefix}/knee/{side}

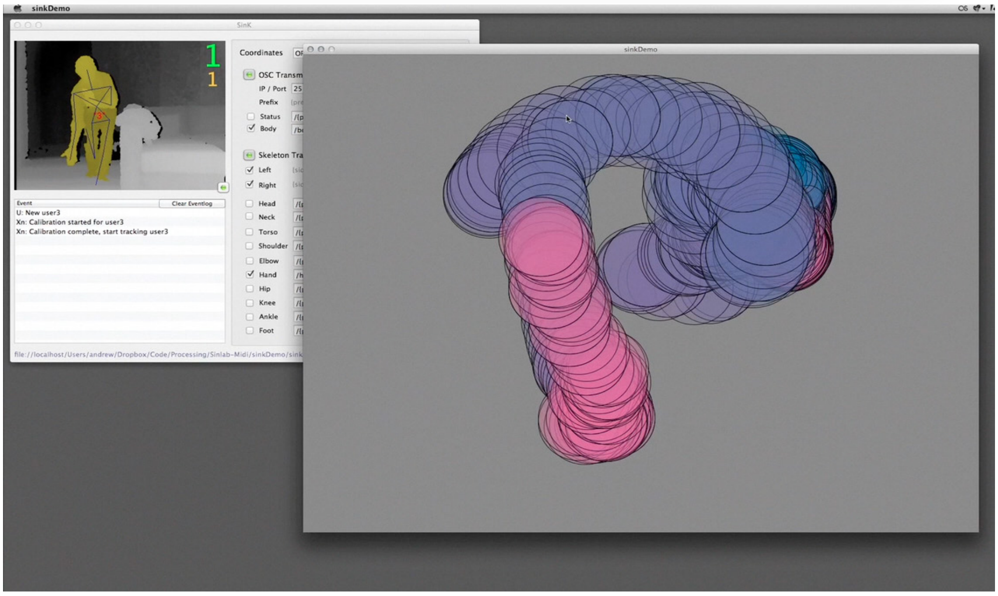
☑ Ankle: /{prefix}/ankle/{side}

☑ Foot: /{prefix}/foot/{side}

```
Event
Initializing Kinect...
Kinect Initialized!
U: New user1
Xn: Calibration started for user1
Xn: Calibration failed for user1
Xn: Calibration started for user1
Xn: Calibration failed for user1
Xn: Calibration started for user1
Xn: Calibration failed for user1
Xn: Calibration started for user1
Xn: Calibration complete, start tracking user1
```

WTFNovember

Feral-Lapdog.local

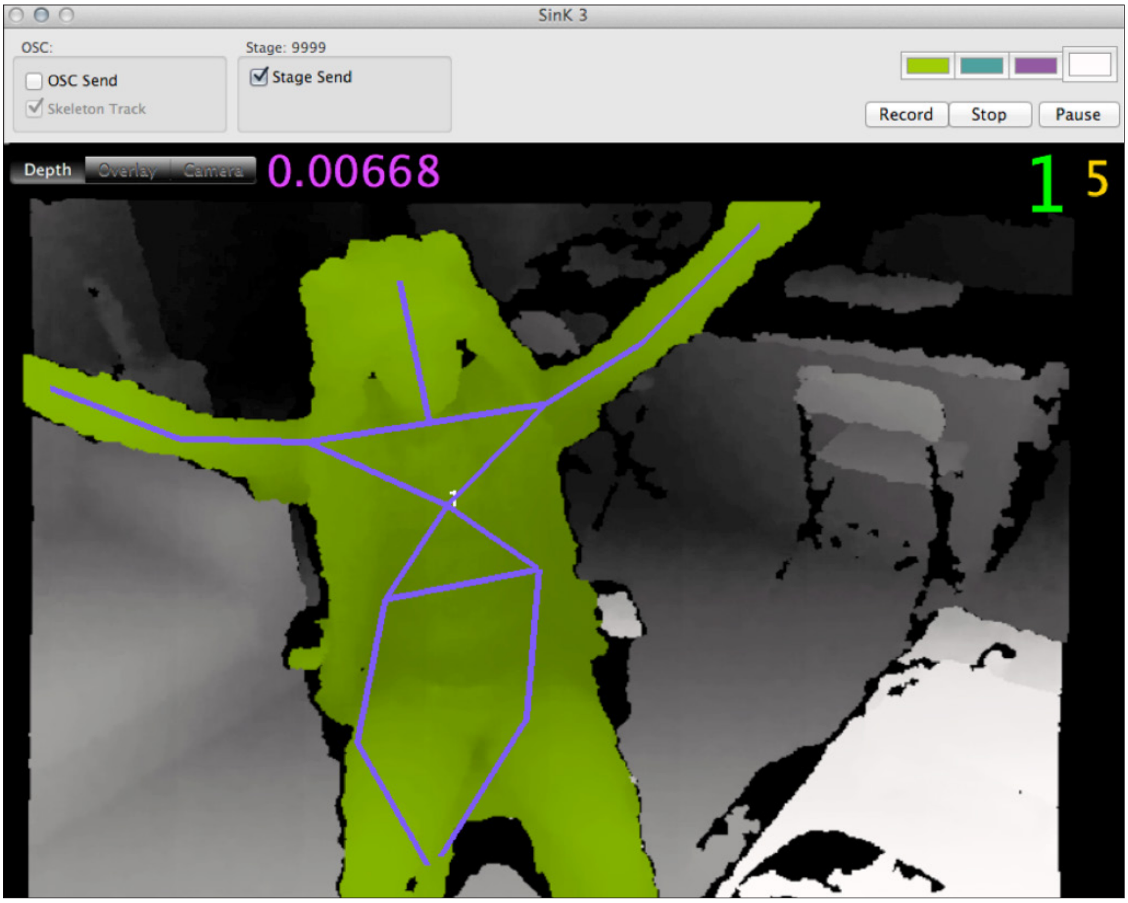


sinkDemo
SinK
1
1
3
Coordinates
OSC Transm
IP / Port
Prefix
Status
Body
Skeleton Tra
Left
Right
Head
Neck
Torso
Shoulder
Elbow
Hand
Hip
Knee
Ankle
Foot
Clear Eventlog
sinkDemo

```
Event
U: New user3
Xn: Calibration started for user3
Xn: Calibration complete, start tracking user3
```

file://localhost/Users/andrew/Dropbox/Code/Processing/Sinlab-Midi/sinkDemo/sink

SinK I connected to Processing. The address panel on the right allows you to live-update OSC address for the wwskeleton data in order to remap it on the fly .



OSC:

☐ OSC Send

☑ Skeleton Track

Stage: 9999

☑ Stage Send

SinK II - functionally identical to SinkI with the addition of recording and playback functionality. SinK remains useful for small scale testing and development but can support at most one camera per computer. ww

WORKSHOP

In October of 2012, I conducted a workshop at Tsinghua University in Beijing, China using Processing and SinK. The purpose of the workshop was to introduce approximately 20 students to the idea of using the Kinect hardware in their projects, which were all proposals for new technologies for narrative to be used by the Beijing Opera in a large scale stage production.

The results of the workshop provided an encouraging initial experience. In spite of the language and cultural divide we were able to work together and the students created simple but complete interactions in a few hours using the provided software. With one exception the prototype SiNK software was installed and running on half a dozen machines in the space of fifteen minutes.

HEAD
SKELETON
SINK
NECK
SHOULDER
ELBOW
HAND
TORSO
ELBOW
HAND
HIP
HIP
KNEE
KNEE
ANKLE
ANKLE
FOOT
SINK
NETWORK
OSC
PERSON

INTER-ACTOR - NOVEMBER 2012

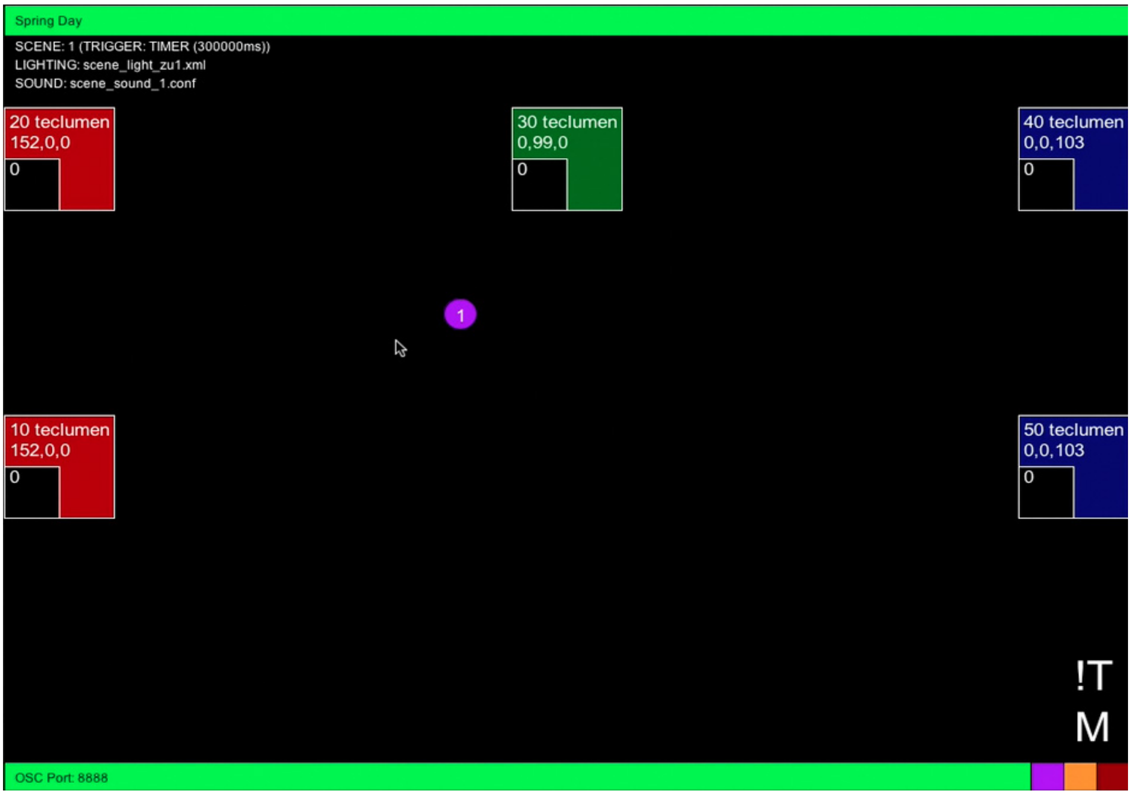
Inter-Actor is the name of the toolkit comprised of a copy of SinK and a special companion Processing sketch called Scene Controller with DMX, MIDI and OSC support. This setup, combined with an Enttec USB DMX interface, allows for the manipulation of sound and DMX controllable stage elements such as smoke machines and lights via body movement on stage.

This software was originally developed in support of the ZHdK Color-Light Lab lightbox project, but I expanded it to include support for audio in order to create soundscapes. To support both use cases I created a custom markup language in XML which describes the configuration of elements in space both real and virtual and how they react to human gesture.

For example, the following markup describes a theatre light of type “zhdk” (a custom color-light-lab fixture), responding on DMX channel 1 in RGB mode with a movement range of 0-255. The on-screen icon for the light is located on the screen at position 0,400 and the lamp’s red or hue channel (RH) responds to the inverse Y-axis movement of the left hand.

```
<lightConfig
        dmx_channel=”1”
        colorspace_mode=”RGB”
        lightType=”zhdk”
        range_min=”0”
        range_max=”255”
        ui_x=”0”
        ui_y=”400”>
        <body>
            <x></x>
            <y></y>
            <z></z>
        </body>
        <left_hand>
            <x></x>
            <y>!RH</y>
            <z></z>
        </left_hand>
        <right_hand>
            <x></x>
            <y></y>
            <z></z>
        </right_hand>
        <distanceBetween1and2></distanceBetween1and2>
        <distanceBetween1and3></distanceBetween1and3>
        <gesture_raiseHand_both></gesture_raiseHand_both>
        <gesture_raiseHand_left></gesture_raiseHand_left>
        <gesture_raiseHand_right></gesture_raiseHand_right>
</lightConfig>
```

The software also supports sound layouts, including custom “sound spots” used to create user navigable soundscapes on stage, MIDI for control of instruments and DMX for control over theatre lighting and equipment. This tool was used in the context of several public demonstrations.



Spring Day

SCENE: 1 (TRIGGER: TIMER (300000ms))
LIGHTING: scene_light_zu1.xml
SOUND: scene_sound_1.conf

20 teclumen
152,0,0
0

30 teclumen
0,99,0
0

40 teclumen
0,0,103
0

10 teclumen
152,0,0
0

50 teclumen
0,0,103
0

!T
M

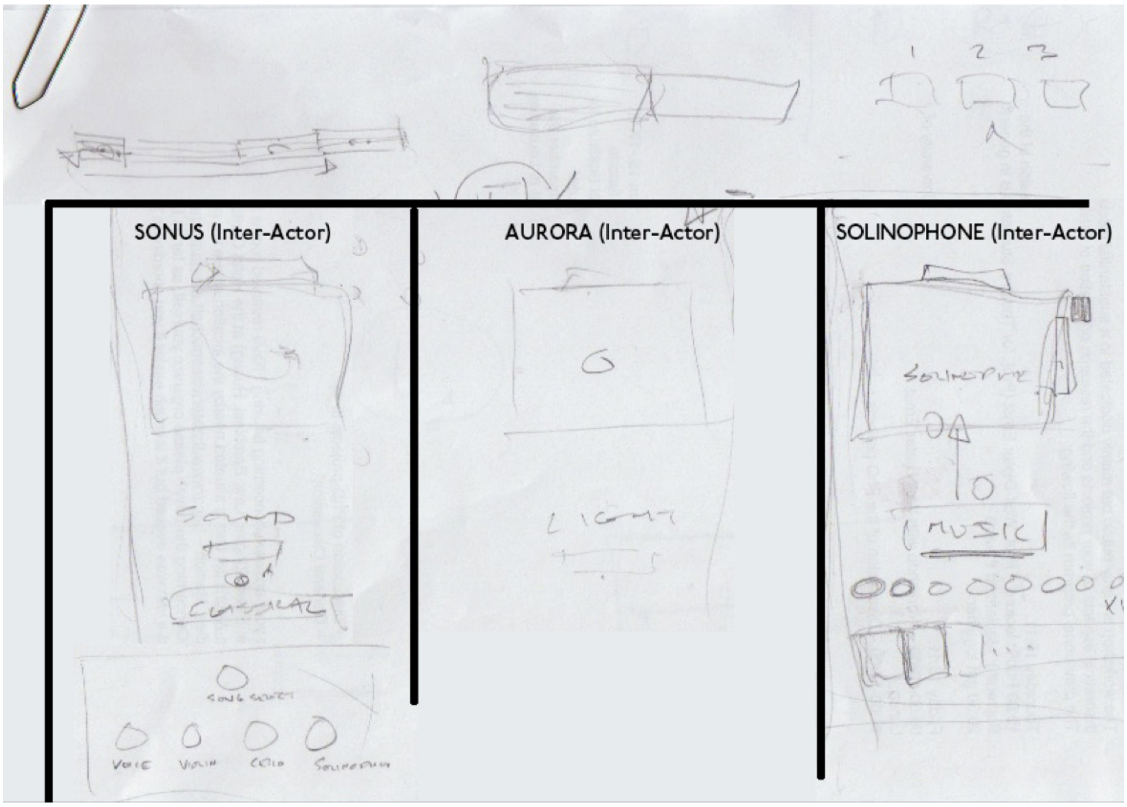
OSC Port: 8888

A screenshot of the Inter-Actor Processing sketch as configured for light control with a single ambient sound track. Green bars at the top and bottom of the page indicate a person is on-stage. Lower right shows the color coding for bodies on stage (purple for actor 1, orange for actor 2 and red for actor 3). Actor 1 is on stage now, as shown by the purple dot with a 1 in the center. Each of the five squares represent one theatre light of type "teclumen" configured in RGB mode and displaying the color as shown in format RRR,GGG,BBB. These lights have an additional "white channel," currently off in the screenshot, indicated by the inset square. Information about the scene is shown in upper left. This software supports multiple scenes. The lower right indicates that the scene timer is off (!T), and that a user is being simulated by the mouse (M).

ENTTEC
OPEN DMX USB
www.enttec.com

Enttec USB/DMX box allows control over most standard theatre equipment via software.

Teclumen brand DMX controllable light fixtures in can and bar configurations of the type used at Stage Digital I.



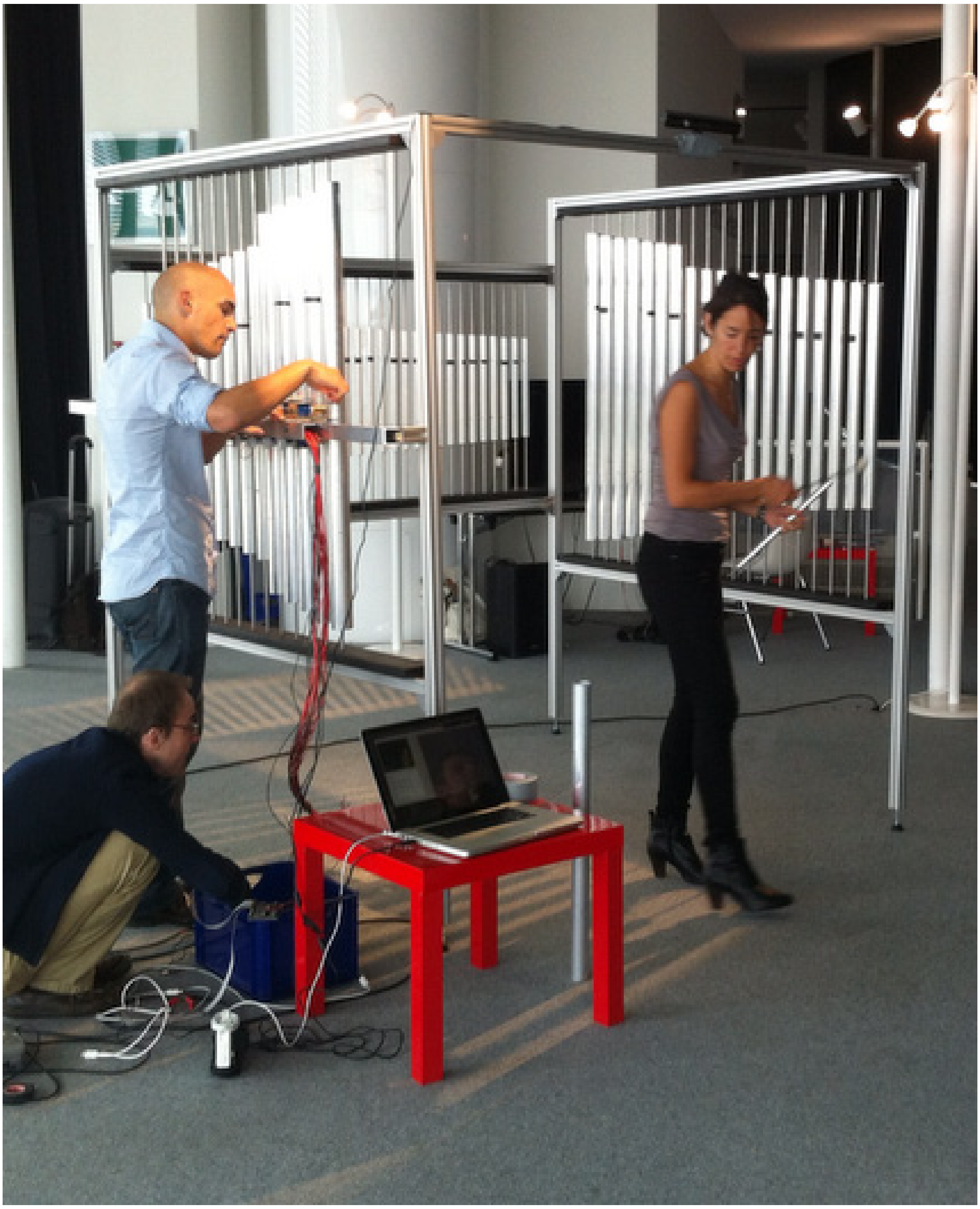
Proposal for the Les Urbains show (Lausanne November 2013), three demonstration areas showing the Inter-Actor system connected to lights, sound and a musical instrument (the Solinophone).

DEMO: MIDI - SOLINOPHONE

Actual implementation is one the most powerful tools in a designer's arsenal. It is not always practical or possible to implement during the design phase but the more chances you have for your abstract tool to meet a concrete task the more real-world problems you will encounter and the better the tool will become.

Early on I looked for collaborators to ensure my software development would not occur in a vacuum. At the time, EPFL researcher and SINLAB friend Hillary Sanctuary saw my Animoog demo. At the time HIllary was working on a microtonal instrument of her own invention called the Solinophone. The Solinophone is intended to be played by hand using mallets but Hillary also worked with EPFL colleague Alain Crevoisier to augment the instrument with an array of MIDI controllable hammers so that it could be played using a standard keyboard. MIDI support meant the system was ready for integration with custom software.

For 2012 Nuit des Musées, I spent a day with Alain and the Solinophone attempting to integrate my prototype tracking system with the hardware Alain had created. To my disappointment we were never able to get the Kinect and Solinophone combination to function smoothly but the attempt convinced me that it was worthwhile to develop all of my systems with flexibility in mind. Whenever possible my systems implement and work with standard industry protocols such as OSC, MIDI and DMX in order to maximise interaction possibilities.



Solinophone at the 2012 Nuit des Musees at the EPFL Rolex Center.
The Kinect is visible duct-taped to the crossbar at the top. Hillary Sanctuary, inventor of the Solinophone, is on the right. Alain who built the MIDI hardware can be seen crouching in the lower left, with an assistant installing the hammers.

DEMO LIGHT - COLOR-LIGHT-LAB

In support of their own research Florian Bachmann and Marcus Pericin of the ZHdK Color-Light Lab constructed a multi layered “light box” large enough to hold a small group of people. By concentrating the light in this space it becomes possible to experience light as a physical phenomena.

The color-light lab was planning on exhibiting their color box at the Stage Digital I event and were looking for a mechanism to control the lights in the box using body movement alone. As light control seemed in line with the notion of digital scenography, I set about creating a system to control theatrical lighting based on Inter-Actor.

For this project it was necessary to support at least three types of theatrical lighting: the Teculmen series in use at La Manufacture, and two additional formats used by the Color-Light Lab. I wrote drivers for these lights in Processing, which communicated via DMX (a standard theatre control protocol) using the Enntec USB box.

In line with my intention to create a tool to “sketch” interactively in space, I wanted to create a flexible user interface. As a first step I needed a simple way to save and load settings and so I created an XML markup language to describe space, light and sound configurations. Ultimately I ran out of time to create the interface I had in mind for the lights, but using the markup language alone Marcus and Florian created more than two dozen scenese featuring various types of light interaction for their demo at Stage Digital I.

Inside the Color-Light-Lab lightbox.

The creation of a markup language helped me to sort out the details of what was important and what wasn’t. It also made clear that in spite of the fact that Marcus and Florian were able to make good use of the system, using markup required a mental shift from physical space to “encoding” or modeling the space

Color-Light lab light box at Stage Ditial I, with Marcus and Florian inside

in written form. This mental interruption was far from sketch-like. If I wanted to achieve a flow between conception and realization I needed to push the interface even further away from this code-like representation and into something both realtime and visual. As much as possible, software written after this period includes a developed user interface for on-the-fly configuration.

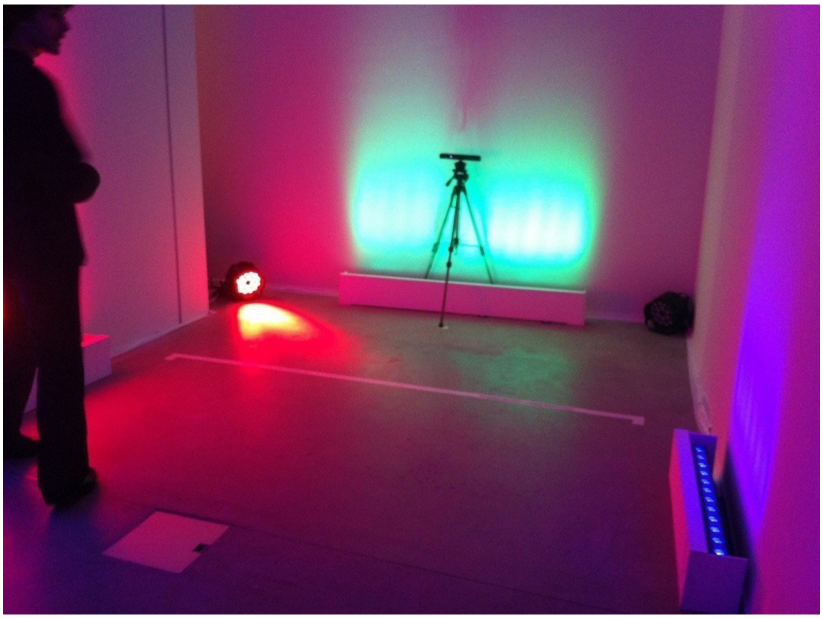
DEMO: LIGHT- AURORA

A version of the lightbox project, called Aurora, was demonstrated at Les Urbaines, where I provided a small square inside of which visitors could mix RGB light by moving the position of their bodies. In addition, this demonstration showed the ability of the system to track the relationship between more than one visitor at a time, as well as automatic timer-based scene-switching capability.

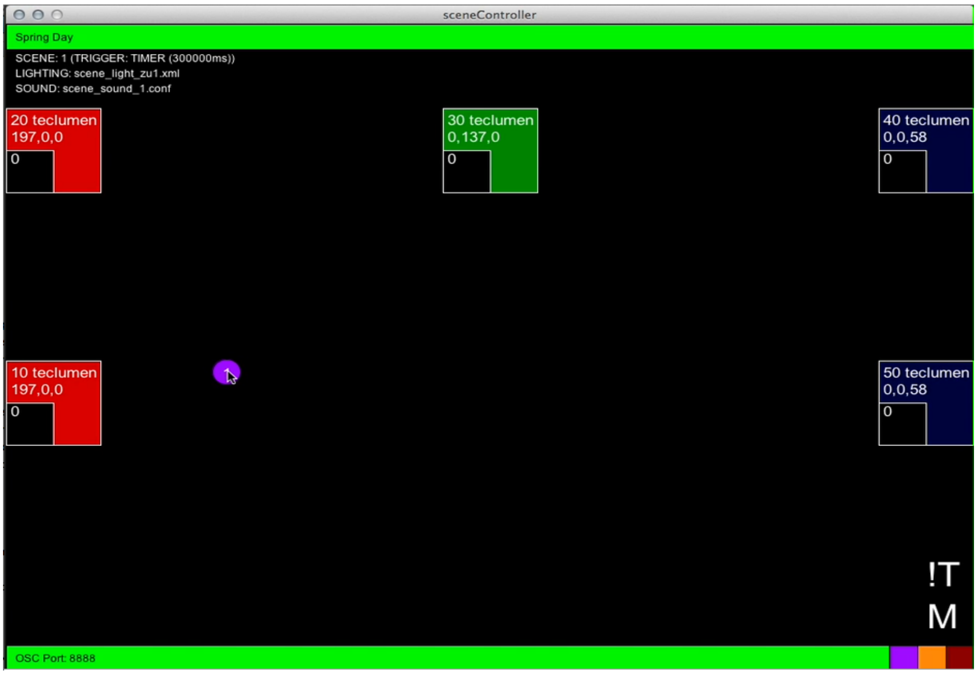
If one user entered the stage, the mixer scenario would run allowing a single user to mix the room's color by moving to the left (more red) forward (more green) and to the right (more blue). If two visitors entered the stage the mixer was replaced with a scene which mixed the color according to the distance between the two.

DEMO: SOUND - SONUS

The sound component of the Inter-Actor system was demonstrated at both Les Urbaines and Stage Digital I as Sonus. Each installation differed slightly in configuration but provided a radically different audience



The single-user Aurora RGB mixer setup in the gallery space and in software representation. Each box represents a Teculmen lamp, the purple dot to the left is the tracked user. You can see how the blue lights on the right are dim, indicating the user is closer to the red.

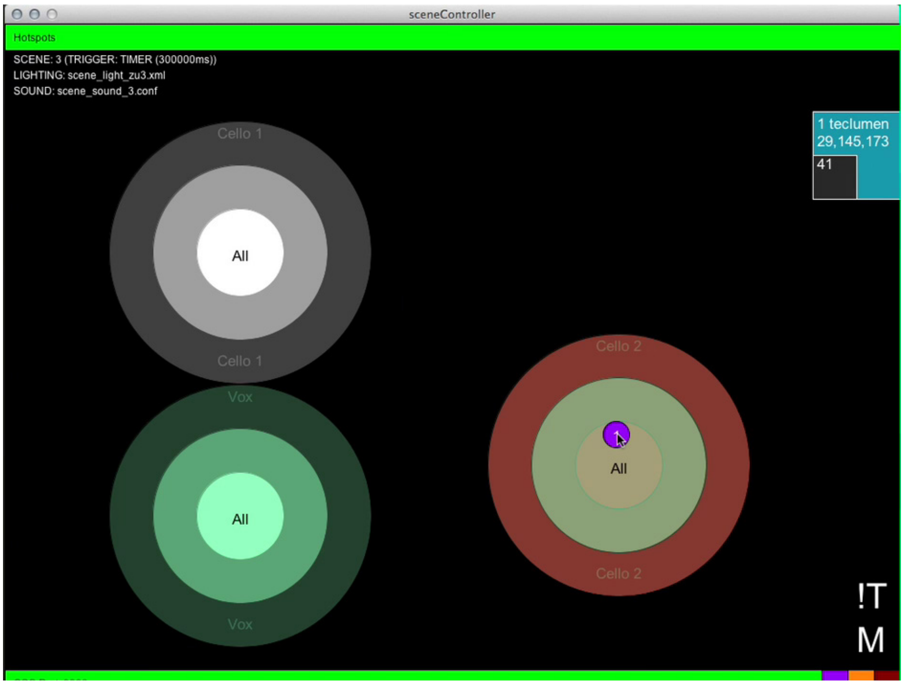


```
Spring Day
SCENE: 1 (TRIGGER: TIMER (300000ms))
LIGHTING: scene_light_zu1.xml
SOUND: scene_sound_1.conf
```

sceneController
20 teclumen
197,0,0
0
30 teclumen
0,137,0
0
40 teclumen
0,0,58
0
10 teclumen
197,0,0
0
50 teclumen
0,0,58
0
!T
M
OSC Port: 8888

experience.

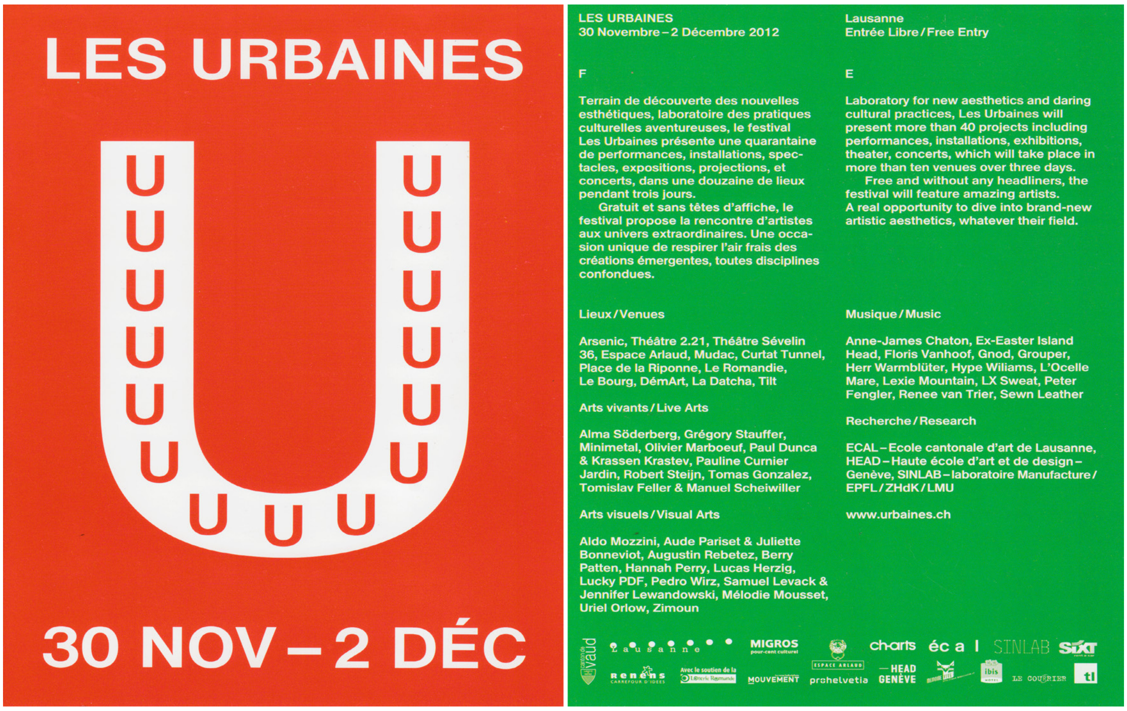
For Les Urbaines, Hillary Sanctuary (the creator of the Solinophone) composed two three-part musical pieces which could be mixed by the presence or absence of an audience member standing in a particular spot. I indicated the spots by using musical symbols on the floor. If a visitor stood in a particular hotspot the audio would fade in smoothly. Occupying more than one spot allowed both parts of the composition to play. The hotspots were arranged physically so that it might be possible for a single visitor with some effort to occupy two spaces at once but never three. In this way we hoped to create an installation which would encourage group play: it would be easy for a single user to discover the interaction but impossible to achieve the full effect without recruiting help. Two different compositions were exhibited one with vocals and cello and one multi-part oud piece. Scenes were auto-rotated using the scene-timer function of Inter-Actor.



```
SCENE: 3 (TRIGGER: TIMER (300000ms))
LIGHTING: scene_light_zu3.xml
SOUND: scene_sound_3.conf
```

Screenshot showing the hotspot configuration of Sonus for Les Urbaines. This shows the composition which consists of a vocal part (lower left) and two cello parts. The scene did include one light, which faded in and out indicating that someone was on stage.

Using the same software, I created a slightly different and more abstract demonstration of the system for Stage Digital I. Instead of relying on marked hotspots I created a field of sound through which a visitor could wander. Presence in one part of the floor triggered certain sound loops. Movement towards another would cross-mix them smoothly. This was accomplished by making the hotspots large and overlapping in the UI, showing how the same basic system might be adapted to create vastly different audience experience.



LES URBAINES

30 NOV – 2 DÉC

LES URBAINES
30 Novembre – 2 Décembre 2012

Lausanne
Entrée Libre / Free Entry

F

Terrain de découverte des nouvelles esthétiques, laboratoire des pratiques culturelles aventureuses, le festival Les Urbaines présente une quarantaine de performances, installations, spectacles, expositions, projections, et concerts, dans une douzaine de lieux pendant trois jours.

Gratuit et sans têtes d'affiche, le festival propose la rencontre d'artistes aux univers extraordinaires. Une occasion unique de respirer l'air frais des créations émergentes, toutes disciplines confondues.

E

Laboratory for new aesthetics and daring cultural practices, Les Urbaines will present more than 40 projects including performances, installations, exhibitions, theater, concerts, which will take place in more than ten venues over three days.

Free and without any headliners, the festival will feature amazing artists. A real opportunity to dive into brand-new artistic aesthetics, whatever their field.

Lieux / Venues

Arsenic, Théâtre 2.21, Théâtre Sévelin 36, Espace Arlaud, Mudac, Curtat Tunnel, Place de la Riponne, Le Romandie, Le Bourg, DémArt, La Datcha, Tilt

Arts vivants / Live Arts

Alma Söderberg, Grégory Stauffer, Minimetal, Olivier Marboeuf, Paul Dunca & Krassen Krastev, Pauline Curnier Jardin, Robert Steijn, Tomas Gonzalez, Tomislav Feller & Manuel Scheiwiller

Arts visuels / Visual Arts

Aldo Mozzini, Aude Pariset & Juliette Bonneviot, Augustin Rebetez, Berry Patten, Hannah Perry, Lucas Herzig, Lucky PDF, Pedro Wirz, Samuel Levack & Jennifer Lewandowski, Mélodie Mousset, Uriel Orlow, Zimoun

Musique / Music

Anne-James Chaton, Ex-Easter Island Head, Floris Vanhoof, Gnod, Grouper, Herr Warmblüter, Hype Wiliams, L'Ocelle Mare, Lexie Mountain, LX Sweat, Peter Fengler, Renee van Trier, Sewn Leather

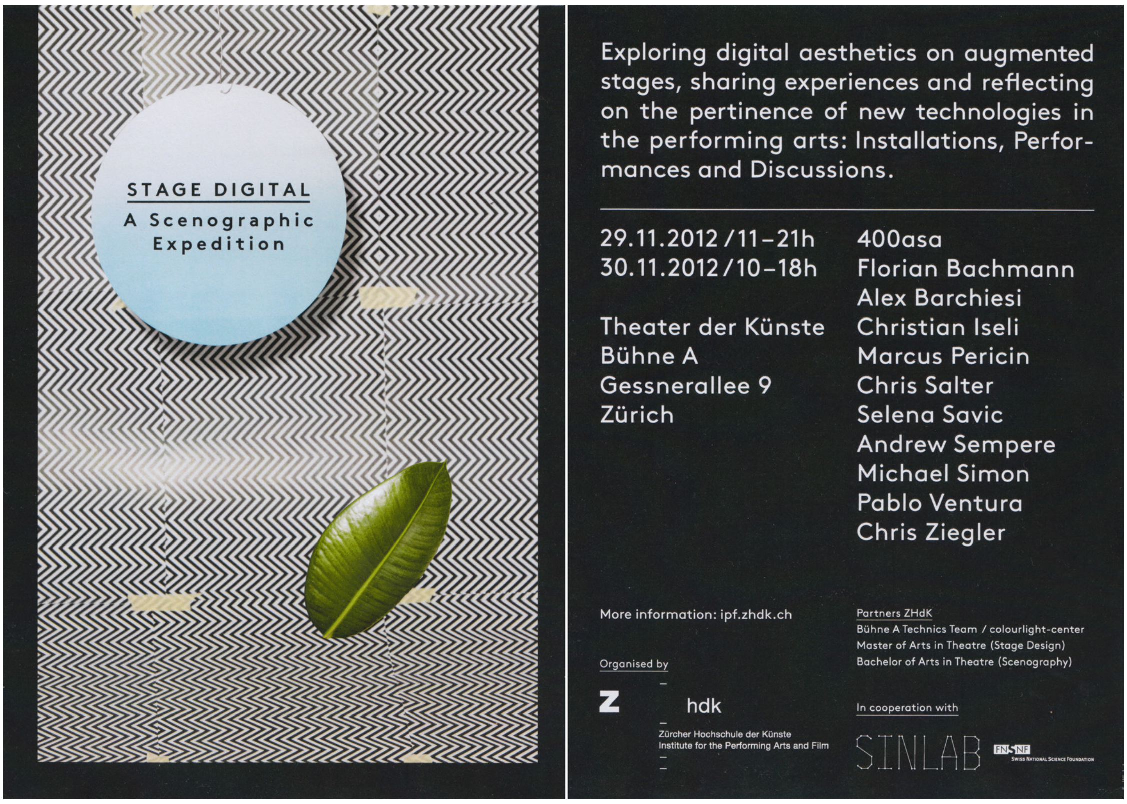
Recherche / Research

ECAL – Ecole cantonale d'art de Lausanne, HEAD – Haute école d'art et de design – Genève, SINLAB – laboratoire Manufacture / EPFL / ZHdK / LMU

www.urbaines.ch

Avec le soutien de la

Flyer for Les Urbaines Festival where Aurora and Sonus were shown.



STAGE DIGITAL
A Scenographic Expedition

Exploring digital aesthetics on augmented stages, sharing experiences and reflecting on the pertinence of new technologies in the performing arts: Installations, Performances and Discussions.

29.11.2012 / 11–21h
30.11.2012 / 10–18h

Theater der Künste
Bühne A
Gessnerallee 9
Zürich

400asa
Florian Bachmann
Alex Barchiesi
Christian Iseli
Marcus Pericin
Chris Salter
Selena Savic
Andrew Sempere
Michael Simon
Pablo Ventura
Chris Ziegler

More information: ipf.zhdk.ch

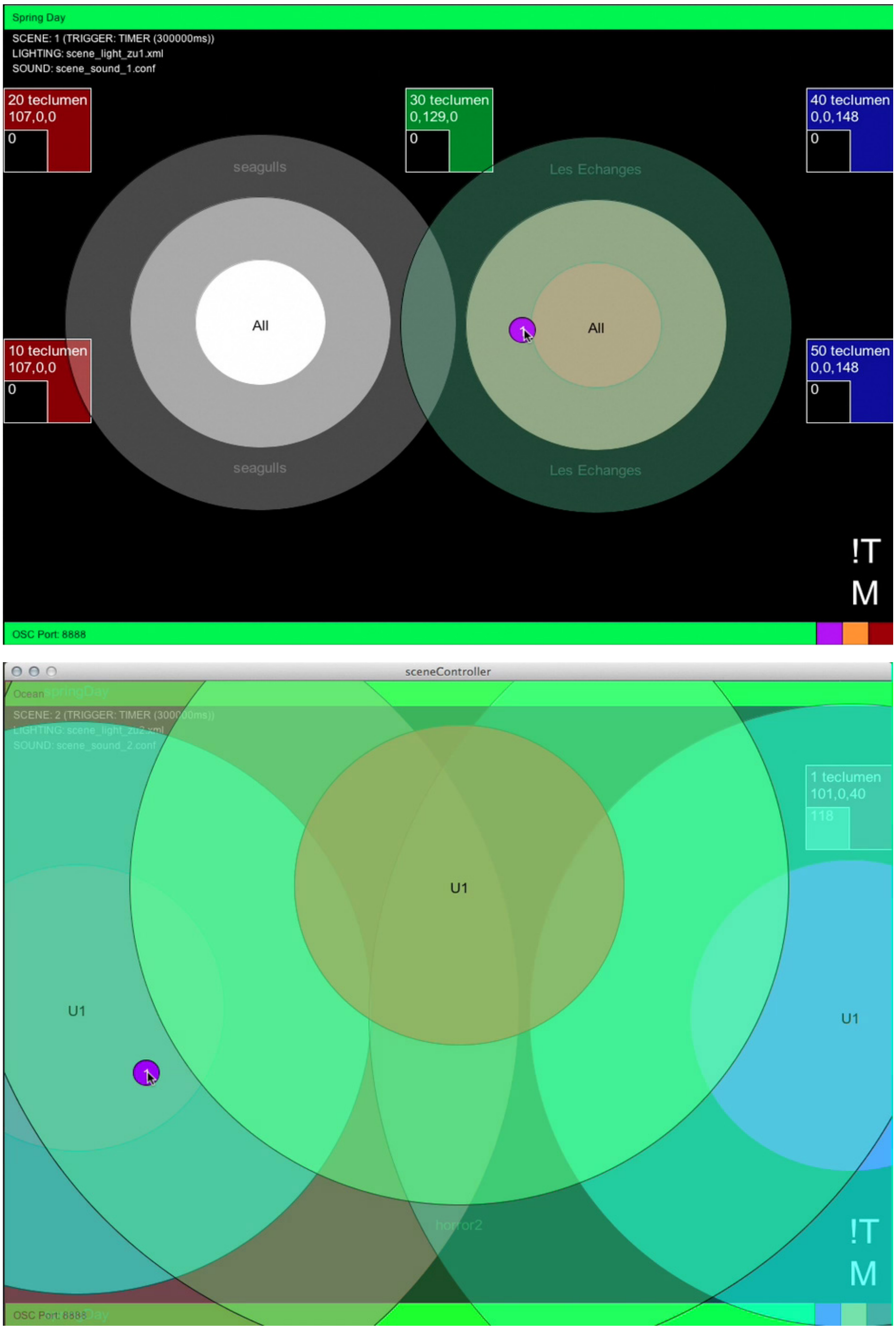
Organised by

Zürcher Hochschule der Künste
Institute for the Performing Arts and Film

Partners ZHdK
Bühne A Technics Team / colourlight-center
Master of Arts in Theatre (Stage Design)
Bachelor of Arts in Theatre (Scenography)

In cooperation with

Flyer for Stage Digital I where Sonus and the Light Box were shown.



Spring Day

SCENE: 1 (TRIGGER: TIMER (300000ms))
LIGHTING: scene_light_zu1.xml
SOUND: scene_sound_1.conf

OSC Port: 8888

sceneController

Ocean springDay

SCENE: 2 (TRIGGER: TIMER (300000ms))
LIGHTING: scene_light_zu2.xml
SOUND: scene_sound_2.conf

OSC Port: 8888

20 teclumen
107,0,0
0
30 teclumen
0,129,0
0
40 teclumen
0,0,148
0
10 teclumen
107,0,0
0
50 teclumen
0,0,148
0
seagulls
All
seagulls
Les Echanges
All
Les Echanges
1
!T
M
1 teclumen
101,0,40
118
U1
U1
U1
horror2
1
!T
M

Screenshots showing two of the four Sonus configurations for Stage Digital I.These compositions consisted of hotspots configured large enough to cover most of the stage. The result was more sound field than composition. Hotspots may also be configured to respond to different individuals on stage. The three spots on the bottom are configured to respond only to user 1 (U1), ignoring the presence of subsequent people who enter the stage. The upper soundscape is configured to respond to whoever crosses the stage (ALL).

PERFORMANCE/SPACE - JUNE 2012

Following development work on Inter-Actor it became obvious that the area a single depth camera was capable of covering was far too small to support real performance. Performance/Space was initially developed as a tool for stitching distributed pointcloud data together. The software is both client and server and is meant to attach to a single depth camera and then broadcast that data over the network.

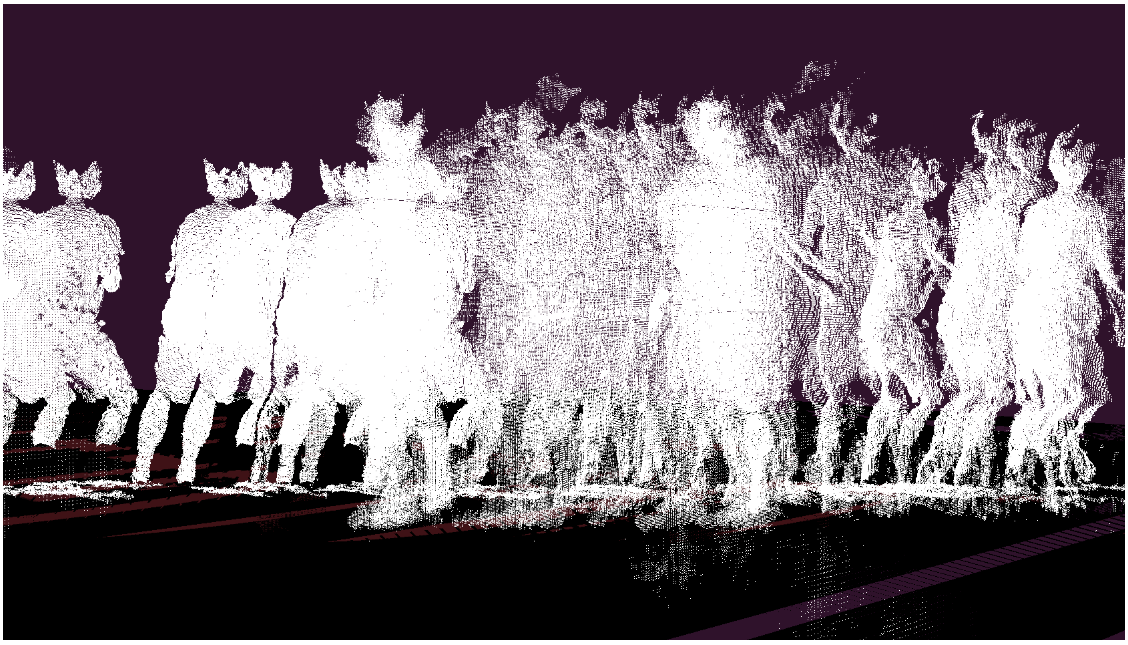
As a client the software can pull together any number of streams and represent them coherently in a single 3D render. LZ4 compression was been implemented on the data packets to improve transfer speed but there is a practical limit of 4 simultaneous pointcloud inputs based on the size of the data itself.

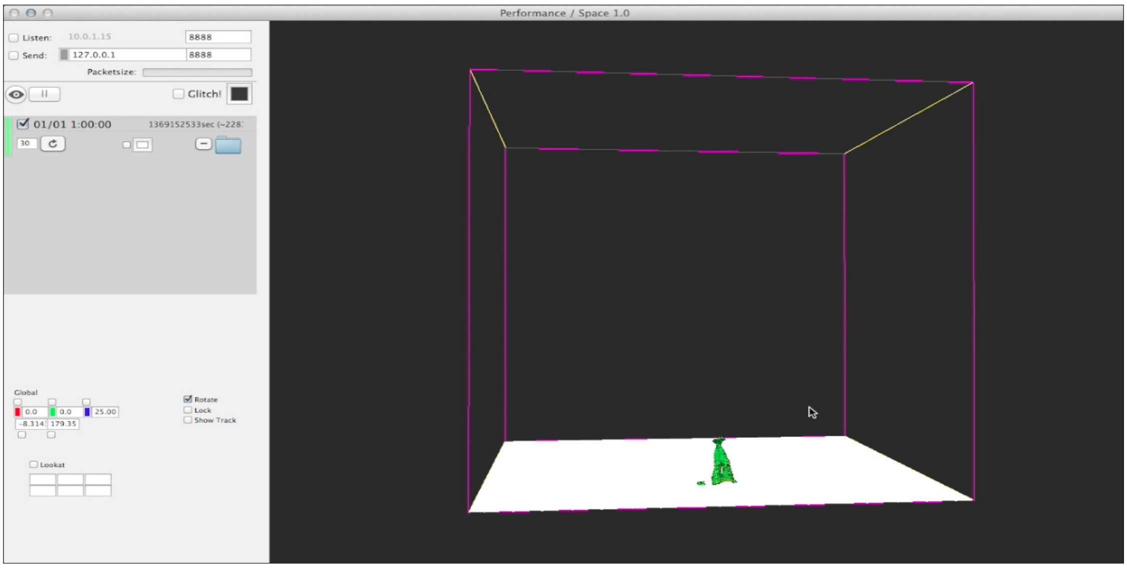
In addition to stitching live data this system supports recording and playback of both local and remote streams via the PCL library.

The original intent of this setup was to use a 3D environment to allow an operator to configure streams for cameras situated around the stage. The intent was then to “rotate” the 3D data in order to perform overhead scene analysis on the pointcloud data via OpenCV blob detection. The result (combined with height data from the pointclouds) would provide three dimensional bounding boxes for each individual on stage.While this implementation did in fact function as intended, it was not the most efficient use of the technology. Ultimately I would replace this setup with a distributed depth camera solution (see: Merge).

Development of the tool coincided with the production of CYBORG[AME] and the tool was reconfigured primarily as a way of producing visuals for stage scenography. Consequently it became important to expand the abilities of the 3D render to include basic 3D shapes such as a “room cube” as well as to strengthen the record and playback functionality. I also added Syphon support and support for live-adjustment of the color of visual elements.

HARDWARE INTERFACE

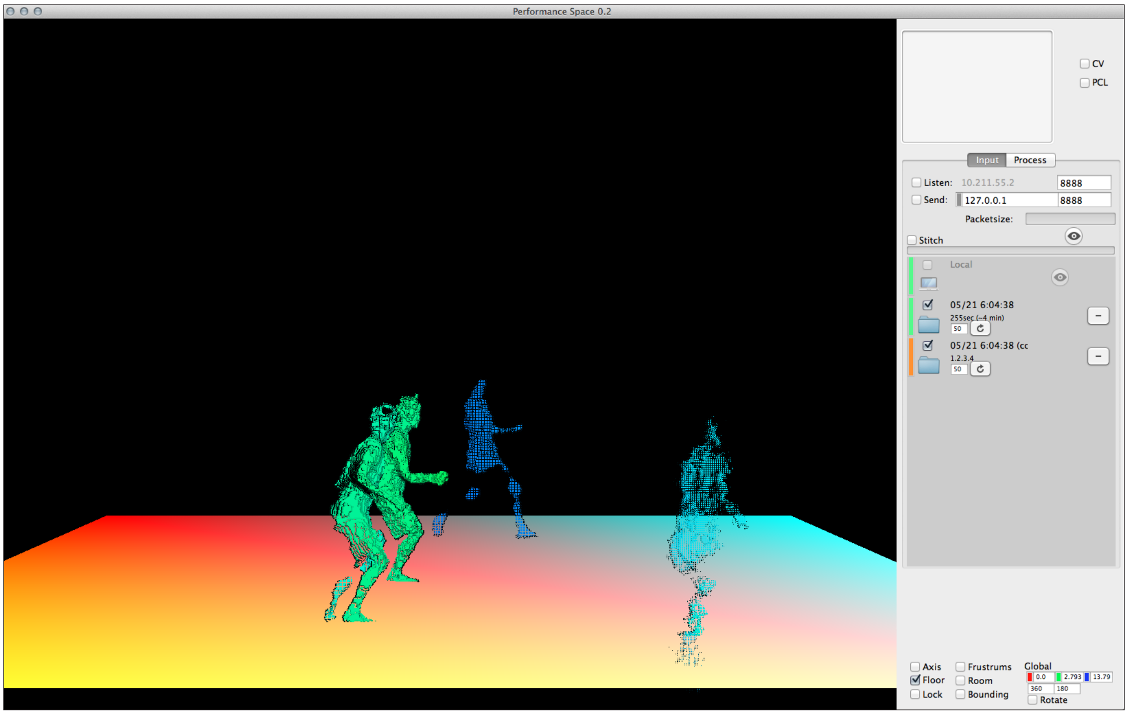




Performance / Space 1.0

☐ Listen: 10.0.1.15 8888
☐ Send: 127.0.0.1 8888
Packetsize:
☐ Glitch!
☑ 01/01 1:00:00 1369152533sec (~228
30

Global
0.0 0.0 25.00
-8.314 179.35
☑ Rotate
☐ Lock
☐ Show Track
☐ Lookat

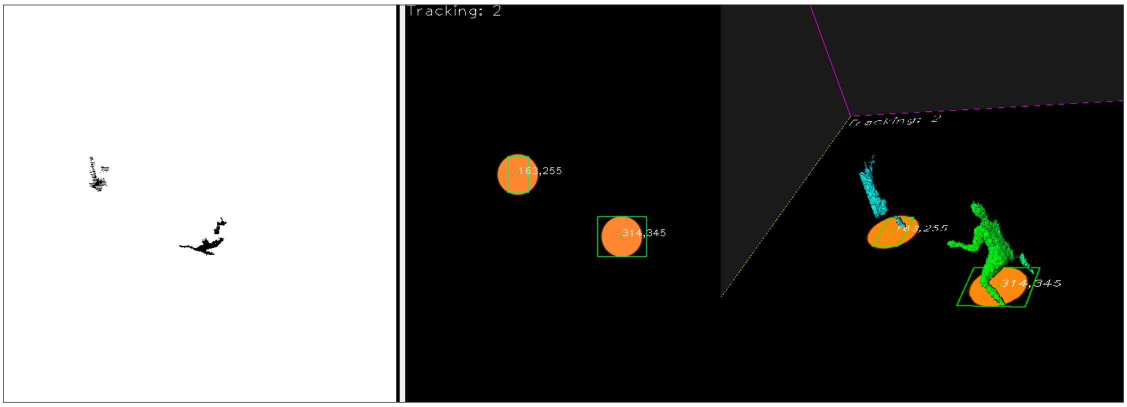


Performance Space 0.2

☐ CV
☐ PCL

☐ Listen: 10.211.55.2 8888
☐ Send: 127.0.0.1 8888
Packetsize:
☐ Stitch
☐ Local
☑ 05/21 6:04:38
255sec (~4 min)
50
☑ 05/21 6:04:38 (cc
1.2.3.4
50

☐ Axis
☑ Floor
☐ Lock
☐ Frustrums
☐ Room
☐ Bounding
Global
0.0 2.793 13.79
360 180
☐ Rotate


Tracking: 2
163,255
314,345
Tracking: 2
163,255
314,345

The three stages of "overhead" tracking using the point clouds. The far left shows the overhead view of the point cloud, adjusted to be high contrast. Running blob tracking on this results in the image in the middle, showing a centroid and bounding box. This can then be projected back onto the pointcloud data (third image).

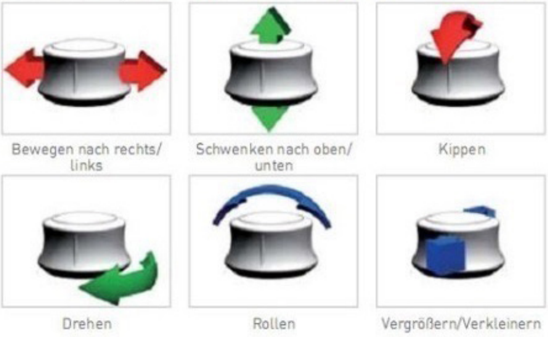
Performance/Space also supports the 6 axis SpaceNavigator mouse and NanoKontrol MIDI Mixer and pad as well as Syphon for visual input and output. These additions were crucial for adapting the tool for performance purposes.

Traditional user interface hardware like the mouse are designed for two dimensional navigation. In 3D space our physical bodies and brains must adapt our motions, and in particular in the case of on-screen controls this is significantly slower than locating a physically discrete control. The difficulty can be felt most acutely during a live performance where many elements need to be synchronized at once.

In order to make the task of operating the software possible during CYBORG[AME], I integrated three pieces of specialized hardware. The first of these, a six-axis mouse called a SpaceNavigator, allowed for smooth "flycam" actions inside of Performance/Space. This was particularly important for simulating cinematic effects such as a dolly or crane shot, and was used extensively during the production

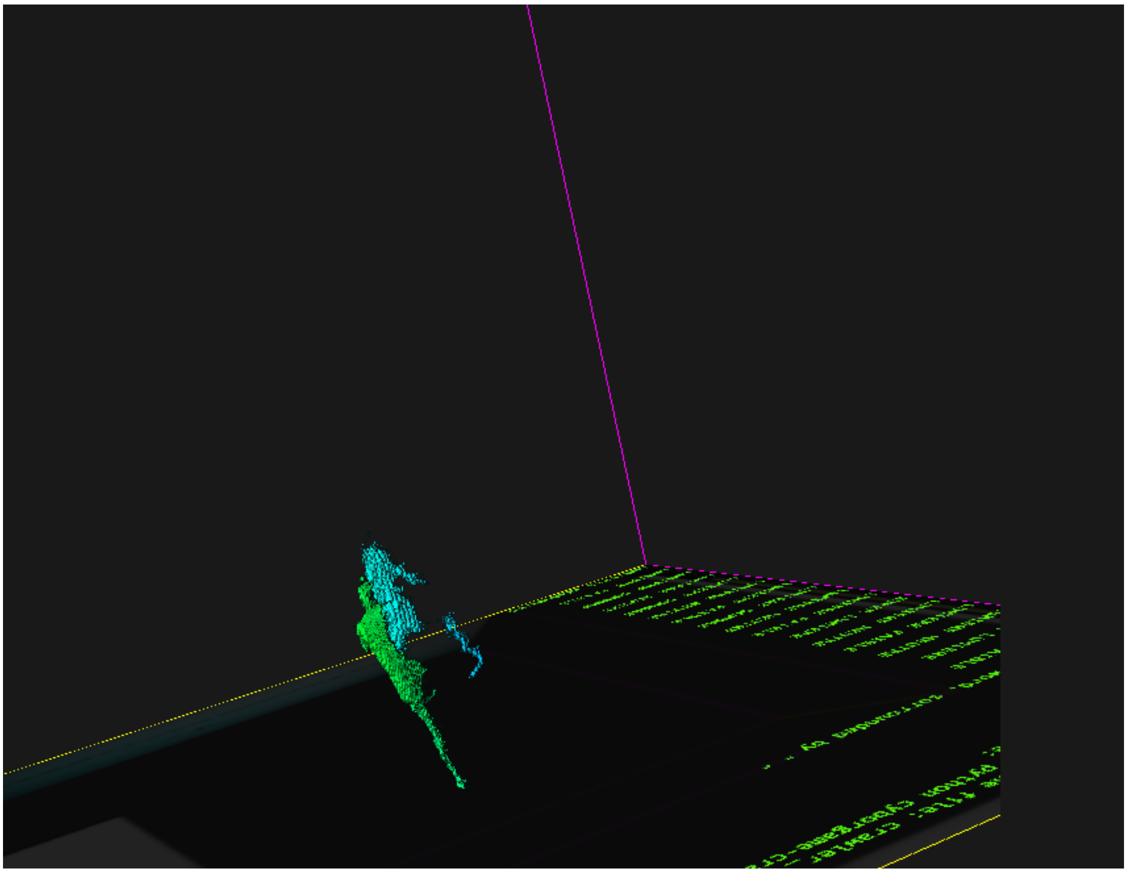
MIDI controllers made it far easier to mix video and provided large easy to hit buttons for intermittent

3Dconnexion


Bewegen nach rechts/links
Schwenken nach oben/unten
Kippen
Drehen
Rollen
Vergrößern/Verkleinern

special effects such as screen-strobe and glitch mode. Finally, as the MIDI controller were configured to work globally, these interfaces could be operated no matter which software was foregrounded at the time. This was extremely useful during the performance itself during which I was frequently switching focus between Performance/Space, Textify! And SyMix.

KORG
nanoPAD2
KORG
nanoKONTROL2
KORG
nanoKEY2



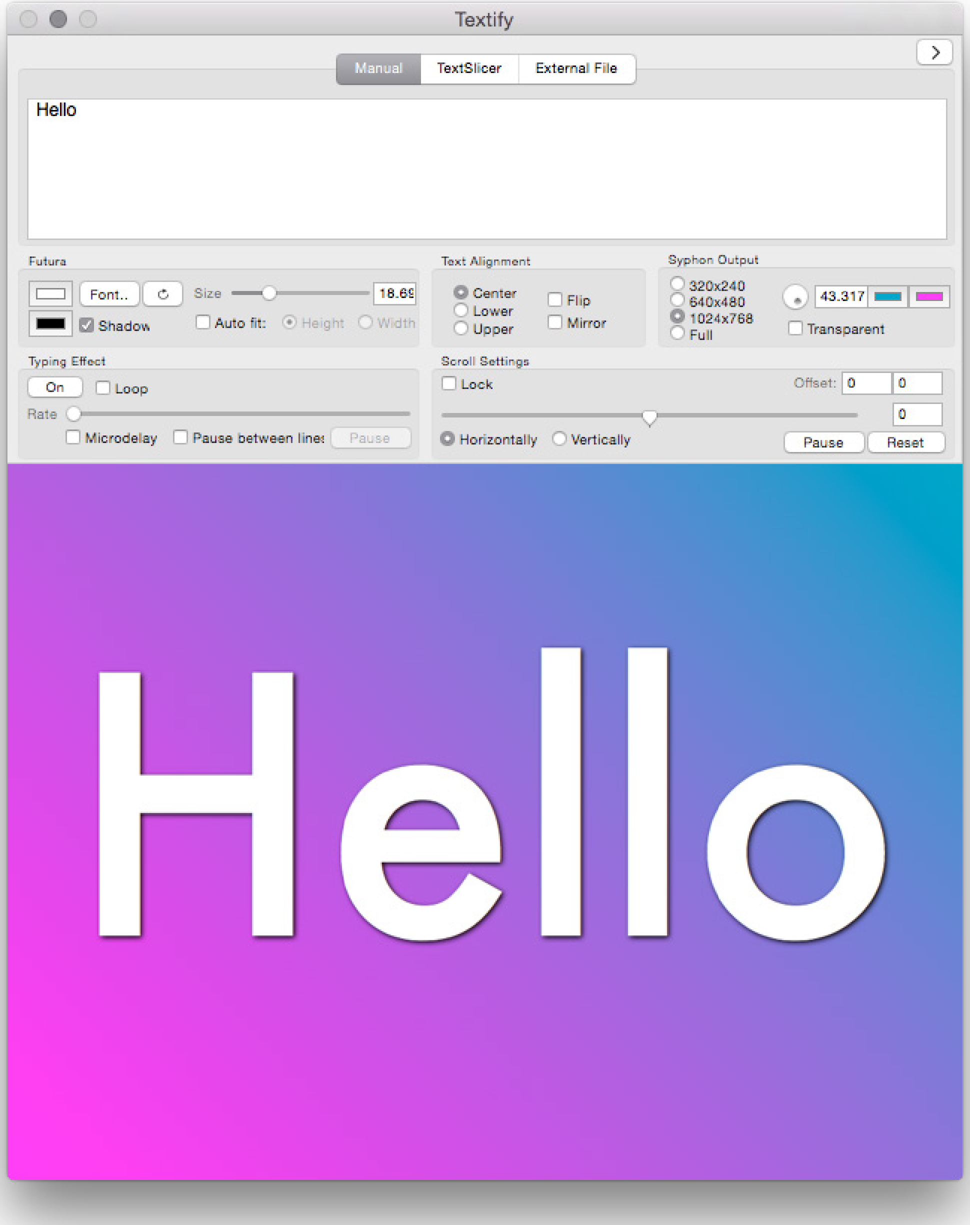
TEXTIFY - JUNE 2012

Textify! is a full featured text string manipulation and scrolling tool originally developed for creating live on-stage titles and text based effects for CYBORG[AME]. The software outputs the result via Syphon.

This software formats and outputs text including support for shadows, background gradients and transparency, color, typeface, size, alignment and screen fit. Scrolling animation can be applied and controlled in both horizontal and vertical direction. The tool also supports an animated typing effect with an option to include periodic micro-pauses which make the effect appear more realistic.

Text may be input in one of three ways: manually in a textbox, via a “watch” which can be placed on an external text file (allowing, for example, an external application or script to update the text on display without interacting directly with Textify!), or via a “text slicer” option which allows random access of a large quantity of text split by linebreaks.

All configuration options may be exported as a settings file, and then loaded or added to a built-in pallet of effects, making it easy to switch between styles and animations during a performance.


Textify
Manual
TextSlicer
External File
Font..
Pause
Pause
Reset

Hello

Futura

Size 18.6

☑ Shadow

☐ Auto fit: ● Height ○ Width

Text Alignment

● Center
○ Lower
○ Upper

☐ Flip
☐ Mirror

Syphon Output

○ 320x240
○ 640x480
● 1024x768
○ Full

43.317

☐ Transparent

Typing Effect

On ☐ Loop

Rate

☐ Microdelay ☐ Pause between lines

Scroll Settings

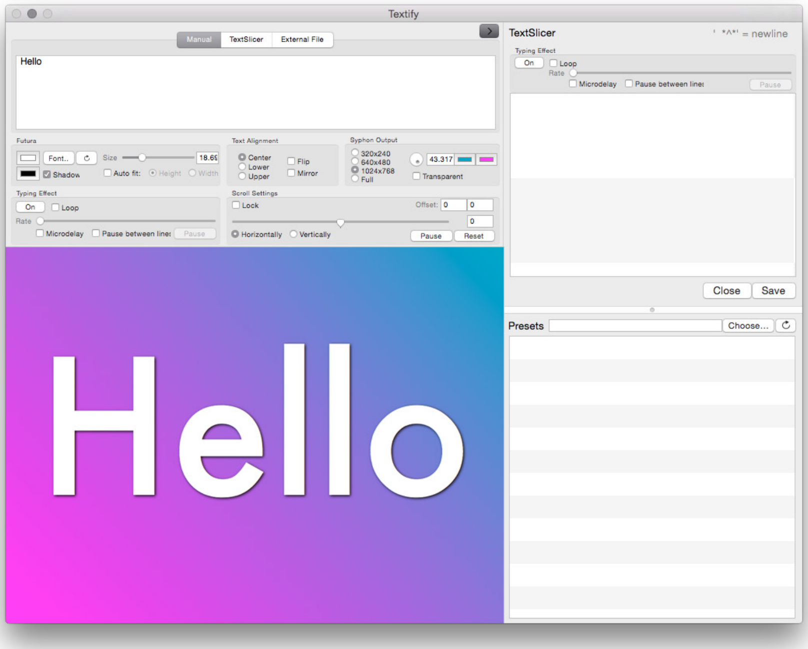
☐ Lock

Offset: 0 0

0

● Horizontally ○ Vertically

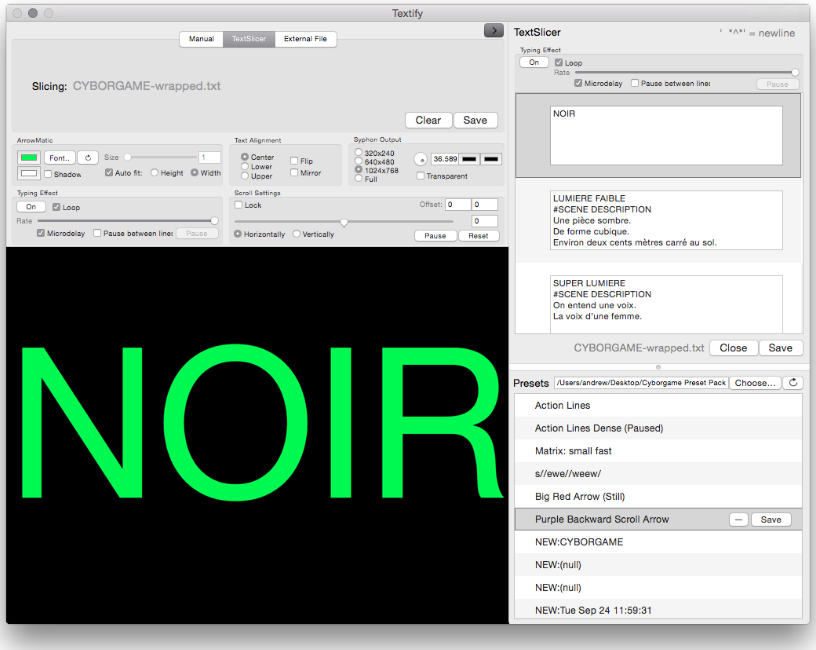
Basic Textify! interface showing manual entry and adjustment of the text.


Textify
Manual
TextSlicer
External File
Futura
Font..
Size
18.65
Shadow
Auto fit:
Height
Width
Text Alignment
Center
Lower
Upper
Flip
Mirror
Syphon Output
320x240
640x480
1024x768
Full
43.317
Transparent
Typing Effect
On
Loop
Rate
Microdelay
Pause between lines
Pause
Scroll Settings
Lock
Offset:
Horizontally
Vertically
Reset
TextSlicer
^ = newline
Close
Save
Presets
Choose…

Hello

Hello

Sidebar expanded to show the TextSlicer and Preset palettes.


Textify
Manual
TextSlicer
External File
Clear
Save
ArrowMatic
Font..
Size
Shadow
Auto fit:
Height
Width
Text Alignment
Center
Lower
Upper
Flip
Mirror
Syphon Output
320x240
640x480
1024x768
Full
36.589
Transparent
Typing Effect
On
Loop
Rate
Microdelay
Pause between lines
Pause
Scroll Settings
Lock
Offset:
Horizontally
Vertically
Reset
TextSlicer
^ = newline
Close
Save
Presets
Choose…

Slicing: CYBORGAME-wrapped.txt

NOIR

LUMIERE FAIBLE
#SCENE DESCRIPTION
Une pièce sombre.
De forme cubique.
Environ deux cents mètres carré au sol.

SUPER LUMIERE
#SCENE DESCRIPTION
On entend une voix.
La voix d'une femme.

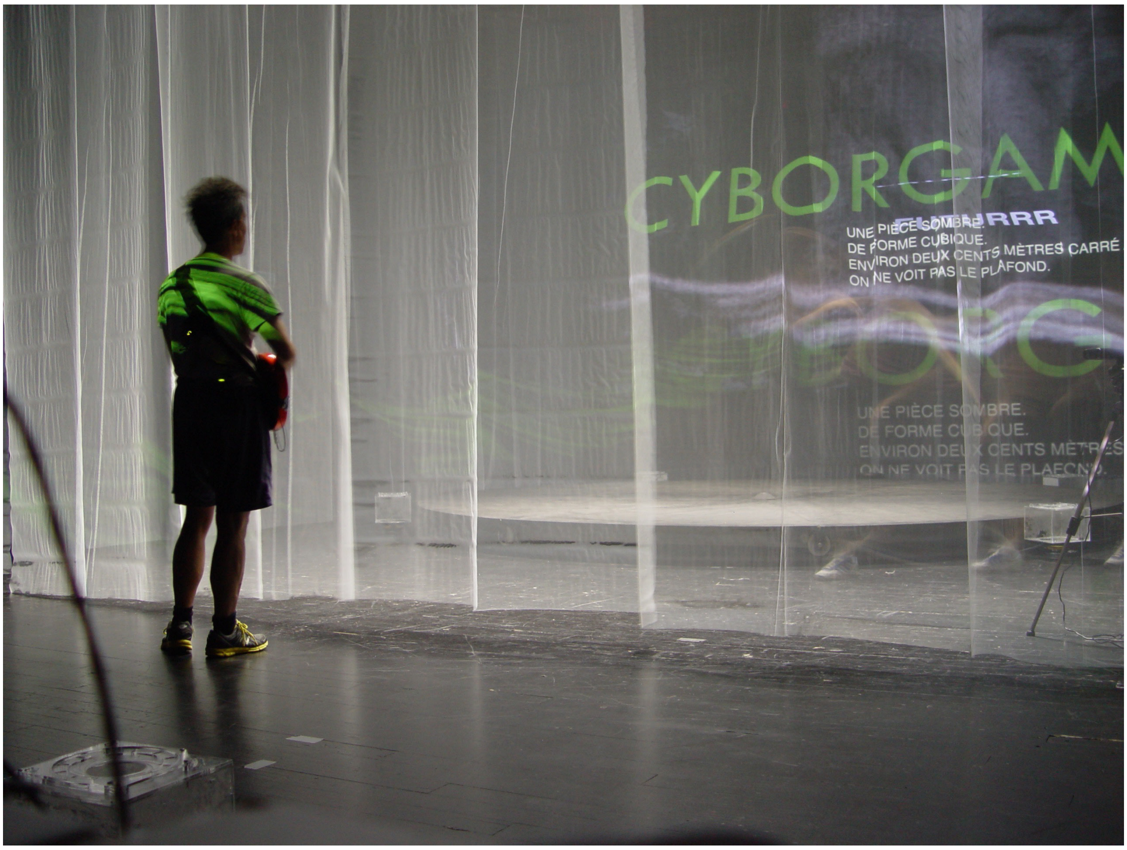
CYBORGAME-wrapped.txt

Presets /Users/andrew/Desktop/Cyborgame Preset Pack

- Action Lines
- Action Lines Dense (Paused)
- Matrix: small fast
- s//ewe//weew/
- Big Red Arrow (Still)
- Purple Backward Scroll Arrow
- NEW:CYBORGAME
- NEW:(null)
- NEW:(null)
- NEW:Tue Sep 24 11:59:31

NOIR

In TextSlicer mode, the software accepts and slices a text file which is displayed at the right for random access of lines. In this screenshot you can also see a number of text settings which have been loaded into the palette in the lower right. Double clicking on these applies the settings to the text.


CYBORGAM
FUTURRR
UNE PIÈCE SOMBRE.
DE FORME CUBIQUE.
ENVIRON DEUX CENTS MÈTRES CARRÉ
ON NE VOIT PAS LE PLAFOND.

Output of the Textify! application projected (via SyMix) onto the CYBORG[AME] stage and mixed with the output of Performance/Space to create the play's scenography.

RGAME
ON NE VOIT PAS LE PLAFOND.
PAS D'ENTRÉE APPARENTE.
P
CHOC
CHOC

CHO
YBOCYBORGAME
PAS DE FENÊTRES.
DÉCOUPÉE DANS UNE FAIBLE LUMIÈRE,
ON DISTINGUE LA SILHOUETTE DU
PERSONNAGE DE ROMAN.
PAS DE FENÊTRES.
DÉCOUPÉE DANS UNE FAIBLE LUMIÈRE,
ON DISTINGUE LA SILHOUETTE DU
PERSONNAGE DE ROMAN.

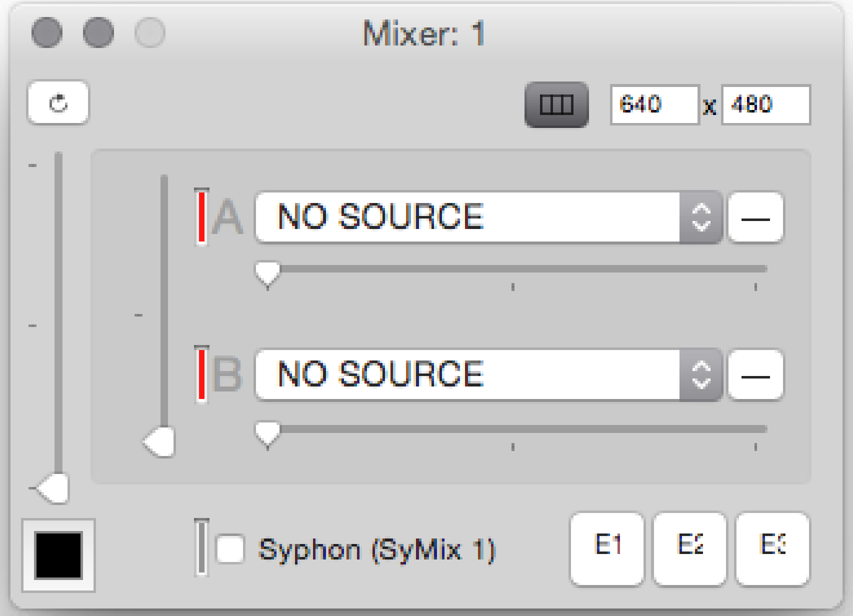
LE COLONEL SE TIENT DANS UNE OMBRE
PROFONDE, RÉFLÉCHISSANT.

SYMIX BETA - JUNE 2012

Syphon is an open source Mac OS technology that allows local applications to share video frames efficiently (http://syphon.v002.info/). SyMix Beta is a straightforward mixing tool which allows for crossfading of two or more Syphon video feeds. The resut is itself output via Syphon, allowing the tool to use it’s own output as input for special effects.

Symix also supports MIDI mixing boards, allowing for hardware mixing of video fees.

Initially developed to mix the output of Performance/Space and Textify! for the CYBORG[AME] performance, this tool would eventually evolve into SyMix, a multi-purpose video mixing tool with streaming support used for the MOTUS production of LIWYĀTĀN/LEVIATHAN.



Mixer: 1

640 x 480

A NO SOURCE

B NO SOURCE

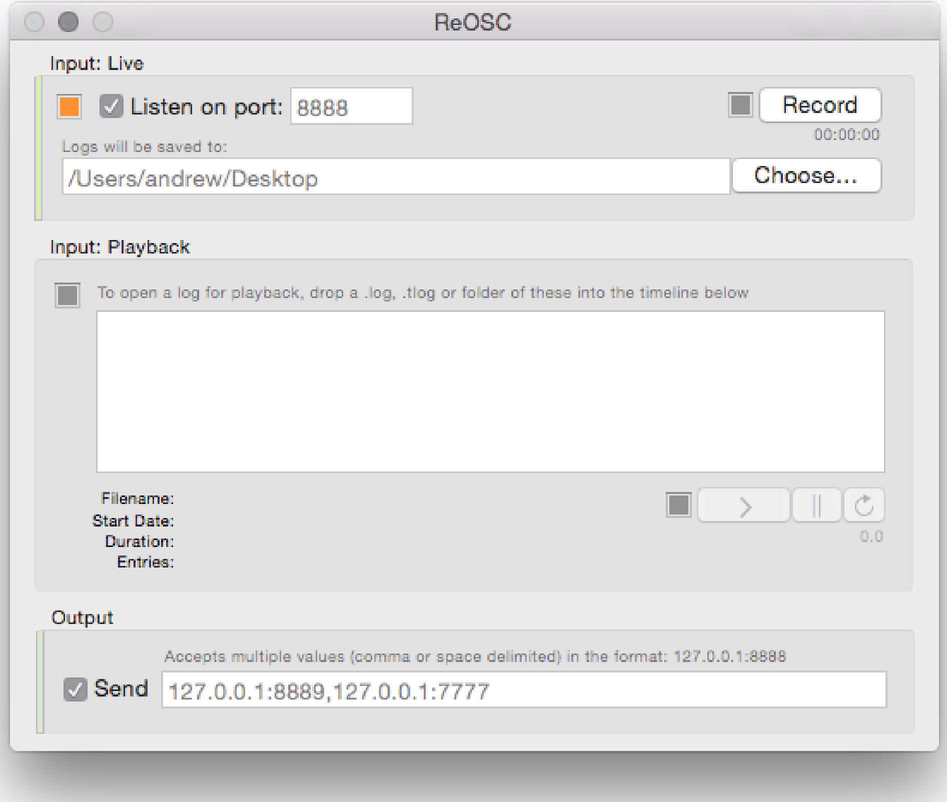
☐ Syphon (SyMix 1)

REOSC - AUGUST 2012

ReOSC can record, playback and re-distribute OSC data live over multiple ports and IP addresses. Recordings can be of indefinate length, allowing for long-term collection of data.

The ability to easily re-broadcast live and pre-recorded data to multiple ports allows a great deal of flexibility for both data storage and playback and testing purposes.

This tool was created during the ENSAL residency for the purpose of recording movement through the space over time. It proved useful in many other cases for testing virtually any OSC based system.



ReOSC

Input: Live

☑ Listen on port: 8888

Logs will be saved to:

/Users/andrew/Desktop

Input: Playback

To open a log for playback, drop a .log, .tlog or folder of these into the timeline below

Filename:
Start Date:
Duration:
Entries:

Output

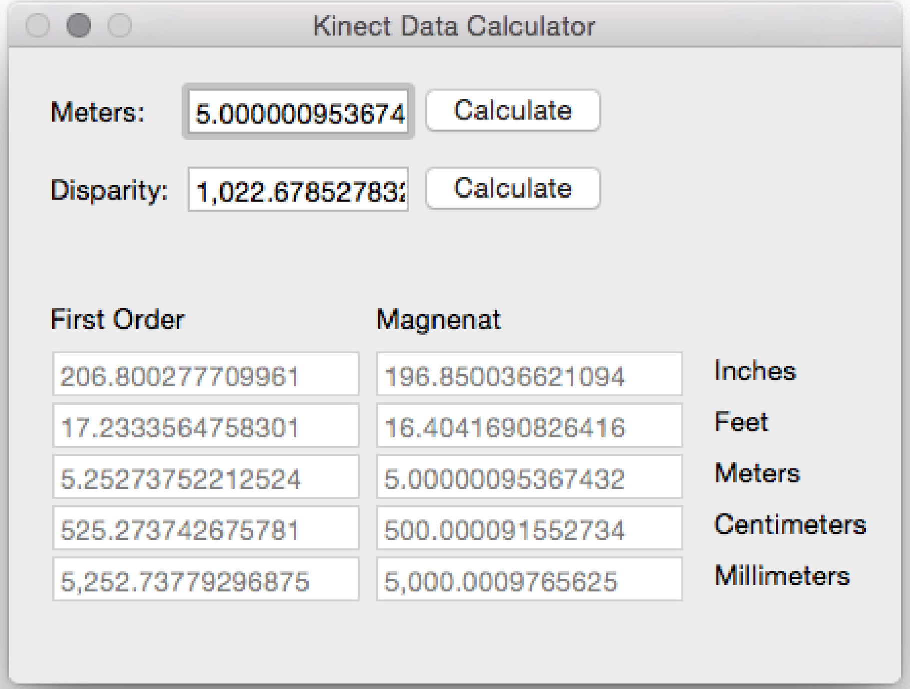
Accepts multiple values (comma or space delimited) in the format: 127.0.0.1:8888

☑ Send 127.0.0.1:8889,127.0.0.1:7777

KINECT DATA CALCULATOR - JUNE 2013

Primesense hardware returns a measurement known as disparity, which is inversely proportionate to depth. Early version of libfreenect returned this value instead of the more useful millimeters. The exact equation for conversion has never been published by Primesense or Microsoft but conjecture and trial and error has given us two equations for conversion. The “first order” refers to this well known equation and “Magnenat” refers to a more accurate equation derived by researcher Stéphane Magnenat

Rarely is real-world accuracy necessary when working with these cameras, however it is occasionally useful for calibration and the calculations are tedious. The Kinect Data Calculator provides an easy realtime conversion between a number of different units including disparity.



Meters: 5.000000953674

Disparity: 1,022.67852783

First Order	Magnenat	
206.800277709961	196.850036621094	Inches
17.2333564758301	16.4041690826416	Feet
5.25273752212524	5.00000095367432	Meters
525.273742675781	500.000091552734	Centimeters
5,252.73779296875	5,000.0009765625	Millimeters

From the OpenKinect Wiki (http://openkinect.org/wiki/Imaging_Information):

Lots of information on calibrating the depth camera is available on the ROS kinect_node page. From their data, a basic first order approximation for converting the raw 11-bit disparity value to a depth value in centimeters is: 100/(-0.00307 * rawDisparity + 3.33). This approximation is approximately 10 cm off at 4 m away, and less than 2 cm off within 2.5 m.

A better approximation is given by Stéphane Magnenat in this post: distance = 0.1236 * tan(rawDisparity / 2842.5 + 1.1863) in meters. Adding a final offset term of -0.037 centers the original ROS data. The tan approximation has a sum squared difference of .33 cm while the 1/x approximation is about 1.7 cm.

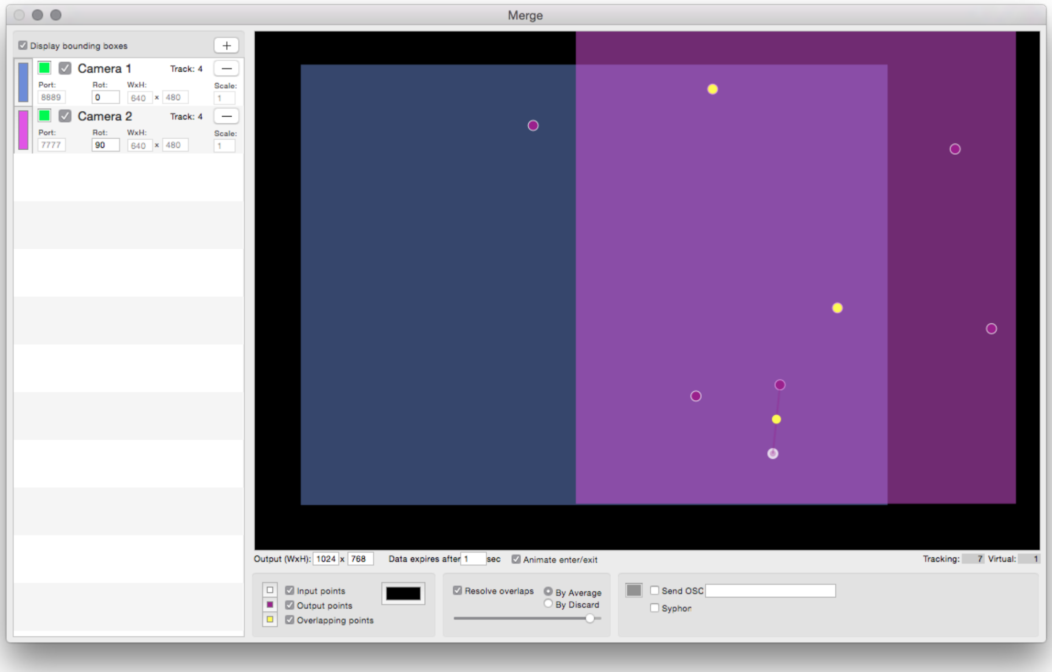
Once you have the distance using the measurement above, a good approximation for converting (i, j, z) to (x,y,z) is:
x = (i - w / 2) * (z + minDistance) * scaleFactor
y = (j - h / 2) * (z + minDistance) * scaleFactor
z = z
Where minDistance = -10
scaleFactor = .0021.

These values were found by hand.

MERGE - SEPTEMBER 2013

Following the development of Performance/Space, I chose to take a different approach to stitching the tracking data from multiple cameras together. Rather than collate point-cloud data from multiple cameras, a number of distributed computers are used. Each computer collects the depth image from one single camera, runs its own analysis and reports the data to a single server. This method reduces the network overhead significantly and allows the analysis to be adjusted to the physical area each camera is covering.

Distributed analysis of each camera was handled by a slightly modified version of TSPS (more information on this below) running on a Mac Mini. Merge was developed to stitch the data provided by multiple networked instances of TSPS into a single coherent coordinate system. The result is then output as OSC using the same TSPS protocol. Clients may treat the output of Merge as they would TSPS itself, allowing for a drop-in replacement that supports multiple cameras easily.



☑ Display bounding boxes

☑ Camera 1 Track: 4
Port: 8889 Rot: 0 WxH: 640 × 480 Scale: 1

☑ Camera 2 Track: 4
Port: 7777 Rot: 90 WxH: 640 × 480 Scale: 1

Output (WxH): 1024 x 768 Data expires after 1 sec ☑ Animate enter/exit Tracking: 7 Virtual: 1

☑ Input points
☑ Output points
☑ Overlapping points

☑ Resolve overlaps ● By Average ○ By Discard

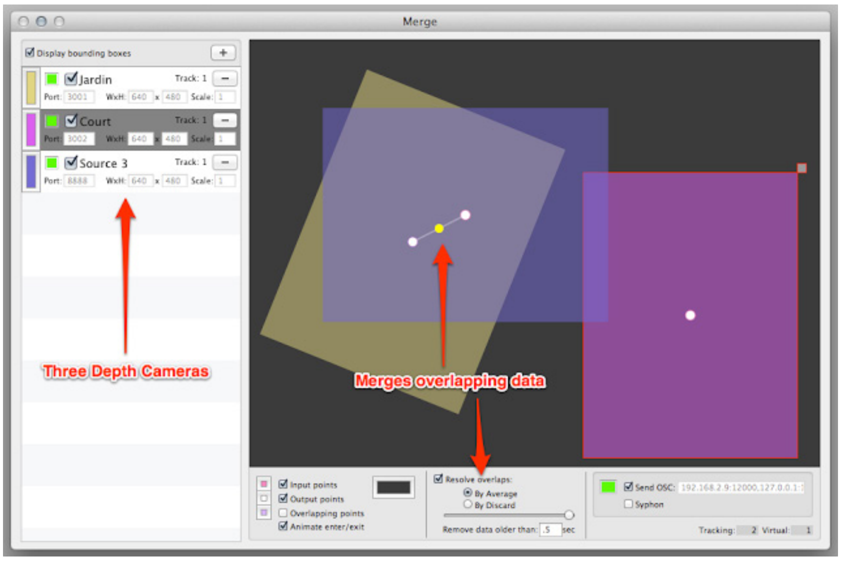
☐ Send OSC
☐ Syphon

Screenshot of Merge showing the input from two cameras (left). Each set of pre-processed camera data arrives as a set of coordinates indicating moving objects in a scene, projected into a 640x480 frame as if the camera was located overhead. Merge can be used to position these "overhead" frames relative to each other, as well as rotate and scale them as needed. Purple dots indicate tracked objects. In this screenshot, yellow dots indicate tracked objects in "overlap zones" which mean that the object may appear on moore than one camera at once. Overlaps are handled by proximity - if two cameras track an object in close proximity simultaneously, that object is considered to be the same. This can be seen at the bottom of the black area of the screen - the yellow dot in the middle is the "virtual point" which is reported as an average between the two points above and below it (connected by a line). This resolution is adjustable by the UI on the bottom, which allows you to specify distance and rejection method (reject one or average).

The TSPS protocol
http://www.tsps.cc/docs/tsps-osc-protocol/

```
TSPS sends messages each time an Event occursaddress: /
TSPS/personEntered  OR /TSPS/personUpdated OR /TSPS/person-
WillLeave

0: pid;
1: oid;
2: age;
3: centroid.x;
4: centroid.y;
5: velocity.x;
6: velocity.y;
7: depth;
8: boundingRect.x;
9: boundingRect.y;
10: boundingRect.width;
11: boundingRect.height;
12: highest.x
13: highest.y
14: haarRect.x;           - will be 0 if hasHaar == false
15: haarRect.y;           - will be 0 if hasHaar == false
16: haarRect.width;       - will be 0 if hasHaar == false
17: haarRect.height;      - will be 0 if hasHaar == false
18: opticalFlowVectorAccumulation.x;
19: opticalFlowVectorAccumulation.y;
20+ : contours (if enabled)
```



Merge

☑ Display bounding boxes

☑ Jardin — Track: 1 — Port: 3001 — WxH: 640 x 480 — Scale: 1
☑ Court — Track: 1 — Port: 3002 — WxH: 640 x 480 — Scale: 1
☑ Source 3 — Track: 1 — Port: 8888 — WxH: 640 x 480 — Scale: 1

☑ Input points
☑ Output points
☐ Overlapping points
☑ Animate enter/exit

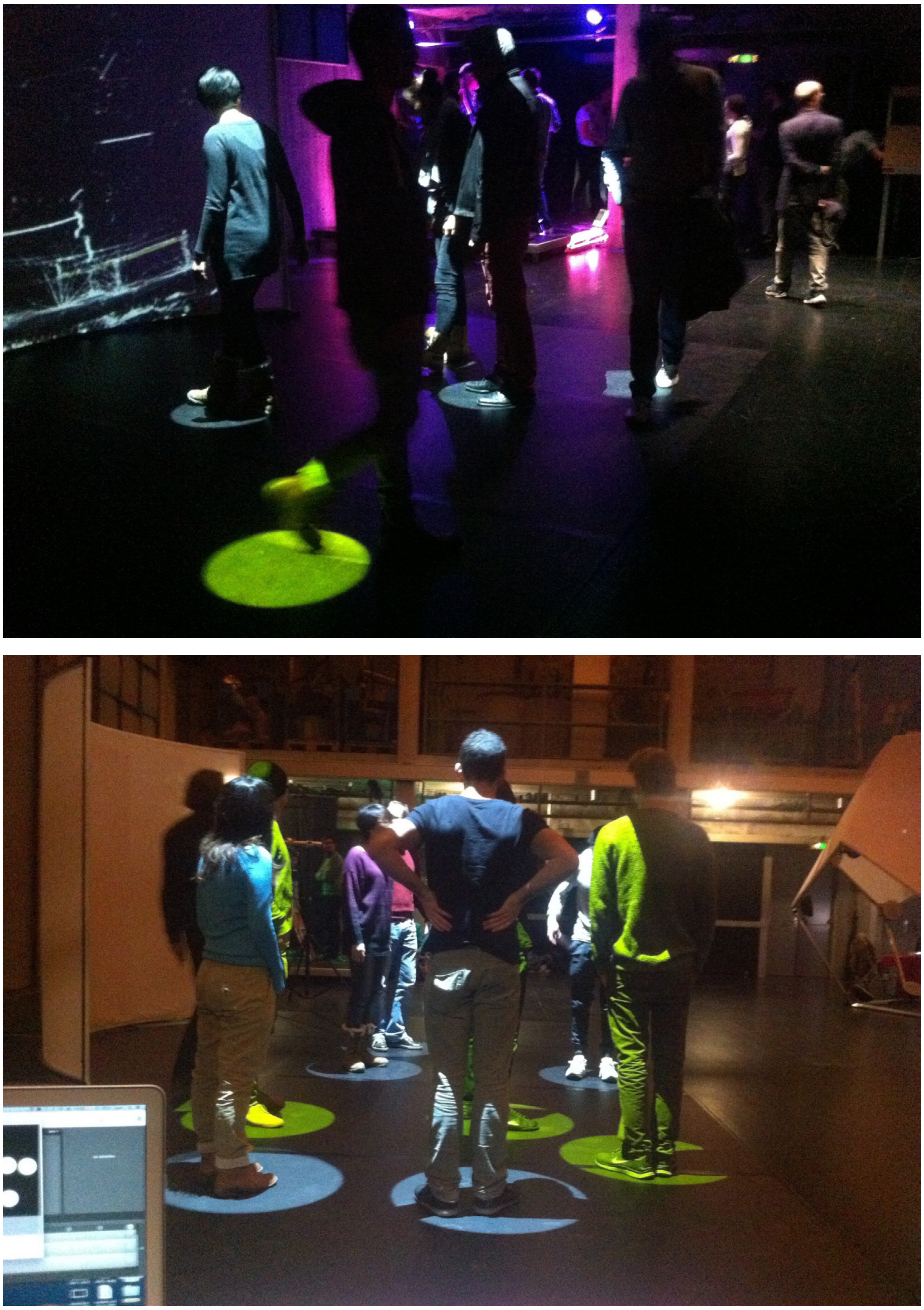
☑ Resolve overlaps:
● By Average
○ By Discard
Remove data older than: .5 sec

☑ Send OSC: 192.168.2.9:12000,127.0.0.1:
☐ Syphon

Tracking: 2 Virtual: 1

Three Depth Cameras

Merges overlapping data

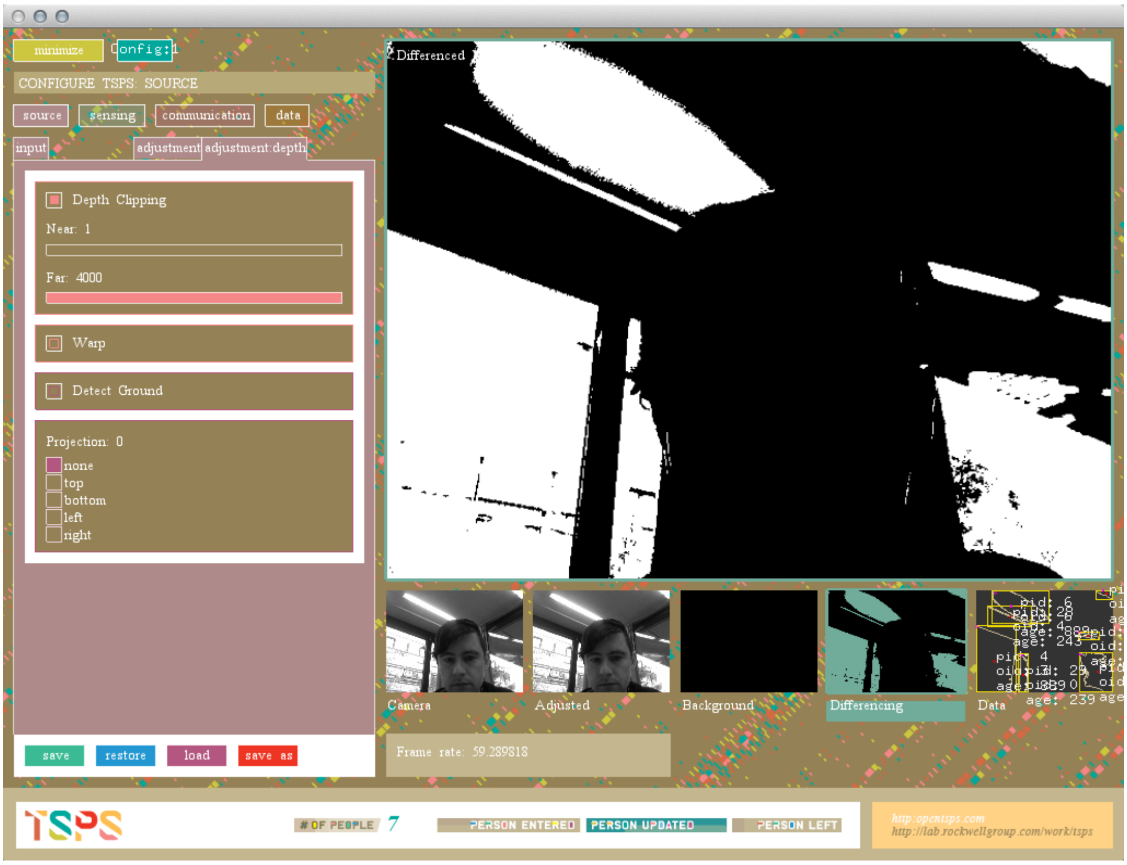


Merge running at Stage Digital I with the output superimposed onto the floor via projection.

TSPS

TSPS (Toolkit for Sensing People in Spaces -http://www.tsps.cc/) is an open source tool developed by the LAB at Rockwell Group and IDEO, built on top of openFrameworks. The tool was initially developed for doing fast computer vision scene analysis for visible light cameras. With some adjustments, it can be used on the depthmap image provided by Pimesense depth cameras.

TSPS provided the scene analysis for the distributed depth camera used in several of the projects described in this dissertation. TSPS itself is a useful prototyping tool and was also used in a production environment (the AToU Company production of SHiNMu), however the cost of pairing a full computer with each camera is prohibitively expensive beyond a few cameras. With additional work the functionality offered by TSPS could be replaced by more robust and less expensive software running on embedded Linux, for example. This is the subject of ongoing and future work.



CONFIGURE TSPS: SOURCE

☑ Depth Clipping

Near: 1

Far: 4000

☐ Warp

☐ Detect Ground

Projection: 0

☑ none
☐ top
☐ bottom
☐ left
☐ right

Frame rate: 59.289818

minimize
Config:1
source
sensing
communication
data
input
adjustment
adjustment:depth
save
restore
load
save as
Differenced
Camera
Adjusted
Background
Differencing
Data
TSPS
# OF PEOPLE 7
PERSON ENTERED
PERSON UPDATED
PERSON LEFT
http://opentsps.com
http://lab.rockwellgroup.com/work/tsps

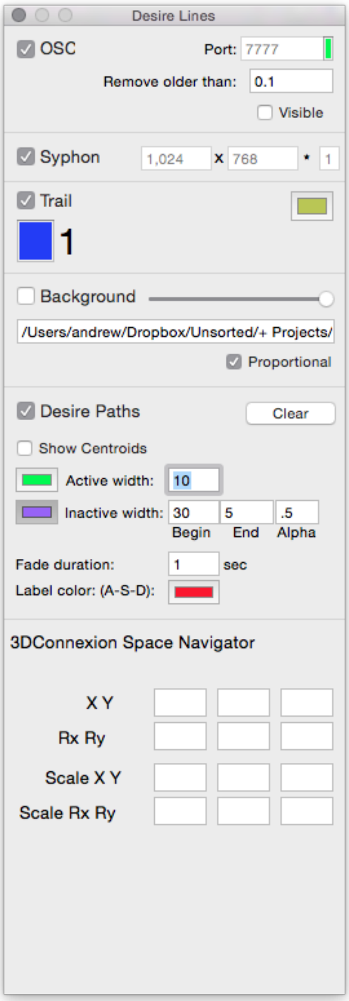
TSPS showing modifications done by myself and David Chanel - The addition of depth camera support, clipping and projection. Note the scene analysis across the bottom of the UI which results in the detection of objects (far right). This is the information which is transmitted to Merge.

DESIRE LINES - NOVEMBER 2013

Desire Lines was created during the November ZhDK residency in order to demonstrate the desire path concept during Stage Digital II. This software creates a live visualization of visitor movement in space by tracing the direction and speed of their travel with a projected line which follows them.

After a visitor leaves the tracking area, the line fades over time, but can be configured to remain visible. Over time, repeated movemtn in the same area builds up a “layer” of lines, creating a visible but virtual “desire line.” In addition the software provides a mechanism to browse the timestamped history of movement in the space.

Deisre Lines is meant as a client of Merge, although it could also be used directly with TSPS or other scene analysis software which sends data via OSC.



Desire Lines

☑ OSC Port: 7777

Remove older than: 0.1

☐ Visible

☑ Syphon 1,024 x 768 • 1

☑ Trail

1

☐ Background

/Users/andrew/Dropbox/Unsorted/+ Projects/

☑ Proportional

☑ Desire Paths

☐ Show Centroids

🟩 Active width: 10

🟪 Inactive width: 30 5 .5

Begin End Alpha

Fade duration: 1 sec

Label color: (A-S-D): 🟥

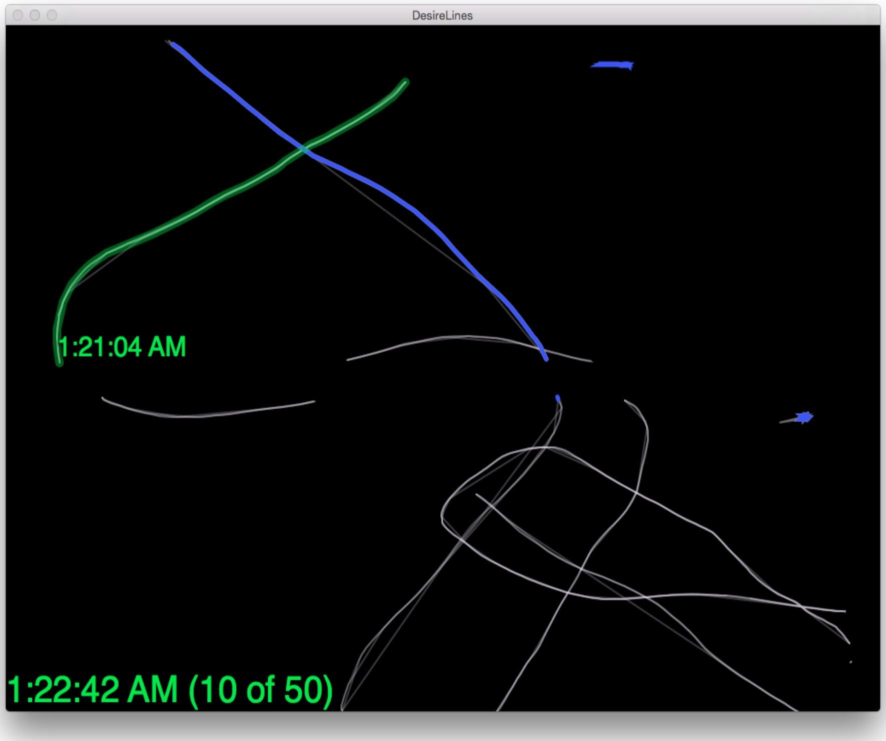
3DConnexion Space Navigator

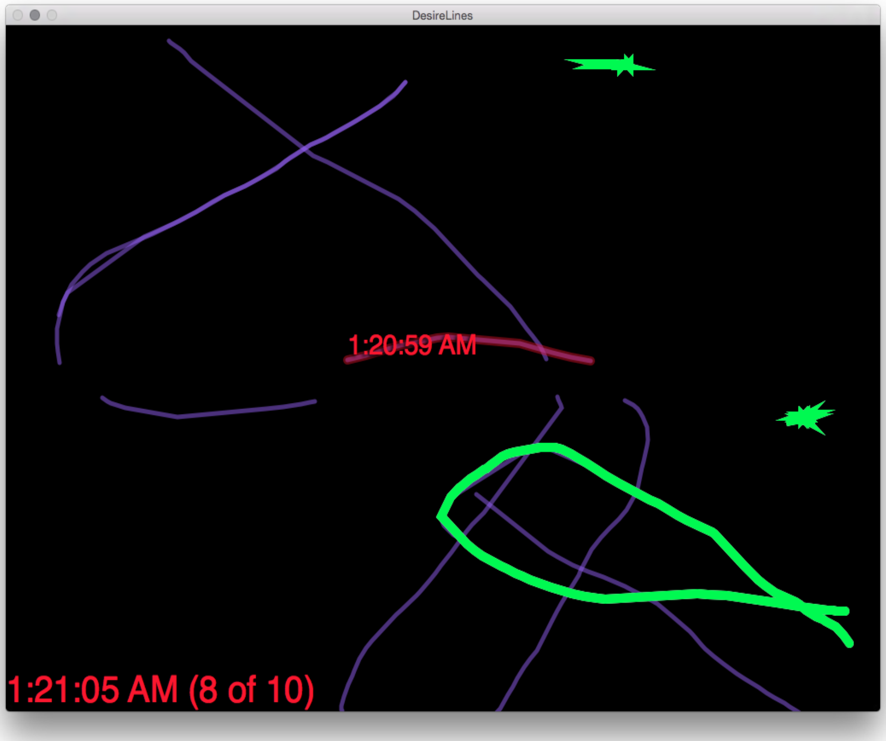
X Y

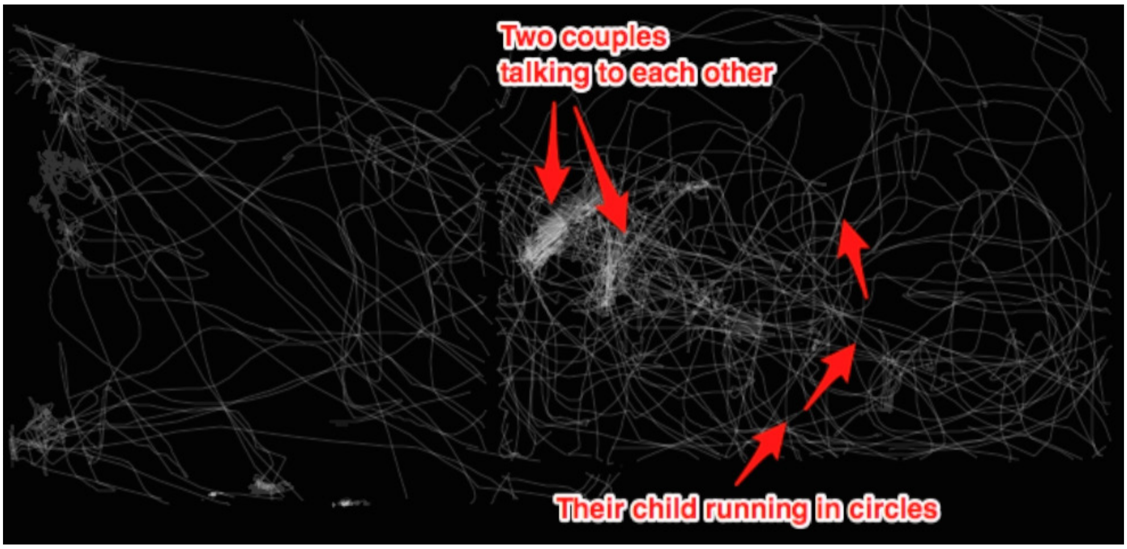
Rx Ry

Scale X Y

Scale Rx Ry


DesireLines
1:21:04 AM
1:22:42 AM (10 of 50)


DesireLines
1:20:59 AM
1:21:05 AM (8 of 10)

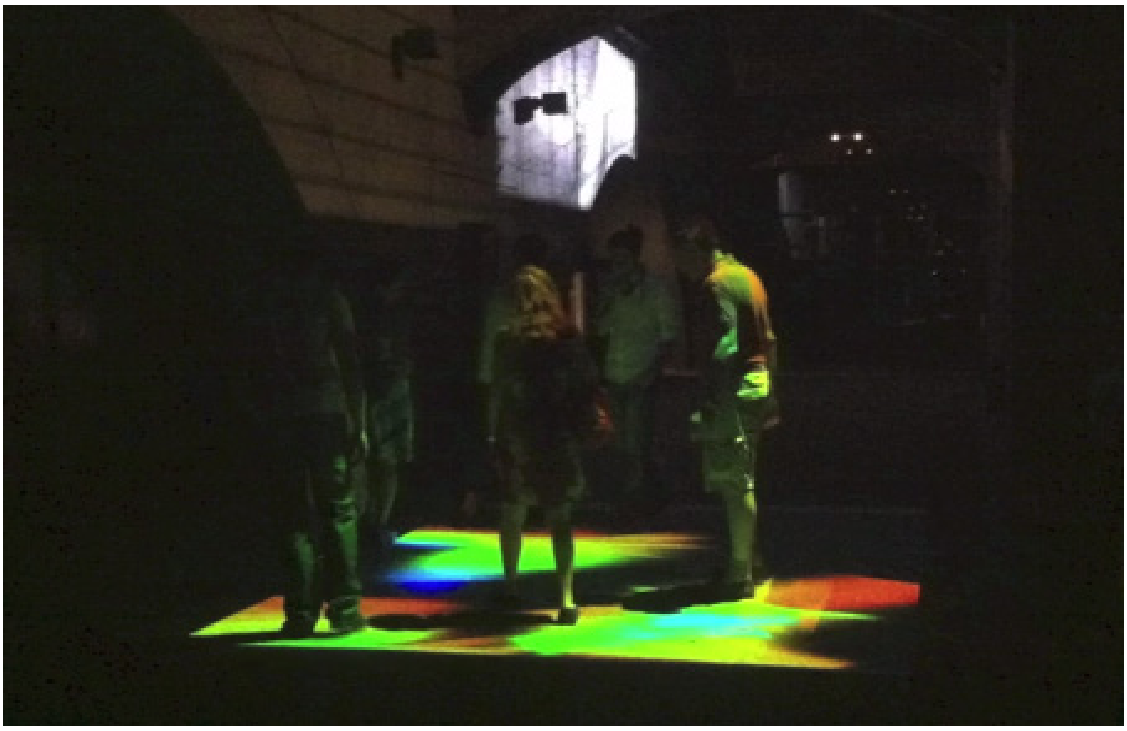

Two couples
talking to each other
Their child running in circles

Over time the software creates a record of movement in the space. (Note the blank horizontal line in the center of this screenshot indicates a since-resolved tracking bug)

ENSAL PROTOTYPE USING UNITY 3D

A prototype of the Desire Lines system was built for an artist residency held in August of 2013 at ENSAL (École Nationale Supérieure d'Architecture de Lyon). This installation was created prior to the development of Merge. The visuals were produced by Unity3D and the tracking was done by TSPS directly.

The visuals for Desire Lines are less sophisticated than those produced by Unity 3D for the prototype, but the system itself represents an advancement of the tracking system: data from two cameras has been combined to cover a larger area, and each of the lines is recorded by the software itself (for ENSAL, only the immediate interaction was implemented - data about travel down the hallway was recorded by ReOSC but not used).



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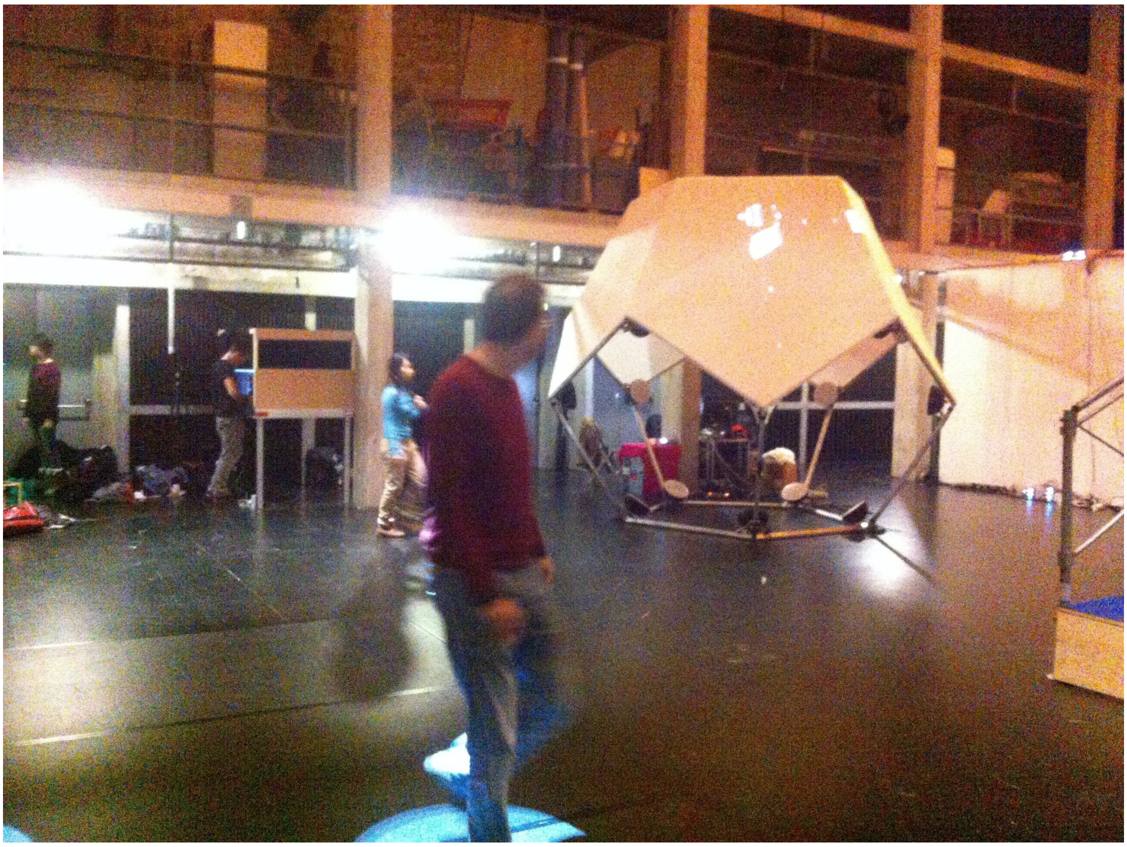
THE DODECAHEDRON

Early on I established interoperability and support for flexible protocols as a design principle. Every tracking system from the prototype onward implemented open data-sharing protocols, most notably OSC (Open Sound Control) and Syphon in order to permit the sharing and processing of the data by other systems.

From April 2012 until November of 2013 I had used my tracking system successfully in several public and experimental installations but always with my own software and tools. During the Stage Digitial II event I was pleased to test the interoperability - over the course of a lunch break, ZhDK researcher Daniel Bisig integrated the data from my tracking system with his own swarm simulation software running in the ICST Dodecahedron.

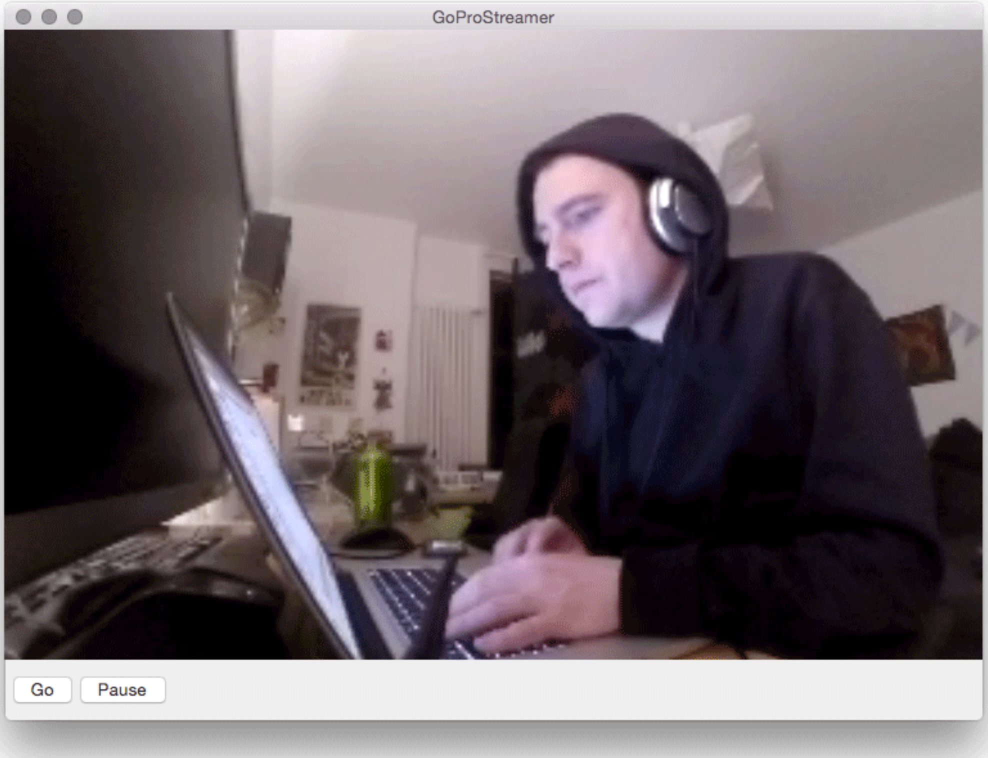
The Dodecahedron is a large twelve sided structure constructed with speakers at each vertex allowing for experimentation with ambisonic sound. It is equipped with projection surfaces and several projectors and runs Max/MSP and custom software which generates visuals to accompany the sound.

Because of the choice made during the design of Merge to send only lightweight location data (rather than the entire point cloud) I was able to set up a private wifi network running on a single MacPro laptop. Using this data as input Daniel was able to modify his Max patch in about half an hour to consume the data and use it to control one part of the swarm simulation and ambisonic sound. This was a simple demo but the relative ease with which it was accomplished confirmed that I had made the right infrastructural decisions.



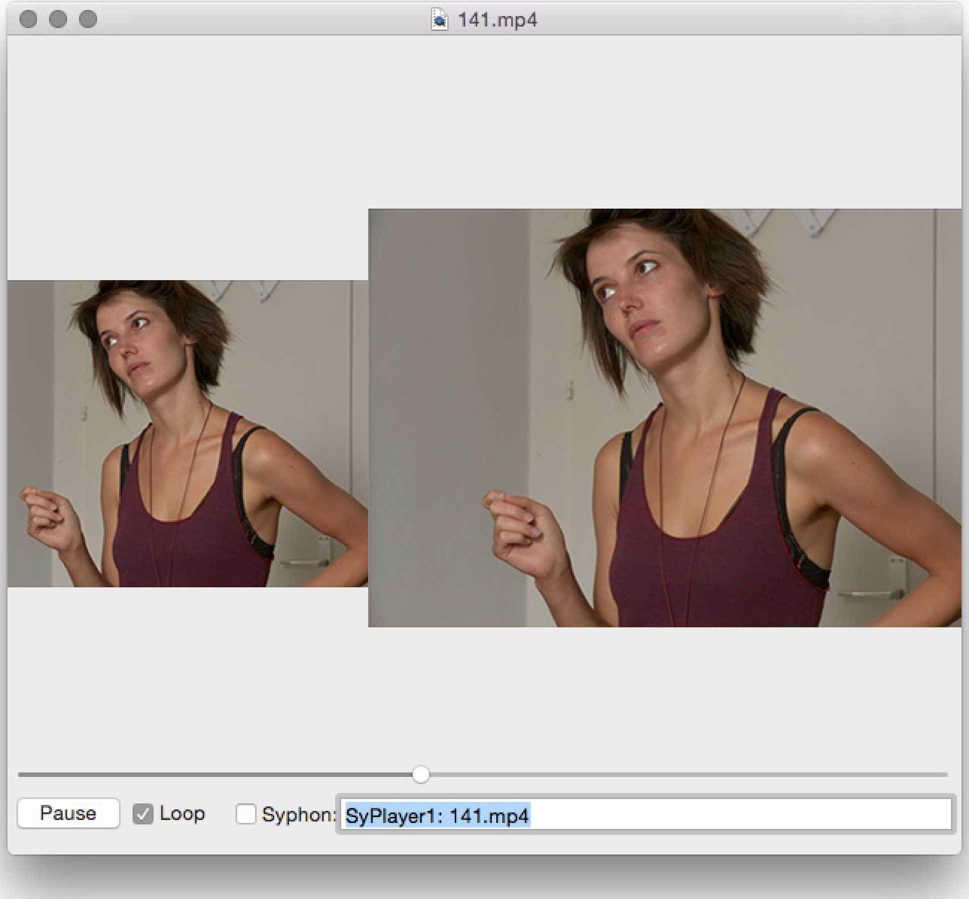
GOPRO STREAMER - MARCH 2014

The GoPro Hero 3+ camera provides a limited and broken implementation of a live video stream. This project was intended to create a consistent smooth stream for use on stage but was abandoned as impractical. Even with my intervention the streaming capabilities of the GoPro are too limited to be useful on stage.



SYPLAYER - MARCH 2014

SyPlayer is a simple video player with the ability to play, pause and loop videos. Output is displayed on screen and sent out via Syphon. This functionality was largely integrated into the SyMix application, however it is occasionally useful to have a standalone player.

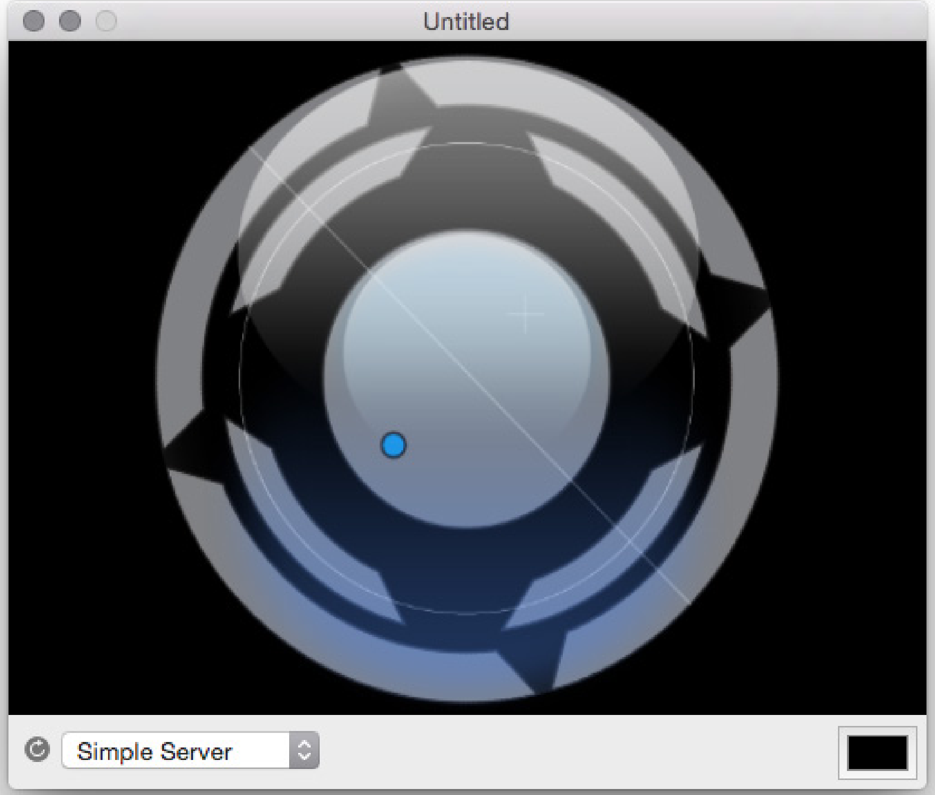


☑ Loop

☐ Syphon: SyPlayer1: 141.mp4

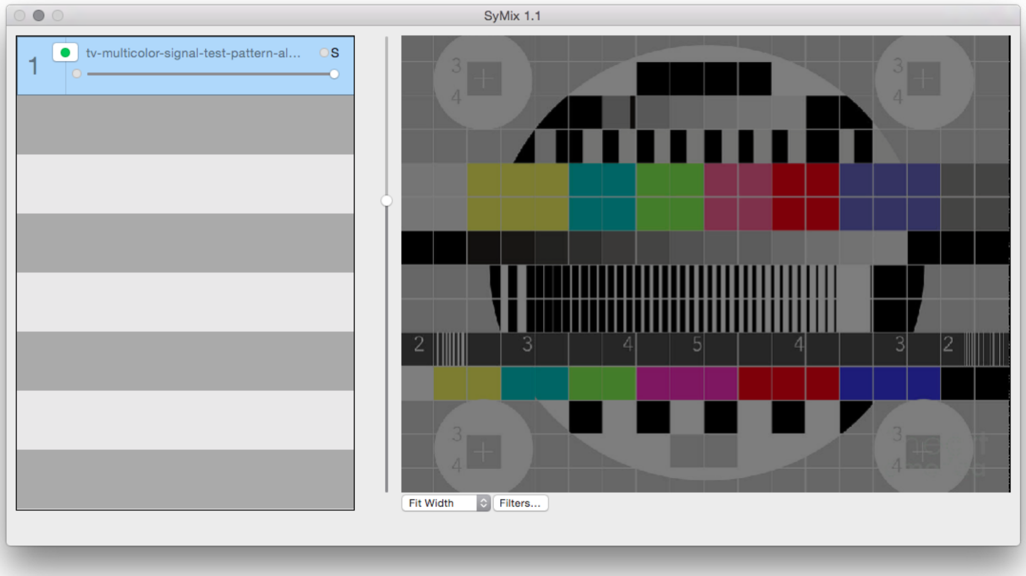
SYSCREEN - MARCH 2014

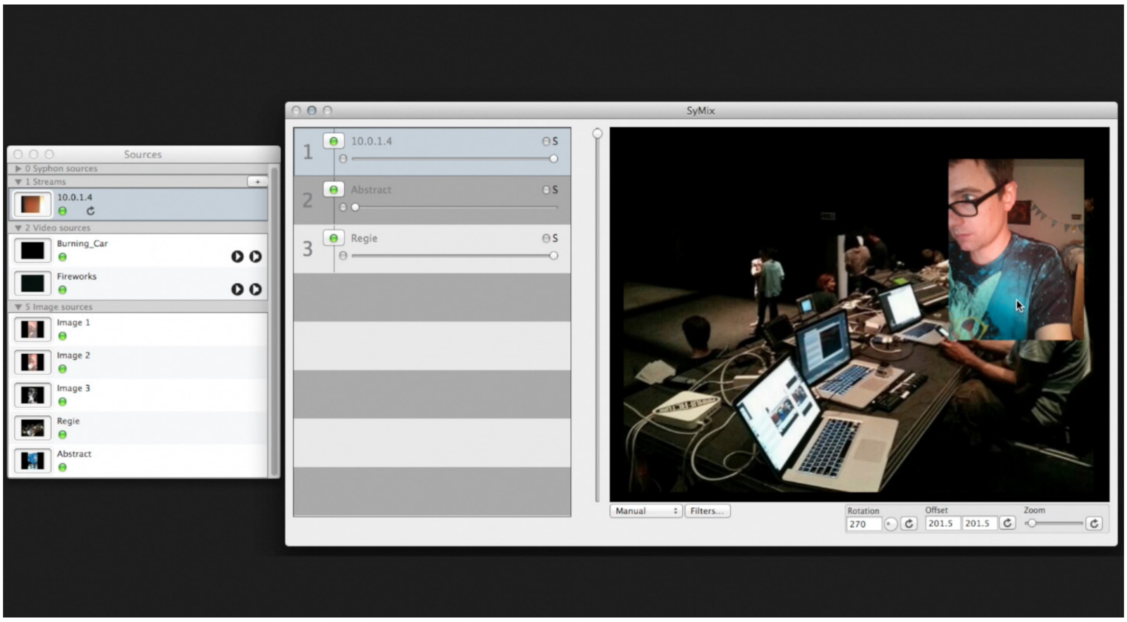
In spite of best efforts, experimental performance software occasionally crashes. SyScreen buffers the visual output of a Syphon stream from any source (including Performance/Space, Textify!, SyMix, and SyPlayer) ensuring that the projector on stage always displays either a functional Syphon output or user-selectable background color. This makes sure that crashes remain invisible to the audience.

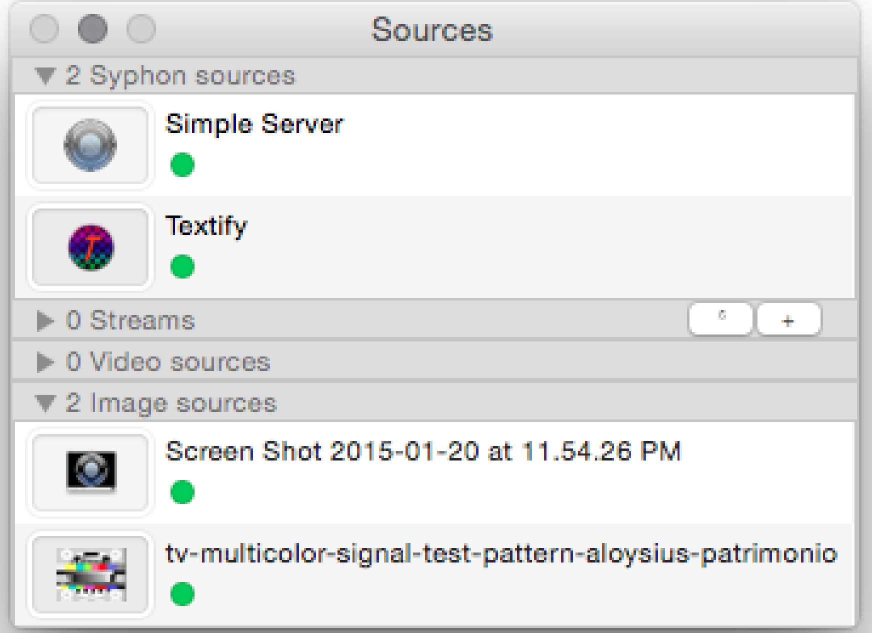


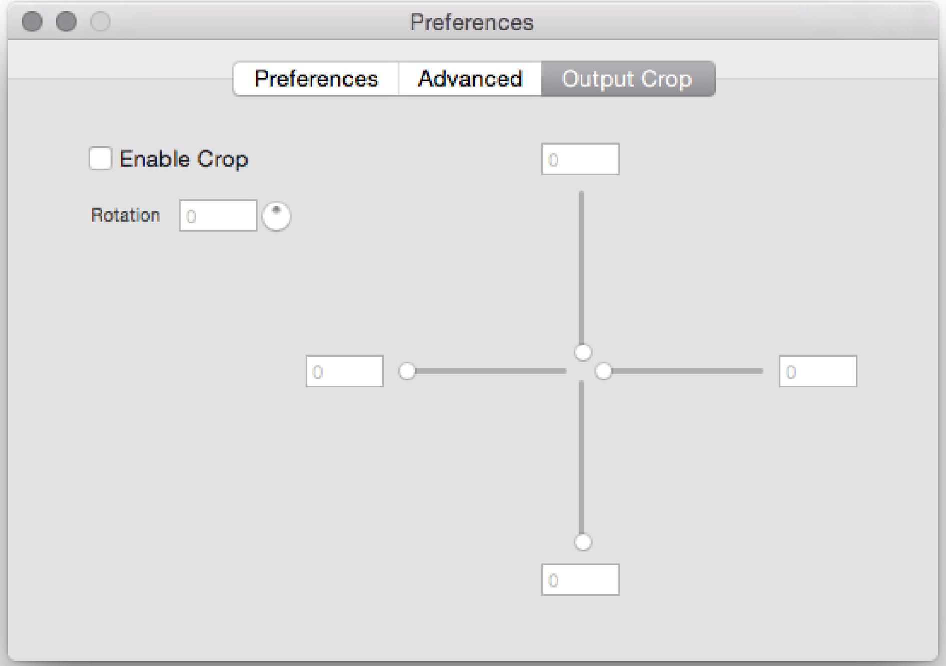
SYMIX - MARCH 2014

A full-featured version of SyMix, this tool supports a large number of layers including transformations, special effects and support for static images, video files and streamed video. This tool was used extensively to collate the data from multiple streaming iPhones for the MOTUS Leviathan production.


SyMix 1.1
1
tv-multicolor-signal-test-pattern-al...
S
Fit Width
Filters...


Sources
0 Syphon sources
1 Streams
10.0.1.4
2 Video sources
Burning_Car
Fireworks
5 Image sources
Image 1
Image 2
Image 3
Regie
Abstract
SyMix
1
10.0.1.4
2
Abstract
3
Regie
S
Manual
Filters...
Rotation
270
Offset
201.5
201.5
Zoom

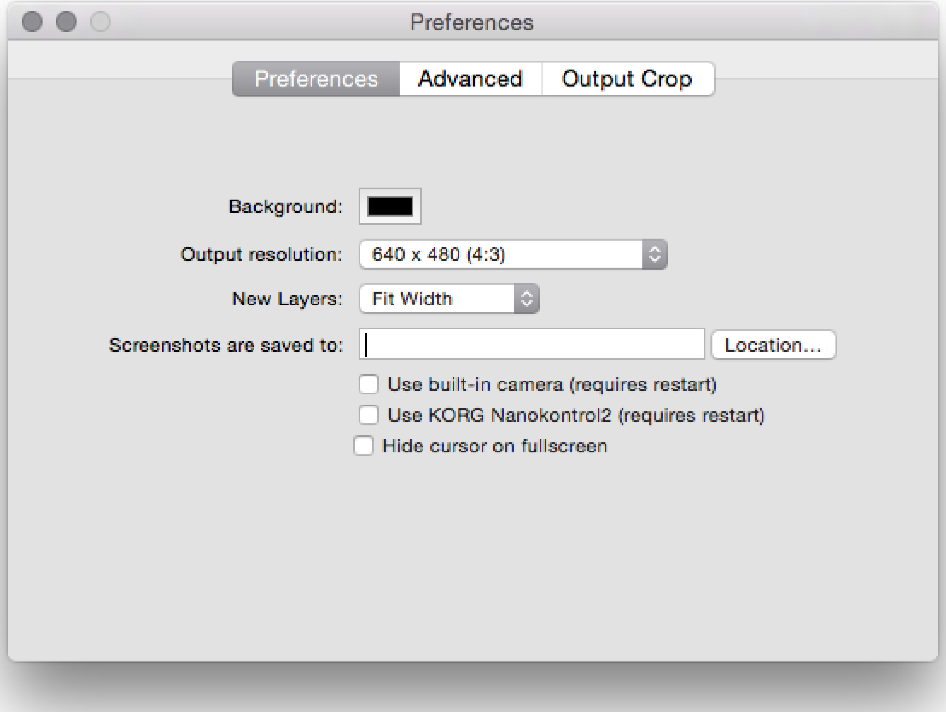

Sources
▼ 2 Syphon sources
Simple Server
Textify
▶ 0 Streams
+
▶ 0 Video sources
▼ 2 Image sources
Screen Shot 2015-01-20 at 11.54.26 PM
tv-multicolor-signal-test-pattern-aloysius-patrimonio


Preferences
Preferences
Advanced
Output Crop

☐ Enable Crop

Rotation 0

0
0
0
0


Preferences
Preferences
Advanced
Output Crop
Location…

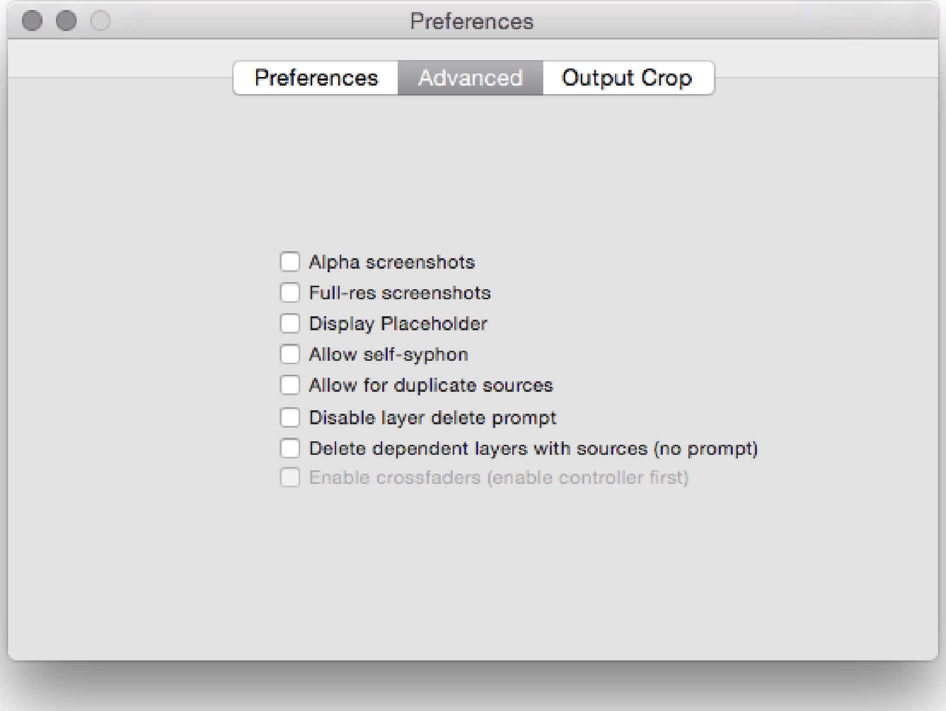
Background: ■

Output resolution: 640 x 480 (4:3)

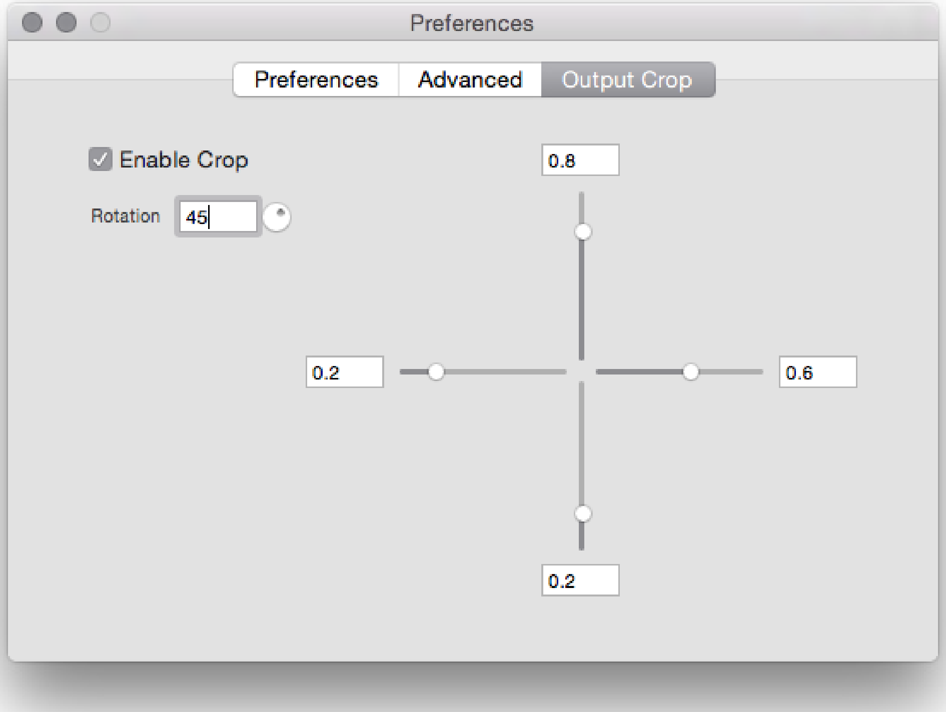
New Layers: Fit Width

Screenshots are saved to:

- ☐ Use built-in camera (requires restart)
- ☐ Use KORG Nanokontrol2 (requires restart)
- ☐ Hide cursor on fullscreen


Preferences
Preferences
Advanced
Output Crop

- ☐ Alpha screenshots
- ☐ Full-res screenshots
- ☐ Display Placeholder
- ☐ Allow self-syphon
- ☐ Allow for duplicate sources
- ☐ Disable layer delete prompt
- ☐ Delete dependent layers with sources (no prompt)
- ☐ Enable crossfaders (enable controller first)


Preferences
Preferences
Advanced
Output Crop

☑ Enable Crop

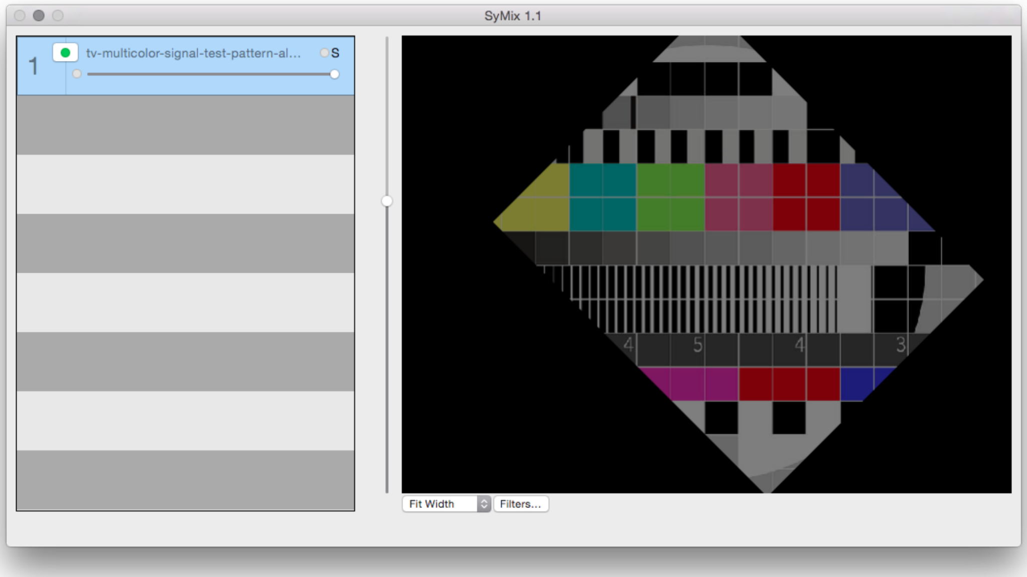
Rotation 45

0.8

0.2

0.6

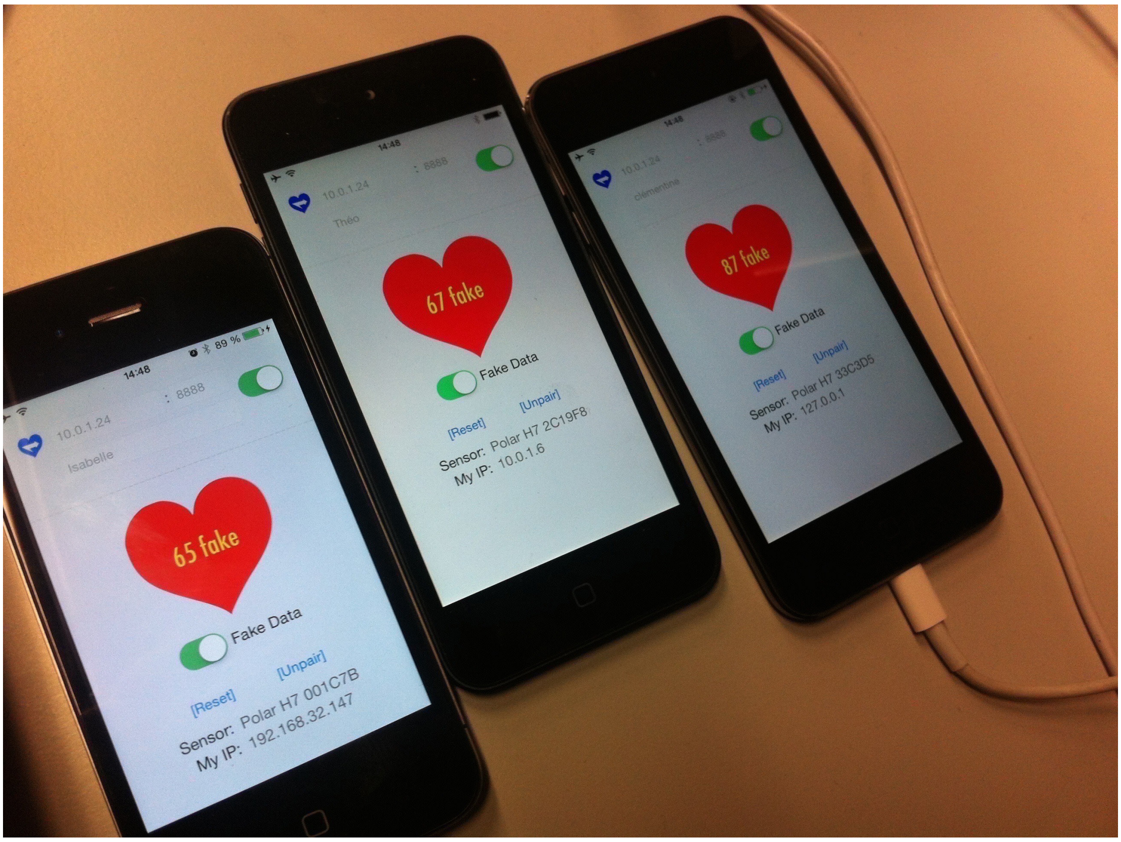
0.2


SyMix 1.1
1
tv-multicolor-signal-test-pattern-al…
S
4
5
4
3
Fit Width
Filters…

KORG
nanoKONTROL2

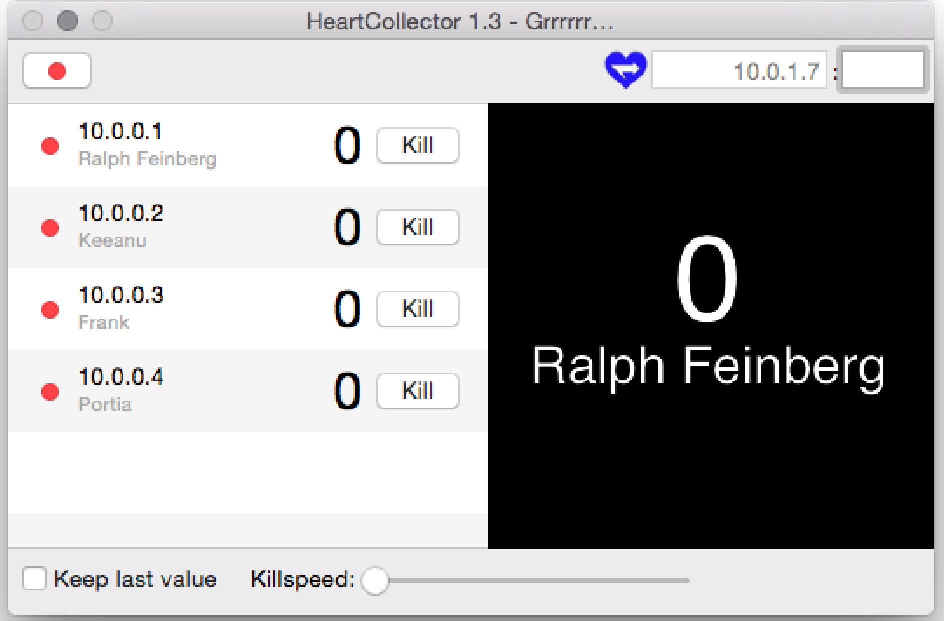
HEARTMONITOR - MARCH 2014

HeartMonitor is an iPhone mobile application that connects to a BLE bluetooth heartrate monitor. The software transmits the heart-rate to a server application (called HeartCollector) as OSC via WIFI. This tool was originally developed for Clementine Colpin's master's project at La Manufacture.


14:48
10.0.1.24
: 8888
Isabelle
65 fake
Fake Data
[Reset]
[Unpair]
Sensor: Polar H7 001C7B
My IP: 192.168.32.147
14:48
10.0.1.24
: 8888
Théo
67 fake
Fake Data
[Reset]
[Unpair]
Sensor: Polar H7 2C19F8
My IP: 10.0.1.6
14:48
10.0.1.24
: 8888
clementine
87 fake
Fake Data
[Reset]
[Unpair]
Sensor: Polar H7 33C3D5
My IP: 127.0.0.1

HEARTCOLLECTOR - MARCH 2014

HeartCollector is a desktop application that collates the output from various OSC sources. Primarily intended for use with HeartMonitor mobile application, this tool takes the heart rate data and generates a number of Syphon visualizations of each stream consisting of the name of the source and the heart-rate. This tool also supports “kill mode” used during a performance, which allows the operator to drop a given heart-rate to zero over an adjustable period of time.


HeartCollector 1.3 - Grrrrrr...
10.0.1.7
10.0.0.1
Ralph Feinberg
0
Kill
10.0.0.2
Keeanu
0
Kill
10.0.0.3
Frank
0
Kill
10.0.0.4
Portia
0
Kill
0
Ralph Feinberg
☐ Keep last value
Killspeed:

CINEMAMUTATION - JULY 2014

A psychogeographic storytelling tool, CinemaMutation was developed for the HotelCity project and drove the interactive installation that was presented at the La Manufacture 10 year anniversary party. This tool allows for the placement of video clips and affiliated documentation at various locations on a map, which can be either a PDF or large-scale image file. It supports interactive and generative modes.

The basic unit of the interaction in CinemaMutation is the “map” which may be any image or PDF document. The map is presented in an endless tiled view, so that a user can scroll and zoom at will. This interaction is familiar to anyone who has used Google maps or similar mapping software, although it is important to note that the map need not be an actual map: the software supports any information capable of being displayed in two dimensions. Thus the “map” might be a document, a portrait, a painting or picture of an object.

For the Hotel City project, the map used was an actual map of the city of Lausanne. Overlaid on the map was a network of locations, each representing one or more film segments. Clicking on a location navigated a user to that spot and presented the user with footage that was either shot on that location, or which was supposed to have taken place at that location within the frame of the narrative.

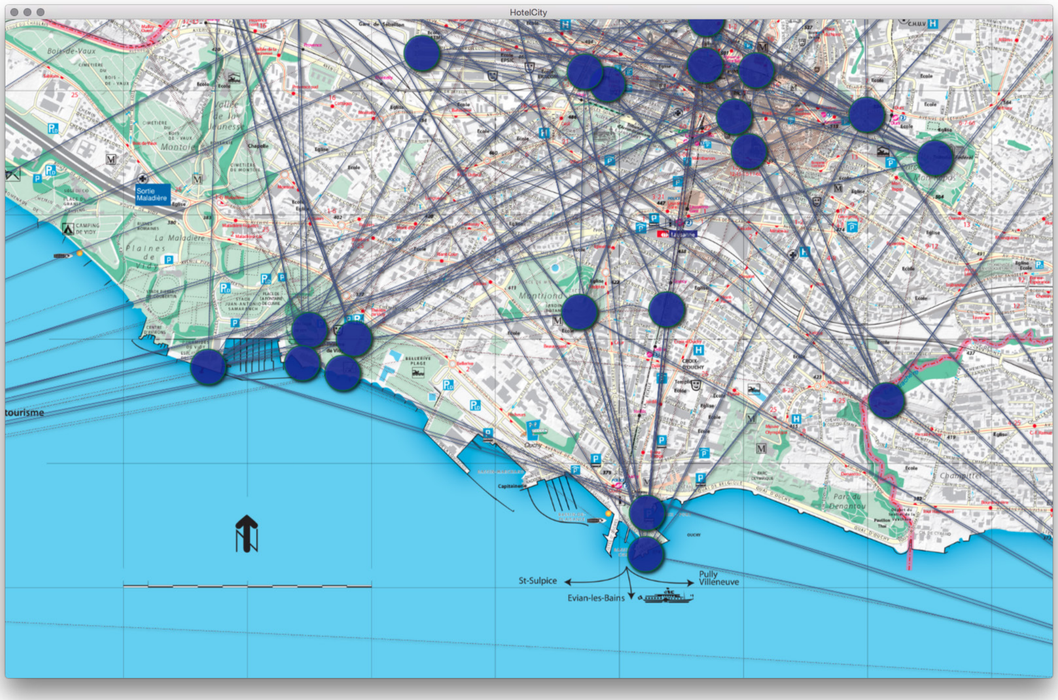
In addition to film clips, many of the locations featured documents that were related to the vignette being displayed. These documents added yet another layer of information about the story and the making of the film. Users were able to explore the map, the locations, and the documents freely in any order and without additional guidance. Thematic connections between locations were indicated by color-coded lines. Strong thematic connections or those involving storyline of the single character were indicated by solid lines. Dotted lines indicated weak thematic connections between scenes

The software is designed so that the only control necessary is a single Apple “magic pad,” a large track-pad that supports multitouch gestures such as pinch and scroll. In this way I was able to present a visually

Apple Magic Pad with gesture support.

minimal interface based primarily on physical gesture, which does not need to account for more than one user at a time and allows us to leverage the interface vocabulary the audience understands from their use of smartphones.

In generative mode, the system is capable of showing a film to an audience in much the same way one might watch a traditional film with the exception that the film has no set sequence. To generate a film CinemaMutation follows a set of simple rules to create a path through film segments. The path is shown via animation, “flying” the viewers to each location before displaying the relevant video clip. In order to generate the path, the system follows simple rules for display and branch choice: the first of which is that any given clip cannot be played more than once for the duration of a single run. The film begins at a randomly selected location. The next location is selected by following a strong link. If more than one strong link is available, the system selects randomly between them, discarding paths that lead to a clips we have already seen. If all of the strong link options are exhausted for a given location, weak links are used following the same pattern. If all strong and weak link options are exhausted, the film ends.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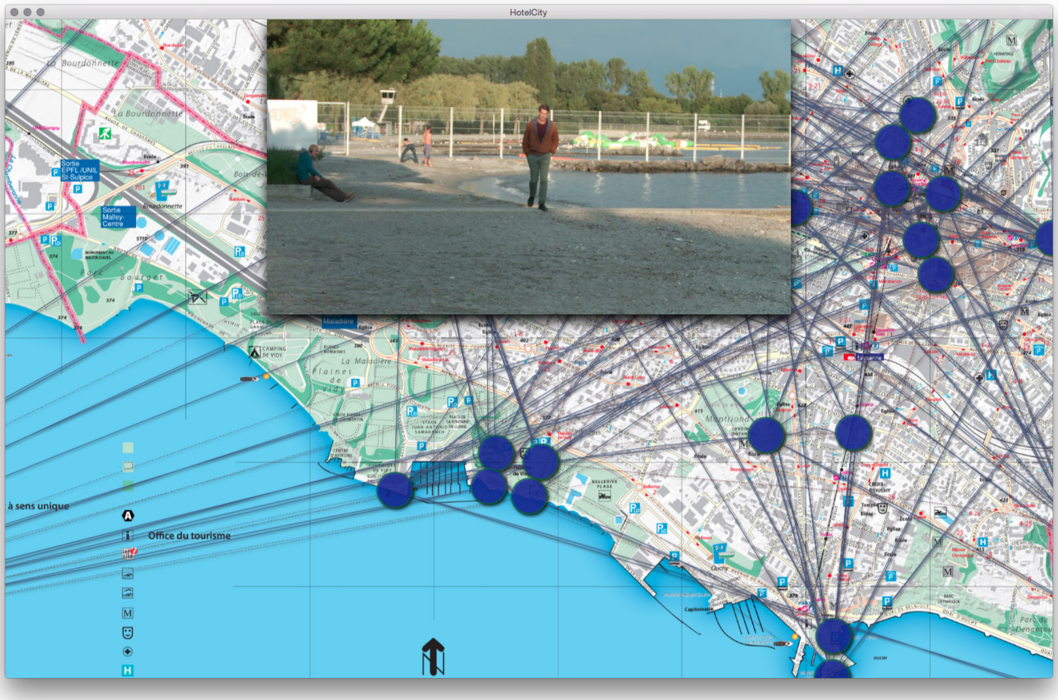
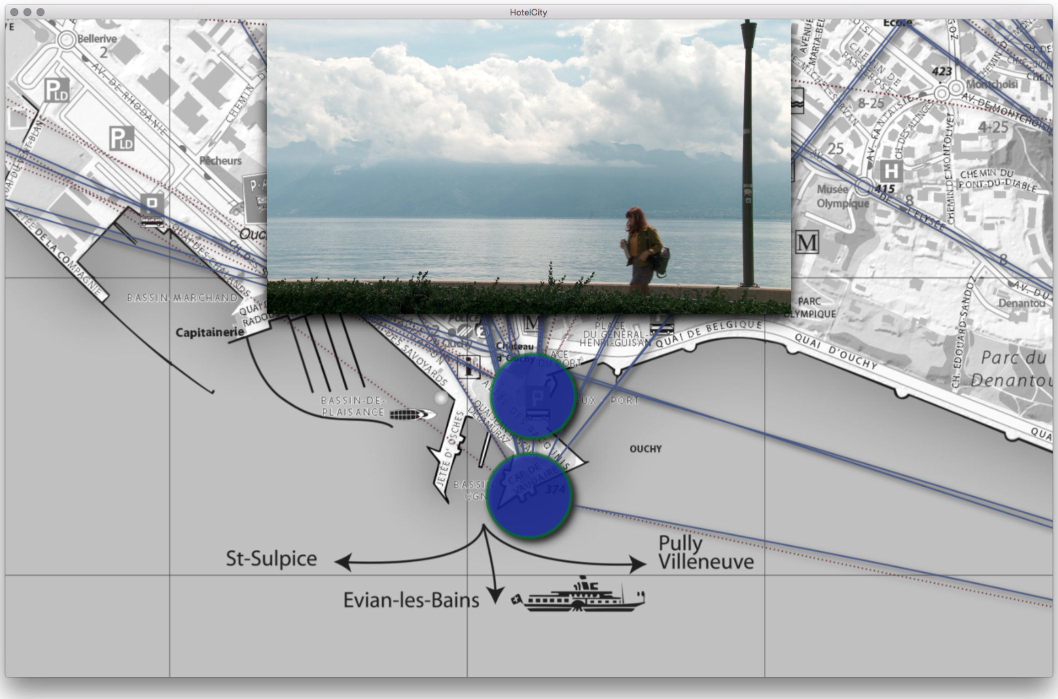
tourisme
St-Sulpice
Pully
Villeneuve
Evian-les-Bains


HotelCity
à sens unique
Office du tourisme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Villeneuve
Evian-les-Bains
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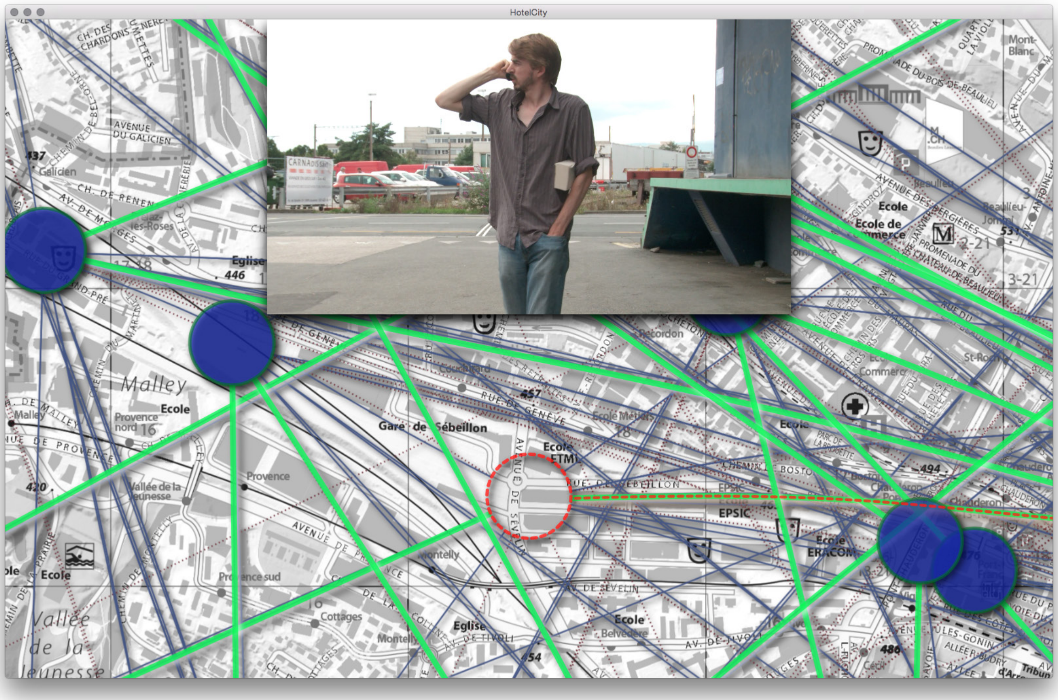
Capitainerie
BASSIN MARCHAND
BASSIN-DE-PLAISANCE
QUAI DE BELGIQUE
QUAI D'OUCHY
Parc du Denantou
Musée Olympique
PARC OLYMPIQUE
Montchoisi
Bellerive


HotelCity
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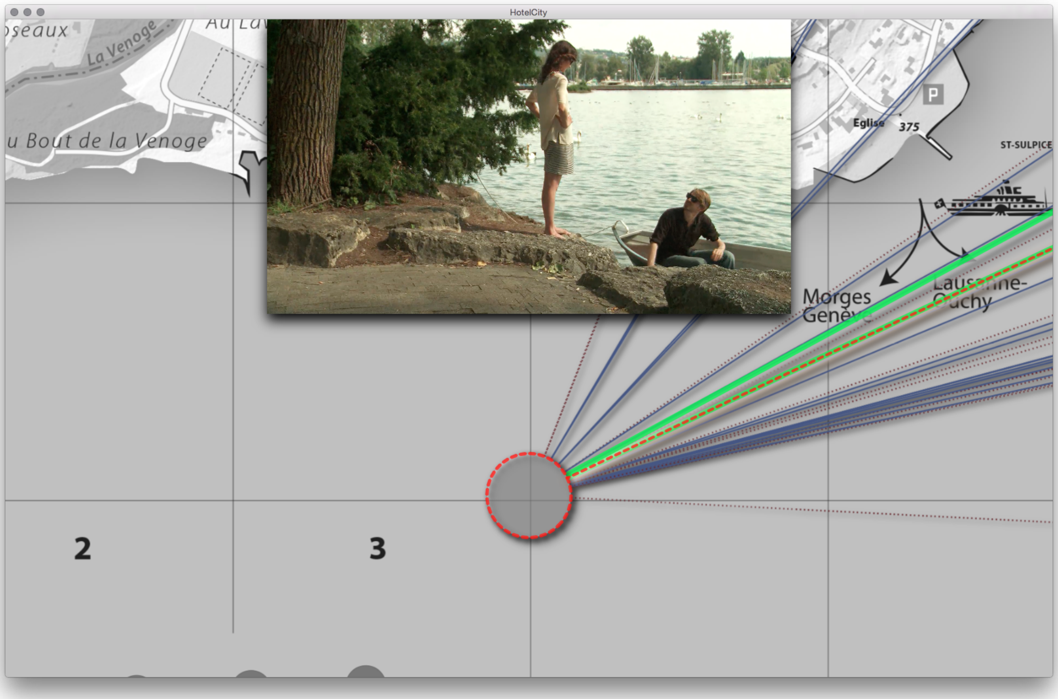
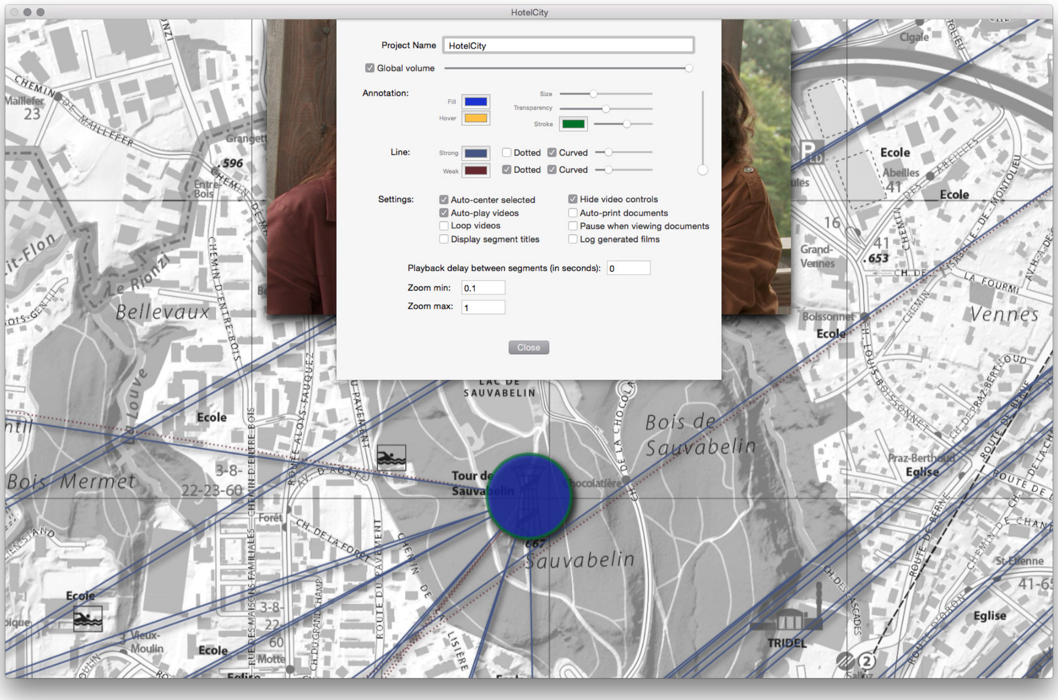
Galicien
Provence
Vallée de la Jeunesse
EPSIC
Ecole
Eglise
Montelly
Cottages
Beaulieu


HotelCity
La Venoge
u Bout de la Venoge
Eglise
375
ST-SULPICE
Morges
Genève
Lausanne-Ouchy
2
3


HotelCity
Bellevaux
Bois Mermet
LAC DE SAUVABELIN
Bois de Sauvabelin
Sauvabelin
Tour de Sauvabelin
Vennes
TRIDEL
Ecole
Eglise

Project Name: HotelCity

☑ Global volume

Annotation: Fill, Hover, Size, Transparency, Stroke

Line:
- Strong ☐ Dotted ☑ Curved
- Weak ☑ Dotted ☑ Curved

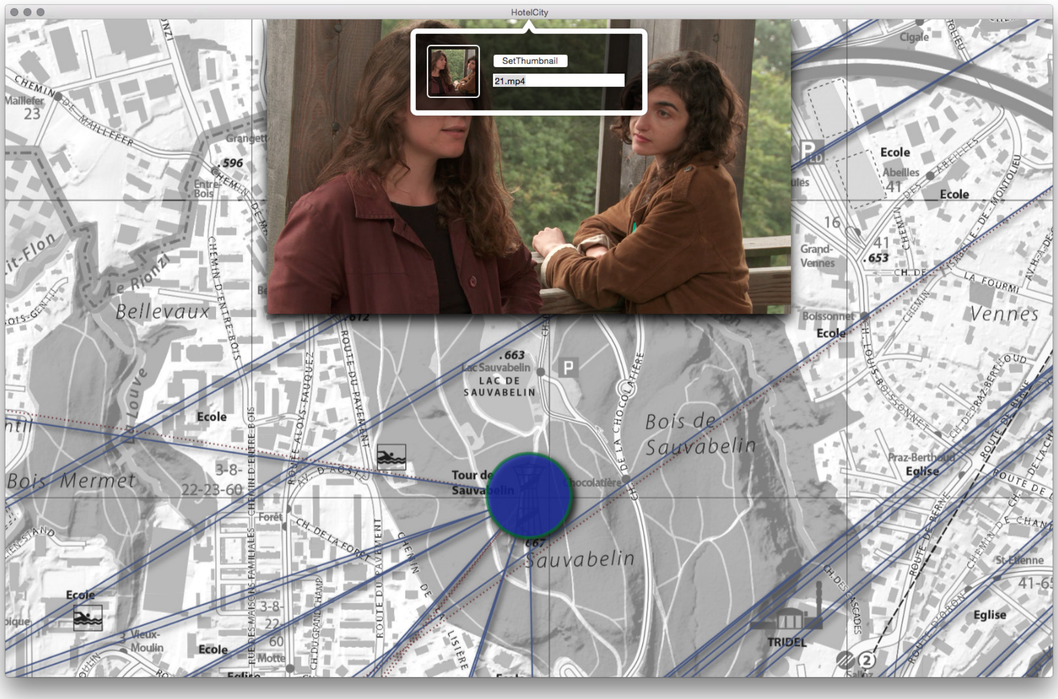
Settings:
- ☑ Auto-center selected
- ☑ Auto-play videos
- ☐ Loop videos
- ☐ Display segment titles
- ☑ Hide video controls
- ☐ Auto-print documents
- ☐ Pause when viewing documents
- ☐ Log generated films

Playback delay between segments (in seconds): 0

Zoom min: 0.1

Zoom max: 1

Close


HotelCity
SetThumbnail
Bellevaux
Bois Mermet
Lac Sauvabelin
LAC DE SAUVABELIN
Bois de Sauvabelin
Tour de Sauvabelin
Sauvabelin
Vennes
Grand-Vennes
Praz-Berthoud
Eglise
Ecole
Forêt
Vieux-Moulin
Motte
Boissonnet
Abeilles
Cigale
St-Etienne
TRIDEL
Grangette
Entre-Bois
Maillefer
.596
.663
.653
612
667

21.mp4

C

APPENDIX C TECHNICAL NOTES

NOTE 1: USER HIERARCHY WITH INTERACTIVE SYSTEMS

The user-hierarchy problem is common across all systems needing to track multiple humans and produce some sort of an output, regardless of the tracking technologies used. Human beings and most mammals are incredibly good at organizing information and switching focus, and in an art context such as theatre, dance or film, we have a number of tools at our disposal to direct focus such as lighting, sound, shape and color. We follow these focus switches smoothly and instantly, and are rarely even aware we are doing it.

A computer has no such ability or understanding and thus a problem emerges: if you have an installation which might include multiple visitors, your visitors will automatically assume a hierarchy which the computer does not understand by default. For example, two strangers visiting the same interactive installation will often behave as if the first person to enter the space is “first” and that they are “second.” In a situation where there is a display of some kind, visitors will often also assume that the person standing in front of them and closer to the display is “foremost.” If the installation is large enough for additional observers, these observers may assume they can “hang back” and observe as a crowd without affecting the interaction of the “primary” visitors.

Thus humans automatically organize into a hierarchy of interaction but unless explicitly modeled, the computer has no way of understanding this behavior and no way of discerning the “first” person from the “second” person. Furthermore without additional work the computer cannot distinguish a group of people from one especially large person, or a stationary individual with their back to the camera from an engaged and focused person bent over a display. This is all especially problematic if the intent is to allow free and unscripted movement through the space.

For *Inter-Actor* I modeled two versions of user hierarchy, one based on physical proximity to the camera and another based on a first-in-first-out (FIFO) stack. The former is the easiest to understand conceptually (the person in front is first) but turns out to have bizarre real-world consequences.

As a simple example, consider an installation where the foremost user *Alice* controls the brightness of a light while the secondary user *Bob* controls the color. Both users indicate their intent by moving in a single axis towards and away from the camera. If you map these roles to physical space, then you find what is likely an unintended side effect: the placement of Alice (our “front” user) effectively limits the range of Bob, our secondary user. As Alice backs away from the camera, she “compresses” the area that Bob has in which to move, eventually rendering him useless. Additionally, it is unclear what the behavior should be if Alice and Bob trade places, since the camera does not inherently understand that Alice and Bob are different people, only their position. Finally in the case where both users are standing side by side, the behavior is completely ambiguous.

Slightly more difficult to model in software but far more intuitive in physical space is FIFO. The first user to walk into a tracking area is issued a rank (number 1). The second user to enter the space is number 2 and so on. If number 1 leaves, number 2 “moves up a rank” and takes the place of number 1. This can be extended indefinitely although practically speaking one need not rank every user. For the *Inter-Actor* system I capped users to an arbitrarily selected 3. Thus the system understood User 1, User 2, User 3 and a category of “additional users” which were tracked but unranked and intended to be treated as “the crowd.” This largely solves the interaction problem by putting the system in line with visitor expectation.

NOTE 2: OPENING PARTY SCENARIO

A special case of the user hierarchy problem discussed in Note 1 is something I call the "opening party scenario" because it arises frequently during the opening of an art event where you have a large number of people in the space who are primarily there to drink and be social rather than to participate or observe the work.

In most cases you can assume that visitors to an interactive space understand they are entering a zone or "magic circle" of interaction. These zones can be reinforced by the introduction of visual or physical markers, such as a wall, doorway or lines painted or taped onto the floor. It is a wonderful effect of human proprioception that we will tend to perceive and obey these sorts of markers nearly subconsciously.

In certain situations however, such as a crowded cocktail party or art opening, our tendency to avoid crossing boundaries and our general care for the space around us diminishes. By default, computers have no way of realizing our level of awareness and so have no way of understanding if the two people they are tracking are interested in the piece or are simply standing with drink in hand, oblivious to the computer desperately trying to interpret their movements.

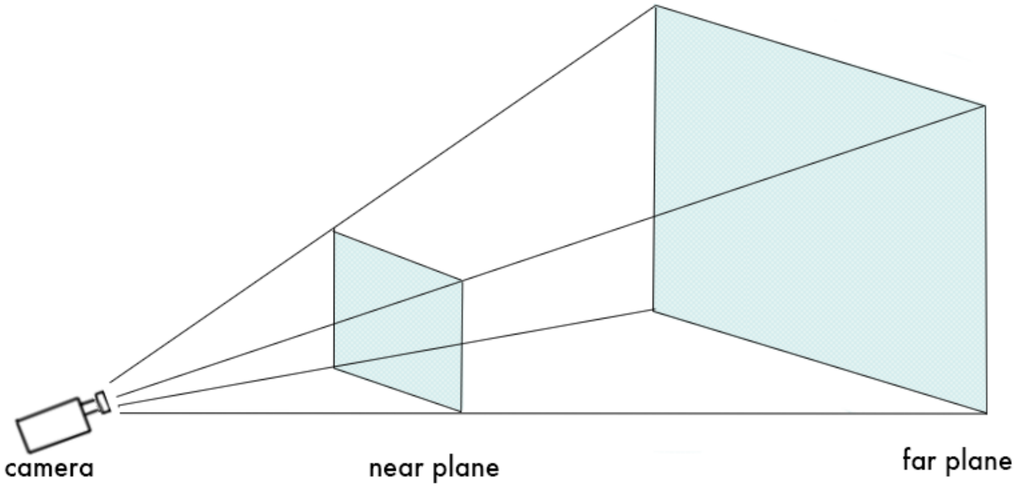
There are many ways to solve this problem, from the high-tech such as using computer vision to model a users behavior, posture and orientation to determine level of awareness and focus, to the low-tech such as posting a docent to inform visitors how many people may enter a space and to direct idlers towards the exit.

For my purpose I used a low-tech approach, demarcating the interaction zone with gaff tape on the floor and implementing a very basic "cropping" function which told the camera to ignore all of the information they received outside of a certain physical area.

If the purpose of *Inter-Actor* was to author public installations installed in arbitrary locations, I would suggest that solving this problem more robustly ought to become a focus of the work. However, the *Les Urbaine* and *Stage Digital* events were both exceptions to the target use case, which was a controlled theatrical event. During a theatrical performance, the stage is already considered a highly protected zone reserved for performers: no audience members will approach a stage without an invitation. If they do, the performance is considered interrupted and the contract between audience and performer is already broken. The software does not need to account for this case.

NOTE 3: DEALING WITH FRUSTUMS IN A UI

Humans are quite used to the idea of a zone or space for activity: a tabletop, room or surface, which is almost always assumed to be rectilinear by default. When we watch a film or video program, we see a flattened rectangular view, but considered in 3D space all cameras, including depth cameras, standard video cameras and the human eye on which they are based, see in a “cone” from the point of origin out into the world. These devices also trade resolution for distance and are inherently more accurate up close than further away. Building a tracking system requires consideration of trade-offs between range and accuracy, and requires understanding that the area covered is not square, but rather the cross-section of a roughly pyramidal shape called a *frustum*.



Because the *Sonus* project existed primarily as a technical demonstration, I opted to mark the viewing angle and range of the depth camera on the floor using tape, thus making explicit the visual “cone” of the camera. This exercise highlighted a serious limitation of the system, which was the fact that a single camera can only cover a small useful area, and demonstrated clearly that the position I had been using (horizontally mounted cameras) was not ideal

Physically, cameras being used for tracking must be oriented in such a way that the frustum intersects your plane of interest. However, since the world is 3D and not 2D, you must also take into account not only the intersection but the viewing angle so that the “sides” of the frustum enclose the entirety of the body that you are looking to track. Cameras positioned on the floor will fail to track a user’s feet or head when they are standing close to the lens, but will be less accurate when the user is standing further away. In terms of tracking position over a large area the most useful arrangement of cameras is directly overhead although this poses several problems of its own.

In terms of user interface, It is difficult to present a UI to compose a stage scene composed of arbitrarily oriented frustum shapes. It is often better for the end user to deal with a projected plane and leave these difficulties behind the scenes. For this reason, and because the most common use of the Kinect camera is to control video games presented on a flat rectangular viewing surface, the OpenNI library provides functions to translate the camera’s internal coordinate system into a projected VGA rectangle. This coordinate system was the one I used in the *Inter-Actor* system, but does assume a perfectly horizontal or vertical orientation in order to work properly.

For all of these early prototypes, I relied on the fact that depth cameras see in three dimensions, but I ignored depth in the interface, treating the space as if it were rectangular and two dimensional with hotspots or zones of interaction painted flat on the floor. In most cases this works quite well, but it ignores some major capabilities of the technology which could be exploited in interesting ways.

Finally, although ideal for tracking in a living room sized space, the region covered by a single depth camera is excessively limiting in a theatre context. Standard stage size is 5 meters in all directions, while a single camera can just cover about 3.5x2 meters. It became obvious after building these demo systems that future work would need to focus on stitching the data of multiple cameras together in order to cover a larger area. This is what lead to the development of the point cloud solution called *Performance/Space* and ultimately to the multiple-distributed-depth-camera solution called *Merge*.

NOTE 4: NONLINEAR PERCEPTION AND LED THEATRE LIGHTING

Humans tend to experience light and sound intensity (brightness and volume) as if they are linear when in fact our perception responds to stimulus logarithmically. LED lights are linear and so in order for an LED light to appear twice as bright, one must apply more than twice the power for our perception to align with expectations. Even when accounted for this can have unexpected consequences when employing the lights in novel ways.

For example, the Teclumen series of lights calls for software to provide 8 bit numbers on each control channel (0-255). It would be reasonable to expect that 127, being roughly half of 255, would appear half as bright as 255. This is not true, although further experimentation showed the problem was not corrected by treating the scale logarithmically either. What was happening and why was this problem made obvious by *Inter-Actor?*

The theatre lights were being controlled by my software via Enttec and on-board LED controllers. It is likely that the designers of these circuits understood the perception issue and put in place some sort of compensation, but did not calibrate the scale very carefully. They would have had little reason to do so - standard practice involves controlling theatre lights with a lighting board or software equivalent, generally using your own eyes to select the proper brightness level. Your perception is part of the feedback control loop and nobody much cares that you have the setting at 123 instead of 119.

In a computer controlled dynamic system where you have removed the user from the control feedback loop, these small variances became immediately and annoyingly apparent. Mapping the brightness to the distance traveled across a room, for example, does not give the expected result because the software *does* expect 127 to behave as if it is half as bright as 255. Without correction the lights seem to react slowly at first, then sharply dimming to nothing as you approach the end of the range.

The solution was relatively straightforward: values were calibrated using an exponential scale adjusted experimentally for each channel and light type. For best results this procedure should be followed not only for each channel but for each individual light fixture depending on the manufacturing tolerance.

What is most interesting about this problem is not the well understood issue itself but the fact that it serves as an example of the kind of problem that only emerges through experimentation and “strange application” of a technology.

D

APPENDIX D CURRICULUM VITAE

Andrew Sempere **andrew@feralresearch.org | andrewsempere.org**

Education

2015	PhD, Docteur ès Sciences Computational Shifts in Theatrical Space École Polytechnique Fédérale de Lausanne Department of Architecture (EDAR)
2003	MS, Media Arts and Science Massachusetts Institute of Technology Media Lab
2001	BFA, Visual Communication / Art and Technology School of the Art Institute of Chicago
1996	Phillips Academy, Andover

Employment

2012 -	Doctoral Assistant École Polytechnique Fédérale de Lausanne
	Researcher Haute Ecole de Théâtre de Suisse Romande SINLAB
2007 - 12	Design Researcher IBM Research
2006 - 07	Senior Software Engineer Pearson Education
2005	Senior Designer Bricolage Systems, LLC
2001 - 03	Research Assistant MIT Media Lab
1997 - 05	Senior Developer/Designer Evolving Systems, Inc

Teaching : Courses

2013	Guest Lecture, HEAD (Haute Ecole d’art et de Design), Geneva Art <-> Design <-> Research Invited “design week” lecture

2013	Teaching Assistant, École Polytechnique Fédérale de Lausanne CS-489: PxS Design studio for computer scientists, special topic: MOOCs in Africa
2012	Guest Lecture and Workshop Lead 1 week workshop in interactive technologies Tsinghua Art & Science Media Lab / Tsinghua University Beijing, China
2006 - 08	Instructor, Harvard Extension School CSCI E-9 Computational Art
2003	Teaching Assistant, Harvard FAS Interactive Environments w/ Profs. Jeffery Huang and Muriel Waldvogel

Teaching : Workshops

2011	Artistic Mediums II Curatorial lecture and workshop New Art Center Newton, MA
2003	Jackal Project Electronics and art workshop with Boston Cyberarts Boston, MA
2002	The City That We Want Electronics workshop with the Bradesco Foundation Sao Paulo and Campinas, Brazil
2001	Codachrome Workshop Electronics and LED wearables workshop MIT Media Lab / Margarita Dekoli Cambridge, MA

Selected Publications

2013	*Experience Catalysts and Architecture: Towards a New Tradition* 2013 eCAADe Conference on Future Traditions: Rethinking Traditions and Envisioning the Future in Architecture through the Use of Digital Technologies
2011	*Architecture and Design for Virtual Conferences: A Case Study* MDPI Future Internet 3, no 3: 175-184
2009	*The Work of Art in the Age of Virtual Production* 25th Annual CHArt Conference Proceedings

2005
Animatronics, Children and Computation
IEEE Journal of Educational Technology & Society 2005, Vol. 8, Issue 4
Special Issue on “Crafting Learning in Context”

2004
CTRL_SPACE: Using Animatronics to Introduce Children to Computation Proceedings, IEEE International Conference on Advanced Learning Technologies

2003
Just Making Faces? Animatronics, Children and Computation
Masters Thesis, MIT

Selected Exhibitions

2014
Hotel City / CinemaMutation
Interactive film installation / game engine
HETSR 10 year anniversary, Lausanne Switzerland

HeartCollector
BLE wearable project
HETSR, Lausanne Switzerland

LIWYATAN / LEVIATHAN
Theatre production/performance
Work with SINLAB Artist in Residence MOTUS Company

2013
CYBORG[AME]
Theatre production/performance
Work with SINLAB Artist in Residence with Gildas Milan

Lines of Desire
Invited Artist in Residence
ENSAL (École nationale supérieure d’architecture de Lyon)

SHiNMu
Dance production/performance
Collaboration with ATOU dance company and Theoriz Crew

Stage Digital II
Interactive technology demonstration and residency
ZhDK Zürich, Switzerland

2012
Les Urbaines
Interactive technology demonstration for a public festival
Lausanne, Switzerland

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2012	*Stage Digital I* Interactive technology demonstration and residency ZhDK Zürich, Switzerland
2011	*The Meaning of Work* Interactive Video for Interior-Ity at the Fourth Moscow Biennale of Contemporary Art Moscow, Russia
	Bowl of Oceans Interactive sculpture exhibited at the Peabody Essex Museum Salem, MA
	Artistic Mediums II Curator for an intermedia show at the New Art Center Newton, MA
2010	*Riders on the Train* Video piece created for Riders on the Train exhibit, Axiom Center for New & Experimental Media Jamaica Plain, MA
2009	*Crowd Reign & Sod Off II* Two interactive installations for the Boston Cyberarts Gala Event Cambridge, MA
	Blues Garden Temporary public art exhibition, Gibson Jazz and Blues Festival. Collaboration with Mary Lucking and Pete Goldlust. Glendale, AZ
2008	*Artistic Mediums I* Curator for an intermedia show at the Museum of New Art Pontiac, MI
2006	*Sod Off* Installation for the 7th Annual Champ Libre Biennial “Invisible City” Montreal, Canada
2005	*Sod Off* 35th Bumbershoot Festival Outside:In Exhibition Seattle, WA
	Primordial Chicken Soup Interactive window installation. Collaboration with Mary Lucking for the Cambridge River Festival Cambridge, MA

2005
Grasshappy: Growing Pet for Increased Happiness
for Dorkbot Seattle's People Doing Strange Things With Electricity II show
Seattle, WA

2004
Creatures
Collaboration with Mary Lucking, commissioned by Stop 'N Look
Phoenix, AZ

2004
Escape From the Mainframe
With Tangentlab Collective
Louisville, KY

2003
Jackal Project
Performance workshop installation with Tangentlab
Boston Cyberarts Festival
Boston, MA

2002
Jackal Project
Performance workshop installation with Tangentlab
SIGGRAPH 2002
San Antonio, TX

2002
Jackal Project
Performance workshop installation with Tangentlab
Museum of Contemporary Art Version 2.0 Festival
Chicago, IL

2001
Paradise Lost
G2 webspace with L,FMI collaborative
Chicago, IL

2000
First, Last Middle Initial
Interactive installation
With L,FMI collaborative for 1926 Exhibition Studies Gallery
Chicago, IL