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Shaping Space as Information: A Conceptual Framework for New Media Architectures

Author
Rincon, Gustavo Alfonso

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Shaping Space as Information: A Conceptual Framework for New Media Architectures

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Media Arts & Technology

by

Gustavo Alfonso Rincon Jr.

Committee in charge:

Professor Dr. JoAnn Kuchera-Morin, Co-Chair

Professor Marcos Novak, Co-Chair

Professor Marko Peljhan, Member

December 2020

The dissertation of Gustavo Alfonso Rincon Jr.

is approved.

Dr. JoAnn Kuchera-Morin, Committee Co-Chair

Marcos Novak, Committee Co-Chair

Marko Peljhan, Committee

December 2020

Shaping Space as Information: A Conceptual Framework for New Media Architectures

DEDICATION

Dedicated to the loving memory of

Gloria Rivillas

(1940 – 2014)

Daughter, sister, woman, wife, mother, & friend

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Firstly, I would like to thank my Mother, Gloria Rivillas (1945 - 2014), Father, Gustavo Alfonso Rincon Venegas, Grandmother Ana Clementina Venegas de Rincon, and immediate family for their support and patience. Also Abuelita Oliveria Rivillias (1903 – 1994) along with Tia Ana Santiago Rincon and Tio Alvaro Santiago gave me an eternal flame for the search for knowledge and the love for truth. Abuelito Ismeal Rincon for offering the knowledge of history. Tia Estellita Rincon for being an example of strength. I want to especially thank my wife, best friend, and collaborator in life, Rebecca Alice-Carter Rincon for her strength and vision of life. I want to thank Dr. Albert Howard Carter III and Dr. Nancy Corson Carter for the years of advice and encouragement.

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VITA OF GUSTAVO ALFONSO RINCON JR.

December 2020

EDUCATION

Doctor of Philosophy, University of California, Santa Barbara, December 2020
Dissertation: Shaping Space as Information: A Conceptual Framework for New Media Architectures
Committee: JoAnn Kuchera-Morin (chair), Marcos Novak, Marco Peljhan

Master of Fine Arts, California Institute of the Arts, June 1998

Master of Architecture, University of California, Irvine, June 1994

Bachelor of Arts in Music, University of California, Berkeley, June 1992

PROFESSIONAL EMPLOYMENT

2014-2020: Senior Researcher, Graduate Student Researcher, AlloSphere, SB, CA

2009-2014: Junior Researcher: Graduate Student Researcher, AlloSphere, SB, CA

2010-2010: Teaching Assistant, Media Arts & Technology, SB, CA

2008-2014: Teaching Assistant, Technology Management Program, SB, CA

2009-2009: Teaching Assistant, University of California Institute for Research in the Arts, SB, CA

PUBLICATIONS

MYRIOI – The Shared Immersive VR Experience: Intuitive, Intrinsic, Instinctive
Leonardo: Vol. 53, No. 4, 2020, MIT Press, 2020
Kuchera-Morin, J., Cabrera, A., Wood, T., Kim, K., & Rincon, G.

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Leonardo: Vol. 53, No. 3, 2020, MIT Press, 2020 (2020): 355-357.

PROBABLY/POSSIBLY?, An Immersive Installation; Interactive Visual/Sonic Quantum Composition and Synthesizer
Kuchera-Morin, J., Putnam, L., Peliti, AlloSphere Design Team and Graduate Researchers,
ACM ISBN 978-1-4503-4906-2/17/10…[GR1], MM ’17, 2017, Mountain View, CA

The Effects of Visual Realism on Search Tasks in Mixed Reality Simulation,

Cha Lee, Gustavo A. Rincon, Greg Meyer, Tobias Hollerer, and Doug A. Bowman
Research: The Four Eyes Lab, Computer Science, UCSB, CA

PUBLICATIONS (Contributions)

The Evolution of Spatial Audio in the AlloSphere,
Computer Music Journal 40 (4) 47-61.

Immersive full-surround multi-user system design,
Computers and Graphics 40 (2014) 10-21.

EXHIBITIONS

Myrioi, SIGGRAPH 2020 - Think Beyond, D.C., U.S.A.
(Special Interest Group on Computer GRAPHics and Interactive Techniques)
Artists: Kuchera-Morin, J., Cabrera, A. Kim, K., Wood, T., & Rincon, G.

Etherial, International Symposium on Electronic Arts Competition, Gwangju, South Korea
Artists: Kuchera-Morin, J., Cabrera, A. Kim, K., & Rincon, G.

Probably/Possibly? ACM SIGMM 25, Arts Installation, Mountain View, CA, USA
Artists: Kuchera-Morin, J., Cabrera, Adderton, D., Wolfe, H., Wood, T., Kim, K., & Rincon, G.

Probably/Possibly? Arts Electronica, International Symposium on Electronic Arts Competition, Manizales, Colombia
Artists: Kuchera-Morin, J., Cabrera, Adderton, D., Wolfe, H., Wood, T., Kim, K., & Rincon, G.

Probably/Possibly? Museum Debut, The Wolf Museum of Exploration + Innovation, SB, CA.
Artists: Kuchera-Morin, J., Cabrera, Adderton, D., Wolfe, H., Wood, T., Kim, K., & Rincon, G.

CATALOGS

Think Beyond, SIGGRAPH 2020, Catalog 2020, Washington, D.C.

Lux Aeterna: ISEA 2019, Catalog 2019, Gwangju, Republic of Korea

25th Anniversary of ACMMM: ACMMM 2017, Interactive Art 2017, Mountain View, CA

BioCreation & Peace: ISEA 2017, Catalog 2017, Manizales, Colombia

White Noise, EOYS Catalog 2016, The Media Arts and Technology Program, UCSB, SB, CA

CURATING

Integration, AWMAS 2020, Art Gallery, UCSB, SB, CA

White Noise: 2016 End of Year Show, UCSB, SB, CA

FUNDED RESEARCH & GRANTS

2020 - National Science Foundation, Elements: Cyber-infrastructure AlloSphere, SB, SB, CA

2017 - Hydrogen-like Atom, The Wolf Museum of Exploration + Innovation, SB, CA

2014 - 2015 - AlloSphere Research Group - Educational, Mosher Foundation, SB, CA

2011 - 2012 - Center for Nanomedicine, Animation & Simulation, AlloSphere, SB, CA

PANELS

Panel Organizer, A Vision for Change, Leonardo/LEAF, CAA 2021, NY, NY

A Vision for Change, Ars Electronica Conference 2020, Linz, Austria

2020 - Tempor(e)alities: time and temporality in XR media (VR, AR, MR) - What is time? What is contemporary time? The Society for Cinema and Media Studies (SCMS) Conference 2020, Denver, CO

AWARDS

Academic Senate Research Grant, Etherial & Myrioi with Dr. Kuchera Morin, MAT, SB, CA

AlloSphere, Goleta's Finest Innovation Award - Goleta Chamber of Commerce, Goleta, CA

Etherial – ISEA 2019: Lux Aeterna, Asia Cultural Center, Gwangju, Republic of Korea

ABSTRACT

Shaping Space as Information: A Conceptual Framework for New Media Architectures

by

Gustavo Alfonso Rincon Jr.

Starting from the notion that every material object/structure **embodies** the information that **enables** its use, the computational platform facilitates exploring **generative** information **constructs** as ever-changing dynamic **structures,** comparable to the self-organizing systems found in nature.

A study of forms, patterns, and spaces has been undertaken for creating generative media artworks designed for **amplifying** the reciprocal relationship between an environment that shapes its content and content that shapes its environment.

A main focus of this research is the generation of unique forms of architecture using agent-based behaviors controlled by self-organizing systems. These unique forms of architecture determine, and are, in turn, determined by, the shape of virtual worlds/environments.

Another important focus of this research is the investigation of software platforms that **provide** the fundamental instruments that produce the content, **and that help make and shape** the virtual worlds/environments.

In a series of designs, exhibitions, and studies, a New Media Architectural Methodology **is** presented.

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δοκεῖ δὲ αὐτῶι τάδε· ἀρχὰς εἶναι τῶν ὅλων ἀτόμους καὶ κενόν, τὰ δ'ἄλλα πάντα νενομίσθαι [δοξάζεσθαι].
(Diogenes Laërtius, Democritus, Vol. IX, 44)

The first principles of the universe are atoms and empty space; everything else is merely thought to exist. (trans. by Robert Drew Hicks 1925) [1]

1.1 Introduction

Everything is information [2] [3] [4] [5]. Space is information. Complex systems are information. Our world outside of our understanding is information; all movement around information links all of humanity together, commerce, the internet, and telecommunications [6]. The computational platform that controls our world uses information as data and has changed our societal progress. Currently, the algorithm [7] [8][9] is the tool that generates the content and the model and makes the world and the information that resides within it. Complexity becomes an essential key for shaping space as information.

This dissertation draws from the concept of complex systems to investigate relationships between the systems' parts and their whole and how the systems' parts give rise to its collective behavior [10] [11] [12] [13] [14] [15] [16]. This notion of complex systems theory will be applied to the making of this field of *New Media Architectures* (*NMA*), the idea that information can be shaped as the content and the environment from the algorithm that generates the data. The various spatiotemporal relationships that occur at various levels of scale in an artistic installation are similar to a complex system. To be able to apply dynamic transformations of space as information among these various levels of scale will be a focus in the field of *NMA*.

This field will draw upon the strengths of the disciplines of art, architecture, media arts, and the sciences to form a new hybrid discipline. From those fields, I will extract three subareas of research that I believe form the field of *NMA*: **Algorithms,** the tool that can create the environment and the content that resides within it, the **World** that is generated from the algorithm that is the environment, and the **Instrument** that is the tool that generates the algorithm that makes the world and the content that resides within it.

1.2 Motivation

In the mid-twentieth century the study of emergence became a subject of interest for fields outside of the hard sciences. With the abstraction of the flocking and swarming algorithm [17] [18] [19] on the computational platform, many different fields could study emergent phenomena [20] [21]. This became an important motivation in the arts [22] [23] [24] [25] [26] in the mid-twentieth century [27]. A new mathematics that allowed one to use self-organization and generative principles in the arts became a driving force in the latter half of the twentieth century [28].

In the fields of architecture and music, this became an important area of growth with the collaboration of composer Iannis Xenakis and architect Le Corbusier [29], who worked together to build the Philips Pavilion out of Xenakis' composition *Metastaseis* [30] [31]. It became clear that the composition and the building are information that can be transformed from one to another. Now with the computational platform as the instrument of choice, solutions are algorithmic and mathematically based, facilitating the use of self-organizing computational algorithms that can shape space over time [32], just as emergence in nature builds structure and form [12].

My motivation for this research into *NMA* is this investigation of complexity in self-organizing systems - a practice to conceptually frame a new area of Media Art Poetics, shaping spaces through emergence, and to formalize a new role for the creation of forms. Architecture and self-organizing systems are the basis of creating environments, one a built-fixed structure, and the other, a dynamically changing structure, that molds its shape according to the needs of the inhabitants.

The use of self-organizing systems as a research challenge is a true reflection of how our world functions through our contemporary understanding of the sciences. As part of my practice in the media arts, I used the domain knowledge of architecture to tackle problems of art, engineering and science to reveal form and shape. Each of the areas of arts research has its own unique aesthetic problems to solve, but focusing on how each one produces patterns and space in time reveals an opportunity to explore and make new discoveries [33].

Our computational tools of today are engaging these challenges through computational models and instrumentation at the highest resolutions currently available. The limitations of these tools are the questions that are being asked of the data through mathematical and theoretical models. My questions are two-fold:

1) How can a natural complex system's state be encapsulated through an artistic practice of architecture? and

2) How can the engagement of the poetic question these systems create be examined rigorously to further evolve the media arts?

1.3 The Problem Statement

With the formal structures and mathematical languages that have been developed over many years in the disciplines of architecture and music, can the computational platform, as a tool for uncovering self-organization, lead to a new and unique approach for dynamically varying forms and shapes in these disciplines? Can this help to shape a language for the new hybrid area of media arts, that encompasses multi-dimensionality of dynamically varying form and shape in the various modalities of sight, sound and the other senses? On the side of technology, can the current limitations in computational power and domain specificity of the software [34] be redesigned to accommodate this new field of media architectures?

In studying those media works that have inspired this exploration of self-organization in both the visual and sonic domain, I will look for commonalities and complementation in patterns that unfold both visually and sonically, and in developing my prototypes for this language, I will use interaction/navigation as a guide for shaping the spatial structures over time. I will also be looking at the technological systems that were applied to these media works, analyzing the limitations of the systems' designs and looking at their assets as well.

In shaping this new language, I propose that forms and shapes are dynamically changing spatial constructs composed of units of information that define the space of our universe. Just as Benjamin Bratton describes in his book the "*Stack,*" different scales of computation, the cloud, the city, the address, the interface, the user, can be viewed not as independent parts but as a technological structure of components working together as a whole [35], one can now look within this structure described by Bratton and use the digital information, the self-organizing algorithms as a basic unit of material to begin to build larger structures that dynamically vary over time [36].

1.4 The Methodology

The engagement of this dissertation through a media arts practice was an evolution of the making of my prototypes that led to a series of investigations that looked at the transformation of information as an algorithmic process that created the forms that occupied the spaces.

The challenges of each artistic immersive work or scientific visualization problem builds on each other to probe questions of composition, narrative and computational system logic.

The challenge in architecture is the exploration of complex emergent works as initiator of forms [37]. The arts explored the phenomenon in the mid-twentieth century with Iannis Xenakis as mentioned above [38], and then progressively the fundamental paradigm shifted to *Liquid Architectures* from Marcos Novak [39] giving rise to the evolution of my conceptual framework that encapsulates information as space and space as information.

NMA explores new territories of composition and design with the multiple dimensions that can be created from complex systems [40]. A seminal integrative factor of *NMA* is the understanding that all things mediated with technology [41] can be filtered and turned into new spatialized structural forms.

The explorations with biology [42] [43] [44] [45], systems theory, and quantum physics inspired exploring the scientific process. The claim of the research is that I locate my work in a search space between architecture, media arts, and material sciences. The research with the AlloSphere [46], directed by Dr. JoAnn Kuchera-Morin, working on architectural engineering instrument design, is a focal point in the investigation of technology between the arts and sciences [47]. The links between augmented, virtual, mixed, and extended realities that I uncovered working with the Four Eyes Lab [48] (Professor Tobias Hollerer) and transLAB [49] (Professor Marcos Novak) will be discussed, including the extensive design research of the various instruments and environments that I discovered amongst those laboratories.

1.5 Structure of the Dissertation

In this first chapter of the dissertation I described the research focus and articulated the motivations and the problem statement including a brief summary of the methodology. Chapter 2 titled "Historical Background of New Media Architectures" frames the fundamental questions of the research through the creation of an identifying list of works that combine architecture, media arts, and sciences focused on complex systems of self-organization. In Chapter 3 "Methodology: Investigations through Prototypes," the challenge of space as an informational computational sensorial art form will be presented in three parts that introduce: 1) the algorithms and the mathematics [50] explored through patterns and object studies, 2) the conceptualizing and building of virtual worlds as a generator of material reality through computational representations describing narrative, and 3) the constructs and instruments of immersion through case studies of created works of media arts and engineering. In Chapter 4 Implementation "What are Media Architectures," I will give a definition of *NMA* and the constructs that define the field. Finally, Chapter 5 will be conclusions and future directions. In this chapter, I will summarize my concluding remarks of this field of *NMA* and discuss the future directions of my research in this new field.

PART I - New Media Architectures: Inspirations

Chapter 2

Historical Background of New Media Architectures

In this history, I will trace through the most important components that I have gathered to define the field of *NMA*. One of the first and foremost areas is the definition of space and how these ties in into the shaping of space [51]. The second most important area is the algorithmic processes for self-organization leading to complex systems because it is the key driver for *NMA* and the shaping of space. The other areas that I will discuss will deal with the evolution of the computational platform that is the instrument for the use of the algorithm and how this grows into using the computer for scientific visualization and representation through the senses. This will lead us to the importance of virtual reality and worldmaking [52] [53].

How does one shape space as information?

2.1 NMA and shaping of spaces

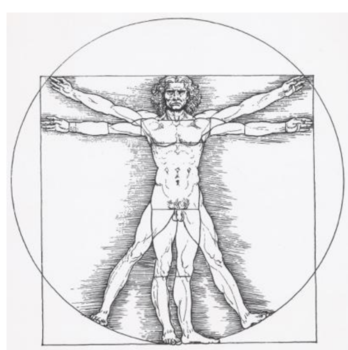


Figure 2.1 An illustration of Leonardo da Vinci's Vitruvian Man, 1490
Accessed on September 15, 2019. https://mymodernmet.com/leonardo-da-vinci-vitruvian-man/

Figure 2.2 An engraving of the Christian Aristotelian Cosmos from Peter Apian's Cosmographia, 1524. Accessed on September 15, 2019. http://abyss.uoregon.edu/~js/ast123/lectures/lec02.html

What is Space? (Figure 2.1) [54] And why can space in itself be shaped as information? (Figure 2.2) Referencing “Radical Dimensions” by Margaret Wertheim, she states,” Aristotelian physics didn’t include a theory of space, only a concept of place [55]. Aristotle denied the theory of Atomism which was described by Leucippus and Democritus as the material world being composed of miniscule particles moving through a void. It took centuries for the concept of void to come back into the history of space through Galileo and Descartes.

Galileo and Descartes' perspectives included the idea of a void that became known as space). In the 14th to the 16th centuries, artists Giotto, Paolo Uccello, and Piero Della Francesca brought into their paintings “Perspective” which became known as, ‘Geometric Figuring.” As one would view a painting at that time, it was though they were looking into another world. This would be in Wertheim's opinion a type of virtual reality. So, in a sense the artists were foreshadowing the formation of three-dimensional spaces through their perspectives in their paintings.

An idea of space unfolding in the real world, came from the studies of Galileo and Descartes. Galileo could show objects like cannon balls moving through space with mathematical laws. Space was an abstraction, a void that was defined by Euclidean Geometry [56].

An Important philosopher of the time was Pierre Gassendi [57], a Mathematician and Catholic Priest. He is accredited for reviving the ancient theory of Atomism. He departed from both Galileo and Descartes in contradicting their ideas that mathematics explained atomism, he believed that this could be explained best by the humanities, philosophy and words. In Max Jammers book, The Concepts of Space: The History of Theories of Space in Physics, he writes, "Gassendi space is a necessary, infinite, immobile, and incorporeal datum of three dimensions. It is certainly no fiction, not even the mode of a substance." [58] While Gassendi re-introduced ancient atomistic ideas of Democritus and Epicurus referencing "On the Nature of Things," by Lucretius [59] [60], his work critically builds on Descartes views on Atomism, which later influenced Robert Dalton in the 18th and 19th centuries in his introduction of Atomic theory into Chemistry [61]. Gassendi's work furthered the modern conception of space [62] [63] [64].

Returning back to Newton's expansion of Galileo's idea of space in the real world to space extending throughout the universe [65]. The structure of space is a geometrical proposition. The forces are what extends space as can be seen by Einstein's theory of general relativity. This is where the forces come into play for extended space. There were three fundamental categories: space-time, matter, and force. Once Einstein solidified his theory of relativity [66]. This is where the forces come into play for extended space. The fundamental categories were three: space-time, matter, and force. Once Einstein solidified his theory of relativity, he found that gravity was an artifact of shaping space. The forces become important in describing higher dimensional space. For Einstein, gravity comes from the inherent geometry of a four-dimensional manifold.

Moving forward into the 1960's, physicists discovered additional forces: the weak nuclear force and the strong nuclear force [67]. These new forces allow the move into higher dimensions. Accelerating now to the present, Carlo Rovelli, theoretical physicist and founder of quantum gravity theory, in his work bridging general relativity and on quantum fields theory [68] [69], reflects back on Democritus when he writes,

> *"it is not just a question of these atoms but also of the order in which they are arranged. We are not atoms; we are orders in which atoms are arranged, capable of mirroring other atoms and mirroring ourselves."*

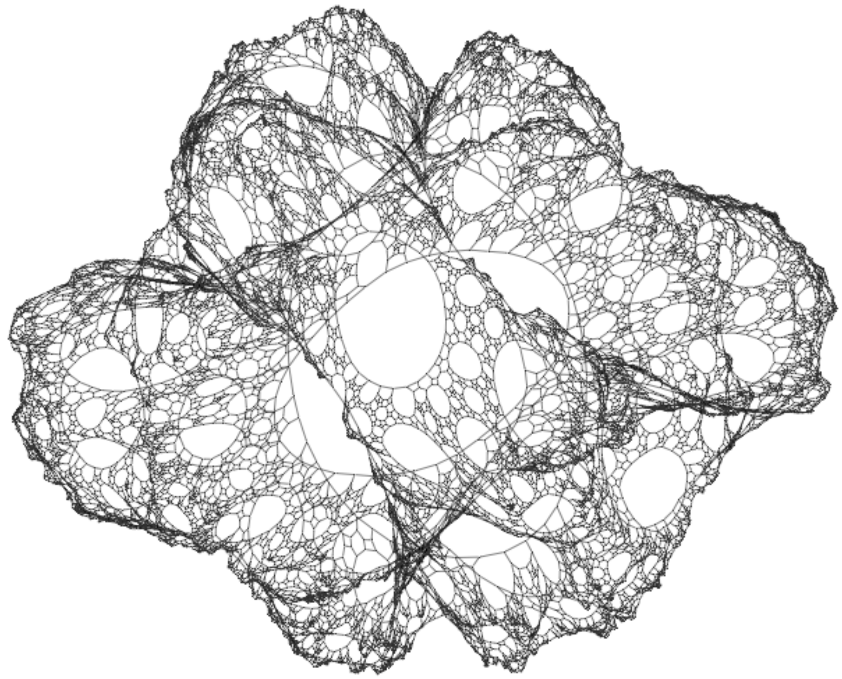


Figure 2.3 Stephen Wolfram, Space as a Network, 2015
Accessed on September 15, 2019. https://writings.stephenwolfram.com/2015/12/what-is-spacetime-really/

Returning to the present, Stephen Wolfram gives the following quote:

> *"Space as a network, so could this be what space is made of? In traditional physics—and General Relativity—one doesn't think of space as being "made of" anything."* [70] [71]

This concludes my historical background of space. For the purposes of this dissertation, we will assume that space is a substance that can be formed and shaped. Space traversing history has changed definition throughout the centuries from investigations in the areas of philosophy, religion, science and technology. I explore the deformation of space as information as both an architectural scholar and media arts researcher.

2.2 Historical Research Areas: Algorithms, Worldmaking, & Instrument Design

If self-organization and the laws of nature shape space by the content residing in the environment, then the algorithm becomes the important driver for shaping space as information on the computational platform.

So, as we go through this history, the fields of architecture, media arts [72], and the scientific fields are most important for defining the field of *NMA*. The algorithm comes from the scientific fields, the world or structure derived from the field of architecture and the instrument that comes from a culmination of the field of media arts and technology, which includes the computational sciences, engineering, and the Arts.

How did algorithmic processes begin to form worldmaking and instrument design in the fields of architecture and media arts?

Starting with Le Corbusier, Xenakis, and leading to Novak with *Liquid Architectures*, we can see with Le Corbusier and Xenakis, the integration of the spatiotemporal aspects of music [73] [74] [75] [76] [77] with architecture and building design. Xenakis used stochastics and probability theory in his musical compositions [38].

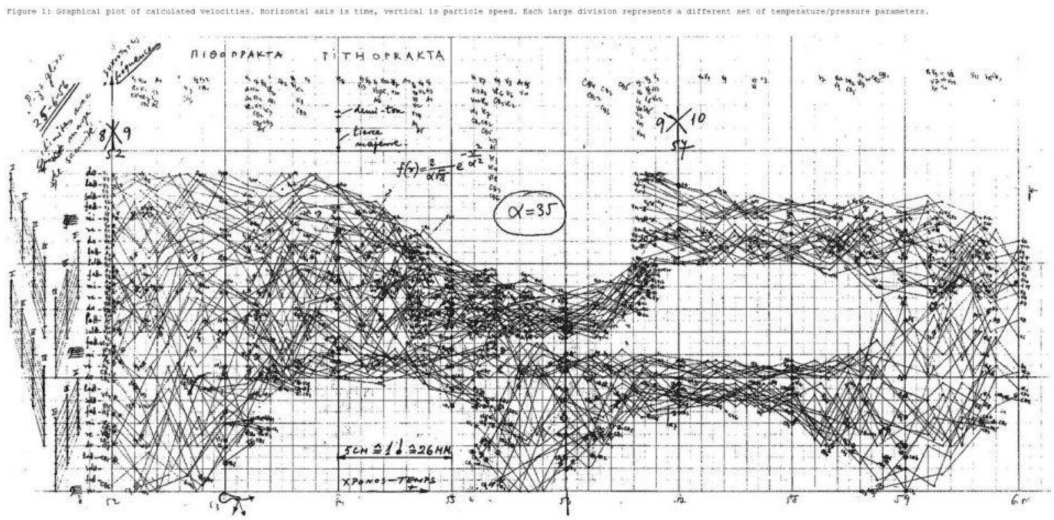


Figure 2.4 Xenakis, *Pithoprakta*, Musical notation: particle velocities to frequencies

Accessed on March 15, 2020. https://music7703lsu.wordpress.com/page/2/

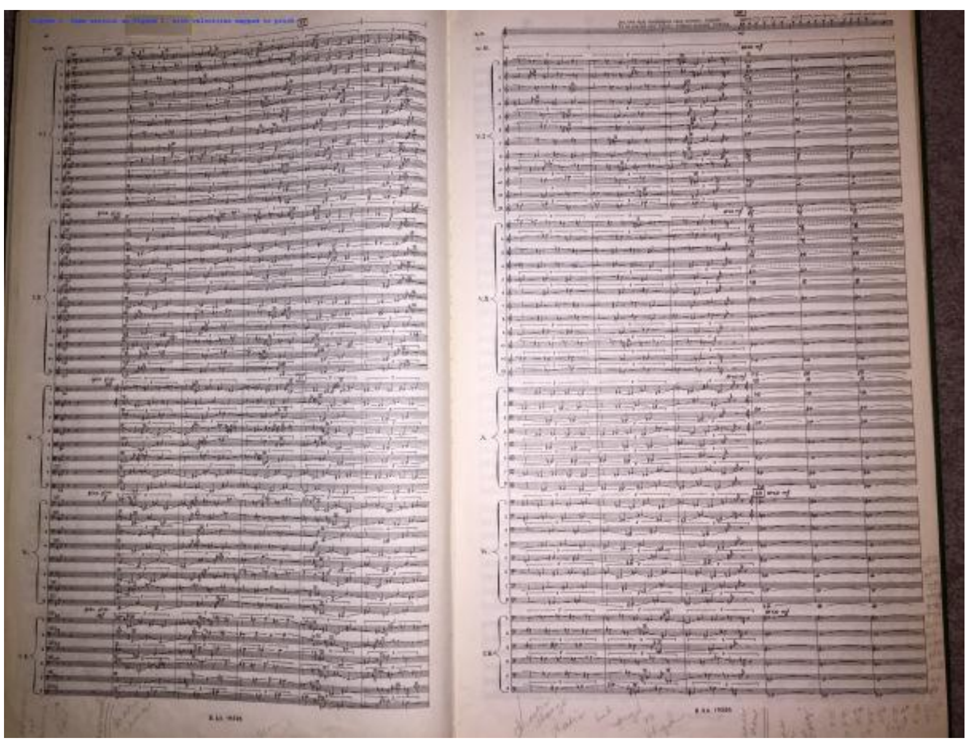


Figure 2.1 Xenakis, *Pithoprakta*, Mapping: the particle velocities section of the score

Accessed on March 15, 2020. https://music7703lsu.wordpress.com/page/2/

The following quote from his book "Formalized Music: Thought and Mathematics in

Composition" points to his use of complexity in his compositions,

> *"I originated in 1954 a music constructed from the principle of indeterminism; two years later I named it "Stochastic Music." The laws of the calculus of probabilities entered composition through musical necessity. But other paths also led to the same stochastic crossroads-first of all, natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws."*

These constructs were taken up by Le Corbusier as he brought these concepts into form and shape based on Xenakis's stochastic musical composition, "*Metastaseis,*" through the building of the Philips Pavilion (Brussels, Expo 58) [30]. Xenakis' musical composition *"Concret PH"* was played while entering the building. Composer Edgar Varèse's "*Poème électronique*," was spatialized by sound projectionists through telephone dial [38].

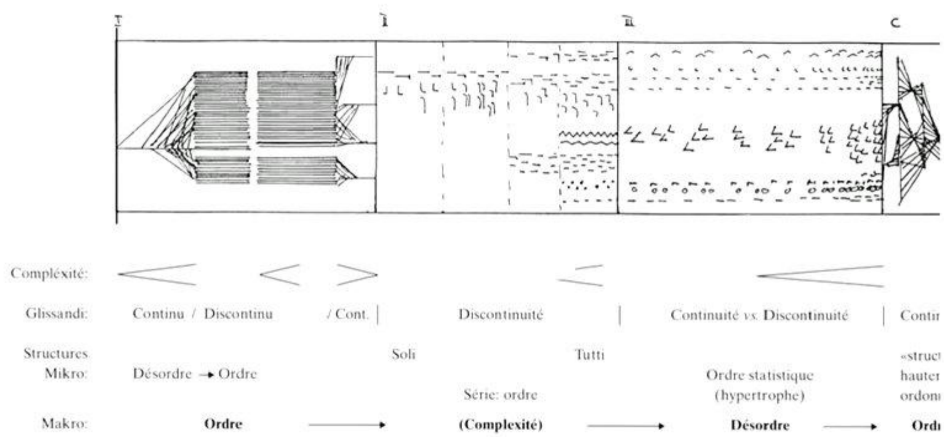


Figure 2.6 Xenakis, *Metastaseis*, a graphic analytical score
Accessed on March 15, 2020. https://music7703lsu.wordpress.com/page/2/

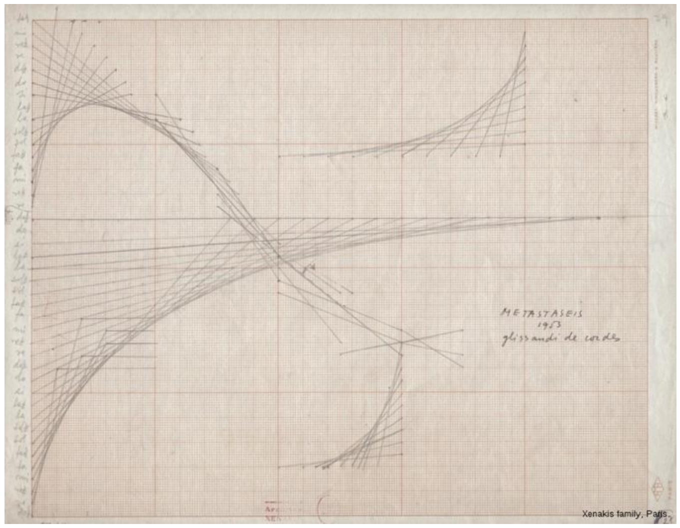


Figure 2.7 Xenakis, *Metastaseis*, **a sketch of part of the musical score**
Accessed on March 15, 2020. https://architexturez.net/file/xenakis-iannis-graphic-lo-1200x926-jpg

Figure 2.8 Xenakis and Le Corbusier, ***Philips Pavilion*** **(Brussels, Expo 58)**
Accessed on March 15, 2020. https://www.archdaily.com/157658/ad-classics-expo-58-philips-pavilion-le-corbusier-and-iannis-xenakis

This led Xenakis to incorporate a new mathematical structure into his acoustic works before the computational platform. Le Corbusier used these same mathematical principles to build the Philips Pavilion [78] [79].

Another forward-looking researcher in the field of architecture was William J. Mitchell. Mitchell strongly believed that computers could aid designers. In *Computer-Aided Architectural Design* (1977), Mitchell predicted that personal computers would revolutionize architecture. In 1992, he became Dean of the School of Architecture and Planning at Massachusetts Institute of Technology (MIT) and launched unusual prototypes of architecture.

Mitchell is well known for developing the use of Computer-Aided Architectural Design (CAAD), which enabled the use of the computational platform in architecture, so that the tool wasn't just used to represent objects manually, but could use a data of information to draw from that is specific to architecture [80]. CAAD not only facilitated this, but also could be a predictor of performance of design solutions and thus generating new design solutions. This was done through algorithmic processes and other methods. This facilitated internet collaboration and the use of the internet as a design of the virtual space for remote collaboration.

Mitchell was a facilitator of algorithmic processes using the computer for architectural design. In his book, "*City of Bits*" published in 1995, William Mitchell discusses the concept of recombinant architecture, that advanced computational systems allow for virtual architectural design that can substitute for the physical, he says that of course built spaces will still be built, but the virtual space will facilitate the organization and facilitation in new ways [81]. According to Mitchell, “Many traditional building types are likely to fragment and recombine.” In my opinion, this book foreshadows virtual reality for architectural design. Computational platforms are predicted to help us redesign space that has become malleable and dynamically transformative. Mitchell describes this change as follows:

> *“ubiquitous computing and mobile wireless networks are used to reconnect us to the real world. We should no longer think of ourselves as 'fixed, discrete individuals' but as nodes in a network.”*

Clearly, Mitchell is a precursor to Marcos Novak’s *Liquid Architectures,* as Mitchell begins to unveil the power of the computational platform as the tool, the instrument for shaping *NMA* [82] [83] [84] [85].

Let’s forward to Marcos Novak. Mitchell was Novak’s former professor and it is clear to see the influence in Novak’s work dealing with the fluidity of structure. In his paper, “*An Experiment in Computational Composition*” published in 1988 [86], he writes,

> *“A compositional study based on a visual interpretation of information theory is introduced. An algorithm is presented that relates variety in spatial parameters to visual information, along with a genetically inspired mechanism for refining a design through cycles of incremental cumulative changes. Two- and three- dimensional examples”*

This article in my opinion represents the transformation of grid-like structures into curvature structures through the use of genetic algorithms [87]. The virtual objects shown below are a result of years of Novak's research in forming genetic algorithms in virtual environments.

Figure 2.9 A transformation of a grid into curvature designs using a genetic algorithm - 1

Accessed on September 15, 2020. https://www.semanticscholar.org/paper/Liquid-Architectures%3A-Marcos-Novak%26%23146%3Bs-Territory-Silva/092391c3418033a875330e6ee68d9f325cef819a/figure/1

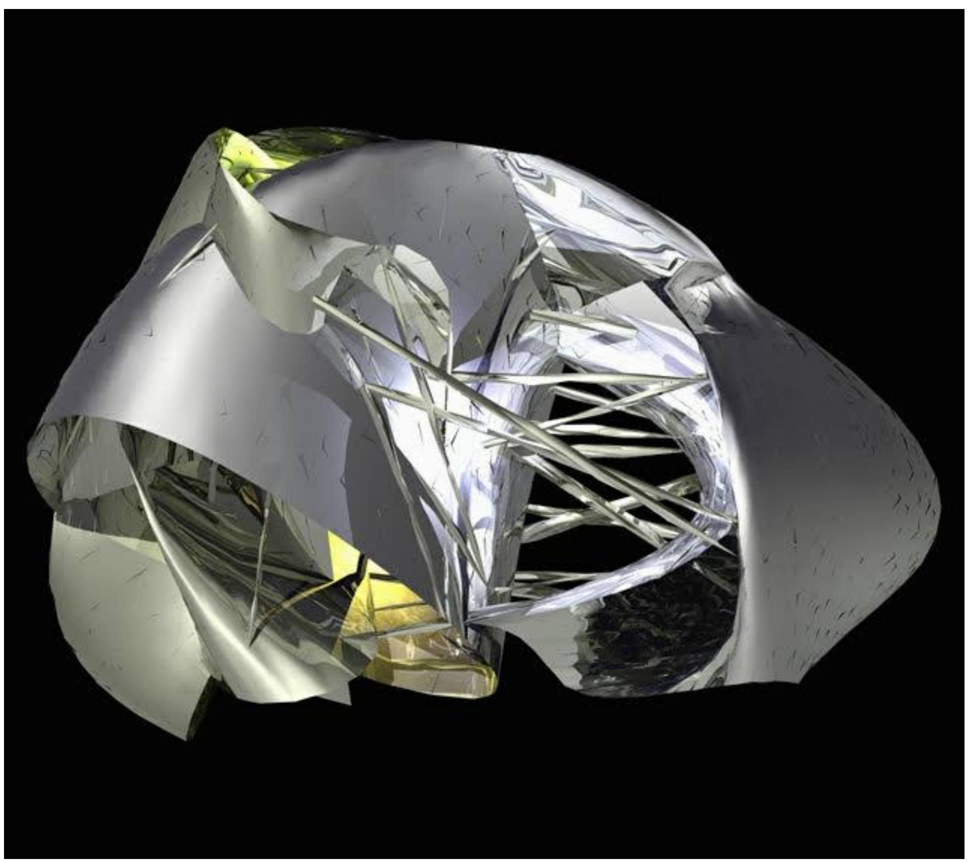


Figure 2.10 A transformation of a grid into curvature designs using a genetic algorithm - 2
Accessed on September 15, 2020. http://www.kmtspace.com/novak.htm

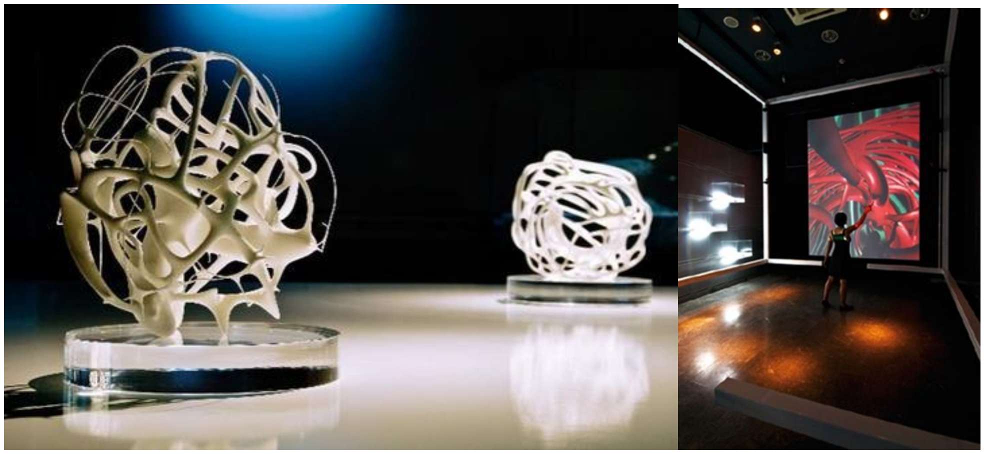


Figure 2.11 Novak's *Turbulent Topologies*, fabricated forms & installation 2008
Accessed on September 15, 2020. http://bloghistapercaso.blogspot.com/2015/06/marcos-novak.html

The algorithmic shaping of spaces found in nature replicated by the computational platform is the new fluidity of shaping form and details how it can reconfigure itself with self-organizing principles [88] [89] [90] [91] [92] [93] [94] [95] [96]. This was a definite contribution from Novak and his predecessors, and an evolution for the field of architecture.

Much like nature can reconfigure itself through self-organizational principles, space can be reconfigured through these algorithmic processes in this same way with the abstraction of the flocking and swarming algorithm. It is information that is being shaped and organized.

Moving to the computational platform as an instrument of choice for using the algorithm for self-organization, Alan Turing becomes an important figure. Turing was responsible for the development of theoretical computer science. He formalized the concepts of the algorithm and computation. This was accomplished with the Turing Machine.

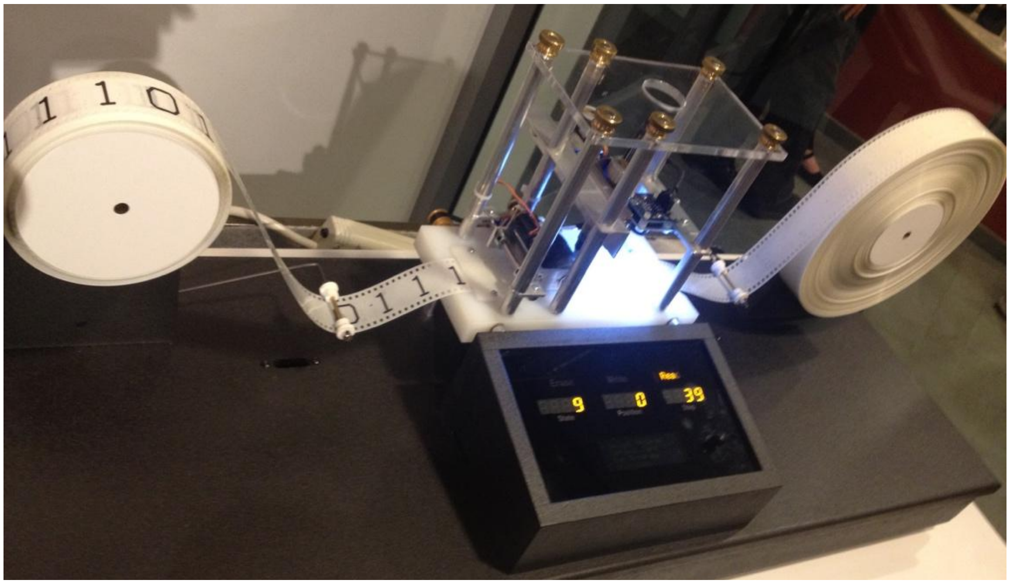


Figure 2.12 An implementation of the Turing Machine
Accessed on June 29, 2019. http://aturingmachine.com/

The Turing Machine is considered a model for the general-purpose computer. In his work titled, "*The Chemical Basis of Morphogenesis*," Turing mathematically proved the links between physics and nature through patterns. He states,

> *"It is suggested that a system of chemical substances, called morphogens, reacting together and diffusing through a tissue, is adequate to account for the main phenomena of morphogenesis. Such a system, although it may originally be quite homogeneous, may later develop a pattern or structure due to an instability of the homogeneous equilibrium, which is triggered off by random disturbances. Such reaction-diffusion systems are considered in some detail in the case of an isolated ring of cells, a mathematically convenient, though biologically, unusual system."*

This biological description into mathematics moves forward as he states,

> *"The investigation is chiefly concerned with the onset of instability. It is*

found that there are six essentially different forms which this may take. In the most interesting form stationary waves appear on the ring. It is suggested that this might account, for instance, for the tentacle patterns on Hydra and for whorled leaves. A system of reactions and diffusion on a sphere is also considered."

In his two seminal papers, as discussed above, Turing describes the importance of his mathematical principles that he then abstracts to the computational platform [97].

As the computer became the instrument of choice, Craig Reynolds, developed the artificial life program [98] [99] [100] Boids, in 1986 [101] [102]. This algorithm is an example of emergent behavior [103].

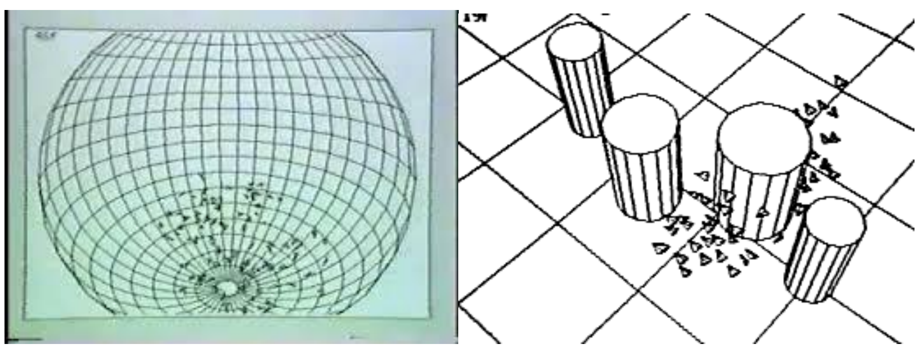


Figure 2.13 Boids algorithm in 1986, computer screen & Boids avoiding obstacles
Accessed on June 29, 2019. https://www.youtube.com/watch?v=86iQiV3-3IA

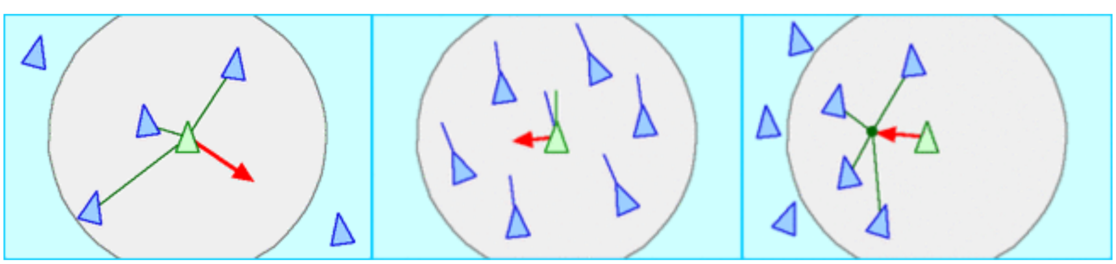


Figure 2.14 Boids algorithm, separation, alignment, and cohesion
Accessed on June 29, 2019. https://towardsdatascience.com/optimising-boids-algorithm-with-unsupervised-learning-ba464891bdba

The example above shows birds flocking together, simulating nature with the simple rules of separation, alignment, and cohesion. Reynolds writes about the character of the virtual agents in his system as,

> *"The motion of a flock of birds is one of nature's delights. Flocks and related synchronized group behaviors such as schools of fish or herds of land animals are both beautiful to watch and intriguing to contemplate. A flock exhibits many contrasts. It is made up of discrete birds yet overall motion seems fluid; it is simple in concept yet is so visually complex, it seems randomly arrayed and yet is magnificently synchronized." (Reynolds 1987)*

Reynolds is clearly stating that although there is individual agent activity the agents work in group formation and are synchronized. This gives us the opportunity to use the computational platform for agent-based modeling and navigation. The computational platform becomes the instrument and the algorithm becomes the tool for shaping space as information.

With the development of the computer, the evolution of the interface became an important area of research. This leads to the history of virtual reality and worldmaking. This helps to contextualize what engineering, media arts and computer science have offered to this field of *NMA*.

Multimodality, the use of human-computer interaction (HCI), and gestural control for navigation become important drivers for virtual reality. The use of visualization and also haptics, are also results from computer science and engineering. The field of media arts focuses on the further senses as well as the aesthetics [104] [105] [106] [107] of multi-modal representation of information [108] [109]. All of these disciplines contribute in part to the building of this new field.

As we look back at the Philips Pavilion and see this as the making of a world through the algorithmic processes, this leads to instrument design and evolves the computational platform as instrument and environment.

The Osaka Pavilion [110] [111] [112] [113], which was an audio installation designed by Karlheinz Stockhausen, was both instrument and environment in my opinion.

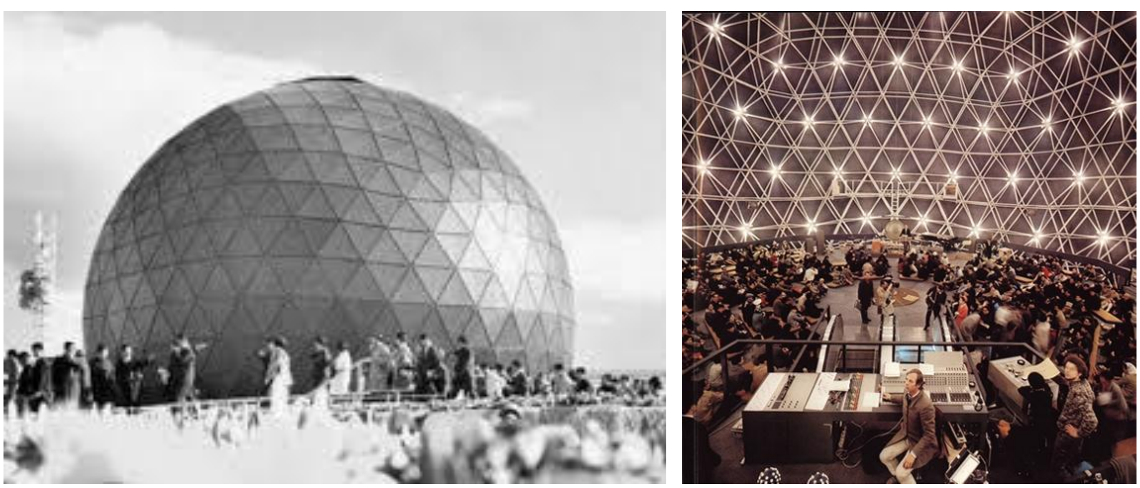


Figure 2.15 Stockhausen's Osaka Pavilion: a photo from outside the Expo & Inside the Dome
Accessed on July4, 2018. http://www.medienkunstnetz.de/works/stockhausen-im-kugelauditorium/

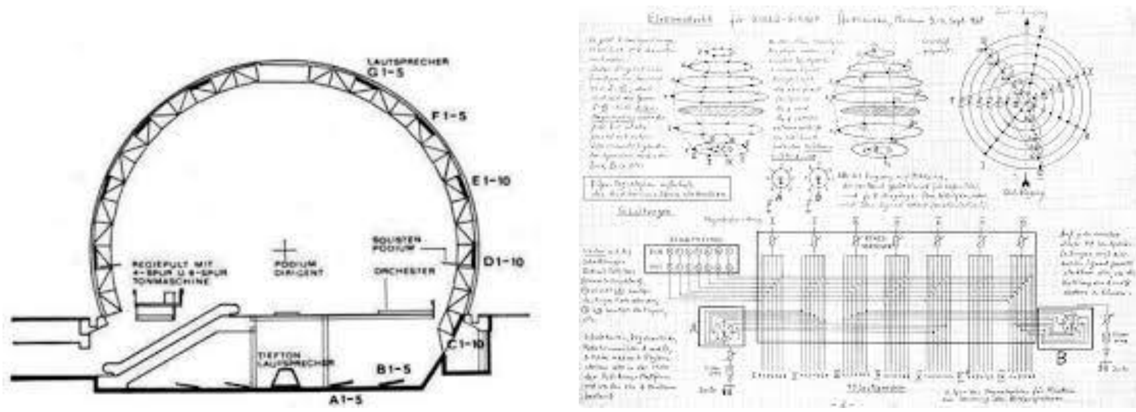


Figure 2.16 Stockhausen's Osaka Pavilion: Section & diagrams of sound projection
Accessed on July4, 2018. http://www.medienkunstnetz.de/works/stockhausen-im-kugelauditorium/

A system was developed that allowed the movement of sound that engulfed listeners in a 360-degree spherical structural environment. At the same time, the Experiments in Arts and Technology group (E.A.T.) from Bell Laboratories led by Engineer Billy Kluver [114] [115], built the Pepsi Pavilion, a mirror dome at the Osaka World's Fair based on a NASA weather balloon [116] [117]. This in essence became the visual counterpart to Stockhausen's audio environment/instrument.

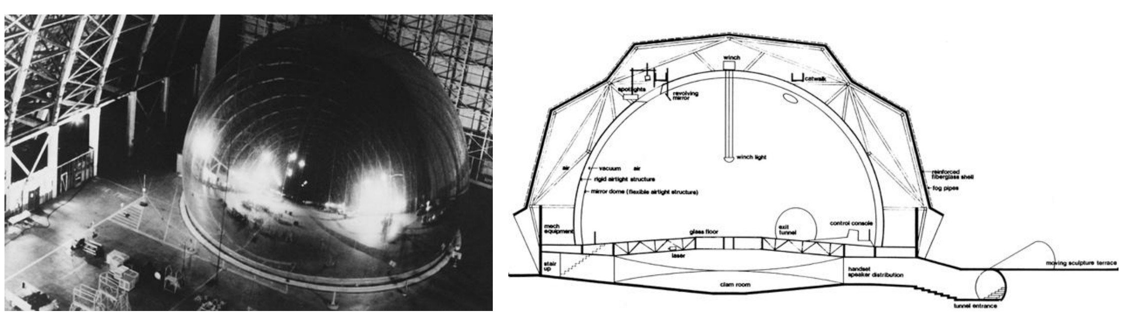


Figure 2.17 E.A.T. Spherical mirror dome prototype & design for 1970 Pepsi Pavilion
Accessed on July4, 2018. http://www.uncubemagazine.com/blog/13753251

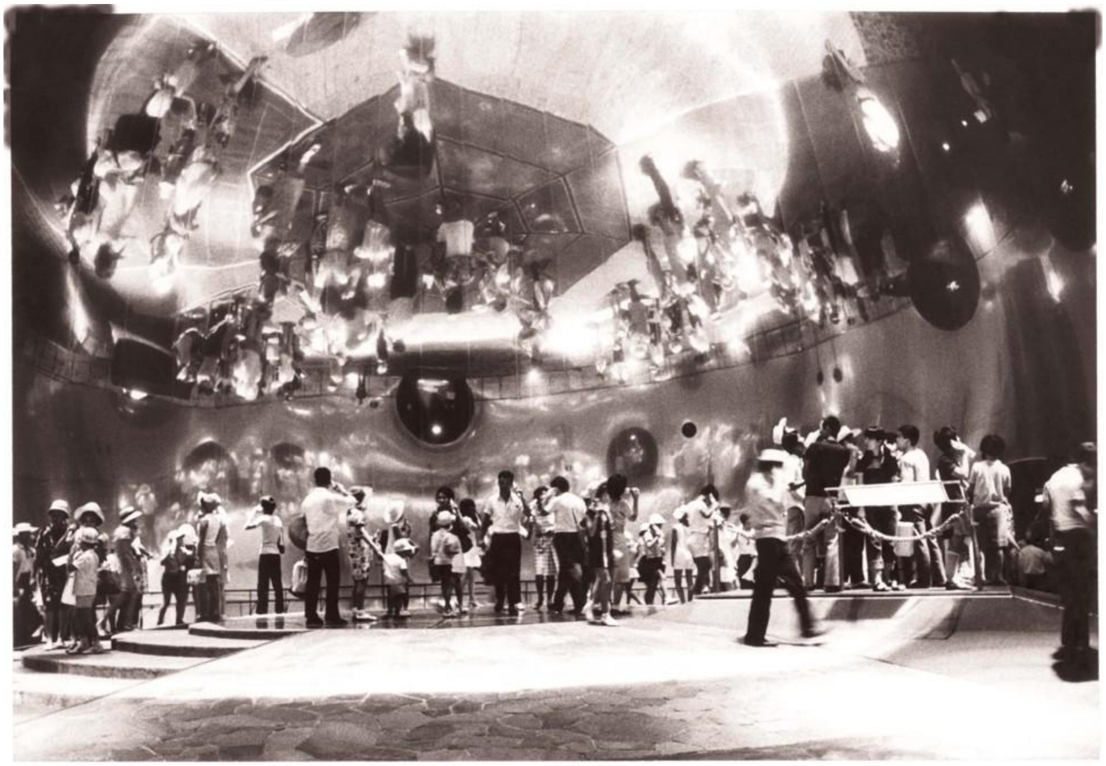
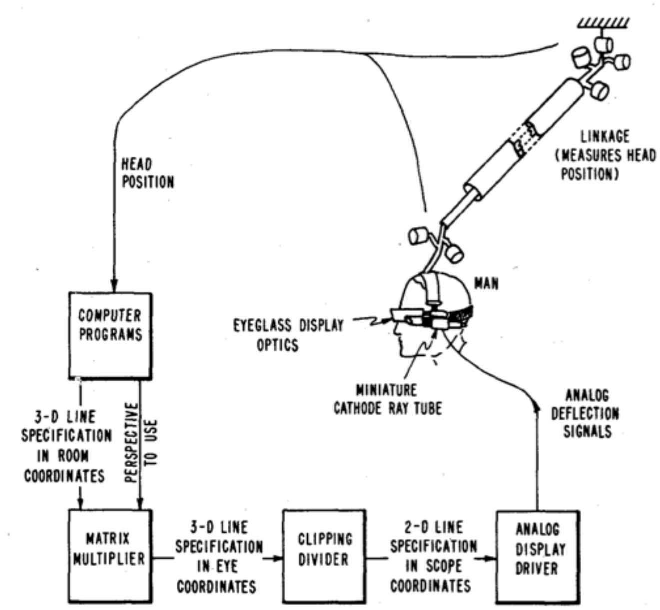


Figure 2.18 E.A.T., Inside the Mirror Dome, 1970 Pepsi Pavilion
Accessed on July4, 2018. http://www.uncubemagazine.com/blog/13753251

Around the same time, the first head-mounted display (HMD), which was an instrument and immersive environment was also being developed. This was the "*Sword of Damocles*," invented in 1968 by Ivan Sutherland and his student Bob Sproull [118] [119] [120]. The term virtual reality was made popular by Jaron Lanier later in the 1980's [121] [122]. Consequently, virtual reality was used by the military for training and by NASA for Aeronautics.



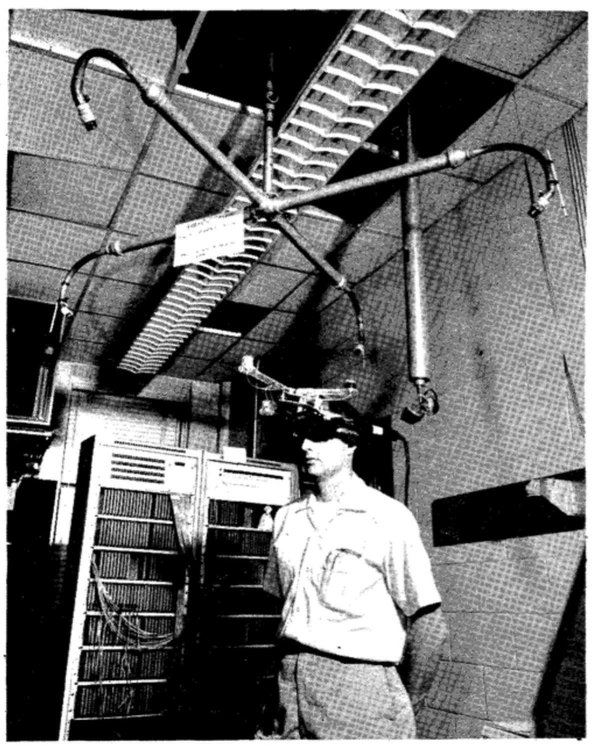


Figure 2.19 Ivan Sutherland, HMD, diagram (top) and documentation (bottom)
Accessed on April1, 2019. https://www.researchgate.net/figure/an-Sutherlands-HMD-31_fig32_216813812

An interesting development in the instrument becoming the environment is Marko

Peljhan’s *Makrolab* designed in 1994 [123] [124] [125]. This is a remote large-scale instrument/environment for the investigation of the intersection between the ecological and technical systems that make our world.

Figure 2.20 *MakroLab*, 1994: Night lab view
Accessed on December 1, 2019. https://www.makery.info/en/2017/07/25/marko-peljhan-lutopie-materialisee-du-makrolab-12/

Figure 2.21 *MakroLab,* 1994: Marko Peljhan and team

Accessed on December 1, 2019. https://www.makery.info/en/2017/07/25/marko-peljhan-lutopie-materialisee-du-makrolab-12/

Peljhan's philosophy of artistic research is that media artists are social activists. Moreover, in the media arts, research is directed by the foundations of the engineering and scientific fields [126] [127] [128] [129].

Figure 2.22 *Polar,* Marko Peljhan and Carsten Nicolai, 2010
Accessed on December 1, 2019. http://www.carstennicolai.com/?c=works&w=polarm

Makro Lab along with other "Machinic" works were analyzed in the book, "*Machine Art in the Twentieth Century*" written by Andreas Broeckmann in 2018 [130].

MakroLab is an example of a portable embedded system that is an environment that one inhabits. As Peljhan's states,

> *"Makrolab is an autonomous communication, research and living unit and space, capable of sustaining concentrated work of 4 people in isolation/insulation conditions for up to 120 days."*

As the separation of instrument and environment became ambiguous, one of the lead artists that was a pioneer in the visual arts for a curved screen projection system that also employed navigation was Jeffrey Shaw. Shaw's work titled "*The Legible City*, *Responsive Environment,*" (1988 - 91) invited viewers to ride a stationary bicycle in front of a curved screen that gave them the feeling that they were pedaling through a city. This work was completed in the late 80's and was visionary for its time [131] [132] [133] [134].

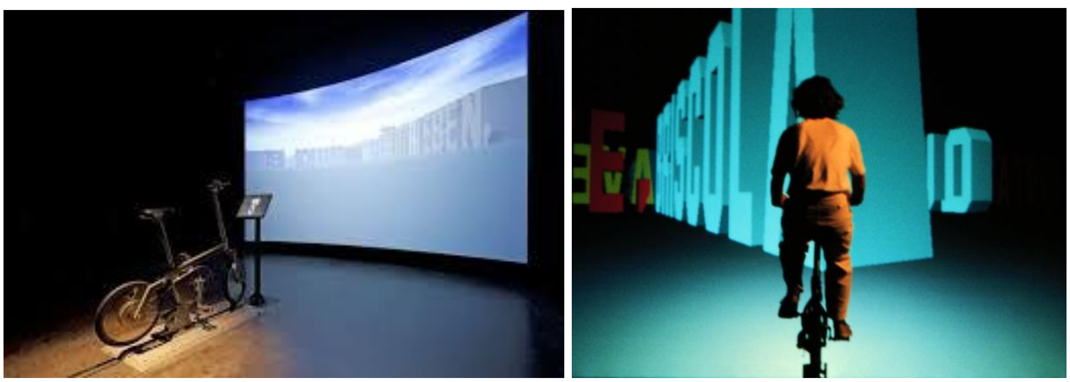


Figure 2.23 Jeffrey Shaw, "*The Legible City*, *Responsive Environment,*" (1988 - 91)
Accessed on September 16, 2019. https://www.jeffreyshawcompendium.com/portfolio/legible-city/

Jeffrey Shaw's career spanned decades. His later works take advantage of full dome capabilities as seen in the picture below [135] [136] [137] [138] [139].

Figure 2.24 Cupola, 2004 in a Hemispherical projection screen of 20 meters in diameter
Accessed on September 16, 2019. https://www.jeffreyshawcompendium.com/portfolio/cupola/

In the early 90's, virtual reality became available to architectural and artistic research through both HMDs and through CAVES. Marcos Novak was one of the first artists to use HMDs for virtual reality installations [39].

His work "*Dancing with the Virtual Dervish: Worlds in Progress,*" 1994 was developed at the Banff Centre for the Arts between 1991 and 1994 [140].

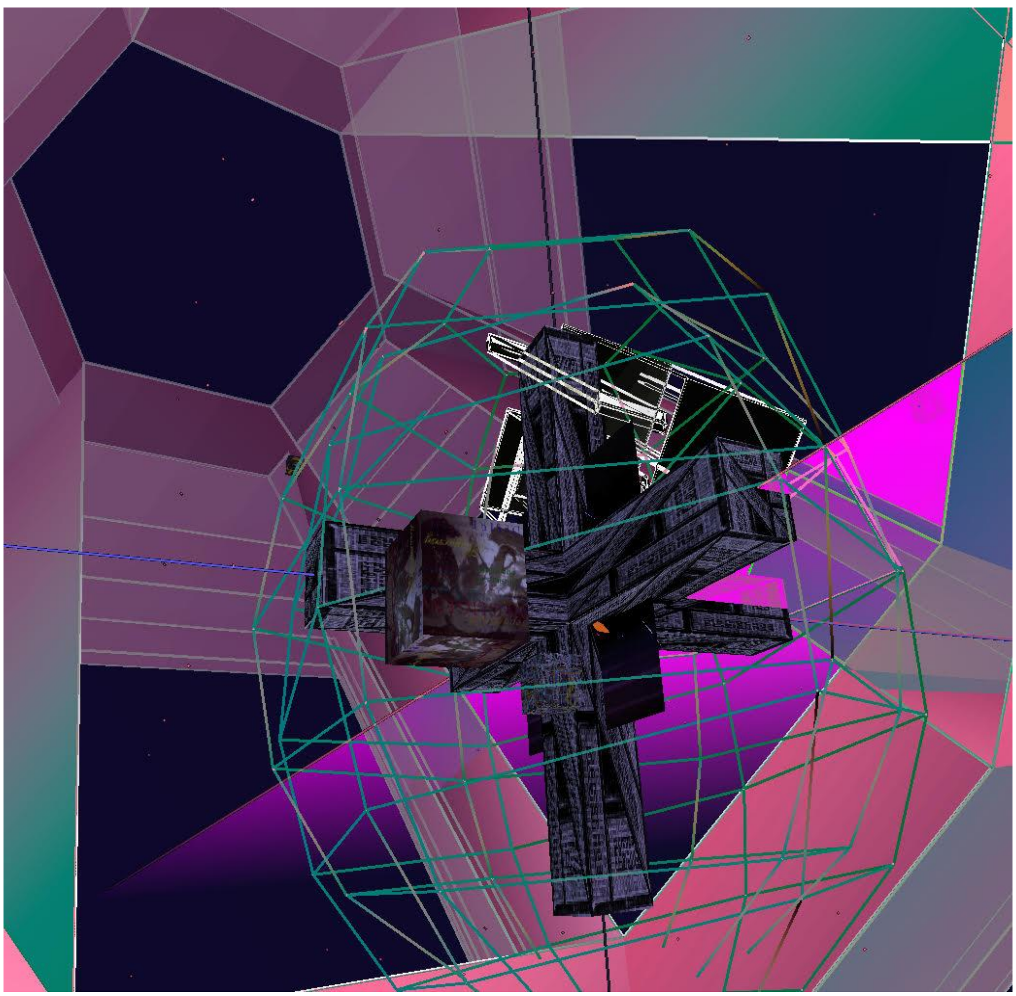


Figure 2.25 M. Novak 1994, *"Dancing with the Virtual Dervish: Worlds in Progress*" an HMD view
Accessed on September 20, 2019. https://repositories.lib.utexas.edu/handle/2152/39485

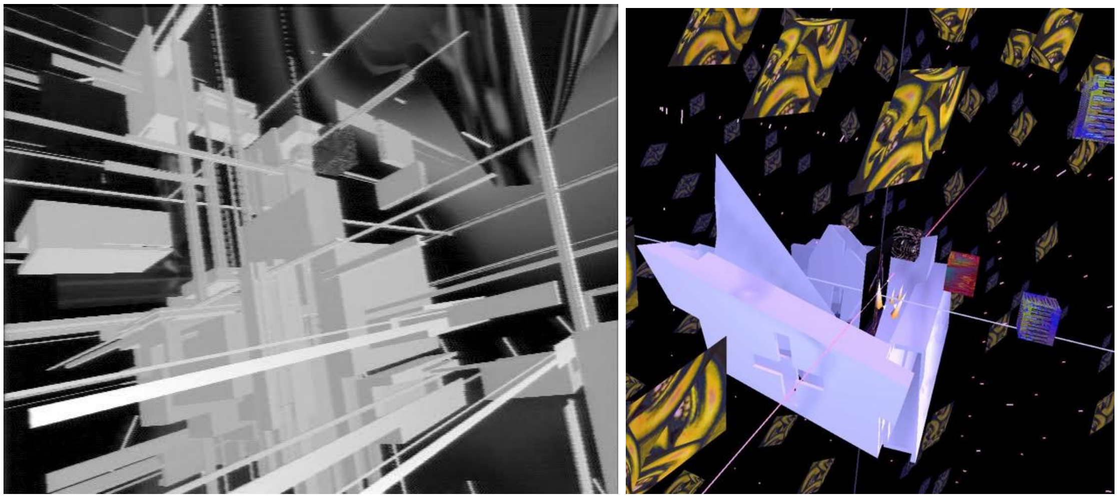


Figure 2.26 M. Novak 1994, *"Dancing with the Virtual Dervish: Worlds in Progress*"
Accessed on September 20, 2019. https://dnarchi.fr/analyses/architecture-resolument-numerique-paradigm-shift-vs-paradigme-albertien-iiii/

Then visual artist Char Davies created the work *Osmose* in 1995 [141] [142].

Figure 2.27 Char Davis, 1995, *Osmose*
Accessed on January 3, 2014. http://www.immersence.com/osmose/

The first CAVE was invented by Carolina Cruz-Neira, Daniel J. Sandin, and Thomas A. DeFanti at the University of Illinois, Chicago Electronic Visualization Laboratory in 1992.

The National Center for Supercomputing was being developed and this brought the hard scientists into the possibilities of virtual reality simulations.

Larry Smarr was one of the leaders in developing the computational platform into the super computer, eventually the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign. In the early 2000's, he moved to the University of California, San Diego in order to build California Institute for Telecommunications and Information Technology, Calit2, that focused on large super computing infrastructure connected to an enormous video wall [143] [144] [145] [146].

Figure 2.28 Larry Smarr, Calit2
Accessed on August 20, 2020. http://sage2.sagecommons.org/2017/02/23/showing-sage2-at-calit2ucsd/

Starting in the mid 1990's, Kuchera-Morin, Composer Media Artists and Chief Scientist of Technology of the University of California, began to design an infrastructure for the University of California, Santa Barbara that integrated the OSAKA Pavilion, the CAVE infrastructure and hemispherical projection as seen in the Hemispherium at UK Tea Side (1998).

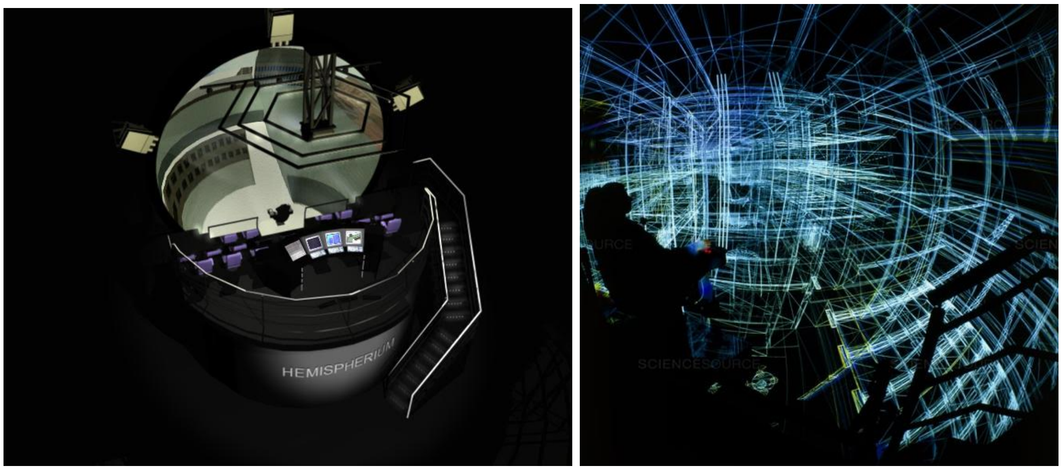


Figure 2.29 Hemispherium developed in 1998
Accessed on August 20, 2020. https://www.sciencesource.com/archive/Wire-frame-VR-Hemispherium-model-of-DSS-offices-SS2141654.html

The combination of these designs plus the idea of a super computational platform were integrated into the AlloSphere Instrument and facility. The idea of a tilt dome hemisphere in a stereo VR environment was also an important basis for building the AlloSphere instrument. Integrating these designs with the idea of a super computation platform into an instrument and facility completed the AlloSphere design [147] [148] [149] [150].

Figure 2.30 The AlloSphere: Interior views – screen and bridge
Accessed on March 20, 2012.https://www.researchgate.net/publication/220721277_The_allosphere_A_large-scale_immersive_surround-view_instrument

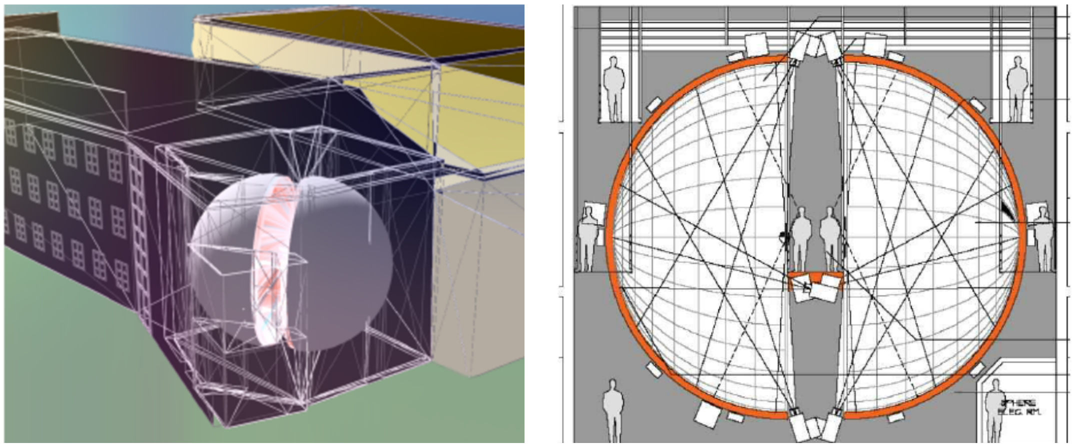


Figure 2.31 The AlloSphere: Design rendering and section
Accessed on March 20, 2012.https://www.researchgate.net/publication/220721277_The_allosphere_A_large-scale_immersive_surround-view_instrument

In 2006, the AlloSphere instrument and facility was completed in its original design, a 4pi Steradian cylinder three stories high, with a bridge extended in the middle that will allow a team of researchers to be immersed in their data while connected to a large distributed computational system. In SIGGRAPH 2007, the first publication describing the design of the AlloSphere titled, "The AlloSphere: A large-scale immersive surround-view instrument," Kuchera-Morin, along with colleagues Hollerer and Amatriain, discuss the details of the concepts, engineering and science, leading to a novel large-scale instrument for immersive visualization and simulation as environment.

The AlloLib [151] computational platform was developed from 2006 to the present, and by 2014, with physicist Lucca Pelitti and media arts researcher Lance Putnam, Kuchera-Morin began prototyping the multimedia compositions based on quantum mechanics [149].

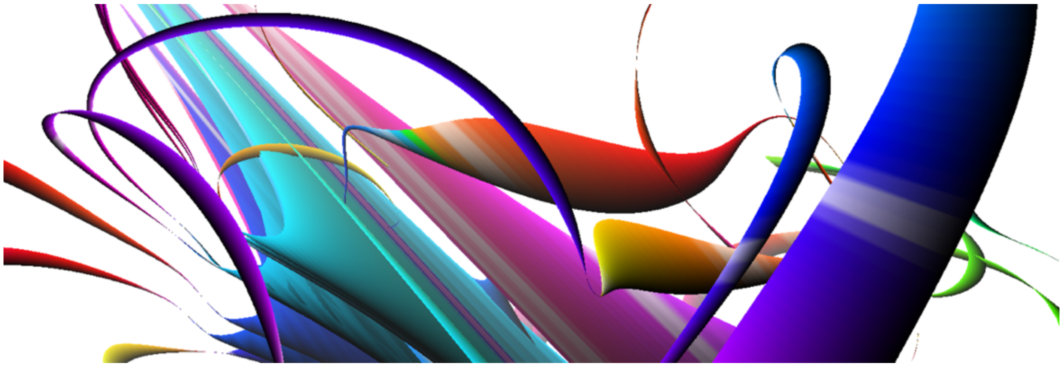


Figure 2.32 Visualization of the Hydrogen-like atom's probability wave function combinations - 2013
Accessed on May 20, 2020. http://www.allosphere.ucsb.edu/research/quantum/

A projection of the first complete visual/sonic composition *Probably/Possibly?* was performed in the AlloSphere in 2017 [152].

Figure 2.33 *Probably/Possibly?*, Dr. Kuchera-Morin inside the AlloSphere next to the interface
Accessed on May 20, 2020. http://www.allosphere.ucsb.edu/kuchera-morin/

The AlloSphere brings together and begins to integrate the three areas that define the field of *NMA*, algorithms, worldmaking and instrument design.

PART II - New Media Architectures: An Idea

Chapter 3

Methodology Integration through Prototypes - The Fusing of 3 Areas

> *Seeing comes before words. The child looks and recognizes before it can speak. But there is also another sense in which seeing comes before words. It is seeing which establishes our place in the surrounding world; we explain that world with words, but words can never undo the fact that we are surrounded by it. The relation between what we see and what we know is never settled. (John Berger)* [153]

> *Space as a Network. So could this be what space is made of? In traditional physics—and General Relativity—one doesn't think of space as being "made of" anything. (Wolfram, 2015)* [154]

As the two quotes above imply, space is a malleable form, it is not an empty void. It is information that can take on many different forms and shapes. This is essential for my definition of *NMA*: the investigation of the integration of architecture, media arts, and sciences as information.

Space or the environment is information and what is contained in that space is informational. A cup is information that describes its use and the liquid in the cup is information with a different use than the cup that holds it. It then becomes important to discuss the world or environment as information that the content (information) resides in, they shape each other. The instrument that produces the world and the content within the world is of paramount importance in its design. The producer of the code, the algorithm is the tool that makes both the world and the content that resides within it. This then allows us to focus on three important areas: the **world** (world making), the content (materials for making the world and the environment it resides within **algorithms** self-organization), and the **instrument (computational platform** that makes both). All of these are information that can dynamically vary and grow just as in nature but now, with the computer, they can be abstracted into a new form of communication.

If one considers space as a configurable network [155] [156] designed by information, then it is imperative to redesign architecture as media through data science. With the compositional tool (the instrument), one can use the algorithm now, to define the content which is describing the world in which it resides, as well as the world in which it lives. The merging of design, multimodal representation, which is a signature of the media arts, completes the three disciplines, the other two being architecture for world making, and the sciences for the algorithm.

The development of the conceptual framework for this new architectural discipline was aided by collaborations, experiments and prototypes that integrated these various disciplines generating our subfields of algorithms, worldmaking, and instrument design. The research practice aiding the direction of the work is the application and merging of architectural query on spatial patterns, computational investigations in the area of complex systems, and investigations in immersive environments. As reviewed in the history section of this dissertation, the study of various examples in each of these fields led to the development of my prototypes that integrated aspects of these fields and facilitated my definition of *NMA*. From studying these examples, I have formalized the basic concept of the modularization of spatial constructs of information as a new type of architecture, both physical and virtual.

Since space is information, I begin by discussing Shaping space asking the following questions: How does the shaping of space communicate as a signal? How is a particular shape expressed in a particular environment as a signal? How do technological mediums affect our senses by aiding or hindering that communication? These questions acknowledge a combined philosophical and scientific nature at arriving at a definition of *NMA*. These were my areas of investigation in the prototypes that I will discuss below.

If space is information, design as an algorithmic code (a set of instructions) is information, then this algorithm can make both the world and the content that resides within it. This then allows us to focus on three important areas, algorithms, worldmaking, and instrument design. All are information that can be dynamically varying and growing just as in nature but now with the computer this can be abstracted into a new form of communication.

My following prototypes that led to my definition of *NMA* deal with the integration and modularization of those three important areas: 1) algorithms - the mathematics explored through patterns and object studies, that form the content that resides in the environment and also forms the environment in which the content resides and, 2) worlds - the conceptualizing and building of worlds (virtual and real) as the environment in which the information exists, 3) the instrument - and its design that shapes the world and content through the algorithms (language), all responding as narrative.

3.1 Algorithms: From the Virtual to the Material

If the man were to try and pretend to be the machine, he would clearly make a very poor showing. He would be given away at once by slowness and inaccuracy in arithmetic. May not machines carry out something which ought to be described as thinking but which is very different from what a man does? (Alan Turing) [97]

Figure 3.1 Boids algorithms, illustrative experiments rendered 3D data & 2D data

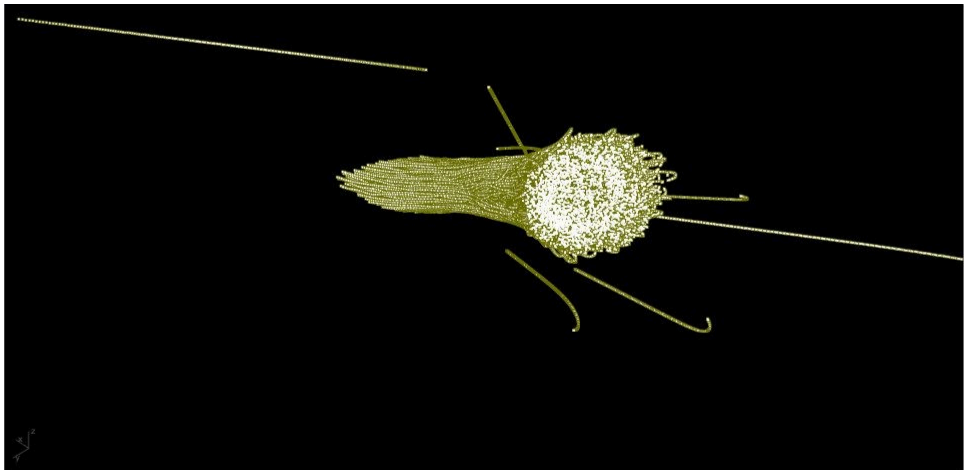


Figure 3.2 Beginning the experiments of a Flocking & Swarming algorithm in 3D space

In the beginning of my flocking and swarming studies, I experimented with synthetic computational algorithms that explored the flocking and swarming model, such as the boids algorithm. I started researching the abstraction of self-organization on the computer platform, starting from particle systems to flocking and swarming systems. The initial studies before creating these systems were experimenting with a random walk algorithm in 3D space and turtle graphics [157] [158] [159]. These studies were focused on having single agents moving [160] [161], while exploring the generative abstraction of pattern making use of mathematical equations, L-systems [162] [163] [164], and generative scripting [165] [166] [167] [168].

The move to study group turtle behavior came soon after observing the phenomena of starlings flocking in nature and facilitated group interaction studies. The forms that were created were resonant with architecture and science. The resultant studies were conceptually created as biological experiments mimicking nature, while AlloSphere research projects were being concurrently applied using scientific information. This process was formulated by the desire to understand the abstractions of biological phenomena, as with my flocking and swarming experiments, while also acquiring an instinctual knowledge of the mathematically abstract models being deployed in the AlloSphere for complex science research.

Figure 3.3 Flocking and Swarming experiments – Agents only points 1

Figure 3.4 Flocking and Swarming experiments – Agents only points rendering 2

The pictures above are examples of group intelligence that begin to display flocking behaviors of fright, flight, and predator-prey, and are more complex simulations. The pictures below are the same flocking and swarming algorithms now data reduced for the possibilities of fabrication.

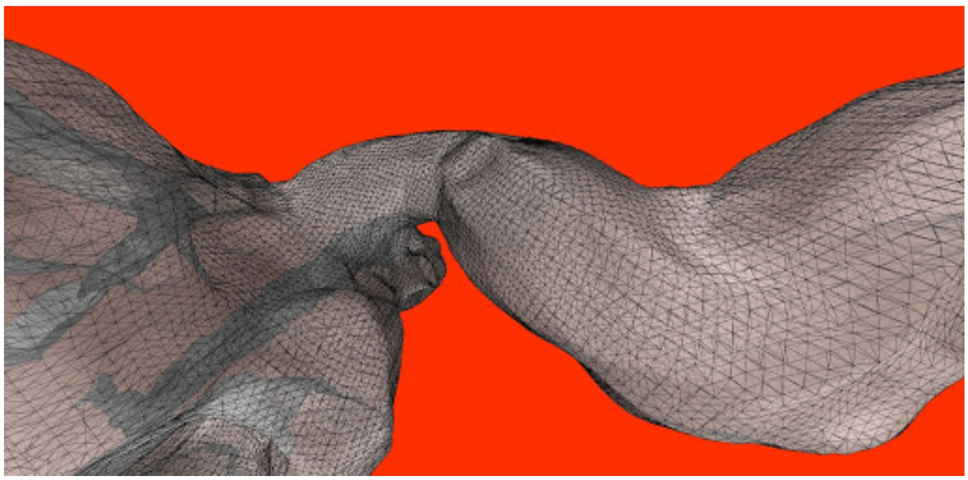


Figure 3.5 Flocking and Swarming algorithm - A data reduction view 1

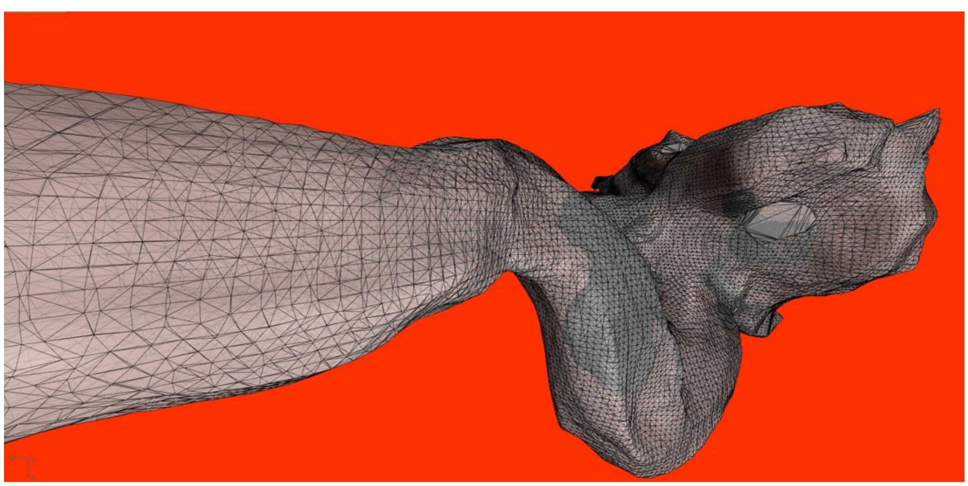


Figure 3.6 Flocking and Swarming algorithm - A data reduction view 2

These flocking and swarming, and Predator-Prey algorithms can be combined. I discovered, as the system becomes more complex, it is not easy to predict the agents' interactions. The more detail and control one has over the computational system, the more the resultant model then can be used as a tool for analysis and prediction to solve the problems of shaping space.

While my experiments were not artificially intelligent [169] [170], capable of learning, or saving the state of a system, the opportunity to research group intelligence facilitated my development of self-organization in virtual world installations. This also inspired concurrent research in self-organization as a method for fabrication designing algorithms for the rapid prototyping machines.

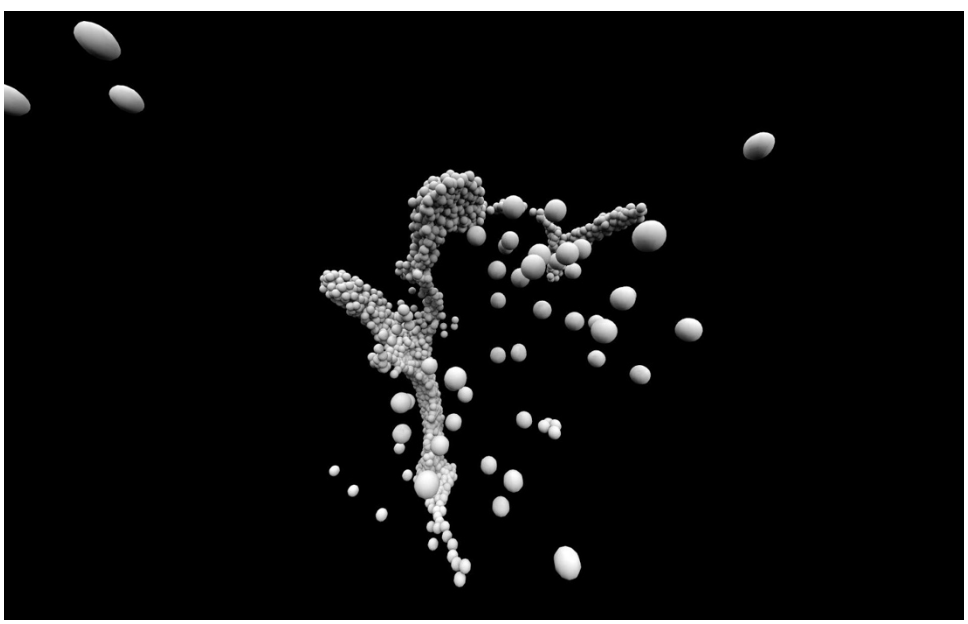


Figure 3.7 Flocking and Swarming system clustering experiments for fabrication

Early emergent experiments led to the development of my flocking and swarming projects in both simulation and fabrication (2013 – 2016). The three studies in the next subsection will be a combination of synthetic computational sciences and biological sciences to reveal 1) flocking, 2) flocking and swarming, and 3) flocking and swarming generations as methods for designing and shaping space.

3.1.1 Computational and Biological Studies of Flocking & Swarming and Flocking & Swarming Generations

Flocking study "*Movimientos Hermosos*." This is a study of flocking and swarming that deals with movement and flow of agents. This study was created to find the possible pathways of flow of agents and how they work together for modeling structure and form. This generative agent-based flocking and swarming model was created using AlloSystems [171] [172] [173][174].

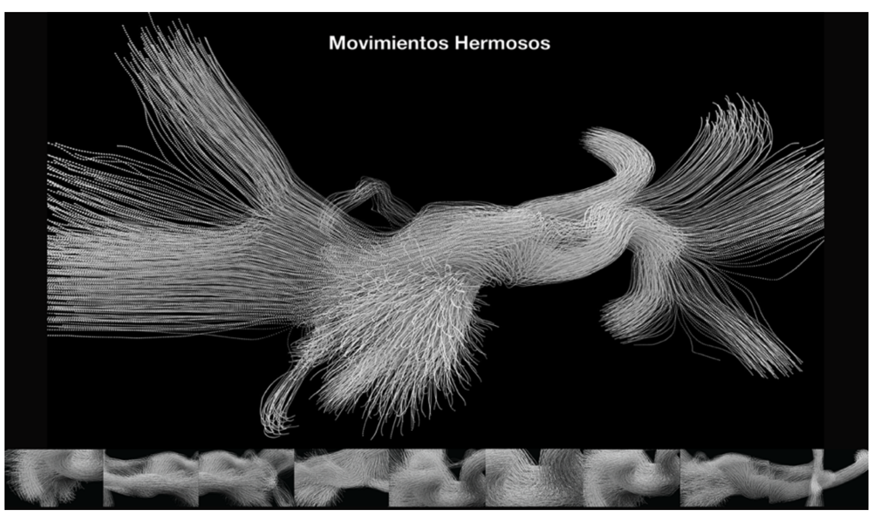


Figure 3.8 *Movimientos Hermosos* - A single species representation of flow

When one is working with these computational algorithms that are exposing flow, there are many different points that can be connected to make various geometries and shapes. The following shapes can be made from the flow of points.

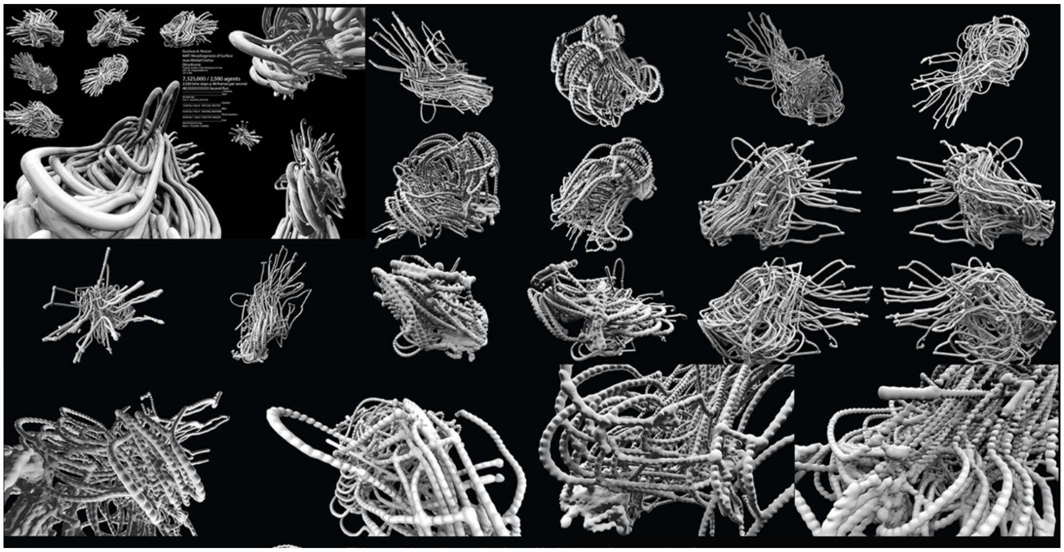


Figure 3.9 ***Movimientos Hermosos*** **– Selected renderings of a fabricated object**

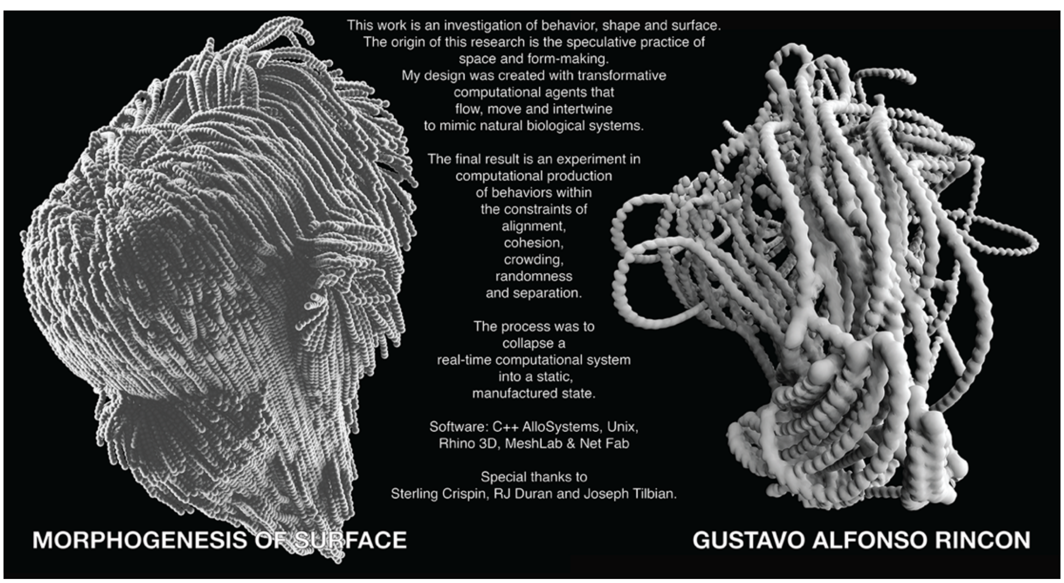


Figure 3.10 ***Movimientos Hermosos*** **– Selected renderings of two strategies**

When one is considering fabricating these objects the number of data points becomes crucial in the fabrication process. One must reduce the data to get a fabricated representation of the object. In the picture above, the first object in the upper left-hand corner, has tens of thousands of points as opposed to the geometries on the right that have greatly reduced numbers.

The first fabricated object and series of renderings in the picture below needed much more data reduction. These examples were created from flocking and swarming

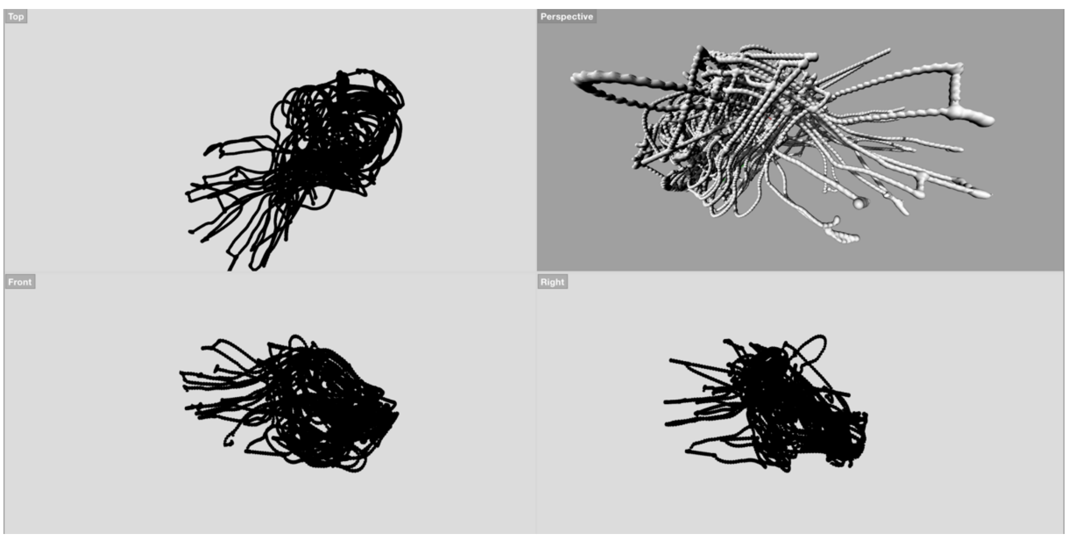


Figure 3.11 *Movimientos Hermosos* - A CAD model view before fabrication

algorithms and were a result of months of searching literary peer reviewed papers, observations, creating a process, and adjusting my computational system as a pipeline for design production and review.

Figure 3.12 ***Movimientos Hermosos*** **- A fabricated model – side view**

Figure 3.13 Movimientos Hermosos **- A fabricated model – front view**

In this phase of my work, I used Processing [175], Mathematica [176], Max [177][178][179], MSP[180], Jitter [181], Java [182], and then C++ [183]. Each language and framework had their advantages and disadvantages. The frameworks that were readily available and the library supporting each language was key in testing the potential of the mediums for art creation. The process of following some architectural design frameworks were also designed to discover the potential of controlling the algorithm in built form. Since the flocking algorithm was used successfully for decades, the virtualization and fabrication combinations were the interconnecting theme.

As I worked toward the possibilities of fabricating these objects. I needed to use data reduction techniques that would allow me to capture the overall shape close to the ground truth principles of the structure as possible, while realistically having a minimal amount of points to fabricate the object. In my second study below, "*Un Abrazo Repulsivo de Un Rebaño de Emociones,*" the level of detail of the previous work "*Movimientos Hermosos*" had to be minimized by reducing the number of points that allowed me to capture the form of the work without going into fine detail of the movement of the flow. In order to capture as much of the flow as possible, I used lighting and depth to capture optimum flock densities.

Un Abrazo Repulsivo de Un Rebaño de Emociones

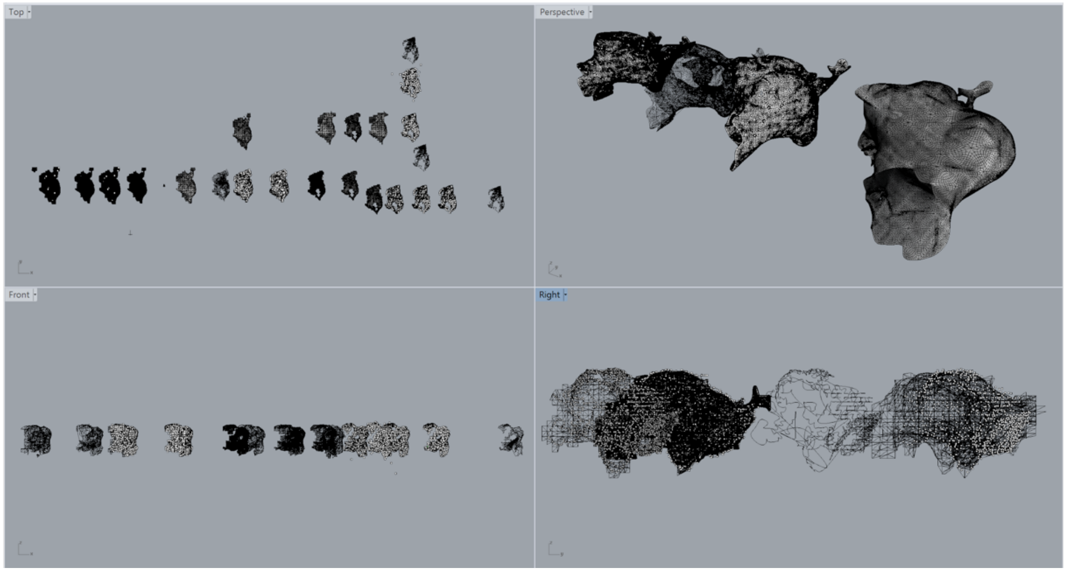


Figure 3.14 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **- CAD**

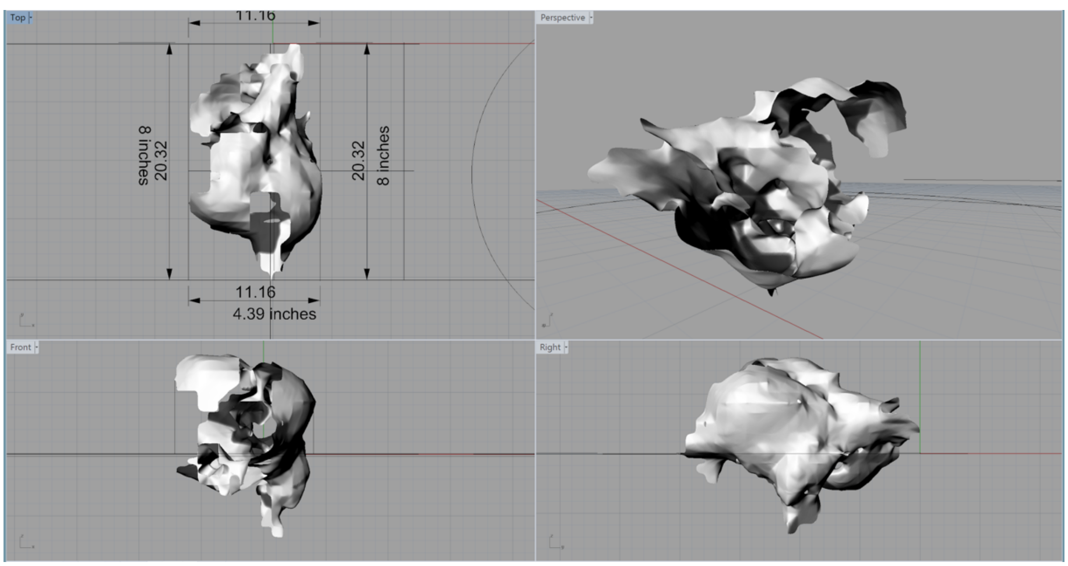


Figure 3.15 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **– CAD for fabrication**

In “Un Abrazo Repulsivo de Un Rebaño de Emociones,” I use deformation and surface logic to create form as a data reduction technique.

Figure 3.16 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **– A study before fabrication**

“Movimientos Hermosos” and “Un Abrazo Repulsivo de Un Rebaño de Emociones” were single species representations, a culmination of putting all of the parts together to make a system to facilitate my flocking and swarming studies for virtual and fabricated objects. In this picture below, I needed to use the following software: AlloSystems, Unix [184] [185], CAD [186], Mathematica, and various fabrication software programs, including MeshLab, MeshMixer, and Netfabb [187]. This methodology allowed me to move from dynamically varying form to fixed structure.

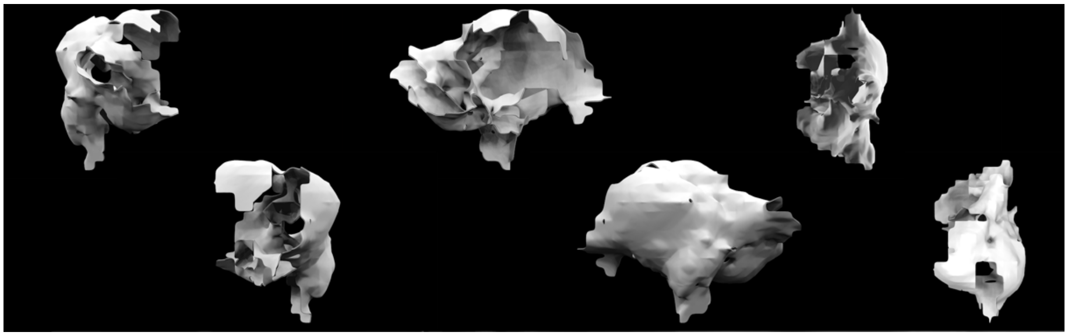


Figure 3.17 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **- A rendered surface study**

Figure 3.18 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **- a rendered interior view + algorithm**

This research thread of combining the flow of movement, surface logic, and the fabrication process opened up further experimentation in the possibilities for the geometry of fabricated objects.

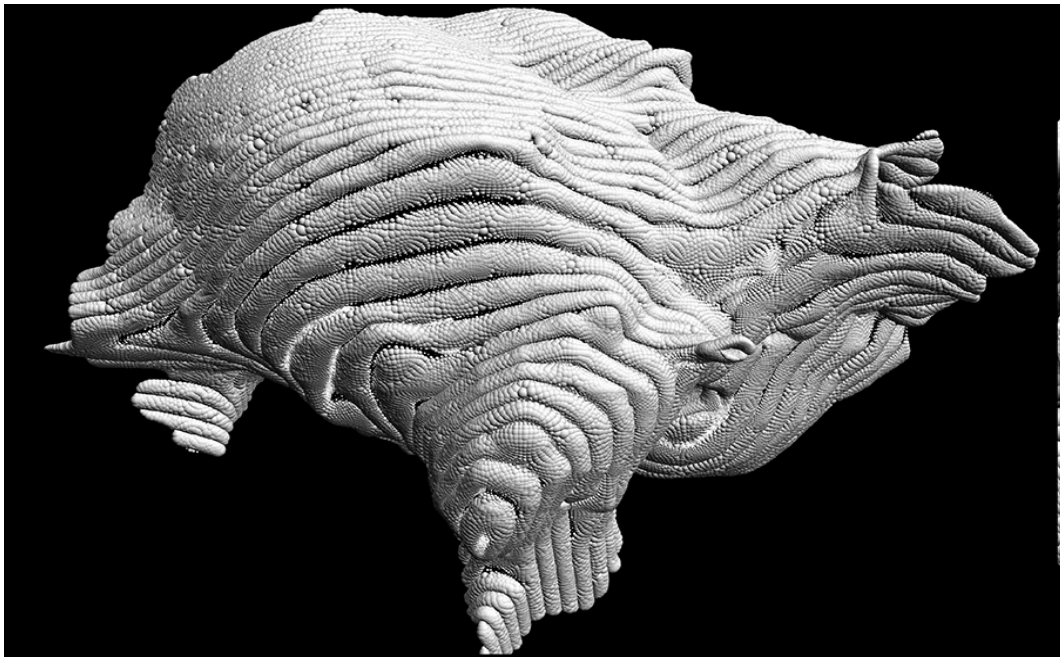


Figure 3.19 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **- An alt. series - surface study view 1**

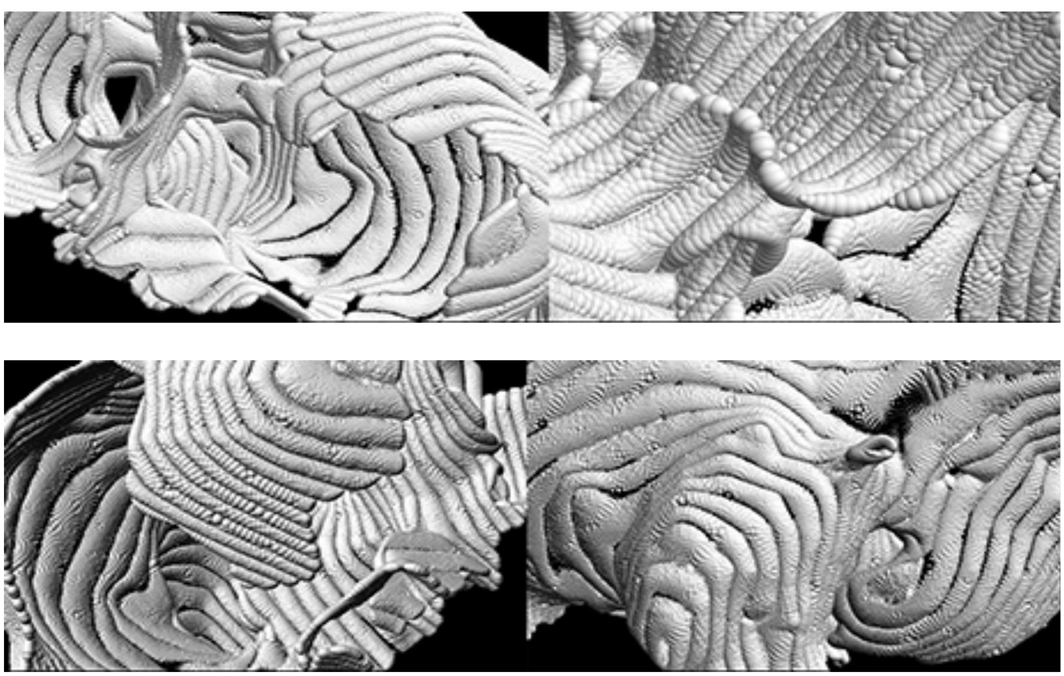


Figure 3.20 ***Un Abrazo Repulsivo de Un Rebaño de Emociones*** **- An alt. series - surface study view 2**

Figure 3.21 Un Abrazo Repulsivo de Un Rebaño de Emociones - A fabrication model view 1

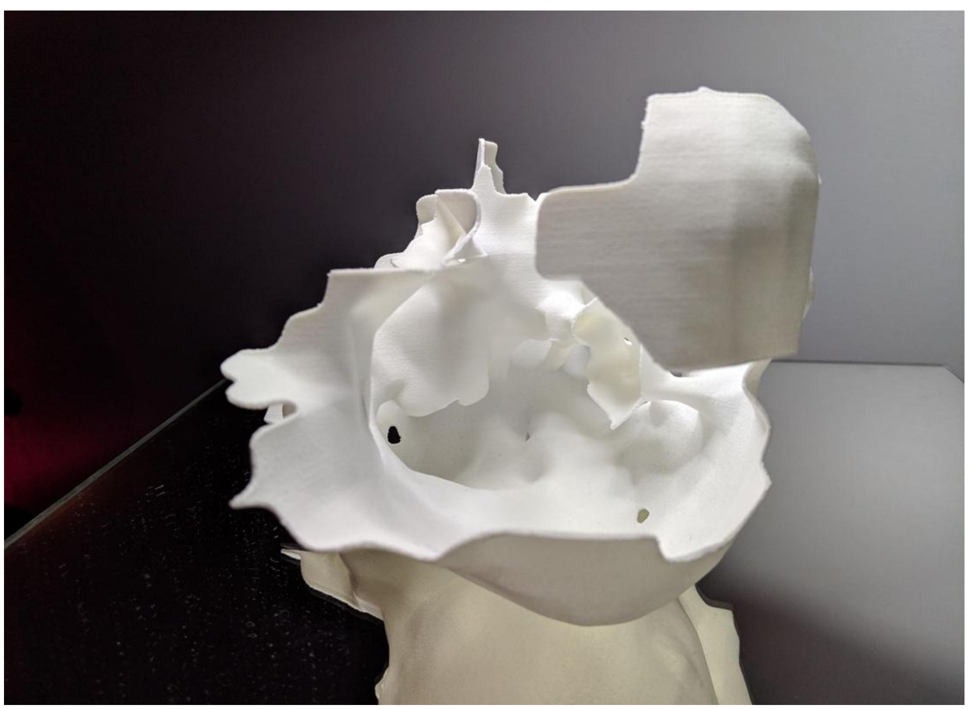


Figure 3.22 Un Abrazo Repulsivo de Un Rebaño de Emociones - A fabrication model view 2

The potential of the different types of computational and mathematical frameworks aided in determining the complexity of the selected fabricated form.

Flocking and Swarming Generations

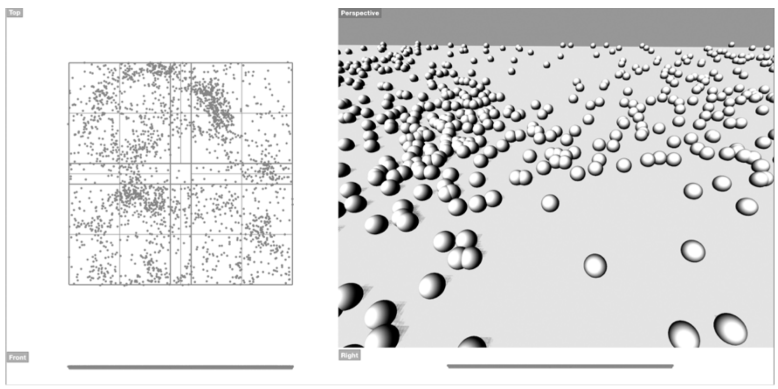


Figure 3.23 Flocking & Swarming Generations – A data output study in CAD - 3D

In the third of a series of experiments with agent-based behaviors, I began to further my studies of dynamically moving form and shape through multiple modalities focusing on sound as a pattern maker of form and shape along with visuals and navigation. In the flocking and swarming generation studies, I used three different species (interspecies and intergenerational exchange) within the ecosystem. When the experiments progressed to incorporate multiple modalities and more dimensions of data, OSC [188] [189][190] was used to identify options for the use of the position data both visually and sonically. In my very first attempt, I gave each species a sound and watched them moving around in space.

This investigation was an effort to move toward the science of agent-based modeling [191] [192] [193] and the research necessary to carry out successful experiments.

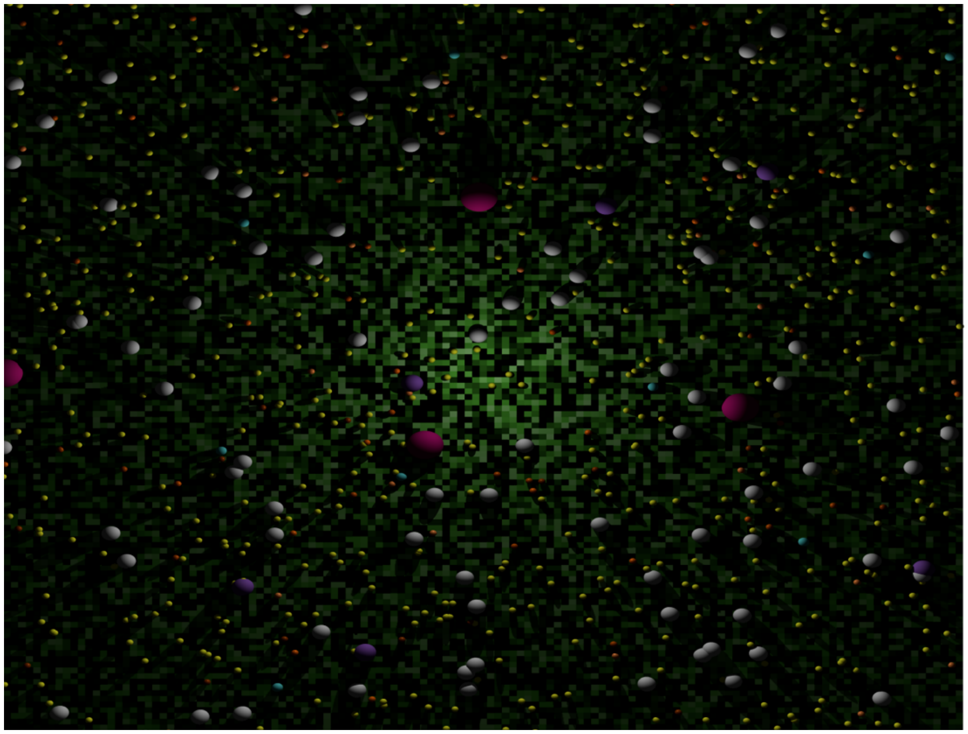


Figure 3.24 Flocking & Swarming Generations – Data rendered representation with colors - 3D

The research that I conducted with Bill Rand, the author of the book "The Introduction to Agent-based Modeling," [194] at the Complexity Explorer Center in the Santa Fe Institute was foundational for the continuation of discovering patterns within Complex Systems [195]. This research furthered an investigation of the extents of a predator-prey Model. It also facilitated my goal of capturing hidden patterns of movement depending upon potential of the system's computational power. The functionality within the program ranged from how one could control the agents of the different species including their energy, rate of speed, and rules of species interaction. Understanding the "how" of tracking population numbers vs. tracking changes of direction and pattern types are two different tasks. In my initial studies, clustering, directionality, and dissipation were important properties of the flocking and swarming systems and helped define form and shape. Some of the other parameters included birth rates and motivations of the intensity of pursuit to identify and investigate in more detail the relationships between the combinations. This type of research yielded an understanding of the potential of the system, but required much more investment to determine its value as an aesthetic medium.

This research thread created a complex system that exponentially generated a multitude of data that was difficult to explore. It became clear to me that I had to work in different areas to refine these techniques, in building these complex systems. The picture below displays patterns that were visual and sonic of the three species. The first picture shows the data paths as patterns of all the species. The second picture is a data reduction scheme to encapsulate the possibilities for fabrication.

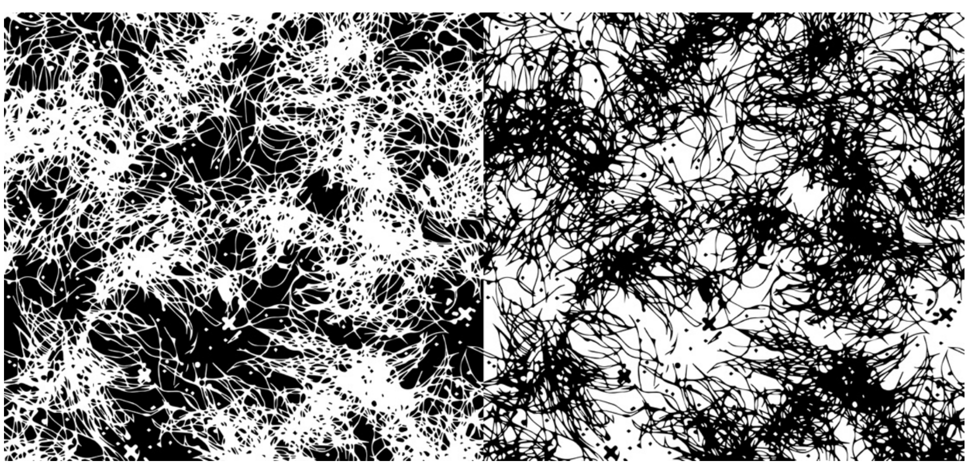


Figure 3.25 Flocking & Swarming Generations - 3 species data lines study - 2D

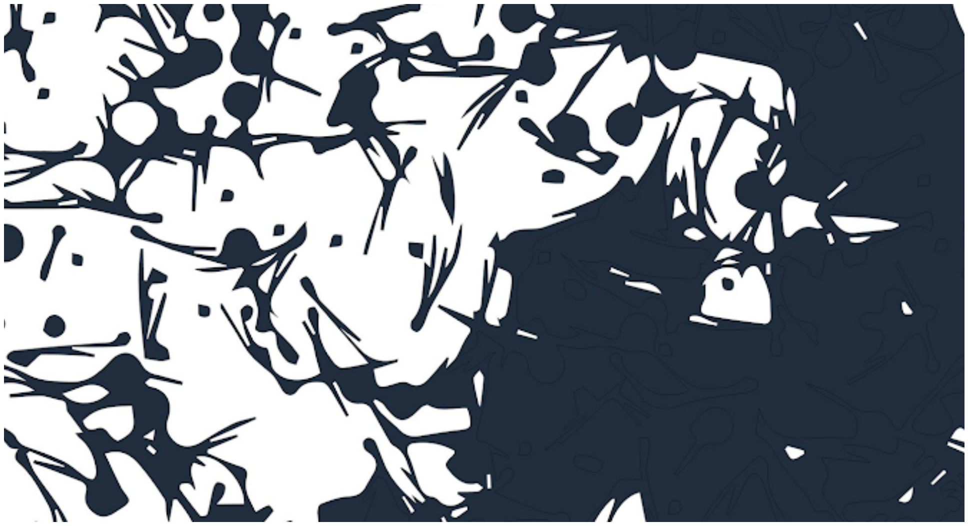


Figure 3.26 Flocking & Swarming Generations - 3 species data reduction study - 2D

Some work was done investigating alternative ways for creating sound works with agent-based modeling. In addition, thinking about the possibilities of how data can be both input and output and be used to drive parametrized images and sounds helped contextualize my early work in Max MSP Jitter, Processing, and P5.js [196]. All coding experiments and framework research helped with deeply surveying the field in creative coding frameworks which aided in the development of AlloLib and the conceptual development of my own system for shaping space. All of these studies aided in further distancing my work from proprietary software like visual programming languages (Rhino - Grasshopper) [197], CAD (Rhino)[198], VR Gaming (Unity)[199], as well as animation (Maya-Mel)[200].

I also began to research the potential of agent-based modeling in C++, MATLAB, & Python. The next section will discuss agent-based behaviors.

3.1.2 Agent-Based Behaviors in Quantum Systems (2016 – 2020) - Simulation to Fabrication

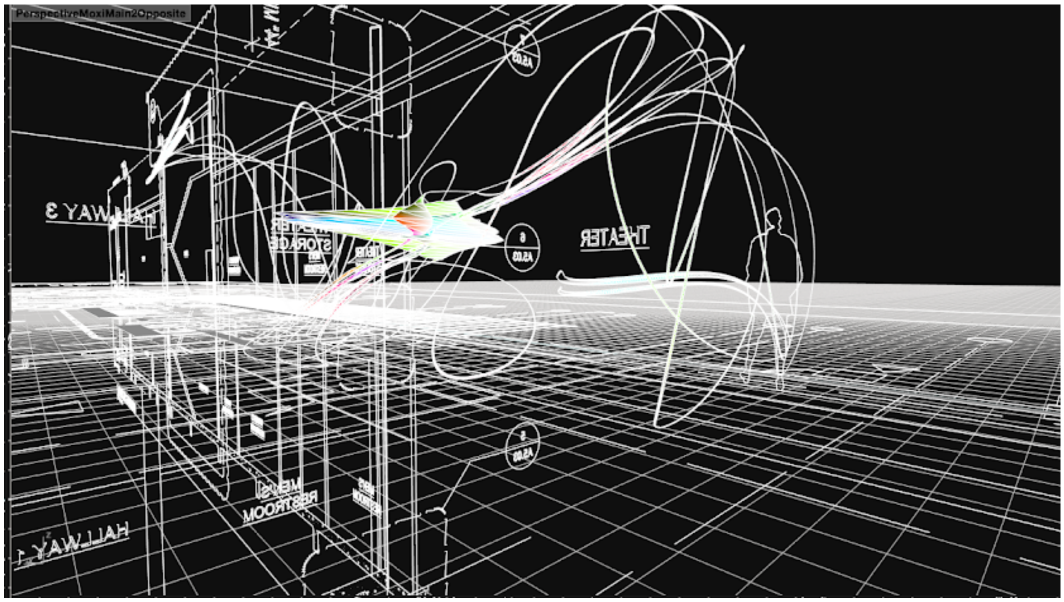


Figure 3.27 A quantum geometry - A large-scale fabricated design proposal for MOXI - perspective

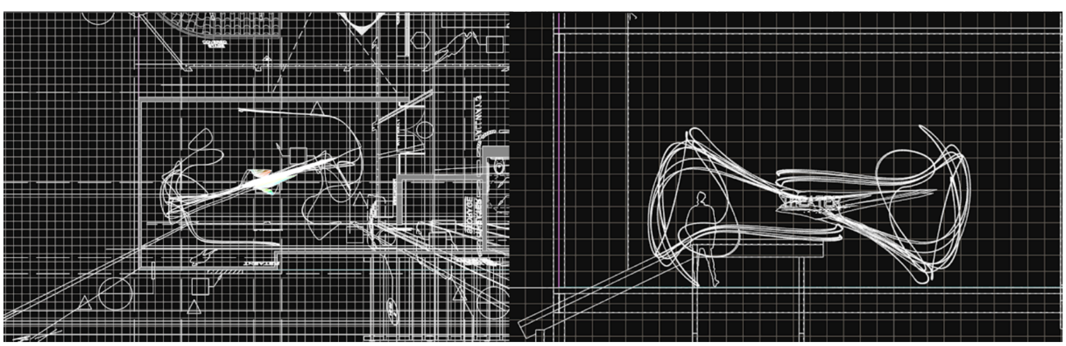


Figure 3.28 A quantum geometry - a large-scale fabricated design proposal for MOXI - top & side

Continuing with Physics, I explored the fundamental nature of quantum forms, from 2016 to the present, in collaboration with Dr. Kuchera-Morin and the AlloSphere Research group. Each research area offered new mathematics and natural force properties revealing new insights of form, structure, and shape. This aligns with the infrastructure and immersive research in the field of media arts. I was able to integrate the union of both the computational and biological sciences as well as the physical sciences.

The initial prototypes for the quantum forms 2016 inspired the "*Probably/Possibly?*" composition by Dr. Kuchera-Morin for the MOXI inaugural installation [152]. The computational representation of mathematics was agent-based in nature. It was part of an original collaboration with Dr. Kuchera-Morin, Dr. Lance Putnam & Dr. Lucca Peliti. While the original quantum form was conceptually proposed to be the size of the gallery as pictured above, the original representation of the Atom was designed as a virtual dynamically varying object, inside the AlloSphere instrument. The architectural/media design challenge offered insights in the process of object making within the AlloSphere Research group. The idea that viewers would experience, move around and under, and simultaneously virtually experience the form. From the initial proposal of 2015, the installation had a fabrication component that would highlight the complex nature of the forms generated.

The complexity of these quantum shapes took a tremendous amount of points in order to draw the forms, so data reduction techniques were used in order to fabricate them. In the process of selecting the first fabricated shape, the study of the system was essential for the selection. The challenge from the abstract concept rendering to the potential fabricated selection required an accounting of the fabrication technology required for producing the shape. The issues in capturing clean data continue to be overlapping points, lines and surfaces. Other problems encountered were rounding errors, and the scale of different geometrical components of points and lines. The final obstacle in analyzing the data was an understanding of fundamentally how to discover a method to unwrap the existing geometry and deconstruct the surfaces in parts to isolate potential problem areas. My selection criteria were to find a logical inner core portion of the geometry and cut the continuous shape and work forward.

Figure 3.29 A quantum geometry – a rendered fabrication study of agent trajectory

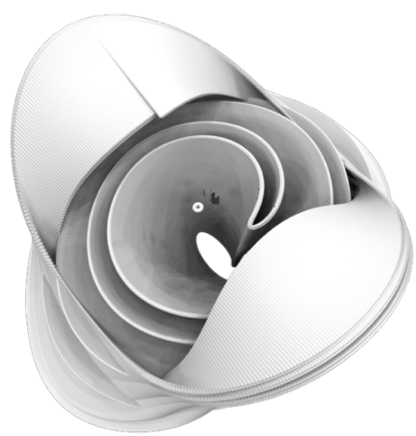


Figure 3.30 A quantum geometry – A rendered fabrication study of agent surfaces

With the first fabricated shape presented above, each view represents a strategy for the fabrication of the quantum form, the tube design that privileged motion by agent movement, and the other solid design that represented the connection of the trails back to the surface (see Figure 3.30 above). This strategy is simple to implement when the form is at an early stage of formal topology.

Figure 3.31 A blue atom - A quantum geometry - rendered fabrication study - agent trajectory

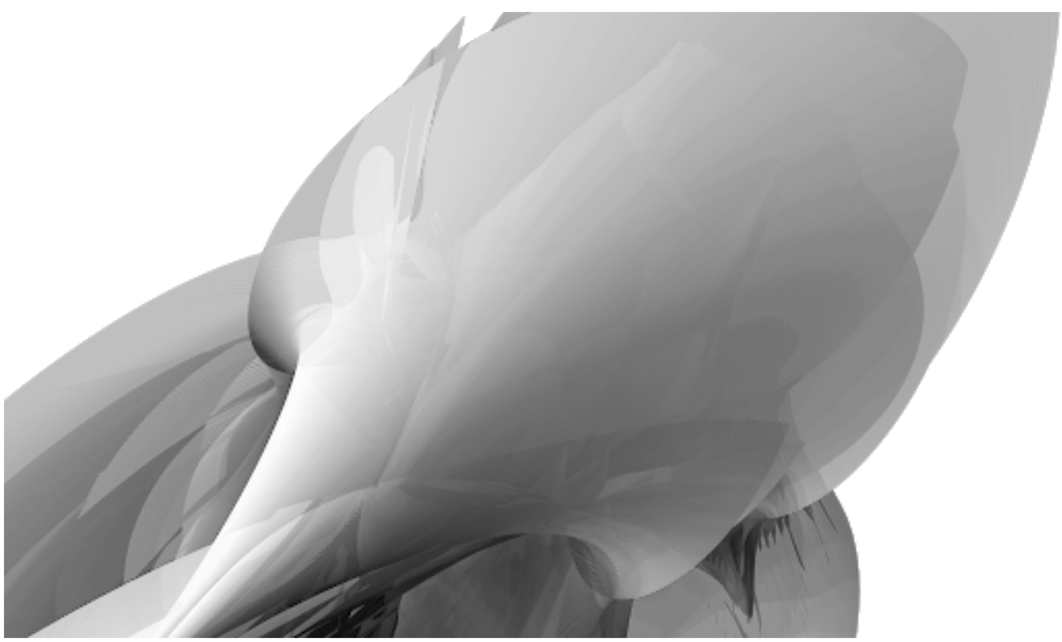


Figure 3.32 A blue atom - a quantum geometry - rendered fabrication study - agent surfaces

In the quantum object study the one that we termed as the "Blue Atom," the complexity of the geometry and the overlapping surfaces made it a challenge to conceptualize a fabrication strategy. The aesthetics of the overlapping geometry shows the beauty of mathematics. The virtual space captured the complexity and the ability to embody the scale of the form.

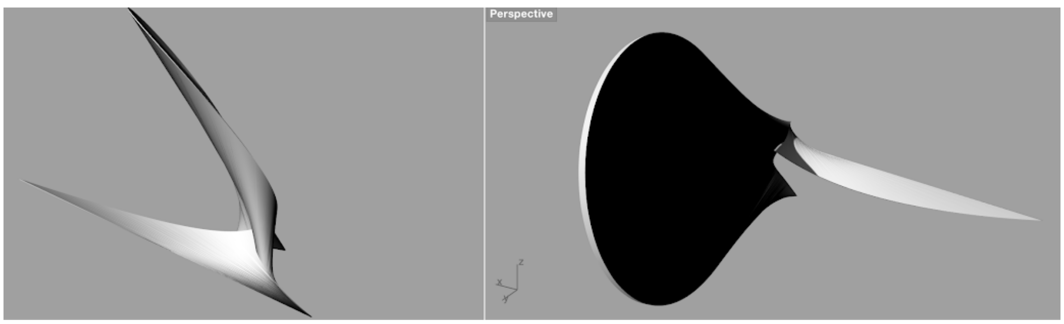


Figure 3.33 *Etherial* - A quantum geometry - A rendered fabrication study – top & mdl. views

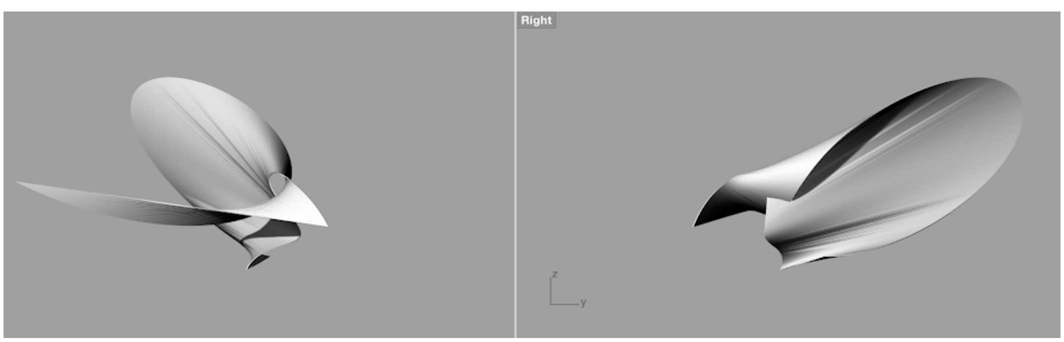


Figure 3.34 *Etherial* - A quantum geometry - A rendered fabrication study – side & front views

Figure 3.35 ***Etherial*** **- A quantum geometry - A fabricated model - prototype - view 1**

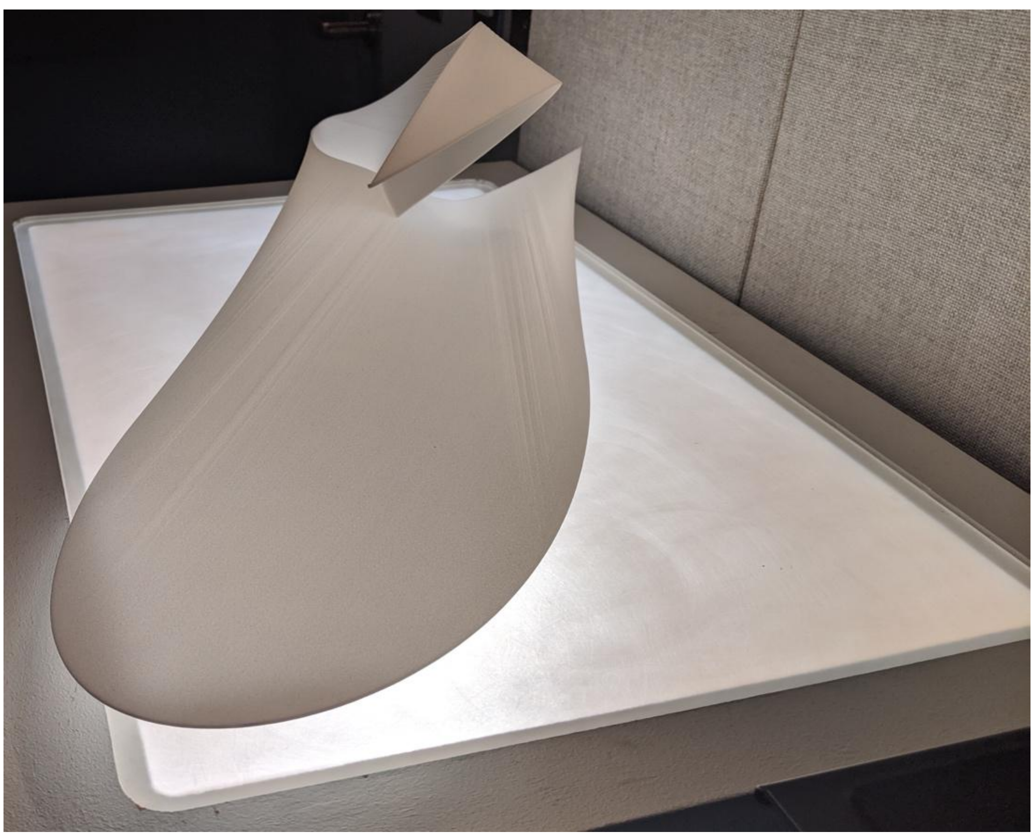


Figure 3.36 ***Etherial*** **- A quantum geometry - A fabricated model - prototype - view 2**

The unwrapping of the geometry and finding a beginning point helped me solve the problem of locating an area with a high likelihood of fabrication success. The result was the fabrication of one section of a larger 16-part dissection. The barriers to creating a seamless print job were the overlapping computational geometry and the level of detail required to be included or omitted from the final fabricated object. The conceptual tools of *NMA* were employed to analyze, breakdown and to implement an artistic solution for fabrication and representation of the original computational form. The geometric complexity embedded in the data of the form itself demanded mixed methods using existing computational frameworks and CAD toolsets to realize a successful form.

These geometric shapes, designed at different scales, facilitated my understanding of their fractal nature. The information can be exchanged on many different scales, ranging from the content (algorithm) to the total environment. I created a conceptual framework and a scaffolding of tools to realize both objects with multiple spatial and metric potentials in augmented reality, virtual reality, extended reality, and reality, which is the physical representation of the information that was previously mediated by screens, sounds, and virtual worlds. In the architectural discipline, the architectural model, fabricated object, scientific representations, and/or sculpture all presented opportunities to experience embodied data in material form. I then began to understand that the algorithm that generated the information is also generating the environment as well.

3.2. Virtual World(s) & AlloSphere Instrument Design - The Environment: Collaborations & Experiments and the Instrument

As I began my explorations in the architecture of virtual worlds by the analysis, creation, and experimentation within various environments virtual and real, I worked in three different laboratories (AlloSphere, Four Eyes Lab, & transLAB). Each lab represented different types of media research ranging from designs, methods, and research motivations. I will detail my experiences and research projects within each lab from the environment to the instrument through the algorithm.

In this section, I will cover my research trajectory starting with the AlloSphere and the Design Analysis of the facility, 2009 - 2011 (Section 3.2.1). This section will cover my initial studies of the AlloSphere Environment from the perspective of an architectural and media arts researcher. I will then discuss the Four Eyes Lab, the instrument to environment, 2011-2013, and a description of the process of realizing a user study within the computational sciences. Moreover, I will discuss my contributions in the project including experiences, insights and lessons learned from identifying a ground truth within the cross reality (XR) modality. In the transArchitectures [92] collaborations, instrument intersecting with Environment Lab, from 2017 - 2019 (Section 3.2.3), I will discuss a philosophy, creative process, and methods based on foundational works to the architectural field (*Liquid Architectures, transArchitectures*, *AlloBio*, *AlloNano*, & *Cyberspace* [201] [202] [203] [204]) [205] [206]. In the final section, I will detail the AlloSphere collaborative installation environments (works) as instruments, 2016 - present (Section 3.2.4). The installation projects were XR spaces. Each of the components of the installation inspired further investigations of immersive space, interaction, and shape.

3.2.1 AlloSphere Facility | Environment to Instrument 2009 – 2011

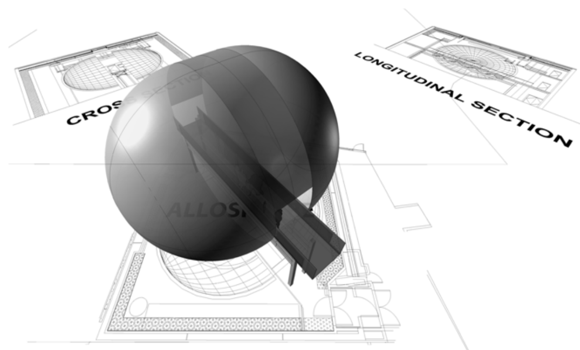


Figure 3.37 AlloSphere CAD model - A model - bridge & screen, perspective view

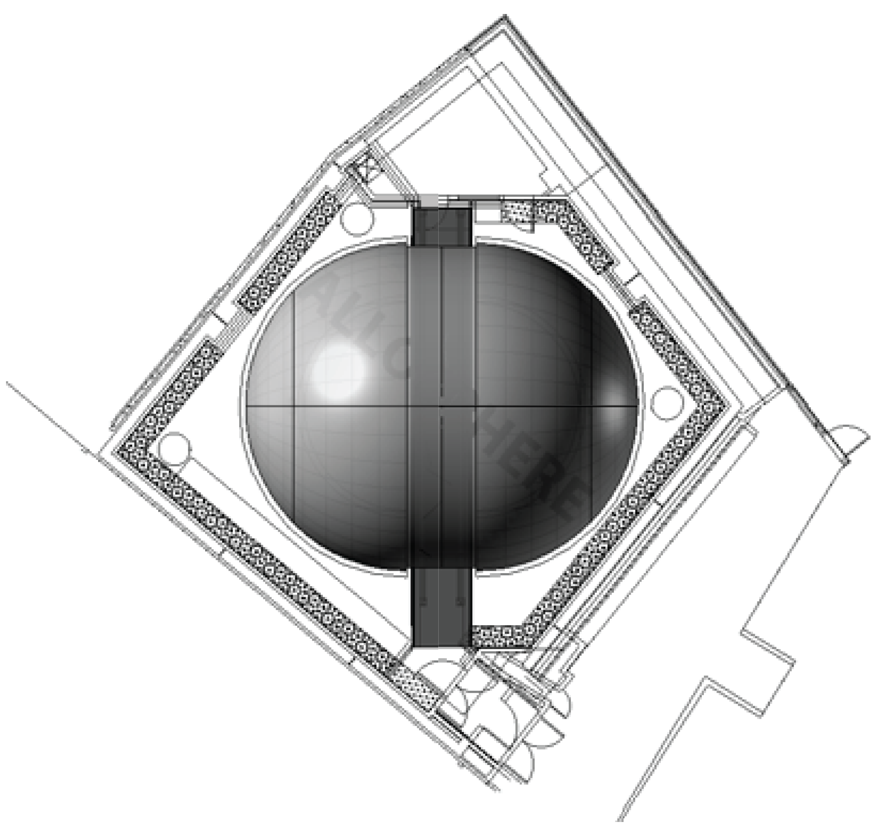


Figure 3.38 AlloSphere CAD model – A model of the bridge & screen, top view

In this section I will discuss my role as an architectural/media arts scholar in the instrument design, and the engineering of the AlloSphere Research Facility. I will discuss some history behind my arrival to this process and research of instrument design. My first real exposure to the instrument and the research carried out by the group was from my participation in a Studio Critic class. While we covered many subjects as a group, we talked about systems creation and development for the aid in scientific research. In the beginning, Professor Kuchera-Morin, recounted as chief research scientist for the University of California (U.C.) System, her access to the latest technologies. Moreover, her academic and industrial experience in arts, entertainment, and multiple scientific fields was crucial for the creation of a new field within the media arts.

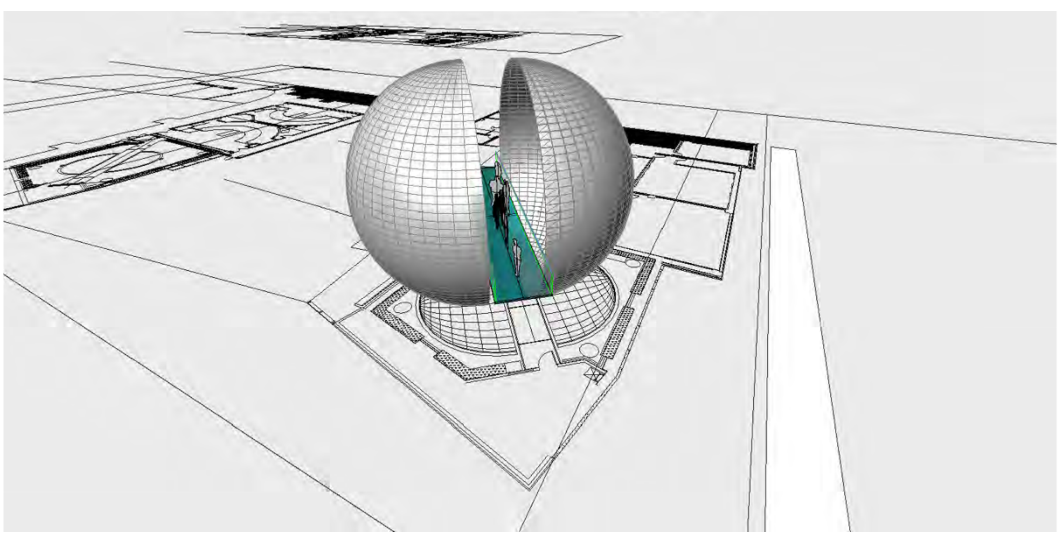


Figure 3.39 AlloSphere CAD model - Analysis of the bridge & screen - hemispherical view

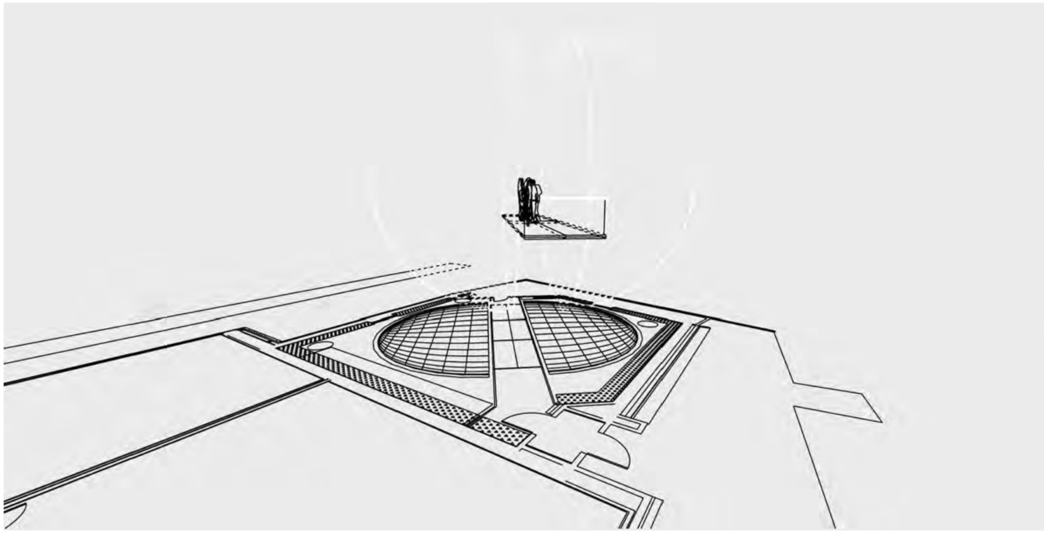


Figure 3.40 AlloSphere CAD model - Analysis of the bridge with researcher bridge view

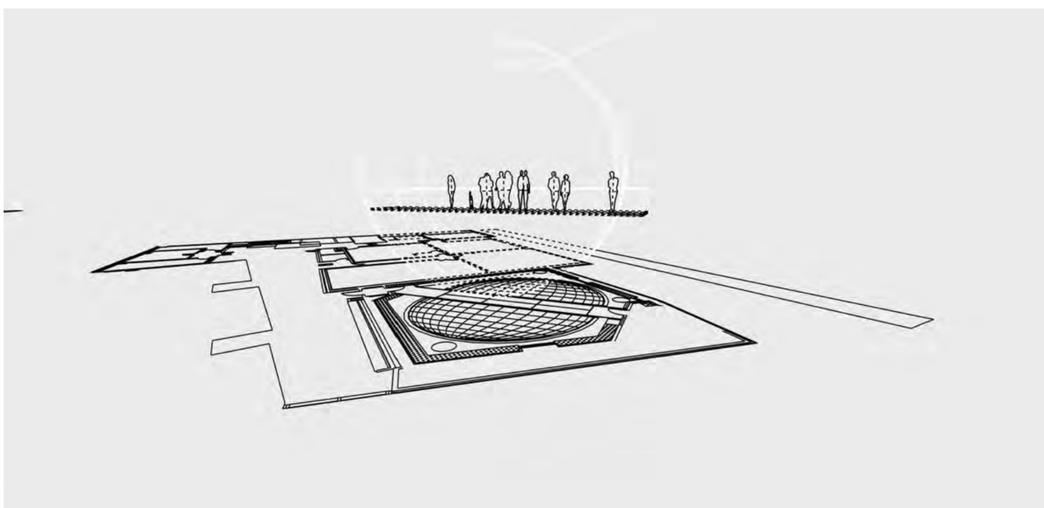


Figure 3.41 AlloSphere CAD model - Analysis of the bridge with researcher bridge view 2

My architectural engineering research questions were tested by studying the potential of iterated design models of the AlloSphere instrument. In my extensive research of the architectural documentation and built facility, Dr. Kuchera-Morin's AlloSphere design, even though planned, was fully implemented to the original design specifications. While the materials and infrastructure were changed based on building codes and budget, the opportunities for a new type of AlloSphere were available based on the successful design of the instrument. My contribution, beyond the initial research, started between 2009 and 2011 with the creation of an analytical design process. Methodically documenting and furthering the existing designs of the AlloSphere instrument was the next logical step to enable a rethinking of the instrument design to be fully modular. The AlloSphere was completed in 2007. In the first published paper titled, "The AlloSphere: a large-scale immersive surround-view instrument [207]," the major design features and motivations that comprised it were described. The future vision of the instrument was declared: "We envision the AlloSphere as a vital instrument for the future advancement of fields such as nanotechnology or bioimaging. It will stress the importance of multimedia for the advancement of science, engineering, and the arts." The novelty in the AlloSphere's beginning was the creation of a unique laboratory that artists and scientists could share simultaneously in unified research, and was in reality also a reconfigurable instrument.

When I began my work in 2009, I was tasked to reconstruct the AlloSphere with as-built drawings so that the hardware engineer could begin to instrument the laboratory. In the beginning of my research, I had always considered the AlloSphere as an environment, a laboratory and yet, in the paper, the AlloSphere is described as an instrument. As I worked closely with media hardware engineer Dennis Adderton, I began to understand the construction of the AlloSphere as a facility, identifying the component parts of the AlloSphere as an environment for research. My architectural design research process started with the creation of a three-dimensional CAD as-built data set.

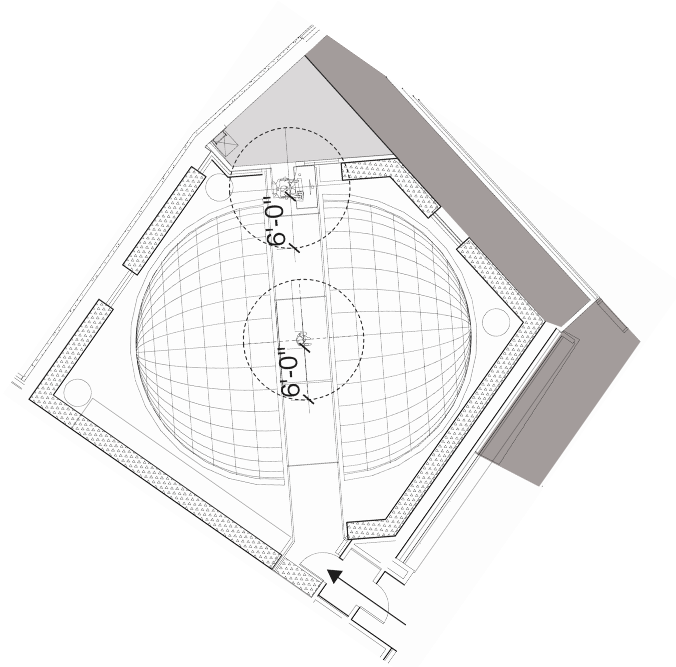


Figure 3.42 AlloSphere CAD - An occupancy study of the AlloSphere for the CNSI

The uses of that data ranged across architectural design, engineering, and simulation research. In the early stages of the research, finding out what was built and what was missing was a matter of discovery and verification. This followed an architectural design process at the beginning to solidify a starting point, but expanded to issues of engineering, software infrastructure and technology. Many informal interviews and meetings with the onsite engineering faculty and staff took place to understand the core issues of the future design challenges of the AlloSphere. As I began working more closely with the plans and construction and the outfitting of the instrumentation, I started to realize that the AlloSphere was more than just a laboratory. It is both an environment and instrument. This process facilitated a deeper understanding of the potential of the instrument's original design intentions while practicing the design/engineering work of realizing a fully functional instrument/environment.

My research work with Dr. Kuchera-Morin spanned over a decade, starting from some precursor work creating foundational documents that led to further research discoveries both in the AlloSphere Instrument and artistic research projects that blurred the definition of media art between artistic research and scientific knowledge creation.

This experience led to the understanding that the parts of the AlloSphere were ideas materialized and reconfigurable in other formulations, locations, and media.

I began to understand that all of the parts were information that would lead to new installations based on the ground truth of the content.

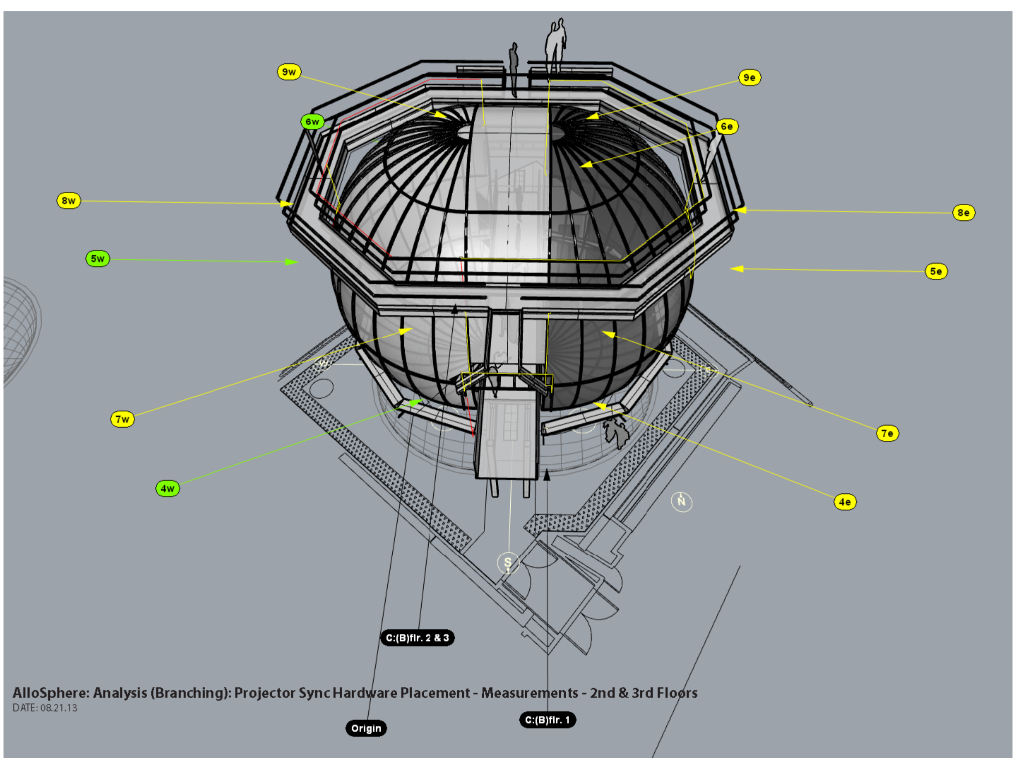


Figure 3.43 AlloSphere CAD model - Internal analysis - A study of a projector sync System - 1

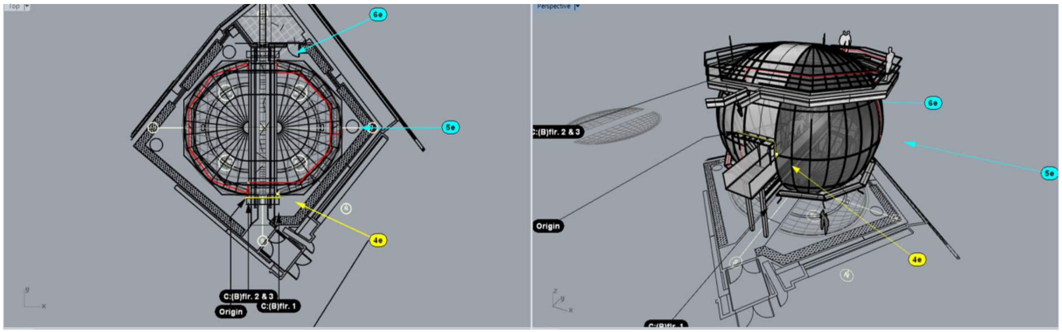


Figure 3.44 AlloSphere CAD model - Internal analysis - A study of a projector sync System - 2

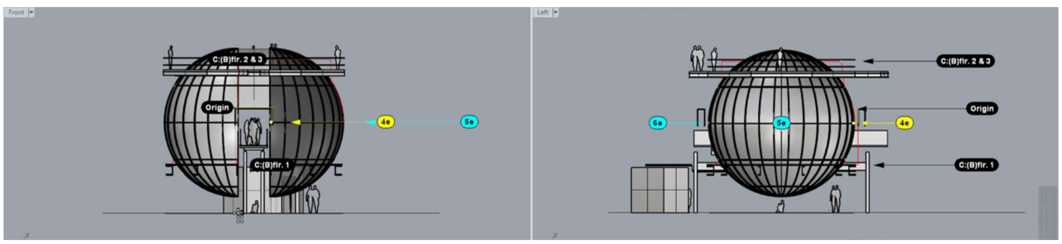


Figure 3.45 AlloSphere CAD model - Internal analysis - A study of a projector sync System – 3

The AlloSphere's original and complete design intentions started to come into focus while working on the research project with the Center for NanoMedicine.

AlloSphere Instrument | Content - The Complexity of The Body 2010 – 2012

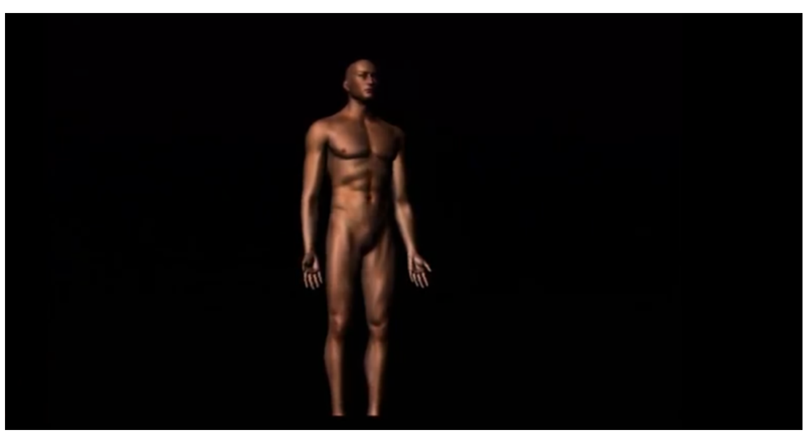


Figure 3.46 AlloSphere: CNM - A human body animation - intro section, video still - 01

My first content creation opportunity working with the AlloSphere Research group as a team leader was for the “Center for Nanomedicine” project with Dr. Jamey Marth, Director, the Sanford Burnham Medical Research Institute at University of California, Santa Barbara. The project involved three phases: 1) Background Research, 2) Conceptual Design & Animation, and 3) Simulation. In phase one, high resolution data was sourced for the use of creating a virtualized simulated body.

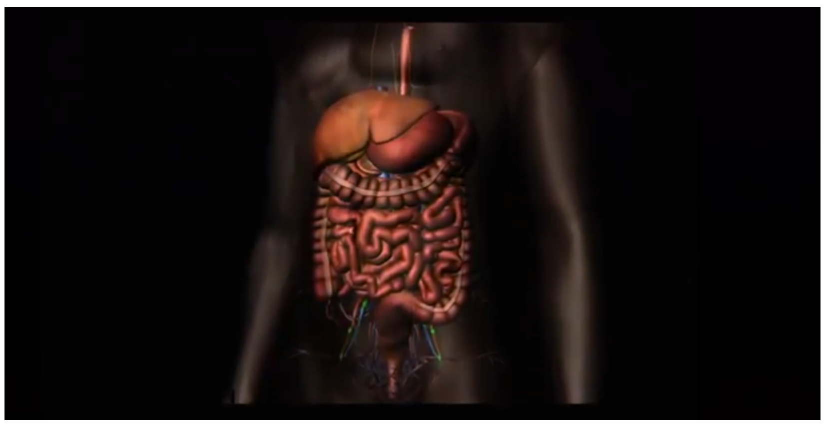


Figure 3.47 AlloSphere: CNM - A human body animation of the intro section, video still - 02

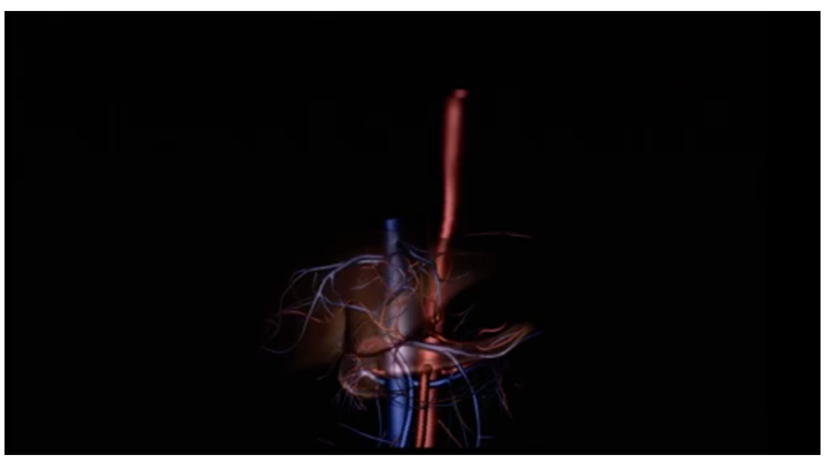


Figure 3.48 AlloSphere: CNM - A human body animation of the intro section, video still - 03

1) Background Research. In the first phase of the project, our team discussed the narrative of what the scientists were going to find in the data. Moreover, we determined that the targeted nanomedicine research required a detailed human body and the simulation of the nanoparticles as they flowed through the body, down to the arteries moving to the organs to cure the disease, pancreatic cancer. In understanding the nature of what Dr. Marth needed to portray, our team planned a video and a simulated model for virtual research. As we began to unfold the video, we implemented this project as a representation and animation which led to further research questions with the domain scientists about how that might move to a virtualized simulation model from the animation.

Figure 3.49 AlloSphere: CNM - A *Fantastic Voyage* animation of the interior - video still - 01

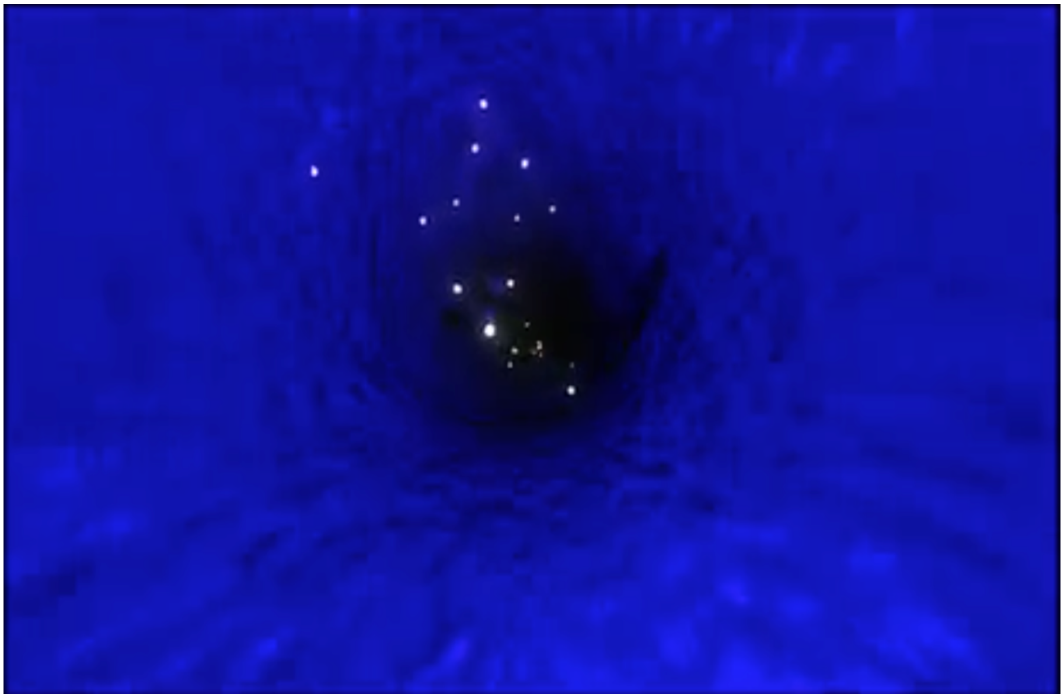


Figure 3.50 AlloSphere: CNM - A *Fantastic Voyage* animation of the interior - video still - 02

2) Conceptual Design & Animation. In the second phase of the project, our team and I tried to render the entire projection narrative with specialized animation software on a computer workstation. As I started working on different objects and environments of the content, it soon became clear to me that the world, the environment, would be a body and the architectural structures would be the arteries (a building). This idea that a simulated virtualized environment was the body, the rendering of the animation on a computer screen was confining and did not represent the body as the world environment. We were in a box, and yet all the animated geometry was a tube and artery that was used as a background to be flown through.

It only became clear to me that a paradigm shift would occur in my research as I moved from screen to the AlloSphere in the next phase. While the box went away, the screen disappeared and the instrument became the environment revealing the power of the animated flight of nanoparticles flying through the arteries of a human body traversing the entire cycle of the flow of the cancer treatment. This was now my first embodied experience transforming an idea, to simulated data into being truly present in a virtualized world [158].

Figure 3.51 AlloSphere: CNM - A *Fantastic Voyage* simulation view of inside the AlloSphere - 1
Accessed on August 13, 2016. https://www.nsf.gov/news/mmg/mmg_disp.jsp?med_id=73451&from=

3) Simulation; the final phase was the evolution of the animation to a simulation. The complete animation would not fit the strengths of the AlloSphere instrument, but the idea of a "Fantastic Voyage," a nanoparticle traveling within the human body, inspired the next series of computational graphics research. Following the path as an "agent" flowing and attacking the cancer and exiting the body was clear and easily understandable to all of the viewers that experienced the journey within the AlloSphere instrument. The AlloSphere now became the literal body, the world, and the instrument that navigated the world within the

body. The algorithm then unfolded and became the driver of the content connecting the world with the information residing within that world [209].

Figure 3.52 AlloSphere: CNM – A *Fantastic Voyage* simulation view of inside the AlloSphere - 2
Accessed on July 14, 2020. http://www.allosphere.ucsb.edu/

Many open questions resulted. The motion of the camera attached to the path was one decision that fueled more queries on the roles of intelligent agents, agent behaviors and the computational physics required for the continuation of mathematically accurate research ready software for pure scientific discovery was still an open question in the field. The final result was a creation of a vision of a simulation that represented a speculative futuristic cure for cancer in a full demo inside the AlloSphere facility. After that research arc, the territory between initial meetings, ideas, research and the visualization of research created a group experience that helped select future research projects. The differences between instruments and environments in virtual reality were clearly demonstrated by the potential of what each technology had to offer. All initial designs and research were with the objective to create content and a group user experience for the AlloSphere.

In the next section, this experience was tested with the HMD instrument becoming the environment during an extensive AR/VR/MR/XR series of research experiments.

3.2.2 Four Eyes Lab | Instrument to Environment: Details in Realism - 2011 - 2013

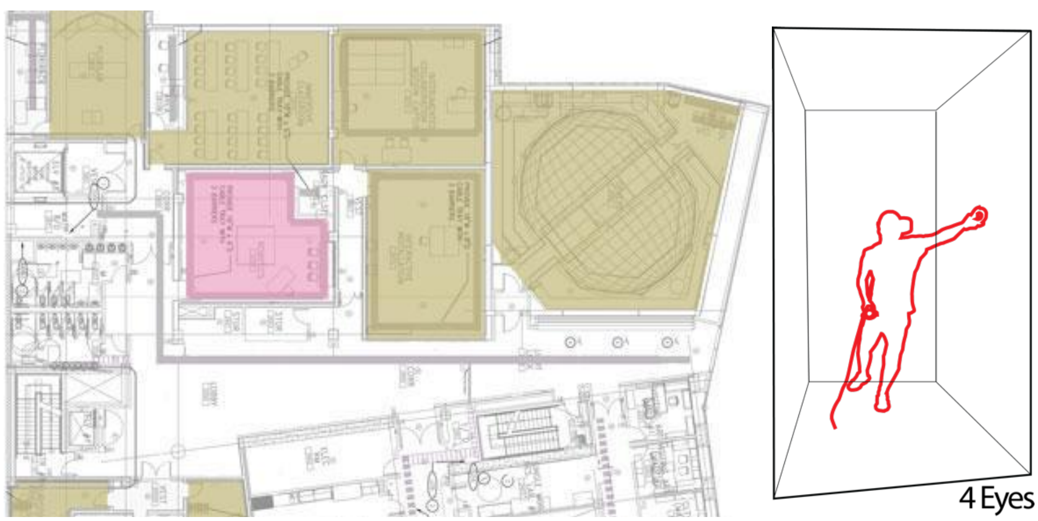


Figure 3.53 Four Eyes Lab at CNSI & a diagrammatic illustration of a VR researcher

My next research collaboration was with the Four Eyes Laboratory. This facility uses HMD's and helmet devices to do research in AR, VR, XR, MR, and Reality. While working with head mounted displays and a facility that researches human-computer interaction, I began working with augmented and extended reality. While using these instruments, it was easy to understand that just as the AlloSphere becomes the environment in which you are immersed, so does the HMD technology. This research revealed that a room can completely disappear, while the user is in the content. This same immersive phenomenon happens in the AlloSphere instrument; one is a disembodied single user experience, the other is an embodied group user experience.

Figure 3.54 Four Eyes user study: a modified design of the HMD adding a camera

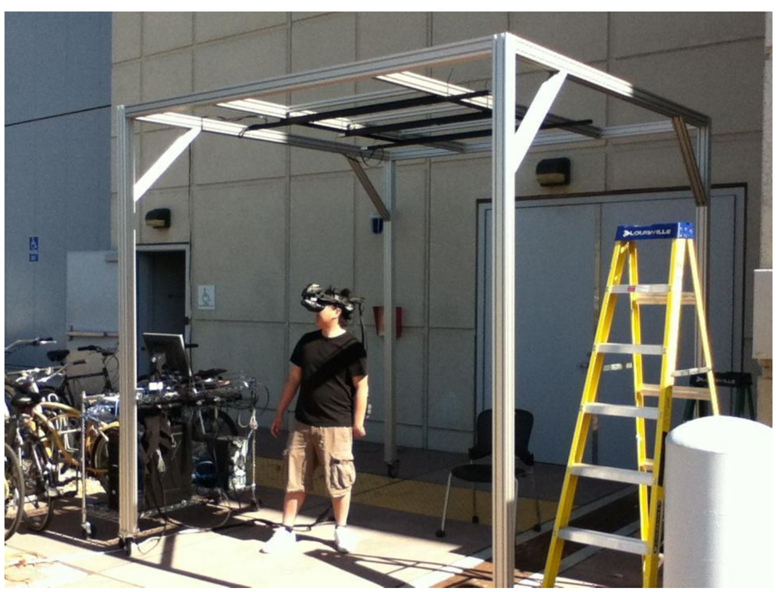


Figure 3.55 Four Eyes user study: Dr. Cha Lee in the experiment rig outside of Elings Hall

Conceptually and technologically, these user experience research paradigms mediate the data differently. The information simultaneously encapsulates the content, environment, and instrument. The transformative power of these interchangeable parts is a core insight to inform *NMA*.

Figure 3.56 The Psychology I Brain Sciences bldg.

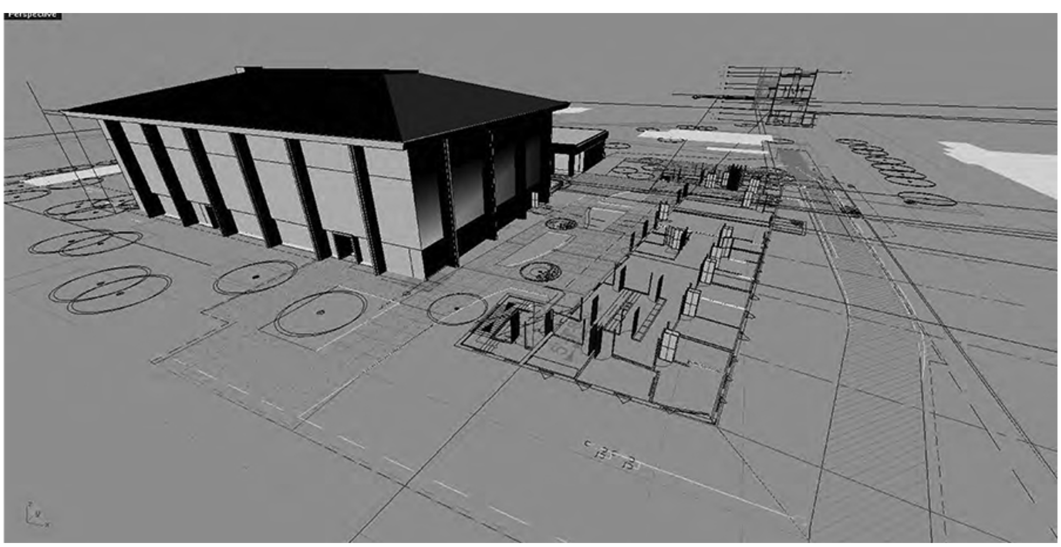


Figure 3.57 Four Eyes user study: CAD of the Psychology I Brain Sciences bldg. design mdl.

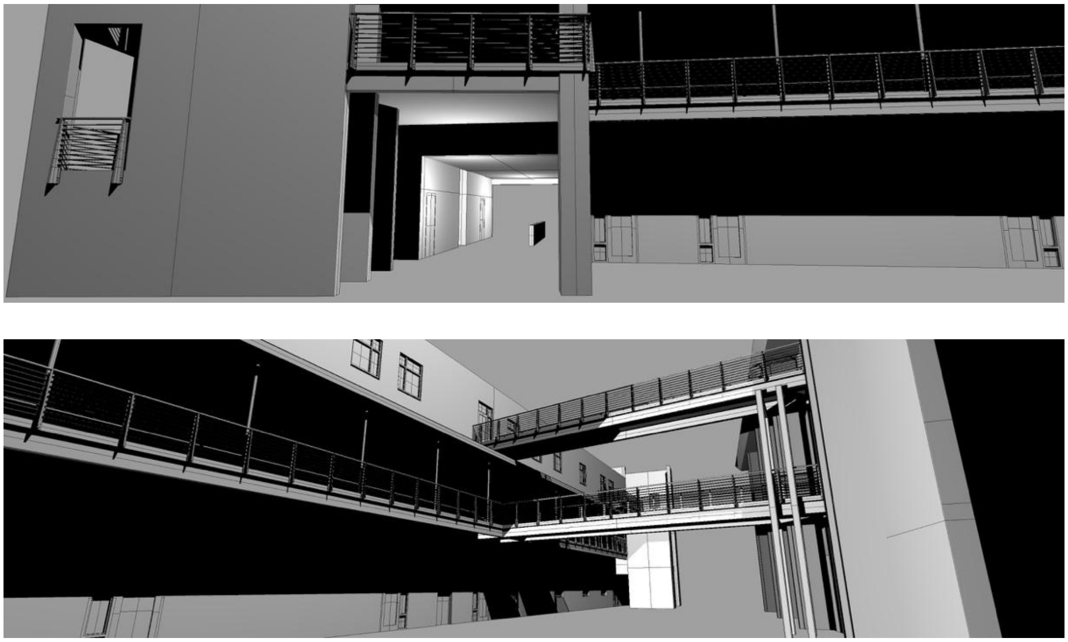


Figure 3.58 Four Eyes user study: CAD of the Psychology I Brain Sciences bldg. - in progress

In my analytical design and computational research work in the Four Eyes Lab, we were tasked to create and map the content (data) with a geometric representation of a building simulated within a virtual world environment. This world's purpose was to recreate as close as possible a courtyard site of the Psychology & Brain Sciences Building on the UCSB Campus. The conference paper that was written as a product of this research titled "The Effects of Visual Realism on Search Tasks in Mixed Reality Simulation" [210] was led by Four Eyes Lab research scientist Dr. Cha Lee with the guidance of Dr. Tobias Hollerer. This paper documented a series of user studies that measured people's responses on how present they felt in a virtual reality simulated environment vs mixed reality (camera) representation. The importance of this research was to find the boundaries of the resolution of the models that need to be made in the virtual world that would convince the user that they are present in the real-world environment. This process was essential to using the computational platform for valid research.

Figure 3.59 Four Eyes user study: An outdoor experiment rig, an onsite test with user participant

To explain how the user study was conducted to allow users to experience the extended real-world data and the simulated virtual world data, the user study was divided into two groups, the first group was housed in the Four Eyes Lab, while the second group was onsite in the courtyard at the Psychology Building. We ran the preliminary studies and in pilot trials among three groups of subjects. The users were asked about their proficiency in finding a symbolic graphic (a label) between the virtual model simulation and the real-world model. The questions were based on their ability to assess the environment, identify the symbolic architectural geometric cues while locating labels within the different levels of detailed VR and XR media. The limitations for comparing real world data models vs simulation models were clearly demonstrated in the conclusions of the paper. The findings were that the extended real world models were more effective.

While the work primarily involved making the simulated models, requiring many layers and dimensions of data (Lidar data, Photographs, and CAD models), the research work aided my understanding of the complexities of simulation of a real-world model. Moreover, qualifying and quantifying the creation of a full user study aided my understanding of the importance of the resolution of the computational model.

3.2.3 transLAB | Instrument intersecting with Environment: 2016 - 2019

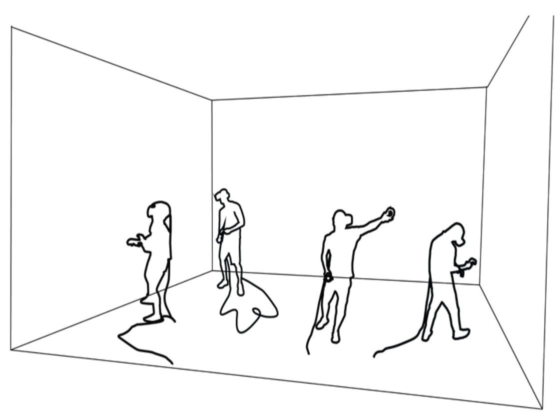


Figure 3.60 An illustrative diagram of HMD research in the transLAB/ CAVE type space

The transLAB Directed by Professor Marcos Novak, was the third laboratory in which I conducted virtual experiments [211] [212]. In the transLAB, the HMD is being used in conjunction with a screen environment. This lab includes the two technologies used in the previous labs. This facility was equipped with a wide array of HMD devices as well as projection-based technologies. It is a space between modalities while extending the definitions of the traditional arts practice. Augmented embodiment, and the potential of virtualized extended space are areas of research in the lab. In this section of the dissertation, I will detail a process of evolving independent research, along these creative lines.

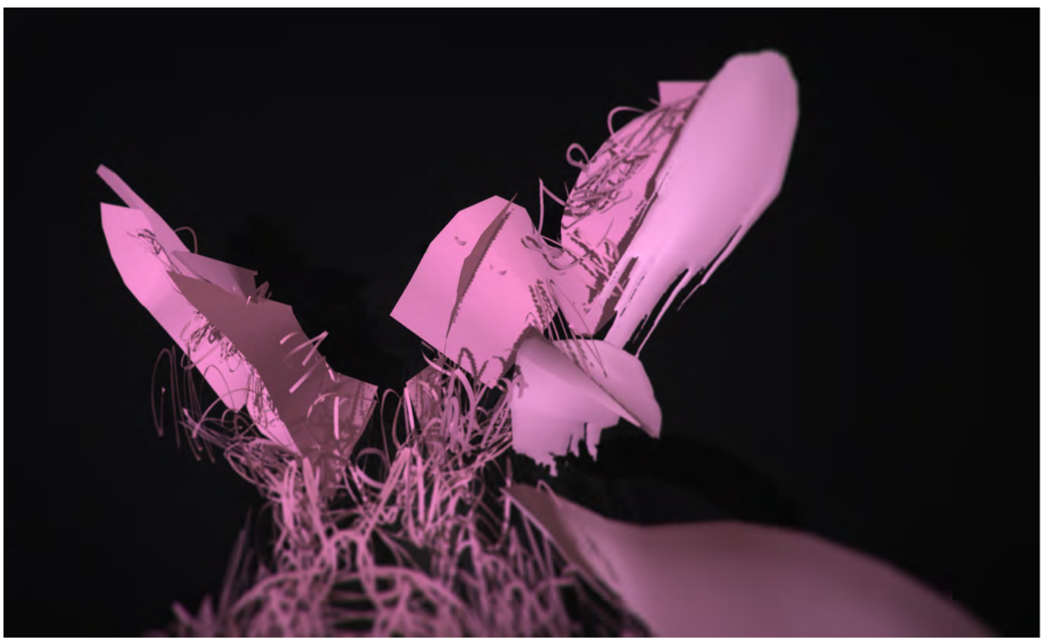


Figure 3.61 HMD experimental content of user motion data, flocking and swarming data - 1

While these series of investigations differed from precise scientific work in the previous labs, the speculative nature of the ideas, designs and narrative expanded the content, and the diverse array of technical equipment HMD's, sensors and projection-based technology, facilitated this expansion [213] [214] [215] [216] [217] [218] [219] [220].

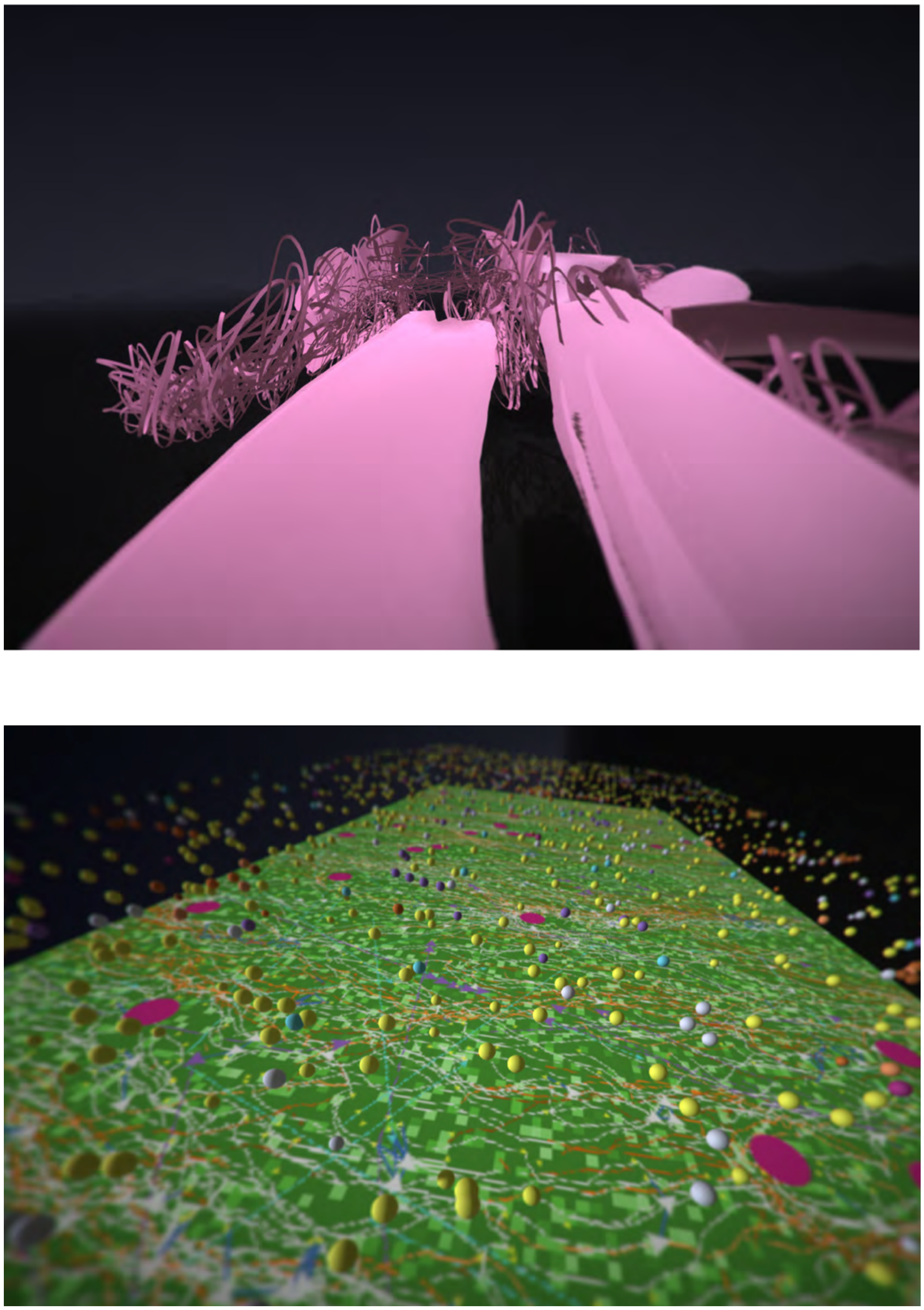


Figure 3.62 HMD experimental content of user motion data with flocking and swarming(t.) & data(b.) 2

In the transLAB, I was able to use mixed methods of experimentation to create Media Art works. All were influenced by Professor Novak's "*Liquid Architectures"* conceptual framework, a concept that encouraged us as media arts practitioners to translate the information of our senses (sight, smell, taste, hearing, touch, vestibular, & proprioception) to agnostic data. This is important for my research, transforming space as information from one content area to another. This resulted in a closer scrutiny of the spatial phenomena within the HMD instrument and the projected spatial environment.

In my research work in the transLAB, I followed two areas of research, 1) complex systems research involving agent-based behaviors in fabricated and virtual worlds, and 2), the creation of collaborative extended reality media art works.

Figure 3.63 transLAB - "*Future Tripping*" EOYS project, data illustrations & sound

The work that is pictured above deals with agent-based behaviors within a virtualized world. This project was my individual project, in the transLAB that began my research in agent-based navigation.

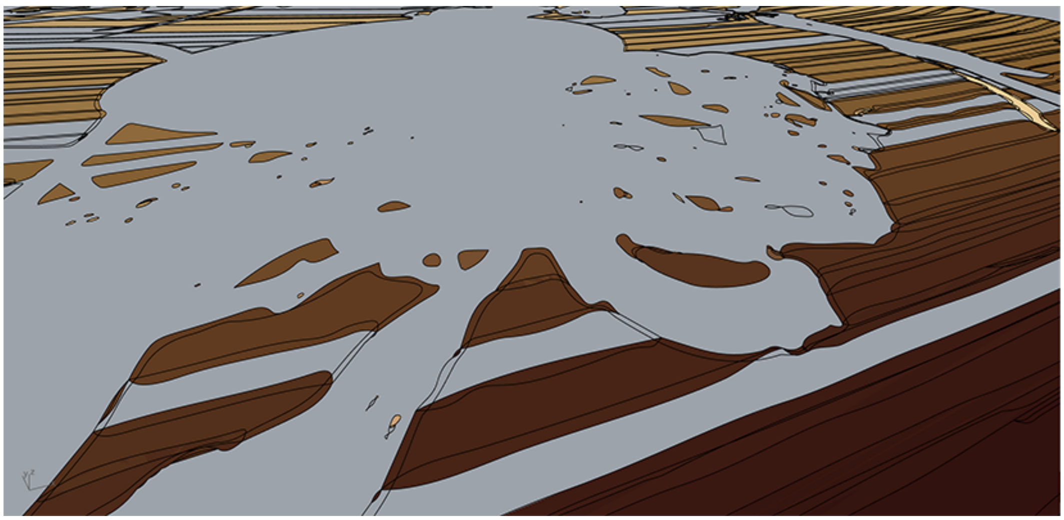


Figure 3.64 transLAB - Directed study for "*Future Tripping*" data illustrations - 1

My virtual world prototype projects dealing with the subject of shared immersive worlds are viewed in the pictures above and below. In this early phase of the project, I worked primarily with making 2D images out of the information data. The project also used agents to create the geometries, navigable paths, and a generative process in the creation of a database of forms and shapes for future worldbuilding [221] [222] that would move into 3D models both virtual and fabricated.

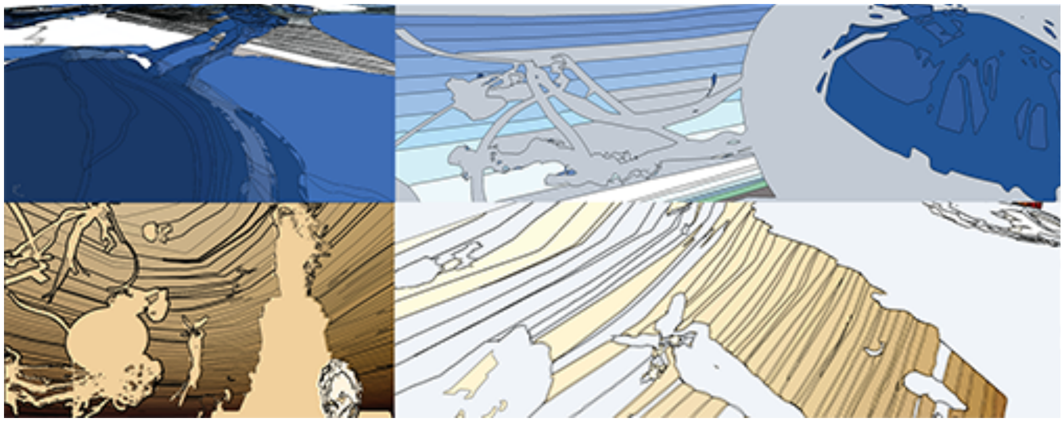


Figure 3.65 transLAB - Study for "*Future Tripping*" geometry, illustrations series - 1

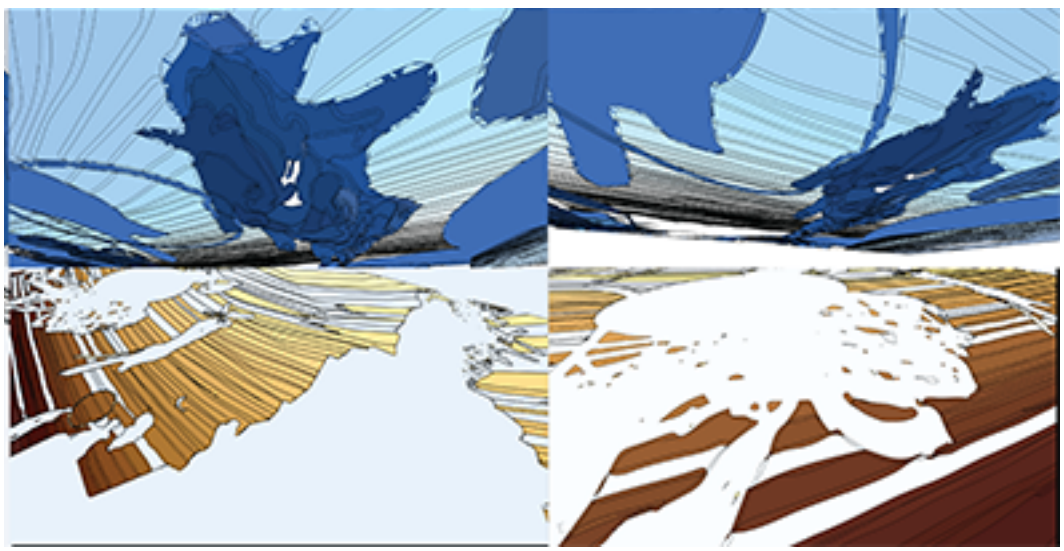


Figure 3.66 transLAB - Study for "*Future Tripping*" geometry, illustrations series - 2

While the process of the creation of the virtual world culminated into an applied set of studies, as shown above, the last phase of my independent research focused on geometric analysis for making 3D representations.

The purpose of this graphical analysis as seen below was to document the virtual world from different angles in order to understand the nature of the complete structure. The interactive virtual model was also created by sonifying the agents. The density of the frozen structures in the fabricated model reveals the intensity of the sound.

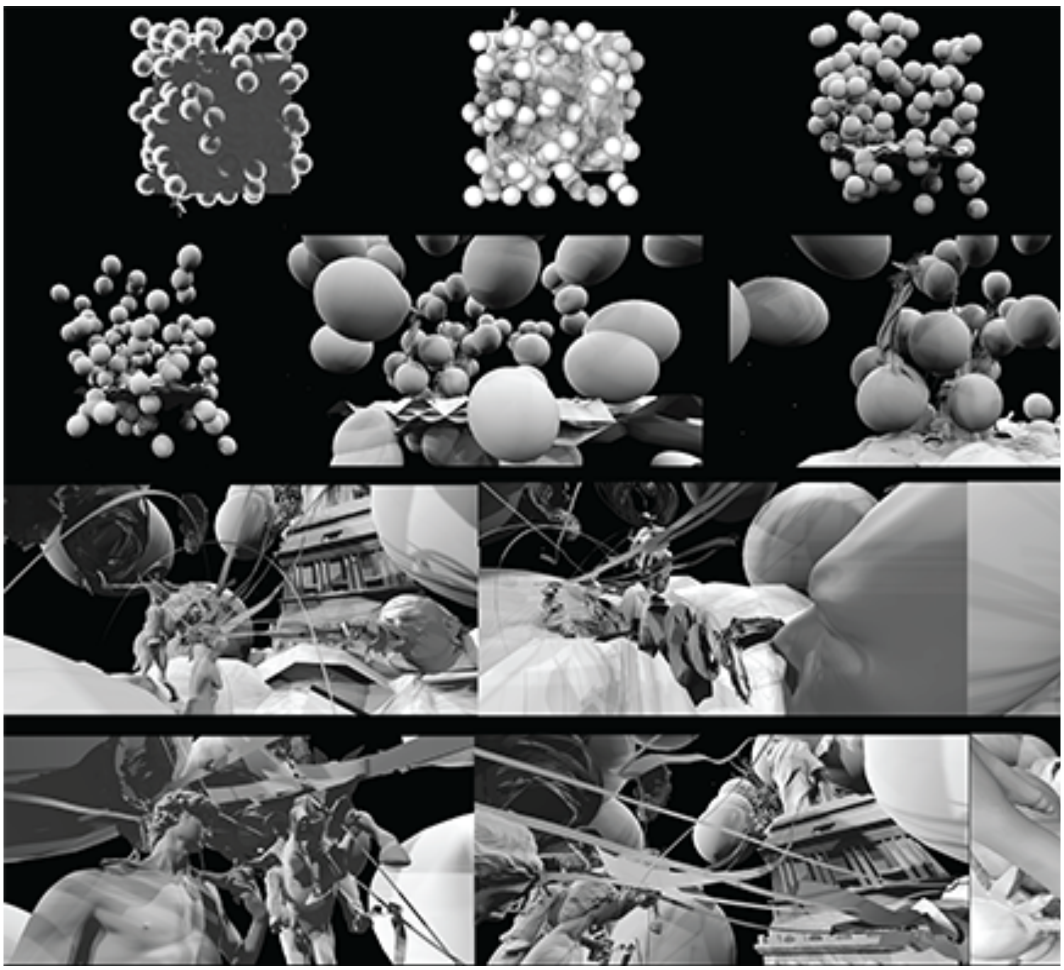


Figure 3.67 transLAB - Directed study for "*Future Tripping*" geometry - data illustrations analysis 1

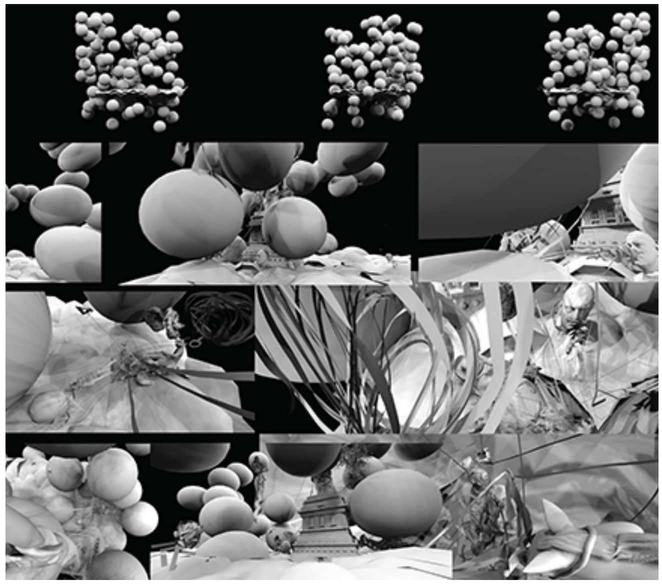


Figure 3.68 transLAB - Study for "*Future Tripping*" geometry - data illustrations analysis *2*

The project titled "Future Tripping" is the first group collaborative work in the transLAB. The audience is viewing this work which integrates multiple projects of the transLAB research community. Much of this process included group discussions, individual research initiatives, and data management by the transLAB researchers for the specific creation of one virtual world. In my project, the investigations started with encapsulating all of my previous transLAB investigations to discover a linear narrative structure through flocking and swarming. The audience viewed this on the projection screen, while a few viewers in the audience experienced this through HMD's. This allowed 2D navigation on the screen and 3D navigation in the helmet. This followed gaming conventions and cues that used agents to influence the behaviors of the viewers. The agents moved independently in this project, which caused some of the viewers in the HMD's to move in opposite directions of the agents.

Figure 3.69 transLAB - *"Future Tripping"* exhibition at EOYS, audience and guided users

This virtual world was visual, sonic and interactive. The generative sound works that I made from flocking and swarming systems were integral to the overall virtual world narrative. This work revealed many obstacles for creating a shared work but also highlighted the opportunities for collaboration. We understood to make an integrated work we needed to transition from one world to the next. Audio is of paramount importance in the linearization of this work. The projection on the walls and the use of HMD portals were positioned in order to make a strong narrative, but the latency and the cumbersome use of the HMD technology, obstructed the flow of the work. In order to overcome these limitations, one needs to orchestrate the narrative accordingly, until technology develops to handle these fluid interchanges.

2. In the second collaborative project titled "Moon Moon" 2018 as seen below, my

colleague Tim Wood is dancing within his reactive system while performing in front of my section of the work responding to the spatialized sound. It follows the same process of the previous work. The difference in this group collaboration was the physical performer integrated into the virtual world. This facilitated the natural integration of the physical audience into the piece.

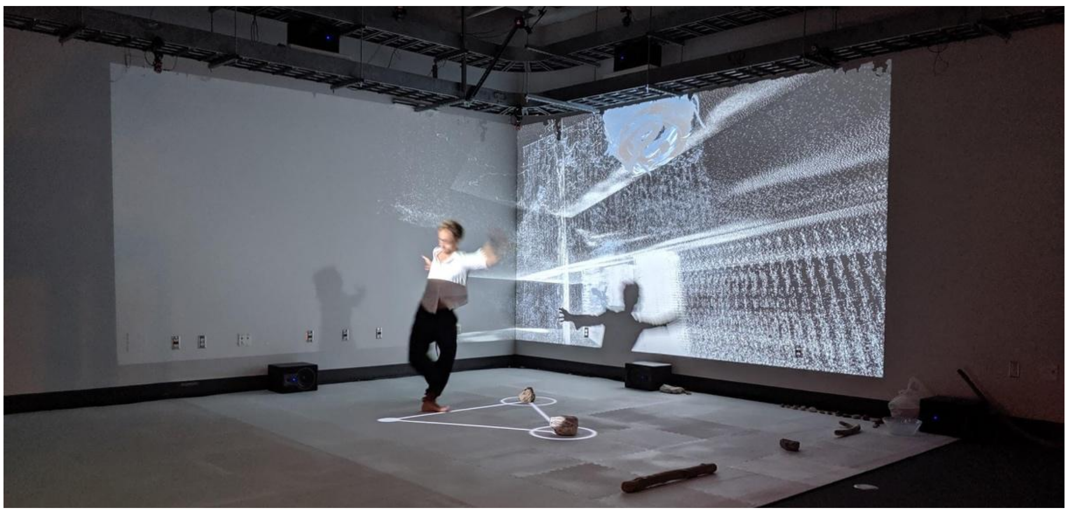


Figure 3.70 transLAB - *A "Moon Moon" r*ehearsal with Tim Wood's dancing

As I continued research experiments in data driven art, I began evolving 2D geometric structures into 3D forms. The purpose of this work was to locate different types of agent-based data and clustering agent documentation for the potential use within a virtual world. These uses ranged from 3D virtual objects to 3D navigable paths among these virtual objects.

As I began to work with 2D and 3D objects in our group virtual research environment, we focused on individual narratives that would make one complete work. The narrative in this group project is based on a historical, and universal theme of conflict. This focused on the creation myth and how it could be transformed into a new structure using these new unique virtual technologies. I created a generative sound composition by combining a female voice and a male voice to harmonically be in opposing tonal dialogues to recreate the Zeus and Hera story.

The next two pictures that follow are data inside the world.

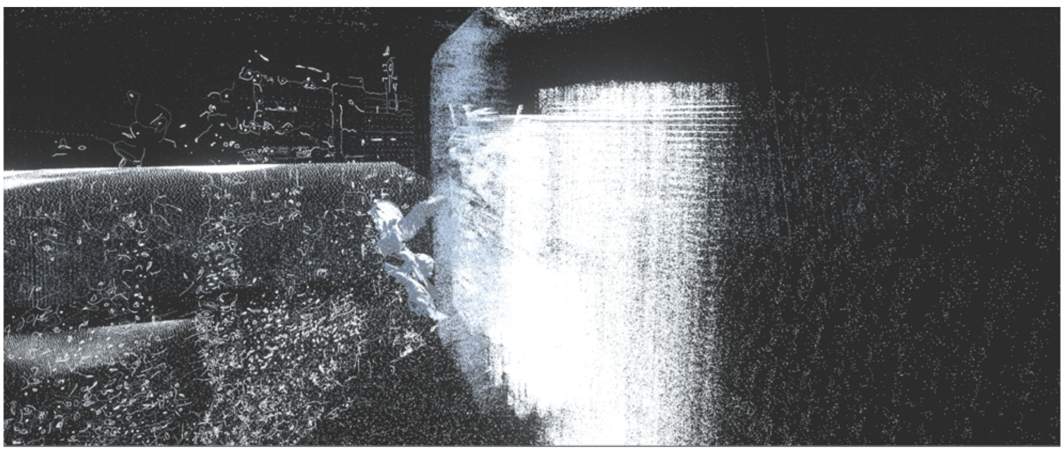


Figure 3.71 *transLAB* - An individual data study for *"Moon Moon"* group world – 1

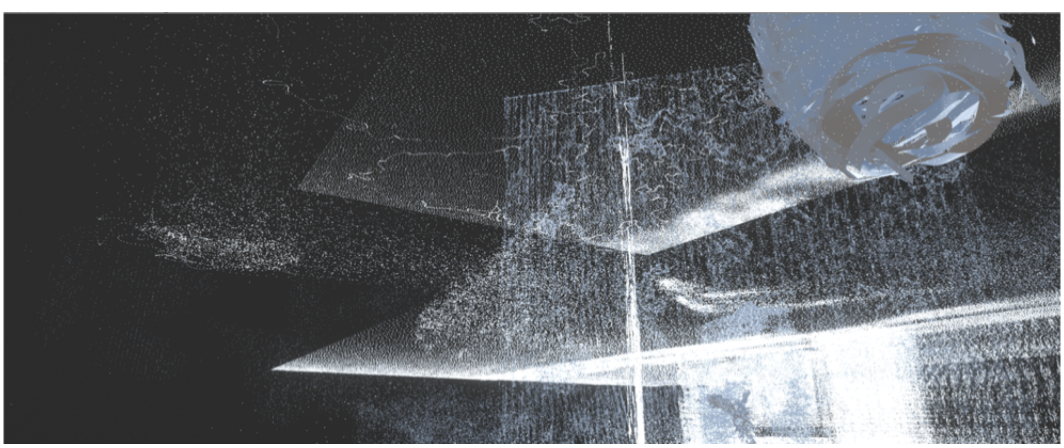


Figure 3.72 *tranLAB* - An individual data study for *"Moon Moon"* group world - 2

The next two photos describe the piece in its totality.

Figure 3.73 transLAB - A *"Moon Moon"* rehearsal, a two performer option Tim Wood & G. Rincon

Figure 3.74 transLAB - *"Moon Moon"* - A research group critique of the performance

Narrative studies informed our formal cinematic vocabulary within the virtual world. Real and virtual characters were integrated in order to make a seamless narrative between the real and virtual. Separate audio and sound tracks were created to be spatialized to add texture and points of interests within a field of sounds complimenting the camera agent movement path. All sounds were spatialized and designed cohesively to feature movement and flow within the created visual virtual sculptural fields.

My contribution to this work was sharing my conceptual framework of *NMA* and to collaboratively forward discussions on the use of architectural structural language of forms, shapes and space. All the major compositional points in the work were moments that could have been iteratively developed further, but the creative scope of the work challenged our groups creative, computational and interactive capacity to compose the work for both the real time generative installation and performative infrastructure.

In conclusion, the obstacles of artifacts, space and technology were explored using the HMD and Extended Reality projected space environment of the transLAB. The majority of these experiments created in my complex science/emergence series of works helped shape a broader understanding of emergent behaviors as conceptual artworks.

In this next section I will continue to evolve my knowledge of immersive technologies and the concept of new media spaces that I gained from my AlloSphere, Four Eyes, and transLAB collaborations. A full-scale implementation of the environment as an instrument will be realized as a form of *NMA* in collaborative work with Dr. Kuchera-Morin and the AlloSphere research group, as we begin to modularize parts of the AlloSphere instrument for various installations.

3.2.4 AlloSphere Installations | Environment as Instrument 2016 - Present

In the culmination of my experiments within the various laboratories, I came to the realization that once one was in an environment where the room can disappear like the AlloSphere or the HMD, the room is not an obstacle to the content. My research in the transLAB facilitated focusing on how to integrate these two types of technologies, the HMD where the room disappears, and a room installation where the projected world is imposed on a cubicle structure. How does one rectify this situation and actually use the room environment to enhance rather than impede the work?

In this subsection, I will discuss how we use the AlloSphere design to compartmentalize some of the structure, making compelling immersive installations that tried to defeat the imposed box-like architectures.

Probably/Possibly? at The Wolf Museum of Exploration + Innovation

Figure 3.75 *Probably/Possibly?* - MOXI installation – representative views of the screen, interface, & seating area

Our first installation where we began this research took place at the Wolf Museum of Exploration + Innovation (MOXI) in Santa Barbara. In this installation we chose to reconstruct the 1,000 sq. ft. box-like structure into a curved screen system, that would allow the room to disappear, and have the viewers be immersed in the content as much as possible. In designing the system, we had to focus on the exact square footage and shape of the rectangular space in order to determine what curved screen size could fit into the space for the best immersive capabilities.

In my role in research for "*Probably/Possibly?,*" which was the media work commissioned by the MOXI, I divided the project into three phases, the architecturally designed installation that included the curved screen design, an architecturally engineered immersive instrument, and fabricated objects.

The goal of the project was to debut a state-of-the-art master installation work while creating a potentially permanent New Media Arts Theatre space for the City of Santa Barbara. My responsibilities were to assist with all of the iterative process of the installation design and to lead the fabrication research of the quantum forms and immersive geometric sculptural works.

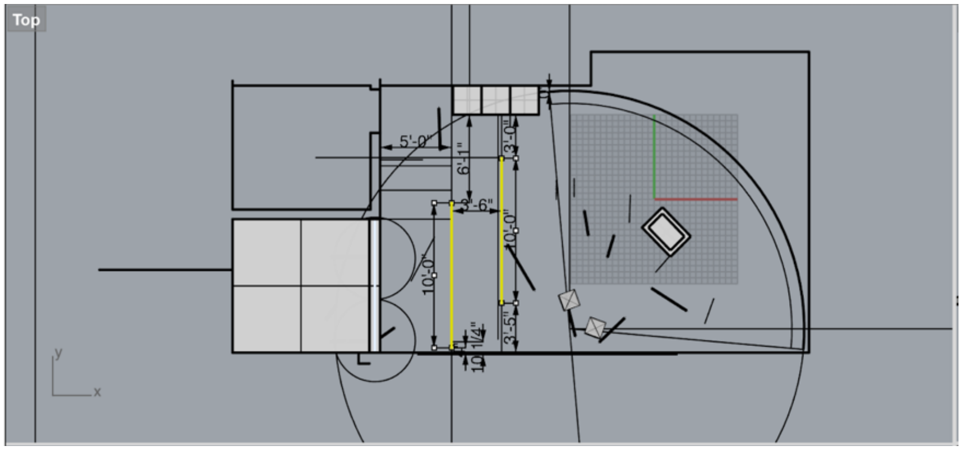


Figure 3.76 Probably/Possibly? MOXI - Exhibition Design - 3D CAD top view

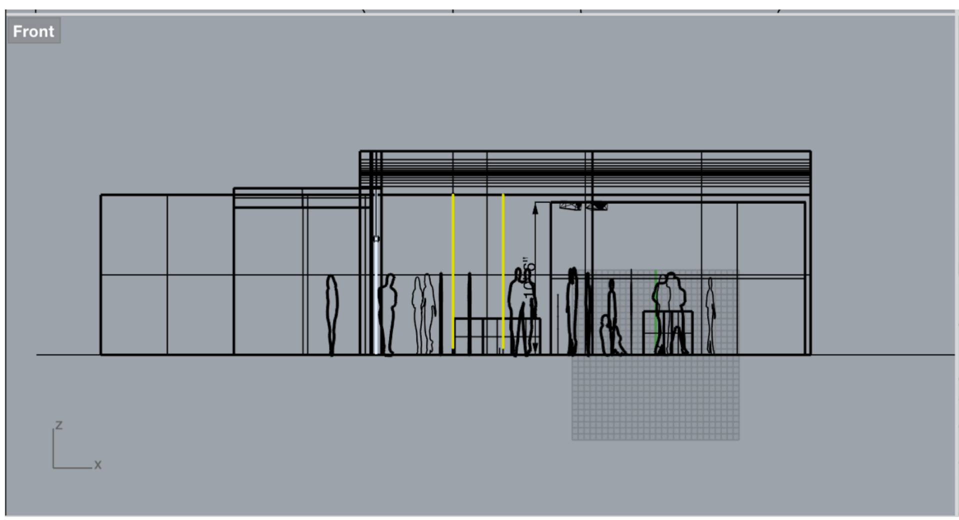


Figure 3.77 Probably/Possibly? MOXI - Exhibition Design - 3D CAD side view

Before the installation could be started, Dr. Kuchera-Morin and the AlloSphere research group tasked me with creating a mockup of the possible proposed media gallery using as-built CAD drawings, and also to consult on the final built specifications with the exhibition director and the managing director of the MOXI Museum and Media Theatre exhibition space.

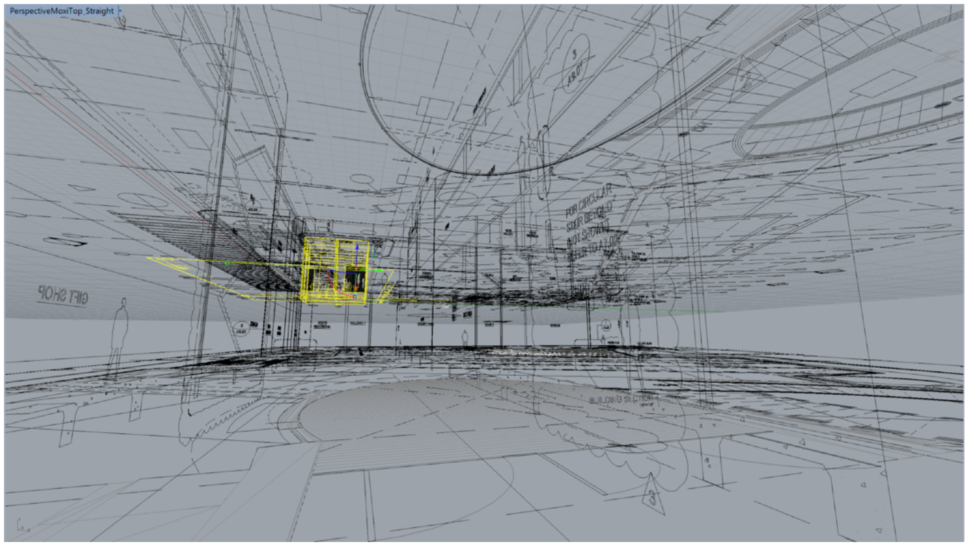


Figure 3.78 Probably/Possibly? - MOXI - An exhibition space as-builts, 3D CAD view 1

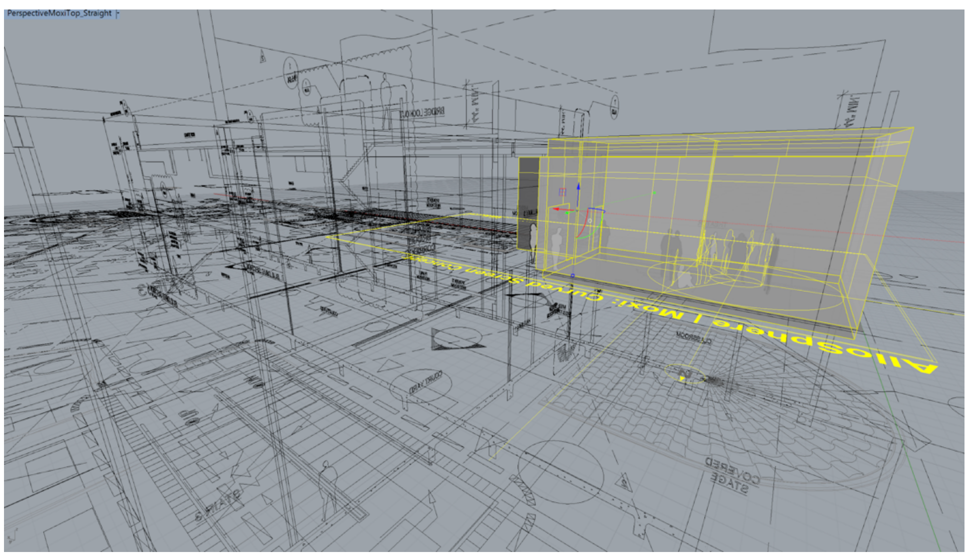


Figure 3.79 Probably/Possibly? - MOXI - An exhibition space as-builts, 3D CAD view 2

The installation design process was finalized while the museum was under construction. Our process, specifying a new projection screen design included all systems (audio, projectors, sensors, & videos), and architectural specifications to optimize the immersive qualities of the space. At this point, we decided to put the curved screen at an angle in the room to offset the box-like structure. The room was painted deep black with the exception of the screen. This facilitated hiding the geometry of the space. The curved screen configuration was inspired by the 100-degree radius of the AlloSphere instrument.

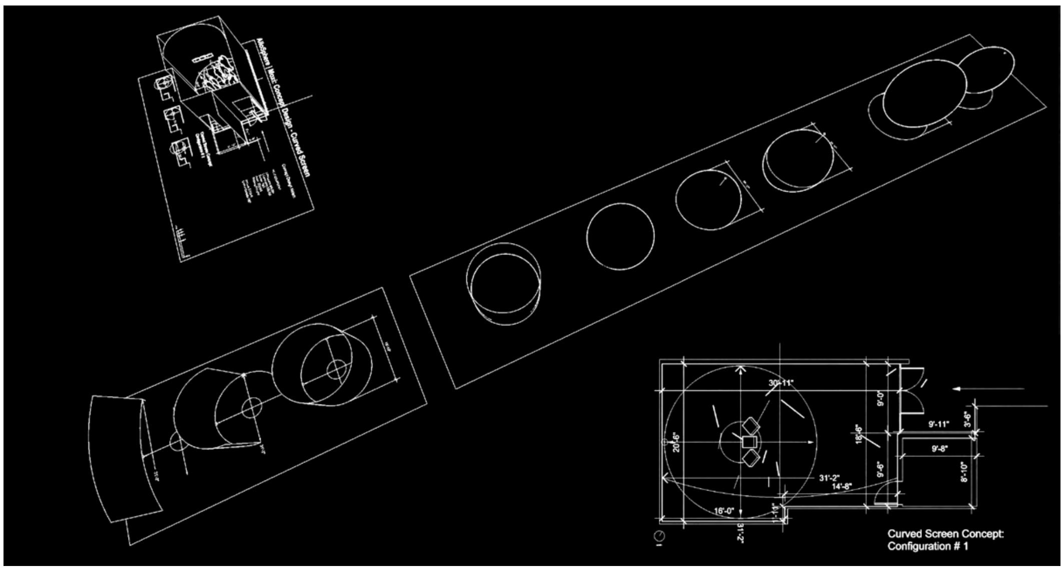


Figure 3.80 ***Probably/Possibly?*** **- MOXI - A screen design concept study**

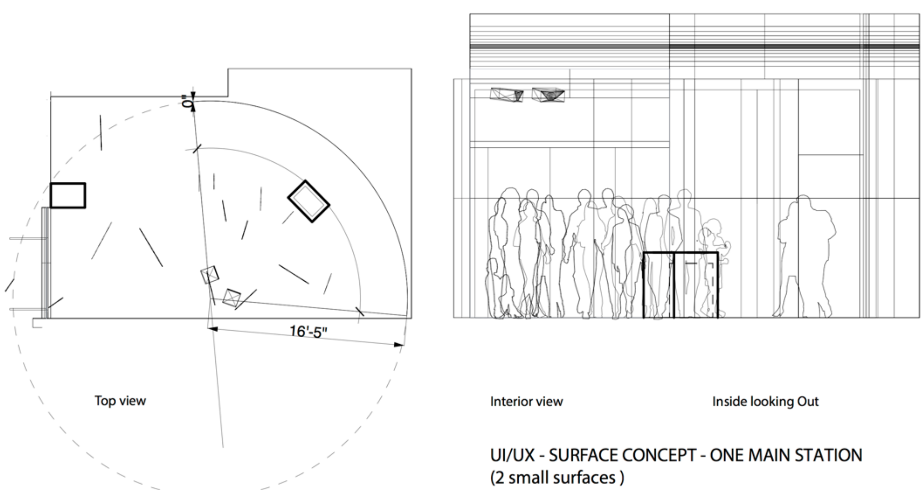


Figure 3.81 ***Probably/Possibly?*** **- MOXI - A screen design study to UI/UX**

The initial CAD documentation revealed the dimensions and the unique design value that existed in the AlloSphere built structure. The AlloSphere geometry now as data with the capability of being tested in either in parts, sections or as a whole in different scenarios led to many inspired design engineering proposals over the years.

I now consider these parts as information. The design and engineering requirements for a next generation of AlloSphere type instruments have been prototyped and tested.

The final design was an extrusion of the curve screen to a 10.5 ft height which was ideal for the MOXI. This also allowed us to modularize the system environment for other spaces. The new design was tested through an architectural design process. The prototyping of a rough scale mockup was then placed in a rectangular room. From the original designs of the AlloSphere a clear understanding of how to place the viewers of the installation for maximum immersive effect was accomplished.

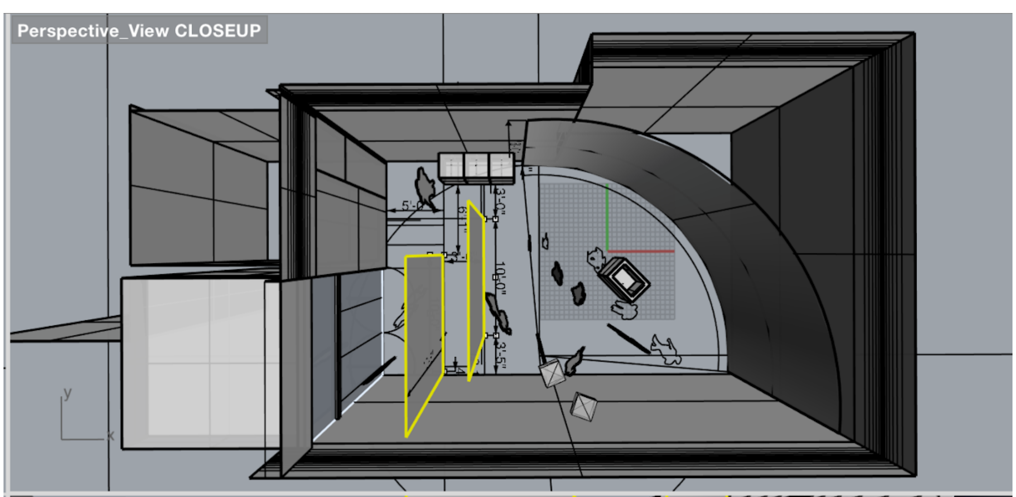


Figure 3.82 ***Probably/Possibly?*** **MOXI - Exhibition design - 3D CAD top view**

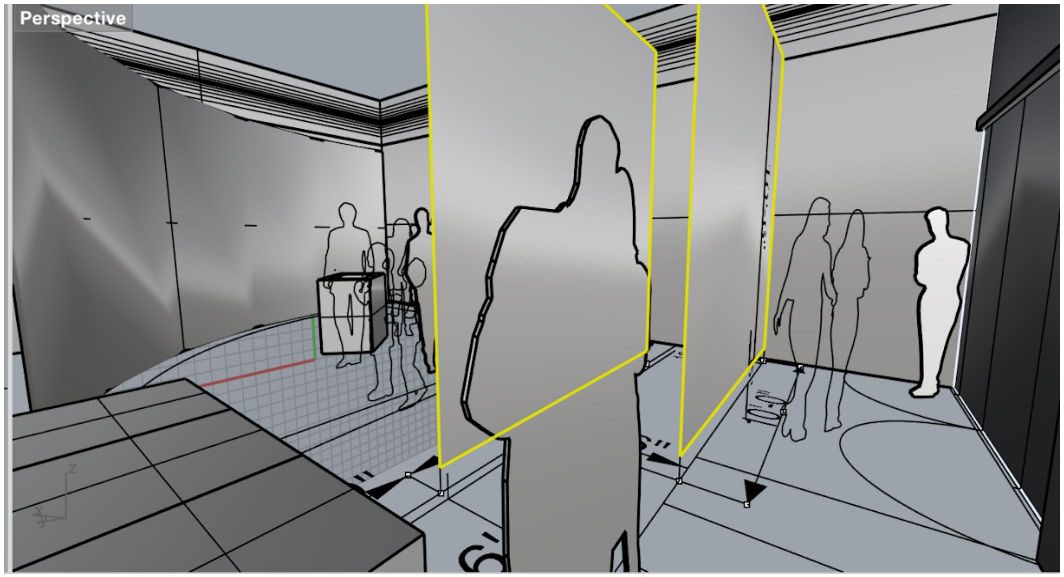


Figure 3.83 ***Probably/Possibly?*** **MOXI - Exhibition design - 3D CAD interior view**

The design of "*Probably/Possibly?*" and the Media Installation space required two major design considerations 1) a new composition with new software infrastructure based on the new AlloSystems framework; and 2) an installation design including an immersive system based on the AlloSphere research facility. The conceptual design, schematic design, design development, and construction phases of the design process were collapsed into one 6 month process. My role within the AlloSphere Research Group varied from consulting in all parts of the architectural specifications, installation design, UX, and XR Designs.

Some of the conceptual threads of the research on the quantum material in the composition included work on the continued analysis of the behavior of the quantum agents in software. The fabrication research component required a close collaboration with the compositional process. The composition was annotated and the virtual objects that were present at the climactic part of the piece were selected as the form to fabricate.

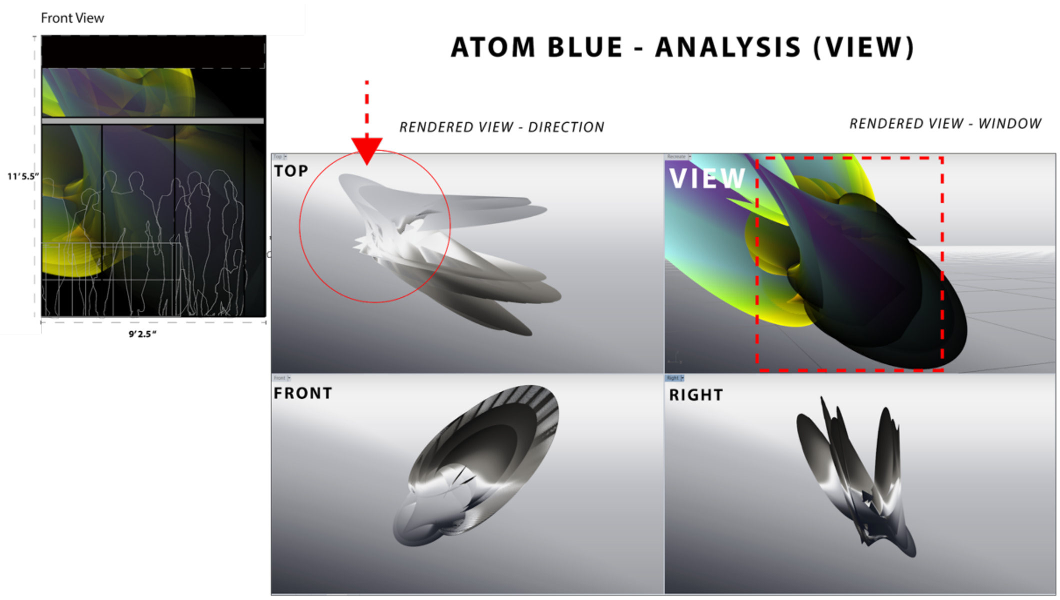


Figure 3.84 *Probably/Possibly?* MOXI, an exhibition design super graphic - 1 of 2

The fabrication research also required a close study of the notes and techniques required to follow along to select the most compelling object form. The candidate topological geometries ranged in complexity, but the isolated Blue Atom graphic was selected for its aesthetic beauty and complexity. My first iteration of the atom was a 2D print that was a super graphic. It was an involved process and took many layers of computational processing and filtering to create the final printed form. This original print was used as the graphic for the entry of the media theatre in 16 ft. x 12 ft. layers of 2D material to create an illusion of a 3D shape. The selected geometry was one beautifully frozen moment of a dynamically varying quantum object.

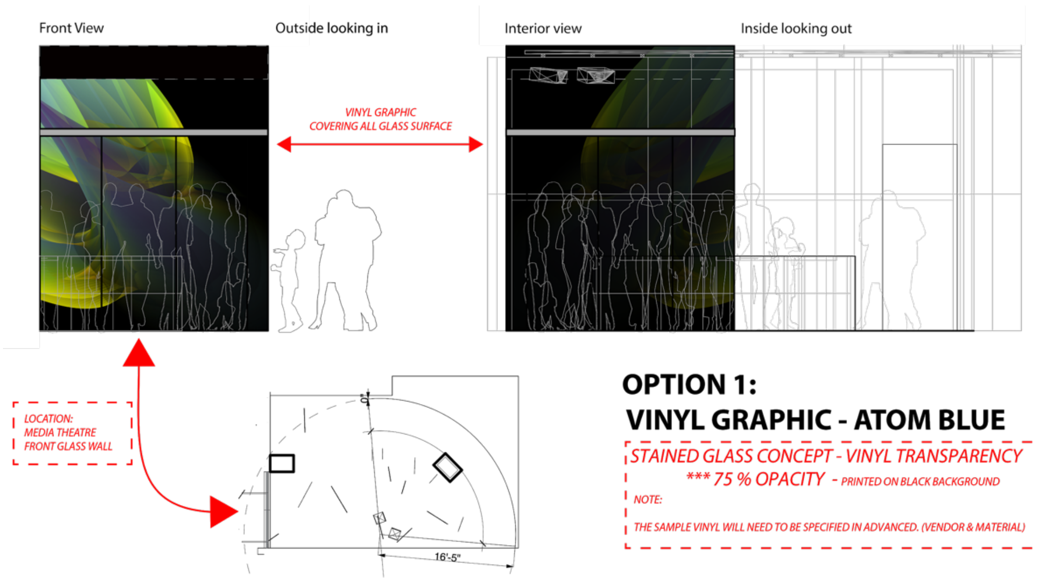


Figure 3.85 ***Probably/Possibly?*** **at MOXI, a Media Theatre exhibition design a super graphic - 2 of 2**

Figure 3.86 ***Probably/Possibly?*** **at MOXI, a super graphic view**

Figure 3.87 ***Probably/Possibly?*** **- A MOXI - Media Theatre exhibition announcement**

In the graphic below, the theater design is pictured in the upper right-hand corner, the left-hand column describes the composition and the user interface is featured in the lower right-hand corner. The interface was in the form of a keyboard, to control and transform the work.

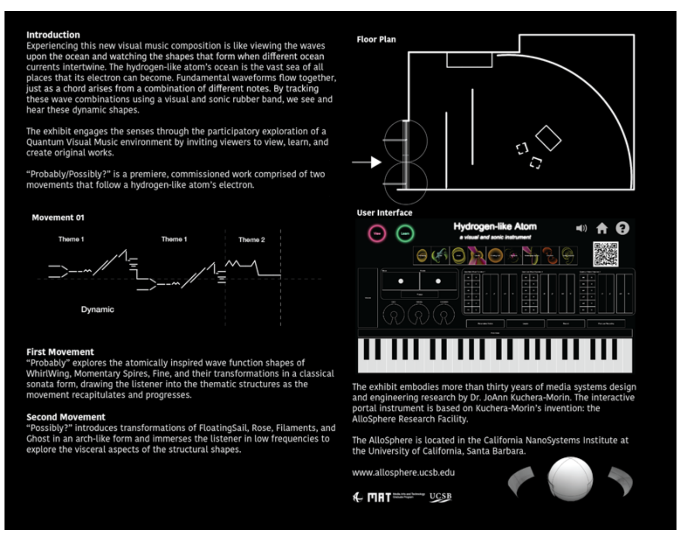


Figure 3.88 ***Probably/Possibly?*** **- A MOXI - Media Theatre exhibition brochure**

The installation was a success as it debuted the MOXI Museum's ambitious plans for a media installation projects space. It also managed to anchor the museum's programming and created a new area of immersive media research works. Many lessons were learned.

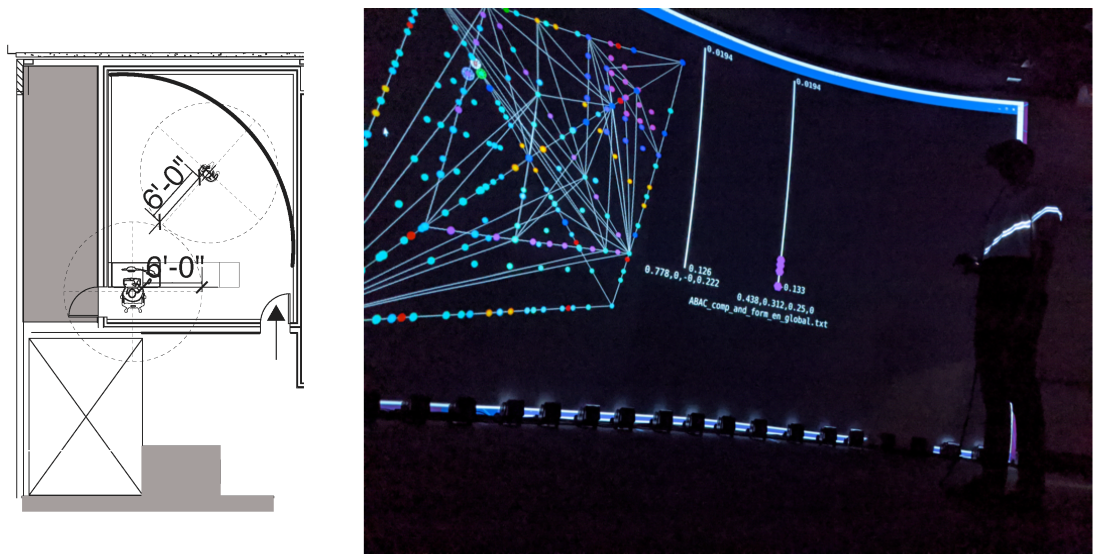


Figure 3.89 *AlloPortal* - An occupancy diagram & a Material Scientist inside AlloPortal

The artistic and engineering disciplines merged into a single unified continuation of the AlloSphere research groups methodology. Soon after moving from MOXI, a new University of California, Santa Barbara lab was created based on the MOXI infrastructure called the "AlloPortal" facility. While the process was rigorous and required much consulting and design development, we created a new modular version as a slice of the AlloSphere.

Etherial

The next project was "*Etherial*" [223] which had a 6-month development process and was completed in June of 2019, the engineering to finalize the completion of the installation on the first day was accomplished by my colleague, Kon Hyong Kim. The setup on site in Gwangju, South Korea, proved that an immersive space with the AlloSphere system could be set up in one week's time. Much of the engineering and development beforehand by Dr. Andres Cabrera and the AlloSphere research team helped secure a stable and robust software infrastructure.

Figure 3.90 *Etherial* - Setting up for ISEA 2019 in Gwangju, South Korea

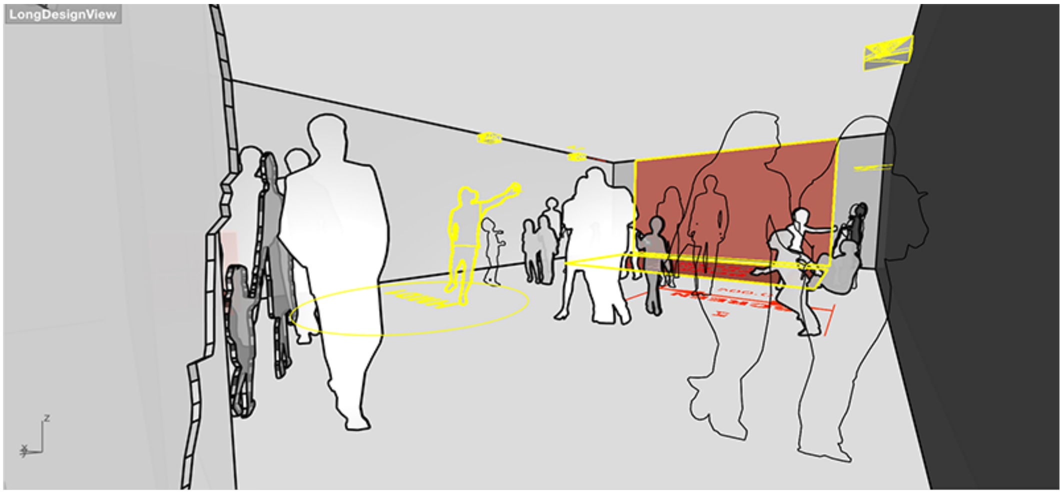


Figure 3.91 ***Etherial*** **- Installation design, an exhibition for ISEA 2019**

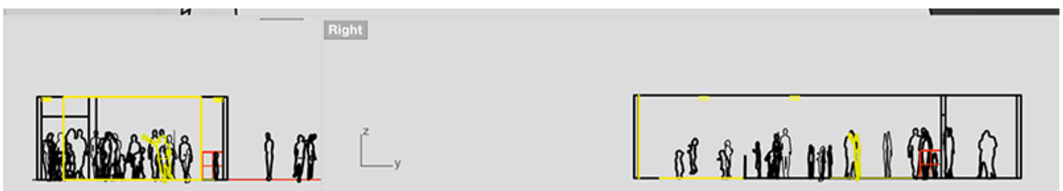


Figure 3.92 ***Etherial*** **- Installation design, a side & front view for ISEA 2019**

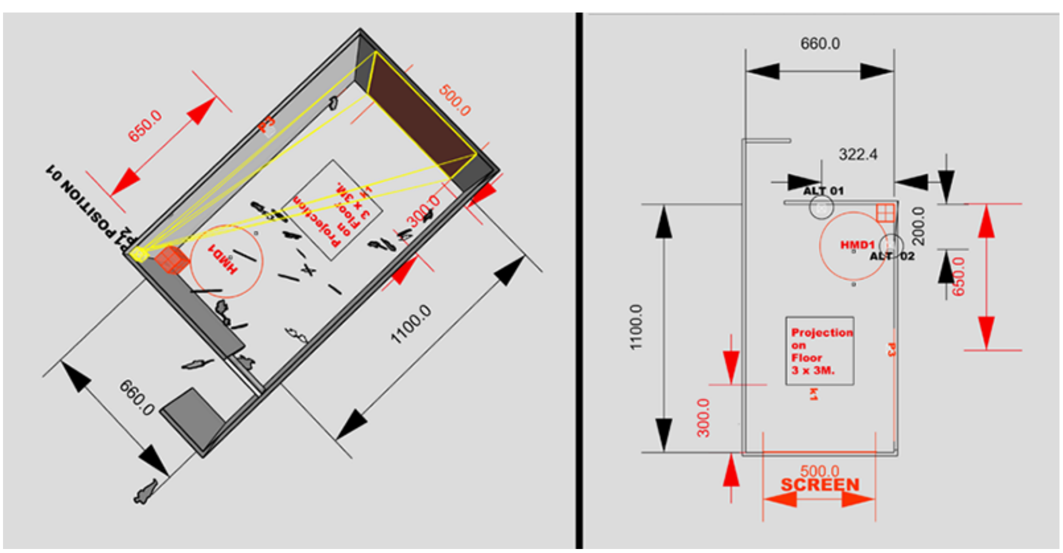


Figure 3.93 ***Etherial*** **- Installation design, exhibited at ISEA 2019 in Gwangju, South Korea**

The original Ethereal installation design had three component parts featured in the project which included an interactive immersive composition, a fabricated work and an HMD of the composition.

The installation, when it was finally realized, had two out of the three components, while the fabrication component remained in the prototype stage.

Figure 3.94 *Etherial* - A immersive stereo environment exhibited at ISEA 2019

The seamless experience created in a museum was successfully carried out even though we did not implement the curved screen design. In order to substitute the lack of curvature for immersion, it was discovered by Kon Hyong Kim that floor projection was an important component to fill the box like structure. The creative use of hardwood reflective flooring helped to connect the front screen with the floor and also created a visually elaborate floating image in the immersive environment.

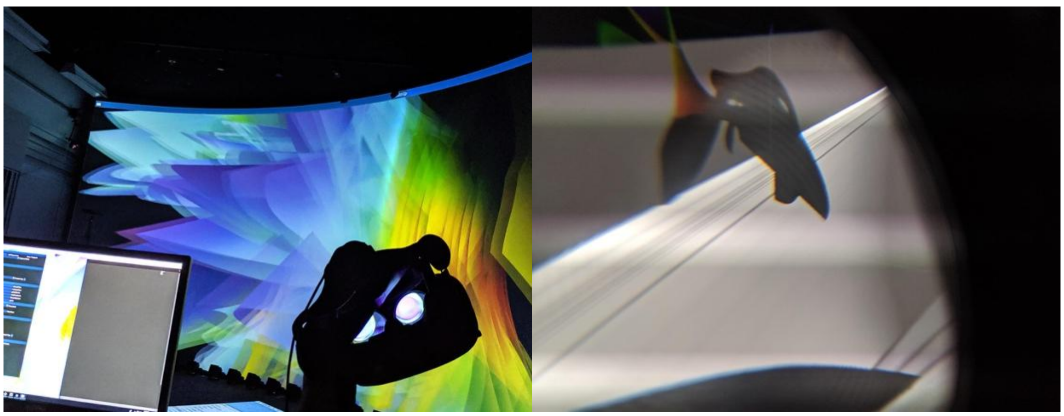


Figure 3.95 *Etherial* - Inside the AlloPortal lab and a view inside the HMD

After constructing, designing, and observing the results, we qualitatively agreed that the museum space offered another type of immersive opportunity to explore quantum content with a combined non-stereo, stereo, and HMD experience. This was the first time to connect the concepts started in the transLAB, now I can connect the HMD environment with the stereo immersive projected environment, as viewed in the pictures above.

Myrioi

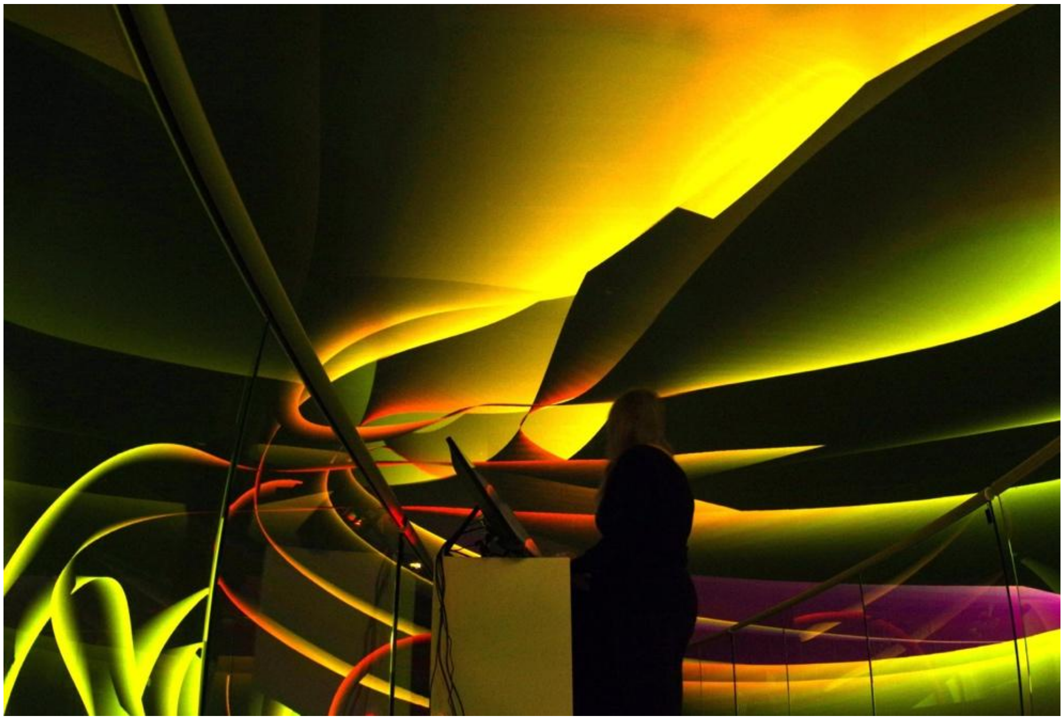


Figure 3.96 *Myrioi* - A view in the AlloSphere exhibited for SIGGRAPH 2020

The *Myrioi* project was premiered at the SIGGRAPH 2020 Conference [224]. We made this collaboration a continuation of the development of a hybridization of the AlloPortal system. The installation was a continuation and an evolution of the immersive quantum composition projects as well. During this time in this situation, it was moved to a virtual venue. For this reason, we set out to take the concepts that we had for the physical installation into a distributed virtual community. The team was directed by Dr. JoAnn Kuchera-Morin (Lead Artist/composer), Dr. Andres Cabrera (Media Systems Engineer), Kon Hyong Kim (Graphics Researcher), Tim Wood (Human Computer Interaction), and Gustavo Alfonso Rincon (Virtual Architecture/Design).

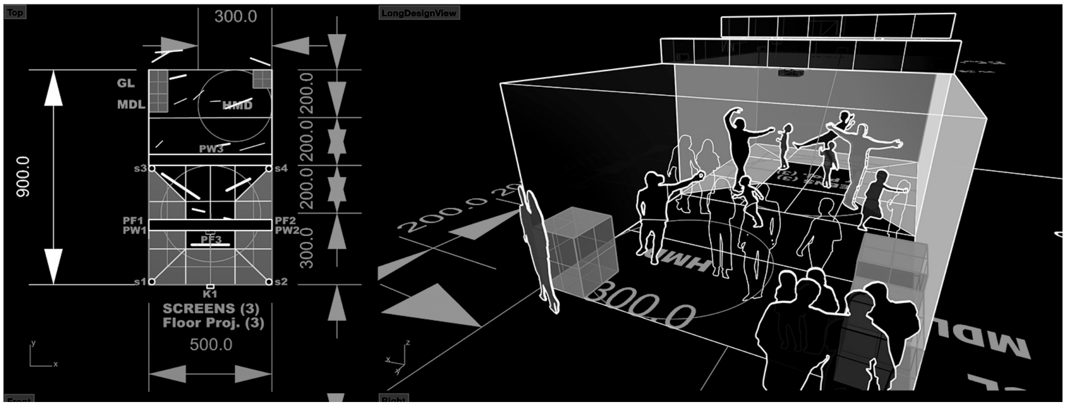


Figure 3.97 ***Myrioi*** **- An installation design for SIGGRAPH 2020 - top & perspective**

Figure 3.98 ***Myrioi*** **- An installation design for SIGGRAPH 2020 - side & front**

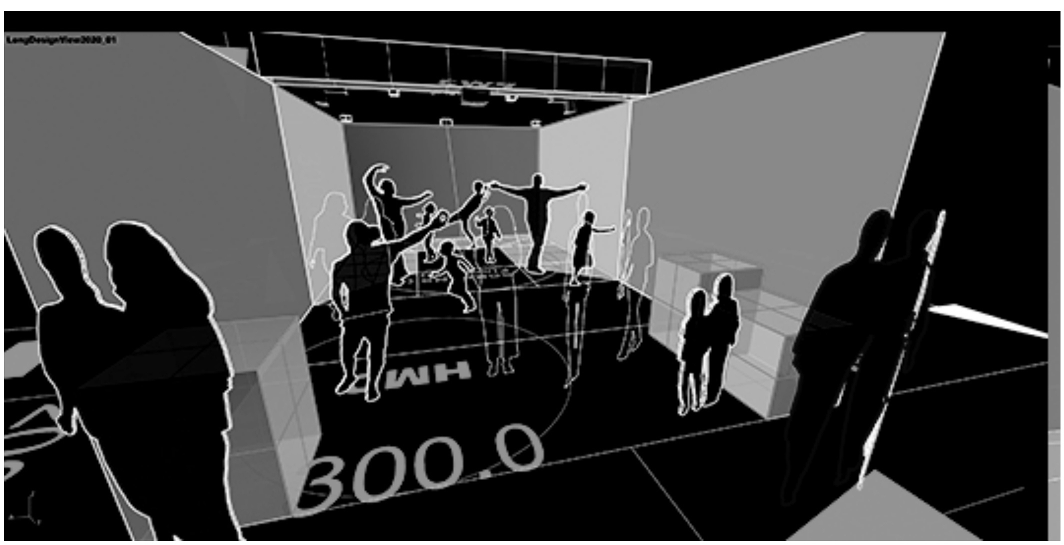


Figure 3.99 ***Myrioi*** **- An installation design for SIGGRAPH 2020, view - 1**

Figure 3.100 *Myrioi* - An installation design for SIGGRAPH 2020, view - 2

The picture above diagrams the physical installation that we had planned for the conference. The four projected surfaces required six projectors for complete coverage.

This included floor coverage which we realized from Gwangju is a very important aspect for immersion in these cubicle spaces.

Figure 3.101 Myrioi - Dr. JoAnn Kuchera-Morin inside AlloPortal at CNSI - 1
Accessed on July 14, 2020. http://www.allosphere.ucsb.edu

As was stated above, the original installation design changed due to the Covid-19 pandemic. Much of the components from the original design concepts were to be worked together seamlessly into one instrument. What transpired during our independent work was a transformation from immersive embodied space to a virtually embodied space. This was done using the AlloSphere and AlloPortal for prototyping, and the HMD to recreate the full surround scenario that was supposed to be physically planned.

The final Composition by Dr. Kuchera-Morin along with Media systems engineer, Dr. Andres Cabrera facilitated the expansion of the AlloLib software infrastructure to meet the computational demands necessary to accommodate multiple atoms simultaneously.

This was an artistic and software design limitation until this project.

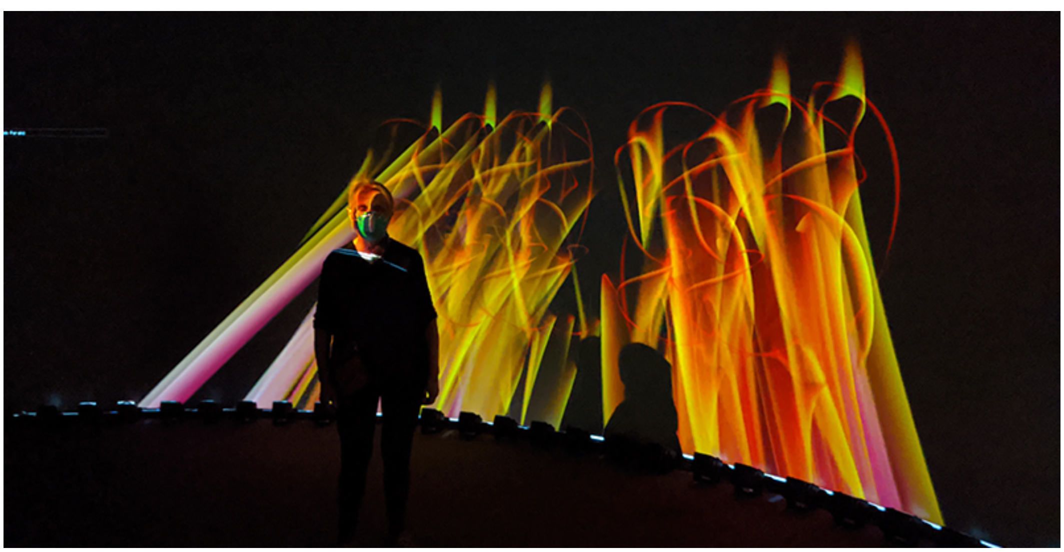


Figure 3.102 Myrioi - Dr. JoAnn Kuchera-Morin inside AlloPortal at CNSI - 2
Accessed on July 14, 2020. http://www.allosphere.ucsb.edu

Creating these three project installations in these varied and different spaces, facilitated our expansion and transformation of the AlloSphere instrument into a modular system that can be reconstructed into many different forms and shapes depending on the size and the shape of the environment that was given to us.

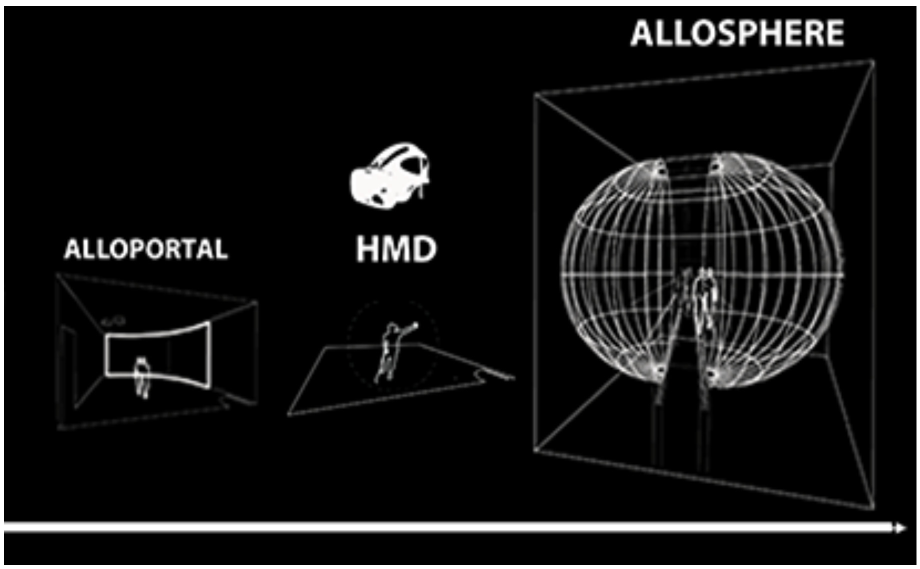


Figure 3.103 AlloPortal (curved screen) to HMD to AlloSphere - full immersion

The picture above describes the modularity of the AlloSphere and how it can be built into components. When working in a cubicle situation as viewed in the picture below, one must solve the constraints of the visual artifacts by as much screen coverage as possible for full immersion.

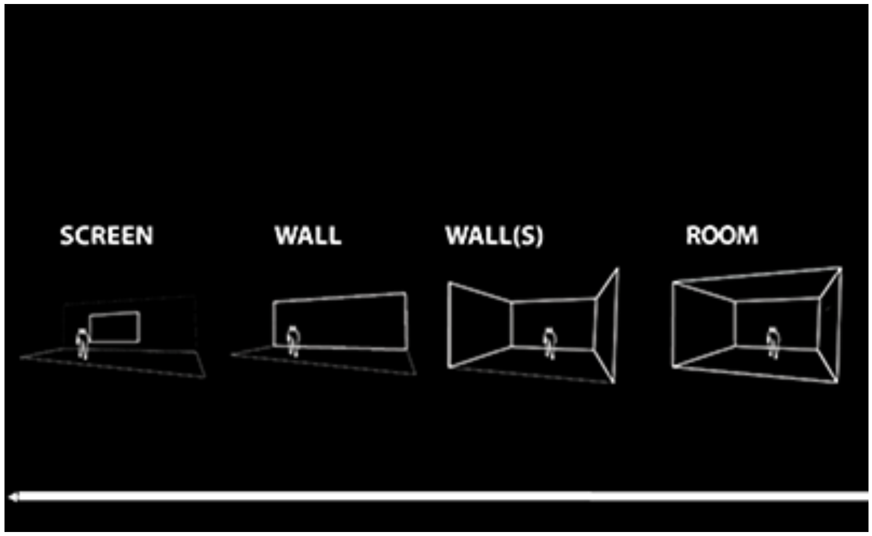


Figure 3.104 Analytical Diagram - A view from a screen, projected walls to CAVE design

Most museums in which artists display, have mainly cubicle structures and this was the limitation that we were confronted with in our installation also in *Myrioi* at SIGGRAPH 2020 Gwangju, South Korea. With these limitations, we began to look at how we can bring the modularity of the AlloSphere instrument into cubicle installations.

My work in these three research laboratories (the AlloSphere, the Four Eyes Lab, and the transLAB), helped me understand how to design these various environments for full immersion, from the spherical to the complete cubicle and transitions in between these two disparate shapes.

This concludes my chapter on my methodologies in defining this new field of *NMA*. I found that it is the algorithm that creates, shapes and forms the information that will become the world and the content in which the world resides.

Chapter 4

What is New Media Architectures?

> *I am interested in the rather singular goal of making the built environment responsive to me and to you, individually, a right I consider as important as the right to good education. (Negroponte,1975)* [225]

> *Our Question, in asking after Beauty, hinges in part upon the relationship between physical reality and our perception of it. ...But there's another dimension to our Question, which is the relationship between physical reality and ultimate reality. Or, if you are (understandably) uncomfortable with the concept of ultimate reality, let's just say the big picture—how we connect the deep nature of physical reality to our hopes and dreams. What, if anything, does it all mean? (Wilczek, 2016)* [226]

In this field that I am describing as New Media Architecture, or *NMA*, the most important component that must be integrated into arts and architecture is the idea of complex systems science and space as a configurable network that can be transformed from one medium to another. As the two quotes above infer, the conception of space leads to a further broader education of one's own environment and a broader relation to a concept of ultimate reality.

Regarding complex systems and complexity, I will explain my experience confronting a phenomenon known as the "tyranny of scales" which asks the question whether we can use our knowledge of intermediate micro- (or meso-) scale behaviors that would allow us to bridge the gap among these various scales from the atomic to the universal [227]. As one can see from this quote, a complex system is one that is open-ended. This is how it is differentiated from a complicated system. As Holland states:

> *...distinguishing complex from complicated involves the 'pile of sand conundrum.' If we start with a recognizable pile of sand and start taking away one grain at a time, when does it cease to be a pile of sand? (Holland, 2014)* [10]

It's impossible to distinguish a pile of sand from a grain of sand. There is no discretization of that process. It is an open-ended question. And typically in architecture [228] [229] [230][231] [232][233], we build complicated systems that are very difficult but have a conclusive end to the design. In a sense, art can be an open-ended system. In really investigating complexity theory and self-organization, it frees up the process, from building the infrastructure from the top down. This is what I want to add to the field of architecture. In my opinion, with the arts, the questions are open-ended, but may not be as rigorous and scientific investigation. I want to bring the rigor of scientific investigation to the arts as well.

The process of self-organization has been implemented in other fields as I have already described, especially with architecture and music as displayed by the collaboration between Xenakis and Le Corbusier. This self-organization principle is further evolved by Professor

Novak's *Liquid Architectures* in the following quote:

> *A liquid architecture, an architecture of relations, an architecture in which the final built object is wrested from an infinite continuum of possible variations. The creation of systems of relationships and the assignment of specific values becomes the foreground of the architect's activity and invention. (Novak, 1988)* [39]

In order to take the idea of *Liquid Architectures* to the level of information, a spatiotemporal architecture can be defined as the process of building relations between a bit (a unit) to a continuum of possibilities, a phenomenon as information.

4.1 The importance of Complex Systems Research for New Media Architectures

These two diagrams represent the progression of a complex system from single agents with simple rules to a complex adaptive system of materials as skin boundary layers.

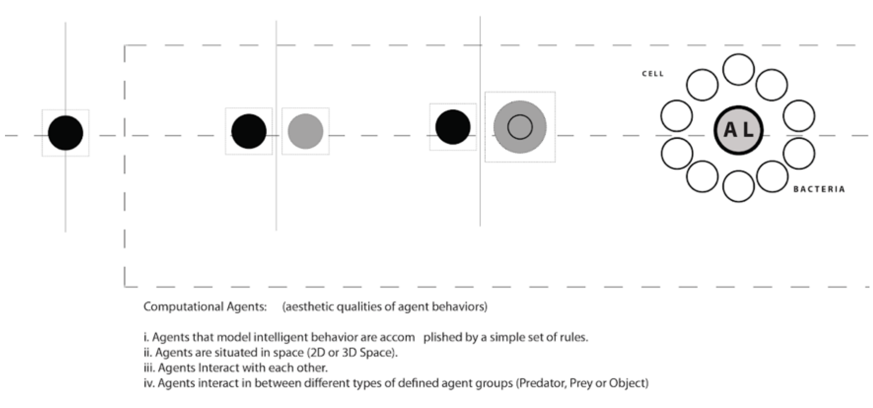


Figure 4.1 Elements diagram of Agent-based behavior originating from simple rules

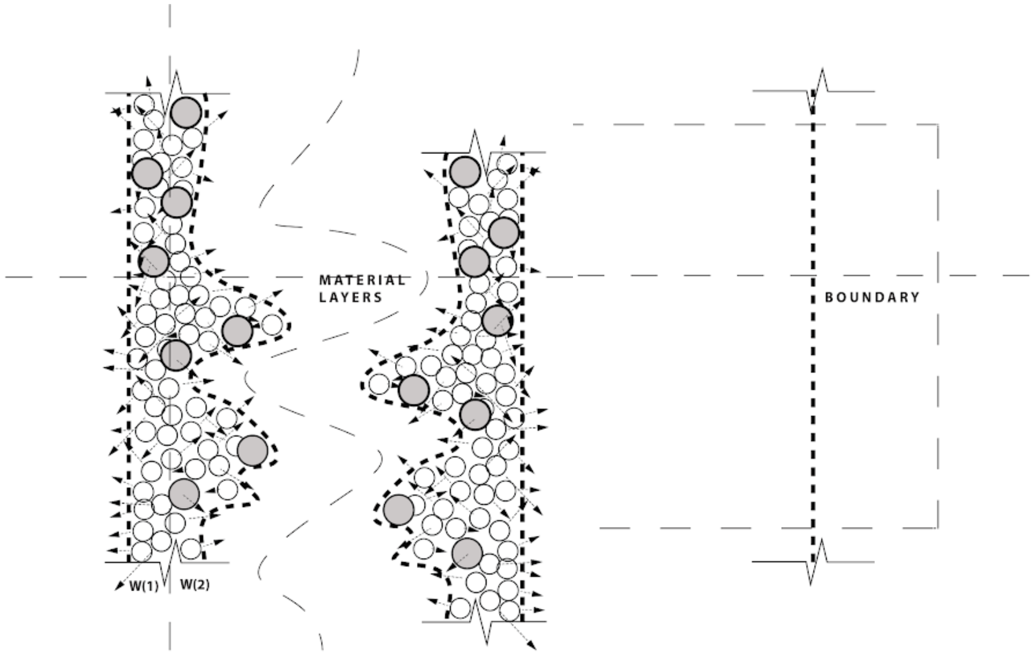


Figure 4.2 Elements: The building of complexity, agents following simple rules

The complex systems series of works that were inspired by self-organization at the biological human scale, was my first step into the research of agent-based modeling (see diagrams above for element to system agents' relations of materials). My flocking and swarming investigations formalized a path for a clear vision to discover invisible architectures of flows of movements and signals for behavior.

My first project that traversed a critical awareness of the issues of scale, and the computational complexity of tracking agents in space within a foreign biological architecture was with the human body project with the AlloSphere research group. This experience formalized an understanding of my lack of knowledge about how these systems work at a cellular and molecular level. Our scale to scientifically visualize and represent a solution was at the nano level, modeling asymmetrical agents flowing through the bloodstream. While that background knowledge was not incorporated due to the lack of the physics libraries needed to accurately represent the fluid dynamics of the blood flow, we did plot pathways to lead a flocking of agents to its intended target destination.

Much of the research group and I discussed all aspects of how to represent these phenomena without the mathematics as a representation but still holding onto the ground truth. What we encountered were months of intense research and over a year of creating and implementing an animation and simulation of this phenomena in the AlloSphere research facility. The management of computational power for animation was switched to the simultaneous processing of simulation. Much of that research dealt with the navigation of the agents through the body as traversing a world. To be able simulate this in the AlloSphere instrument facilitated this process.

The next area of research we encountered in this project focused on the flocking and swarming studies that were based on research undertaken by our group with Professor Samir Mitragotri, who was the experimental material scientist assigned to make the nanoparticles. In the Samir Mitragotri Lab (Bioengineering), the research of asymmetrical nanoparticles was explained detailing the opportunities vs. traditional geometric design methods of symmetrical particles flowing through the body to a predetermined destination. We ended up working with the spherical particles as selected by this research. However, Dr. Mitragotri did explain to us the difficulty of the binding of the nanoparticles to the arterial walls in order to leak through to organs of choice. We adapted the simulation accordingly with this in mind.

This realization gave me the first-hand knowledge of simulating this phenomenon but at a computational level as a media artist. Moreover, this also opened scientific visualization territories to expand my architectural knowledge and categorize and identify different internal body typologies. This thought also helped me create a logical hypothesis to find shape through the forms of movement and flow of the agents that created the architectural fluid structure even though we were unable to have the real fluid dynamics incorporated into the project at the time.

I witnessed the shaping of space as information by the scientific visualization of the agent traveling through the arteries as nanoparticles delivering medicine to the organs going from one form to another. That was the opportunity to unify my architectural, media arts and scientific interests together as one. What I discovered, without the proper mathematics in the algorithm for ground truth simulation, was that we are simply giving a conceptual idea describing the narrative. This realization was a factual awakening that the information in a complex system is vast and not calculable, open-ended, as we have discovered in the definition of a complex system.

Flocking and Swarming Systems Research Series:

In the CNM project, the flow of the agents began my studies in flocking and swarming algorithms. The following code is the Boids flocking and swarming algorithm as I have designed it in the AlloSystem software.

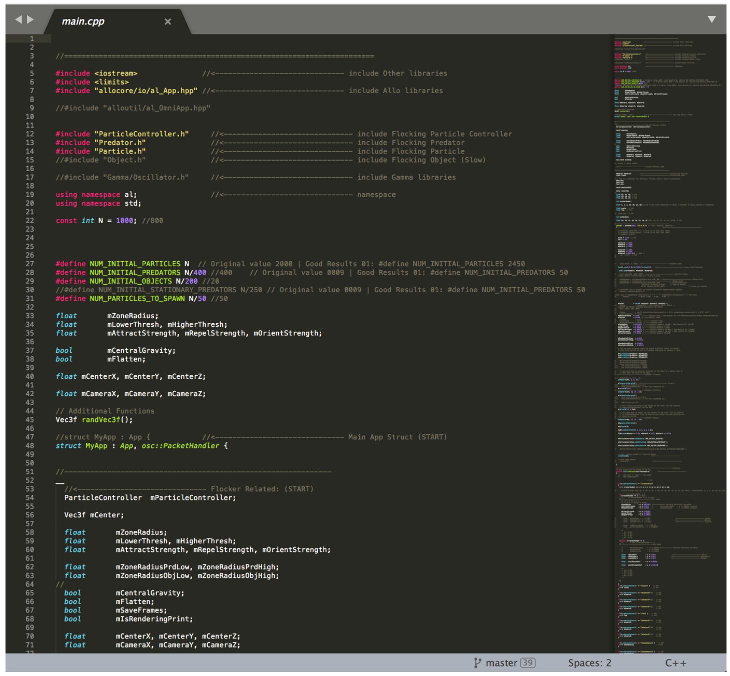


Figure 4.3 AlloLib Code - Agent-based model - Flocking & Swarming | Predator-Prey

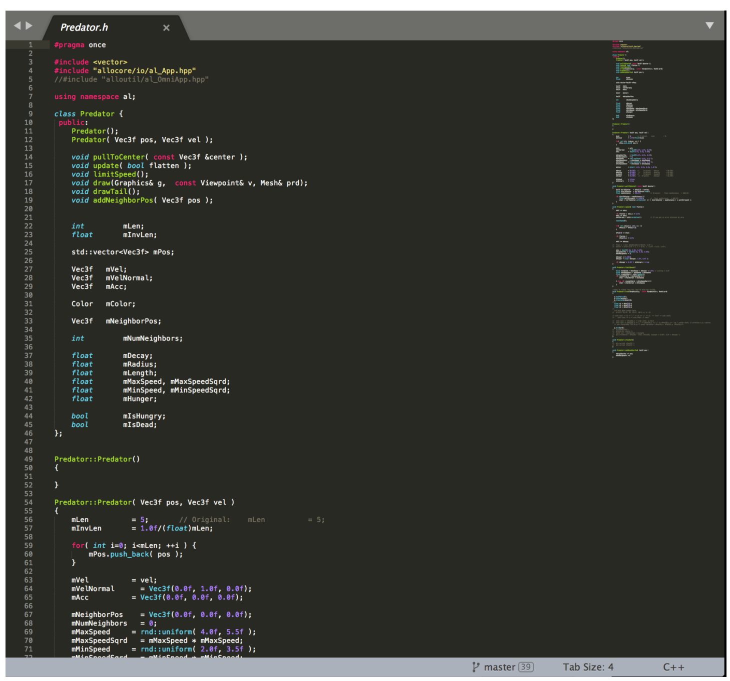


Figure 4.4 AlloLib Code - Agent-based model - Flocking & Swarming | Predator-Prey

The replacement of all the manual labor of animation, calculation, drawing, and modeling, was the first step in designing and visualizing movements through the creation of agent-based modeling programs. In my series of works leading to flocking and swarming systems and the progression to interspecies interactions within a responsive environment ecology, the steps traversed different artistic research, human-computer interaction designs, and programming languages [234] [235]. Ultimately, I settled for a conservative route of evolving an architectural design paradigm of learning through existing programming languages and frameworks to use algorithmic processes to form shapes.

This knowledge of merging mathematics and science with the media arts was my key to undertake a multiyear series of works that built upon the knowledge of turtle graphics to the creation of group flocking and swarming behaviors. The system that was created and built upon in a series of works from fabrication, renderings, and virtual worlds was a flocking and swarming system. These multiple species program was first implemented in C++ in a 3D space, I soon realized the constraints of making the model from the realities of what happens in nature. The advantages of this system were the mimicry and the potential of alternative methods of form creation informed by scientific principles.

This work in the flocking and swarming 3D series going from the virtual simulation to fabrication through data reduction, directed me to how complicated these problems were to solve. The areas of fabrication and representation were problems that were not directly solved in the program itself, but were integration problems using other software packages and methods to create artistic media artifacts as materialized results. The use of CAD (Rhino) was the software to process and to visualize the data output from the program. The data were points in space (point clouds) that could be represented by geometric substitution or formalizing a method of selecting areas that could be polygonised through operational tools found in the software package. This was the data reduction technique that was used in the fabrication process.

This path did not directly apply to my research for analytical pattern recognition, but was insightful in the many potential outcomes for fabricating these flocking and swarming objects as close to real as possible.

Many tools from original experimentation with agent-based methods (became libraries) within my framework that directly applied to an experimental architectural design for my *NMA* conceptual framework.

This facilitated my research in experimental fabricated works and helped me to create a pipeline for analytical and formal design scaffolding. The fractal nature of the program and the potential of these systems led to further investigations back to the sciences, focusing on the identification of patterns in an agent-based modeling research paradigm. The two pictures below show my agent-based program with all parameters including code.

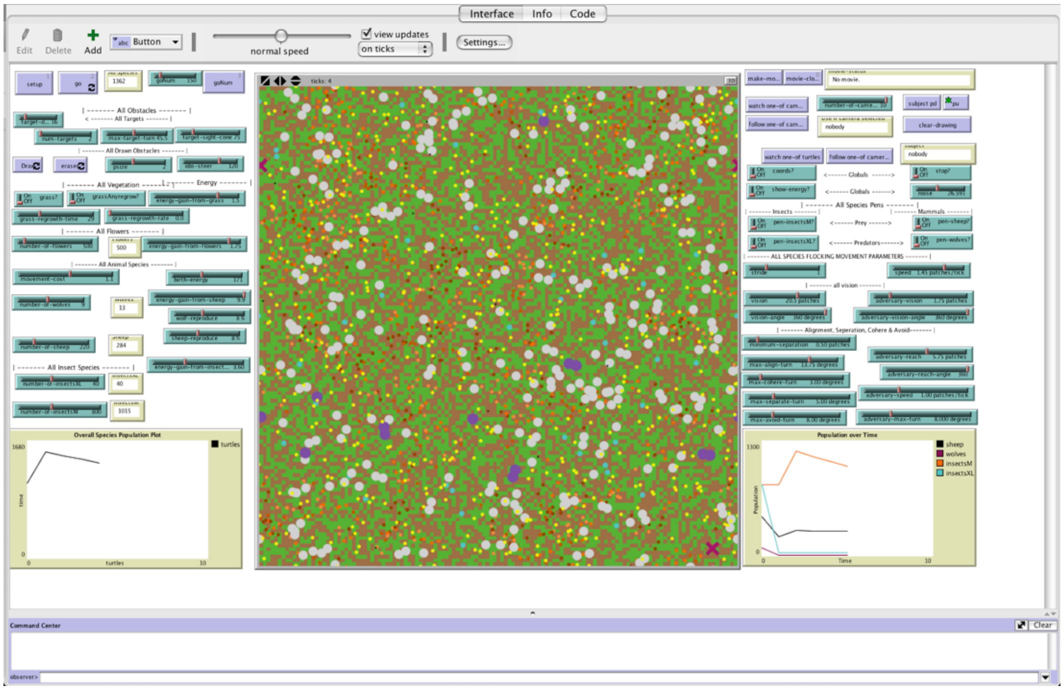
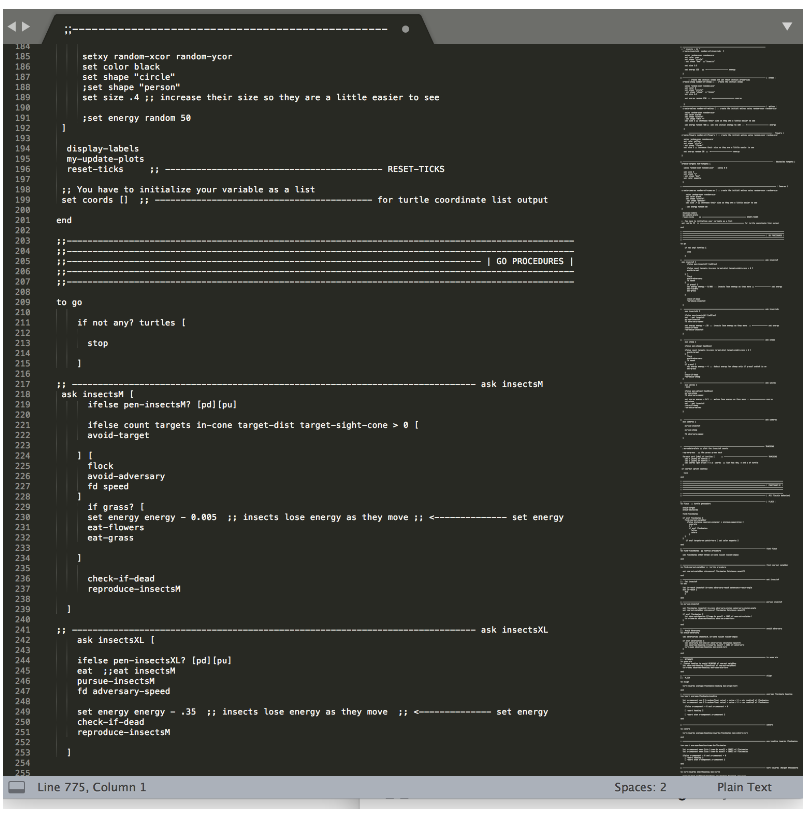


Figure 4.5 ***Colony Collapse*** **- NetLogo - Agent-based model simulation & interface**



```
        setxy random-xcor random-ycor
        set color black
        set shape "circle"
        ;set shape "person"
        set size .4 ;; increase their size so they are a little easier to see

        ;set energy random 50
    ]

     display-labels
     my-update-plots
     reset-ticks     ;; ---------------------------------------- RESET-TICKS

    ;; You have to initialize your variable as a list
    set coords []  ;; ---------------------------------------- for turtle coordinate list output

   end

   ;;------------------------------------------------------------------------------------------------
   ;;------------------------------------------------------------------------------------------------
   ;;------------------------------------------------------------------------------ | GO PROCEDURES |
   ;;------------------------------------------------------------------------------------------------
   ;;------------------------------------------------------------------------------------------------

   to go

       if not any? turtles [

         stop

       ]

   ;; --------------------------------------------------------------------------- ask insectsM
    ask insectsM [
         ifelse pen-insectsM? [pd][pu]

         ifelse count targets in-cone target-dist target-sight-cone > 0 [
         avoid-target

       ] [
         flock
         avoid-adversary
         fd speed
       ]
         if grass? [
         set energy energy - 0.005  ;; insects lose energy as they move ;; <-------------- set energy
         eat-flowers
         eat-grass

       ]

         check-if-dead
         reproduce-insectsM

     ]

   ;; --------------------------------------------------------------------------- ask insectsXL
       ask insectsXL [

       ifelse pen-insectsXL? [pd][pu]
       eat  ;;eat insectsM
       pursue-insectsM
       fd adversary-speed

       set energy energy - .35  ;; insects lose energy as they move  ;; <-------------- set energy
       check-if-dead
       reproduce-insectsM

     ]
```


Figure 4.6 Code from the ***Colony Collapse*** **work creating in NetLogo**

The novelty in my research was the understanding that creating visualized solutions to design problems was the path that uniting architectural and scientific fields. In the architectural & design fields have their own software tools developed for their disciplines. Moving towards general purpose systems used in computation, freed me up from current constraints and limitations of these discipline specific software packages. The parametrization and use of the open source packages such as the NetLogo system was also another level of research [236].

In developing this software framework for *NMA* that integrated open source packages already made with other C++ code, I was able to conduct a series of experiments. Those experiments were twofold: 1) to find new patterns within a flocking and swarming system; 2) to create a program that recreated flocking and swarming intergenerational predator-prey multi-species systems.

The diagram below shows the progression from agents to multi-agents, to a flocking and swarming system based on a particle engine. The last series shows a required swarm optimization so that all movements can be accounted properly.

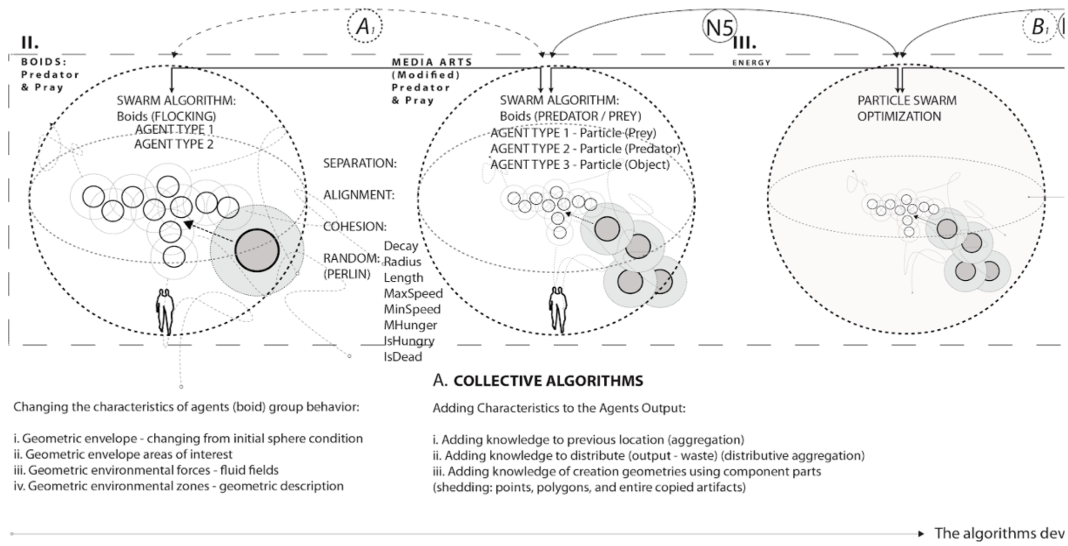


Figure 4.7 Algorithm Analysis – Diagrams: swarm behavior to computational design

In this series of works described above, the capturing and observation of data was one component. The other was the output and integration of other software frameworks.

4.2 Shaping Spaces as Information

My work in the various labs facilitated the shaping of environments and instruments as information. For instance, my work in the AlloSphere allowed me to understand the evolution from the CAVE design, in my opinion, is typically seen as an environment, to the AlloSphere as an instrument. A case in point, is the anatomical human body. The CAVE design would have made it difficult to experience the body as the world. The AlloSphere facilitated the shaping of the information, which were the arteries and the body as the environment.

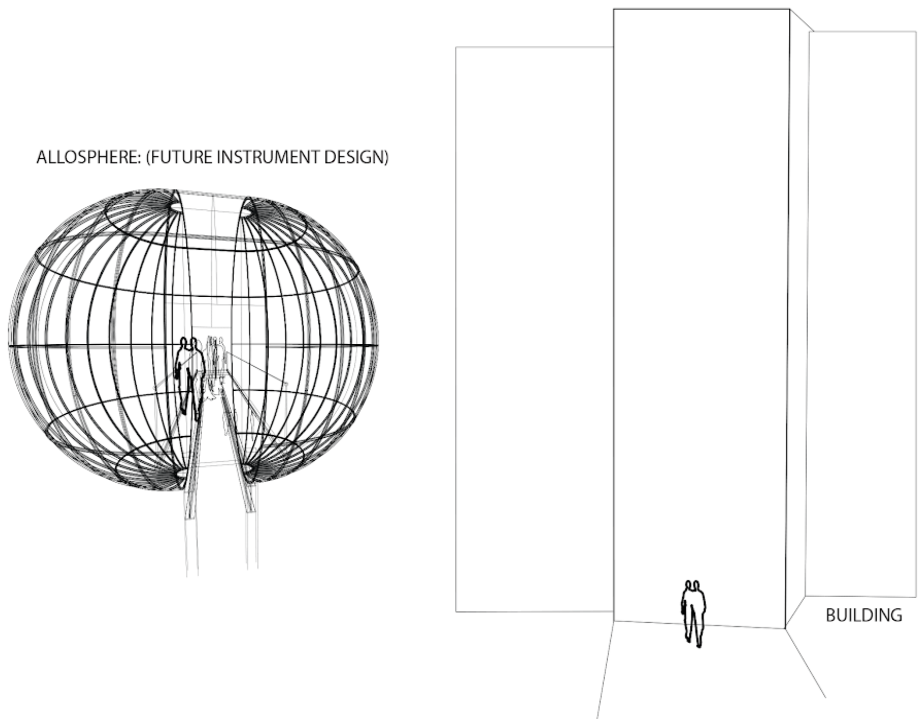


Figure 4.8 AlloSphere: a diagram of the instrument to building scale

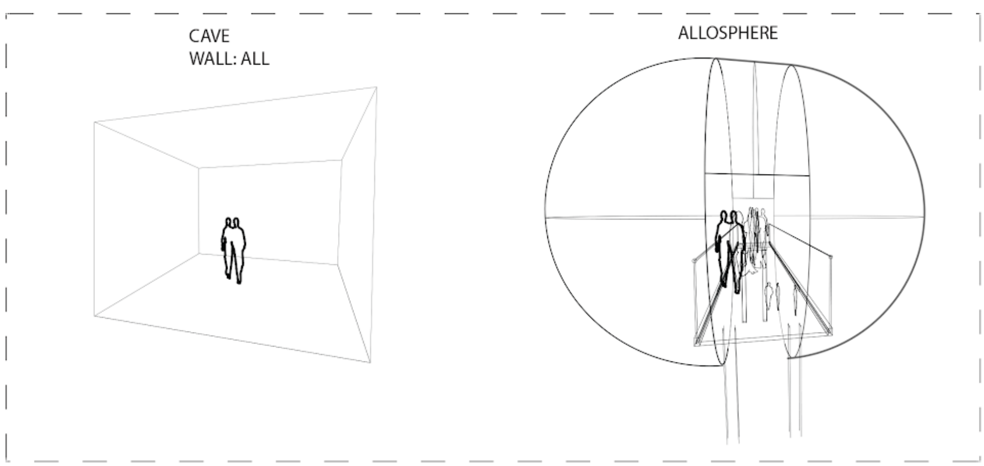


Figure 4.9 AlloSphere: a diagram of then evolution from the CAVE to the AlloSphere

In the research work encountered in the other labs, Four Eyes Lab, and transLAB discovering how to shape space as information varied compared to the instrument/environment in which I was working. The HMD system in the Four Eyes lab facilitated the shaping of space as information similar to the AlloSphere. The instrument became the environment and there were no artifacts or walls in the environmental design. This facilitated the shaping of space as information.

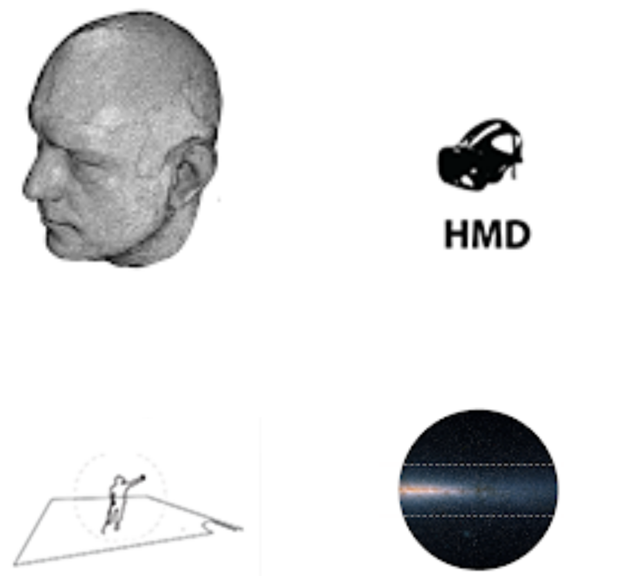


Figure 4.10 HMD Diagram of designing Virtual world experiences in space

While the work with the Four Eyes Lab was purely a scientific investigation and an opportunity for an accelerated research overview of AR/VR/MR/XR research, the challenges in replicating and studying a spatial phenomenon of representational data in these systems facilitated integrating different levels of virtual reality with real world data.

The experiments I did in the Four Eyes Lab brought the realization of how important and accurate the model needs to be, if one is to use these instruments for scientific studies.

Reflecting on the impact of this work to my process, the Four Eyes Lab was a transition between the mixed methods research done with the AlloSphere Research Group and the computational science focus methods researching AR/VR/MR/XR instruments/spaces [237].

The transLAB

The transLAB research works collapse complex systems, geometry and interactive immersive spaces into narrative virtual worlds. With regards to shaping space as information in this lab, I was confronted with two different types of systems that did not easily integrate together as a whole. The lab was equipped with both HMD's as well as projection systems as displayed in a four wall CAVE like situation. I was able to take my HMD research forward from the Four Eyes Lab into shaping spaces as information in the HMD which gave me the freedom from being obstructed from the room design. I was also able to investigate this HMD as a narrative and further my studies in flocking and swarming algorithms for navigation. This is due to the fact that the transLAB offered me space to move around. For instance, in the first work titled "Future Tripping," I incorporated a flocking and swarming system into a virtual world that requires feedback and navigation tools to create the illusion of an artificial computational space. The algorithms were used for the navigation paths that we were going to take in the virtual world interestingly enough, I used audio as the source for the flocking and swarming algorithm as navigation. The navigation was based on the movement of the agents, and the viewer's choice in roaming the world. This was both an experiment and an exercise to engage a pure implementation of content from the flocking and swarming series as geometry, but evolved into incorporating the algorithm at a code level to work with the possibilities within the Unity framework. What I learned from the installation “Future Tripping” was that I could use audio navigation in my part of the project for viewers to move to other virtual worlds of the group.

When confronted with the projection system in the transLAB, which was non-stereo and, in my opinion, semi-immersive, I was able to further my studies with group user interaction in both encumbered technologies like the HMD, and the unencumbered space of the CAVE projection system. I was not able to integrate these two systems at this time. In working with the projection-based system, this led me to the understanding that once one is in a lab where there are artifacts such as the corners of the walls, I had to contend with the environment that could possibly impact the immersive capabilities of shaping spaces as information.

In this project titled “*Moon Moon,*” I was confronted with physical performers within the virtual projected space that was non-stereo, while the audience was viewing the performer in this virtual world space. The independent research that I brought for this project was the use of basic machine learning in image collection. This was a break from the previous work. Inspired by the work from computer vision, this work explored through a series of exercises on how flocking and swarming behaviors are found in images and could be translated to point cloud and vector data to repopulate a world. This allowed me to free up my virtual material objects into point cloud data that was more abstract.

My use of agent-based navigation in this work was different from the previous works. I used point cloud as visuals for my flocking and swarming algorithm as a backdrop for the physical performer. In this work, the instrument was a hybridized theatre and dance work within a media arts backdrop in a simultaneous sound field.

Another key section of the work was world building. In this work specifically, we did exercises in drawing and in collaborative creation. The decision to interweave the performers and the virtual world was decided upon by encouraging our groups core artistic interests (architecture, composition, and dance). While the piece seemed theatrical in nature, it did impose many different narratives both digitized and embodied by the flow of movement.

While the two works followed two different strategies, "*Future Tripping*" was designed for full immersion and navigation, the other "*Moon Moon*" was created as a backdrop for an immersive dance environment. Another key feature that aided in the geometric union of space between the real and virtual was the further investigation between the performer, technology and science.

My last group of installation projects dealt with uplifting parts of the AlloSphere instrument design in order to make modular systems that would take care of integrating the room that may have artifacts to full immersive designs that would take advantage of these artifacts.

I continued my work with the AlloSphere team to create, experiment and formalize new designs for the installation works *Probably/Possibly?*, *Etherial*, and *Myrioi*. While the original first design of *Probably/Possibly?* was engineered for the MOXI museum as described in Chapter 3, the design of that installation was modular so that it could be uplifted into a new environment the AlloPortal in the CNSI. As was described previously, the room design of the MOXI facilitated my architectural engineering part of the spherical design to change that box space into a curved space, as was stated we choose a 100-degree curved screen. Again, this was an ideal curvature to begin with for box spaces that were approximately 1,000 square feet. This will lead to expansion of this curved design to accommodate larger spaces for installations as will be discussed in the future directions of this dissertation (Chapter 5).

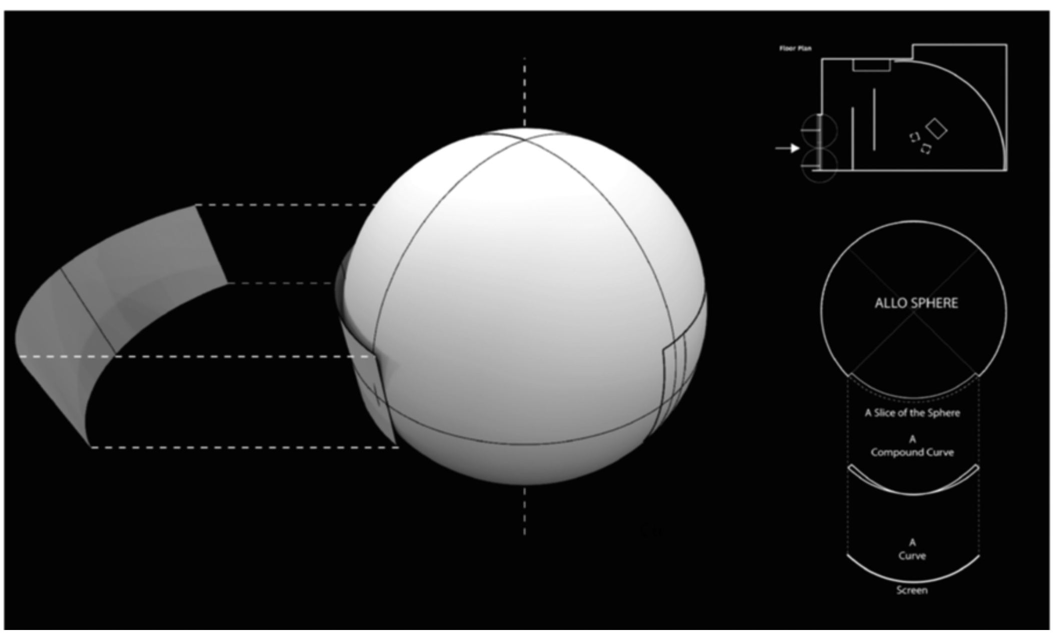


Figure 4.11 *Probably/Possibly?* A 100-degree curved screen design at MOXI based on the AlloSphere

Figure 4.12 ***Probably/Possibly?*** **An installed 100-degree curved screen at MOXI**

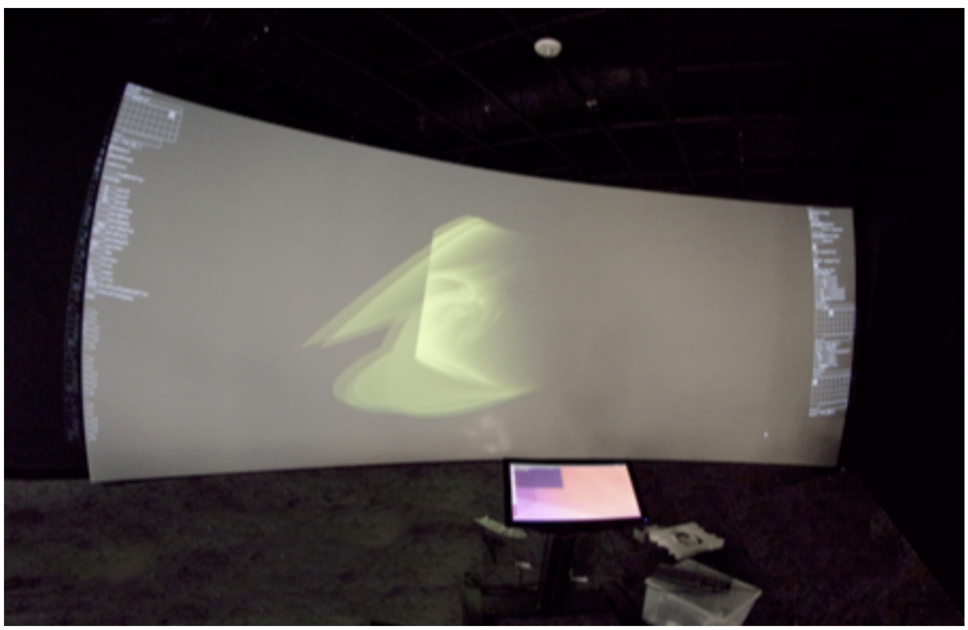


Figure 4.13 ***Probably/Possibly:*** **An installed 100-degree curved screen at MOXI, on**

Moreover, this design implementation was the most modular expression of the AlloSphere framework to date. The use case of creating a new prototyping lab and a new more flexible user experience unencumbered with the technology of the main instrument aided in the discovering screen size to viewer phenomena. This AlloPortal space, while smaller, also had the advantage over the AlloSphere of the modularity and accessibility to add different projection modes for immersive visual projection. The experimentation of direct floor projection was based on the room dimensions and equipment configuration and the research of my colleague Kon Hyong Kim. Although we could not match the curvature of the floor screen with the curvature of the screen directly in front, it still gave more a feeling of immersion due to the fact that the surfaces were directly in the person's proprioception space.

Figure 4.14 A picture of Kon Hyong Kim in the AlloPortal Lab at the CNSI

While in all cases the front and floor projection were important, the Human Computer Interaction component with interface tablets and Kinect sensors were a layer that further integrated the immersive interactive design. Moreover, while many phenomena were explored including the sound systems and interactive devices in the later work at Gwangju, the HMD research was integrated with the projection system to completely integrate the disembodied HMD with the embodied experience of immersive projection design. Another important constraint that we had to deal with in the Gwangju installation "*Etherial*" was that we were not able to have curved screen designs in that museum space. We had to rely on the cube design and focus on the proprioception of the front and floor screen projection to integrate and give us the most immersive experience with a room full of artifacts. This aspect of shaping space as information afforded us the opportunity for these new and interesting designs.

What was key in these designs were the human to architectural space components and the interface linking both real and virtual worlds. All designs accounted for the human, space and the technology including the interface. The simulated representations of the design gave us a contextualized understanding of how to account and create all parts that were essential to the design. This was my contribution to these installations. The content, although an important part in these series of works, inspired fabrication works that were interfaces both as conceptual components to the virtual space and possible interfaces for future installations. This work also yielded one of the first large-scale design concepts of the atom that would inspire future works.

4.3. New Media Architectures Questions Posed

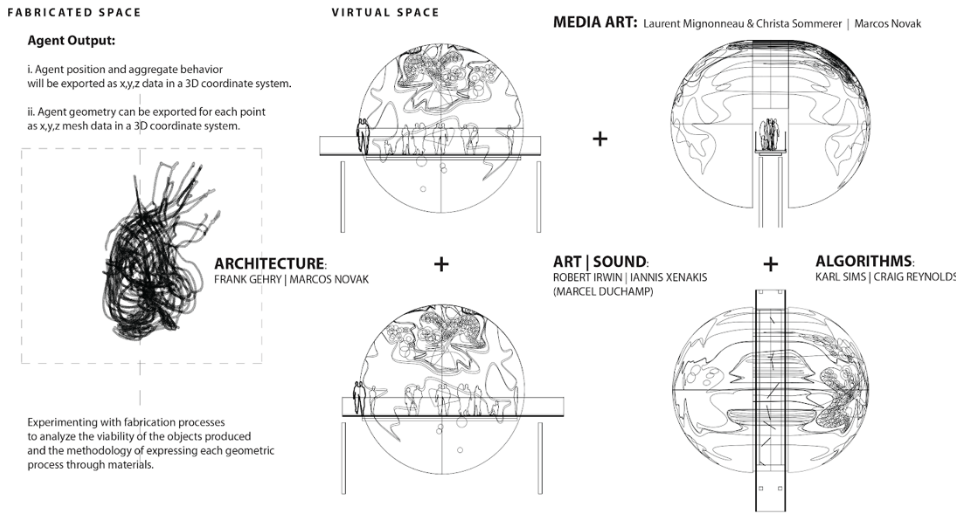


Figure 4.15 Complex Systems to Generative Art, fabrication to virtual world spaces/instruments

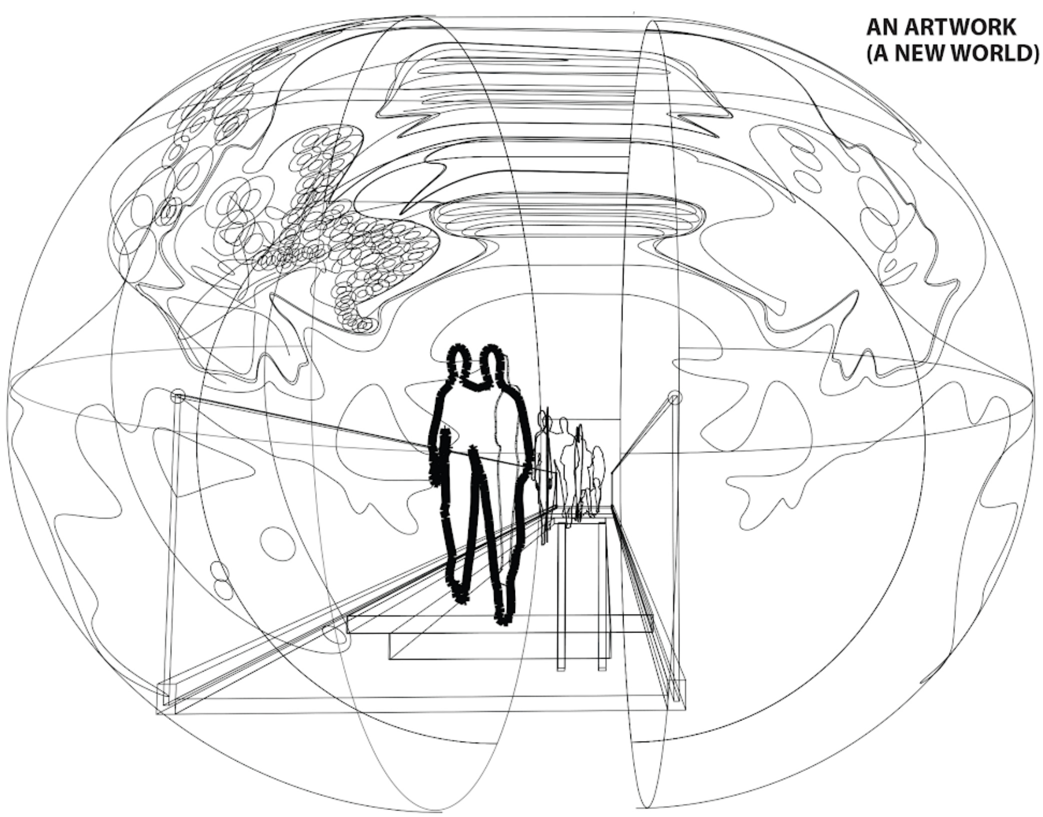


Figure 4.16 AlloSphere: A virtual reality world space - environment as instrument

In this section, I will discuss five questions that I have posed while conducting research in this new field of *NMA*. The questions that I will discuss are 1) How can Natural Complex Systems be encapsulated through a media arts practice of architecture?; 2) How can the engagement of the poetic question these complex systems, to further evolve the media arts discipline; 3) Can a new tool be created to uncover self-organizing systems, leading to a novel approach for these disciplines, for discovering dynamically varying forms and shapes?; 4) Can new tools aid in shaping a language for the media arts that encompasses multidimensionality and modalities (sight, sound, and all other human senses) of dynamically varying form and shape?; and 5) Can the current computational limitations of both hardware and software be redesigned to accommodate this new field of *NMA*? I will now discuss these questions in detail.

In answering question 1 as mentioned in this Implementation chapter, in my opinion, architectural design connotes complicated systems not complex systems. I have begun explorations in my installations and prototypes using the algorithmic processes that will allow shaping space in architectural form to be open-ended.

Answering question 2, as was explained in the transLAB research section of this chapter, I was able to take the scientific processes in the AlloSphere and the Four Eyes lab into a more of a narrative situation in the transLAB. In researching this, I hope in my own works that I can imbue more scientific rigor into my aesthetic narratives that will be the basis of my installations.

Answering question 3, as stated previously, this had already begun in the mid- to late twentieth century with the abstraction of the complex systems of flocking and swarming as an algorithm to other disciplines. I have taken this idea to an area of research in which information is the data (material) being shaped. This led to this novel approach of using dynamically varying forms and shapes as information.

Answering question 4, yes. This is a definite contribution of the media arts and engineering. My research on multi-modality is an important driver for representing information. The representational strategies used were discussed in Methodologies (Chapter 3) and will be elaborated further in Conclusions & Future Directions (Chapter 5).

Answering question 5, yes. This is what I accomplished, the bringing of many different frameworks, programs, and software packages together to make my own conceptual framework of *NMA*. As discussed in the Methodologies (Chapter 3), this approach was used to create and organize my process creating a set of tools for my own research sets of experiments and prototypes.

In this next Section, I will discuss my *NMA*: What are the parts of the Shaping of Spaces and suggest how they can possibly come together as a Unifying Conceptual Framework (Section 4.4).

4.4. New Media Architectures: A Unifying Conceptual Framework

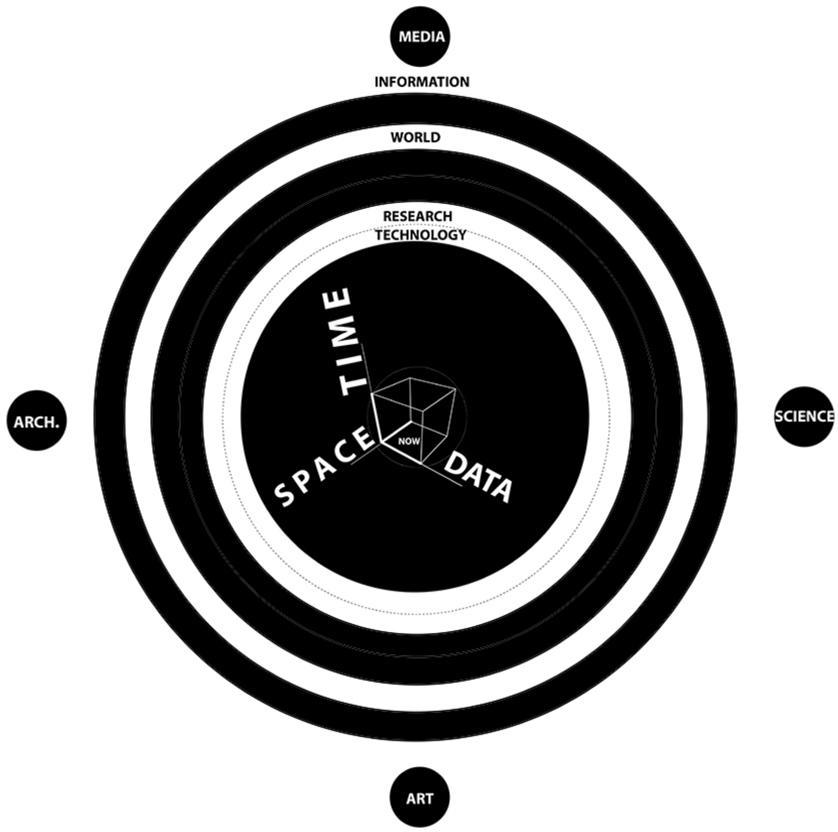


Figure 4.17 Three areas of research: Art/Architecture (Space), Media Arts (Time), & Science (Data)

In this section, I will discuss the unifying conceptual framework that unifies my three areas of research practice (as pictured above) titled "New Media Architectures." The initial question that I could not imagine asking was "What intellectual disciplines are primarily spatially oriented?" In my opinion, architecture and traditional visual arts are spatially oriented. However, if one looks at music, this is primarily a temporal domain, although spatial constructs in music are apparent by the textural organization of many different layers of instrumentation lines on top of one another that form spatial structure. In music, the spatial temporal information is sonic.

We have seen in the mid-twentieth century, it was a conundrum for Xenakis and Le Corbusier. This was resolved with the construction of the Philips Pavilion as I have stated is based on the composition "*Metastaseis.*" We now see this intersection from architecture becoming more spatiotemporal like we see in music, where we only see audio. When one views research in the sciences, I believe that spatiotemporal information exists in their data but it was primarily visualized when using the computational platform. Another contribution that came directly from the sciences was the use of complex systems in their studies. The extraction of complexity into other fields has introduced multimodality into the process of representing these complex systems.

In the field of media arts and computational sciences, multimodality becomes very important when using the computational platform for research. For instance, the human computer interaction portion of the computational sciences, starts to deal with visualization and navigation working with two modes. The area of engineering is beginning to focus on haptics in an important area of research. In the media arts, the use of all of the senses to display and interact with data, becomes a significant push forward.

These three disciplines have anchored the basic components for *NMA*. The self-organizational principles coming from the sciences has facilitated the transformation of different types of data into different spatial constructs. The diagram below shows these various component parts related to these different fields.

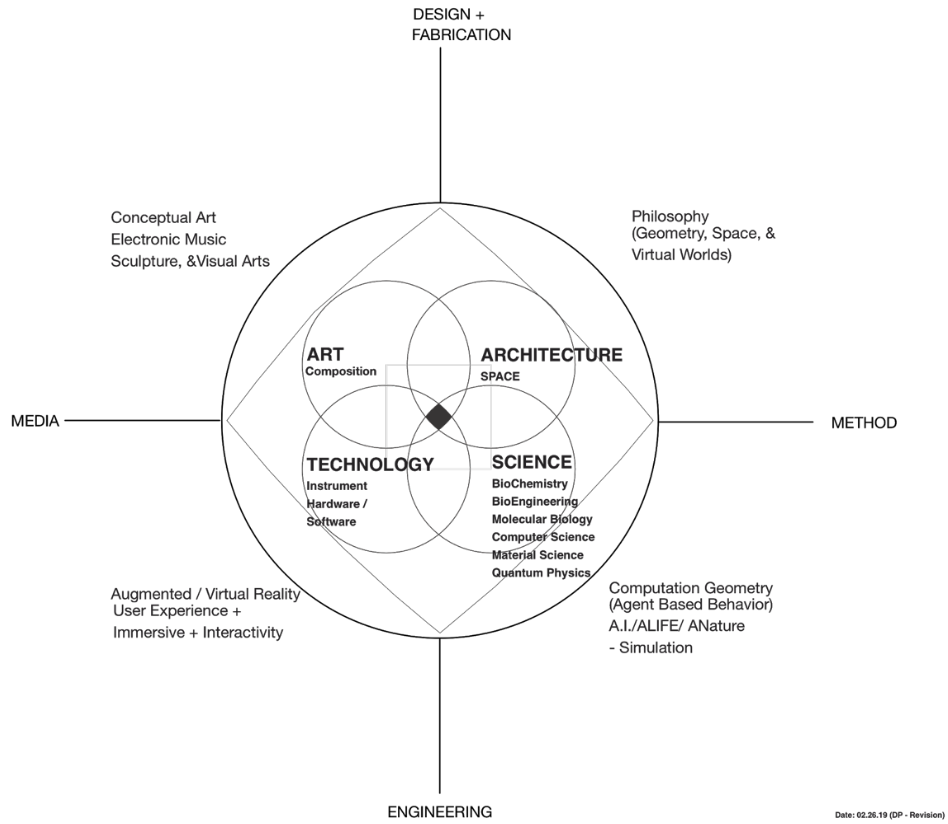


Figure 4.18 A diagram of the New Media Architectures discipline

What is unique about *NMA* in my opinion is the different types of spatial constructs are all various forms of information.

Before the computational platform was created, we relied on physical material to construct our models in our experimental labs. With the computational platform, putting these physical systems into virtual models has given us the ability to represent and transform these models dynamically over time. This becomes an important aspect for dynamically shaping spaces as information in various forms. Hence, *NMA* relies on the computational platform as its basic tool.

PART III - New Media Architectures: A New Conceptual Framework

Chapter 5 Conclusions & Future Directions: What is New Media Architectures?

Human beings, viewed as behaving systems, are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves. (Simon 1969) [238]

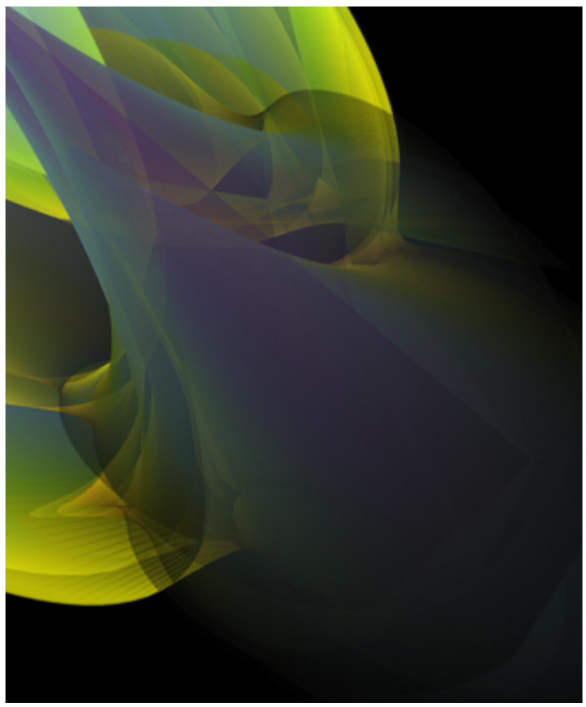


Figure 5.1 *Probably/Possibly?* - The hydrogen-like atom: 3D CAD data

The challenge of *NMA* in building these complex systems, like the probability wave functions of the hydrogen-like atom, as viewed in the graphic above, deals with the following question: How can we live in these complex worlds as though they are the natural world that we inhabit? In my opinion, this deals with the understanding of navigating higher dimensional spaces like we navigate in the real world.

5.1 Contributions and Questions Answered

The three main contributions of this dissertation are 1) the creation of a new conceptual framework that creates a new media arts research branch of architecture, 2) the creation of an identifying timeline tracing *NMA* origins to identify current precedents to fit into this framework, and 3) the advancing of a new research practice methodology that unites design, media and worldmaking, virtual and real. Space as an aesthetic requires design and scientific research including a clear understanding of form and narrative creation to further develop the technology of the day.

Many questions remain about our roles as media arts researchers in the process of scientific experimentation and how that leads to discovery. Our collaborative role in the sciences is only one part of a larger pursuit for knowledge that crosses architecture, media arts, and the sciences. After that insight, I solidified the foundations of a research question by exploring the interrelationships of complex systems in the human body while contending with the basic research of bringing this information into the instrumentation of the AlloSphere. This was the Center for NanoMedicine project. This first question that I encountered while working in the AlloSphere caused me to posit other questions as well.

What am I adding to this field of New Media Architectures?

While reviewing my works I have added an overall practice based experiential understanding of a need to create a conceptual framework for the union between media architecture, media, and the sciences. While I am aware that my independent experiments were all initial studies and prototypes in scope and depth, they did explore high levels of aesthetic investigations that were based on scientific rigor.

My collaborative works yielded a higher level of experiential consolidation of group knowledge and problem solving as well. While the aesthetic content driving the technology had scientific grounding, this led to my further investigation of using the scientific method in validating my aesthetic practice. Moreover, the integration of a fundamental level of spatializing complex systems into designs, requires an aesthetic language structured from a combination of the technical areas of computer graphics, computer science and engineering. While the combination of and integration of research fields is not unique, the application of experiments, studies and works detailing a new direction of novel research experiences enabled this new field.

How does New Media Architectures impact my ability to make new works?

The impact on my work is singularly the expansion of the practice and theory of shaping spaces from information. This new philosophical insight has led to the unification of queries that fundamentally ask about the origins of this new field. The implementation of my *NMA* research work requires a combination of practice based architectural research together with media arts experiments. The social and scientific components are realized in the form of the narrative of the media arts installations.

My clarity of moving beyond architecture as-built form to media as information as-built form facilitated new shapes and new forms inspired by the sciences. Data as a new material is not a new concept and can be attributed throughout history starting from the Greek philosophers (conceiving new sciences [239]) and with contemporary researchers such as William J. Mitchell and Marcos Novak. However, executing and formalizing a new architectural structure through practice was my contribution.

The series of works that focused on flocking and swarming, demonstrates the scope of the challenges and problems of analysis and representation of these complex systems.

The computational power necessary to represent these systems that go from the very small to the very large is daunting. While the tasks seemed to be on average manageable, the work required in formalizing and restructuring a complex system (flocking & swarming) or quantum computational mathematical equation required a combination of tools that spanned many software packages and many ideas of parsing and representing the data.

The creation of worlds based on complex systems surpasses the traditional discipline of architecture and media arts and requires the combination of gaming and contemporary digital humanities intersected with the sciences. This facilitates different models of narrative creation both fictional and non-fictional. The telling of audio-visual and spatiotemporal stories are open research questions that encompass many fields. The limitations of architectural representation as visualization, data visualization, and scientific visualization are not present in *NMA*.

The territory of finding linkages between the poetry of language as art is a problem that can also be formalized through the study of symbolic representation. That symbolic representation in *NMA* is the algorithm.

In the works of instrument design, the totality of the analysis and creation of an instrument to explore spatial phenomenon throughout the many spatiotemporal scales of information, leads to new discoveries in collaborations between the arts and sciences.

Figure 5.2 At the MOXI Museum for children
Accessed on May 20, 2020. http://www.allosphere.ucsb.edu/

While this new field of research is needed for my work, I simply see the union of a hybridized artistic research methodology as a connecting, finding, and the sculpting of information that already exists into novel geometric forms that leads to bringing the ground truth principles of the sciences into the arts.

Figure 5.3 The AlloSphere Research Team for Probably/Possibly?
Accessed on May 20, 2020. http://www.allosphere.ucsb.edu

5.2 Future Directions

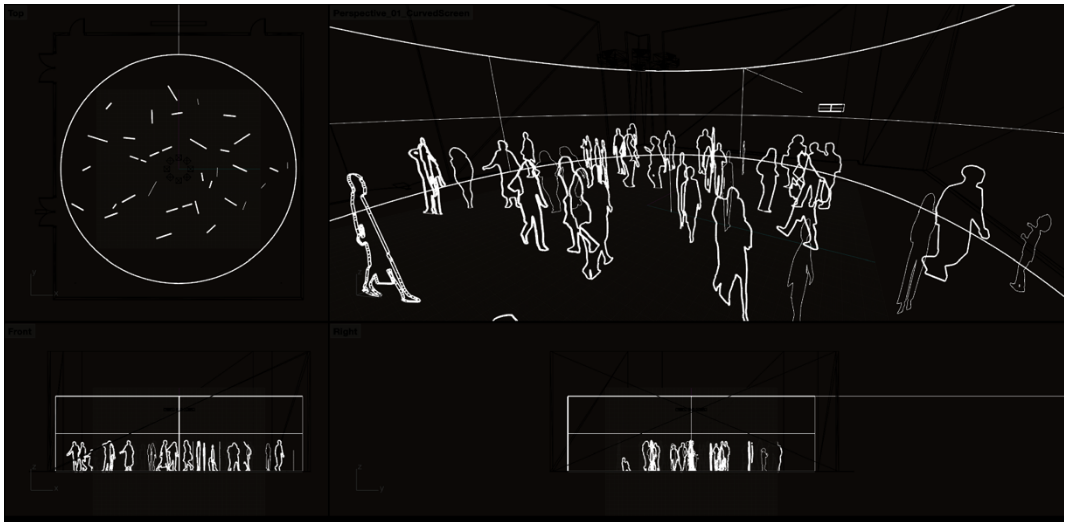


Figure 5.4 ***Allo2 - Concept*** **- CAD for Analysis/Architectural/ Engineering design**

In my Future Directions, the AlloSphere research group is currently designing a new Installation “Allo2.” I will be extending my 100-degree curved screen design to extend the curve into a 360-degree space that will facilitate a large group within that space. This cannot currently happen within the AlloSphere instrument.

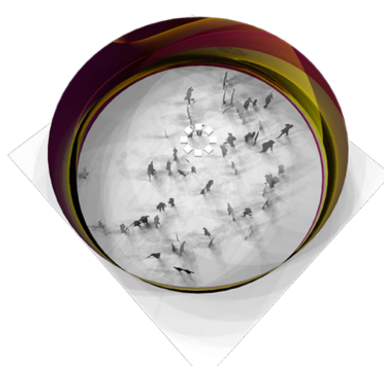


Figure 5.5 Allo2 - Concept - CAD for analysis/architectural/ engineering design, top

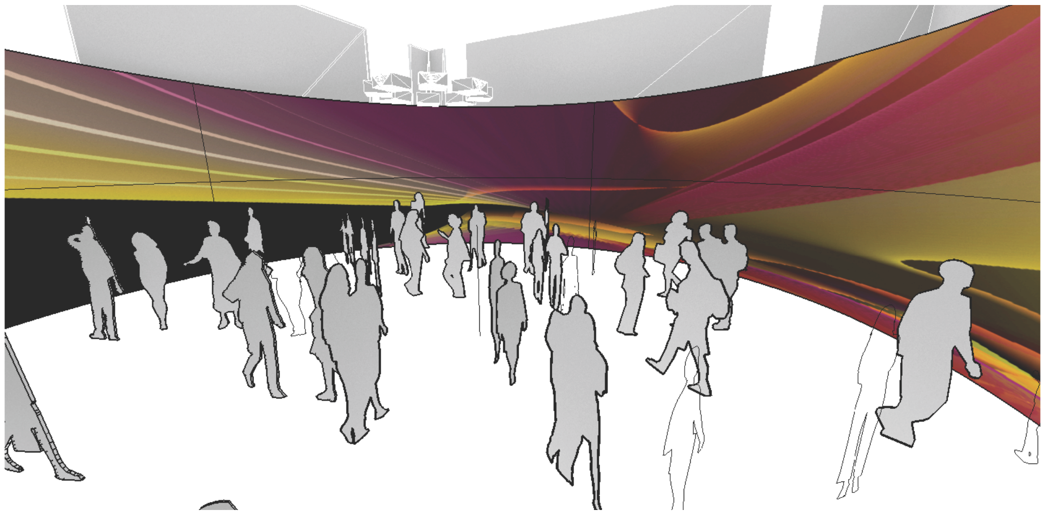


Figure 5.6 Allo2 - Concept – A rendering inside the cylindrical screen viewing *Probably/Possibly?*

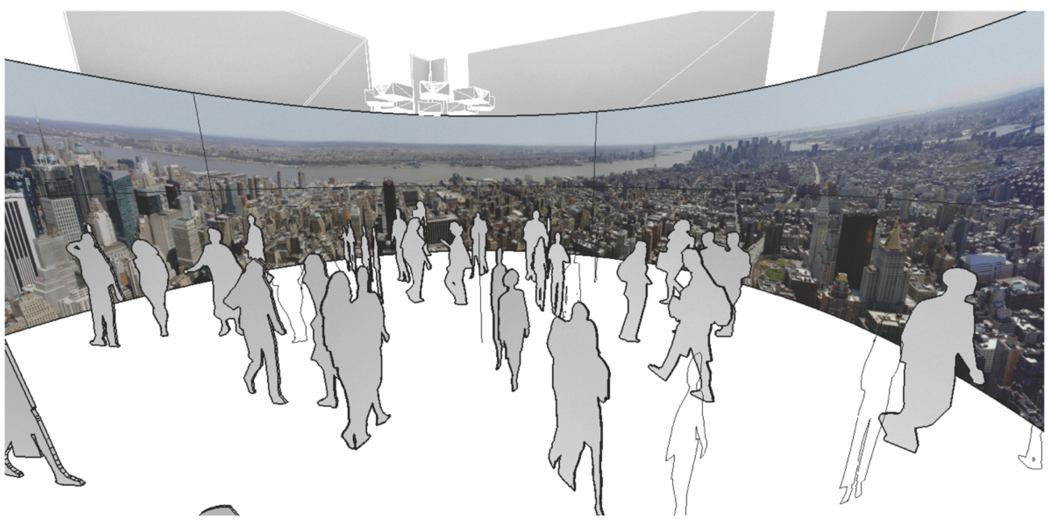


Figure 5.7 Allo2 - Concept - A rendering inside the cylindrical screen viewing a City

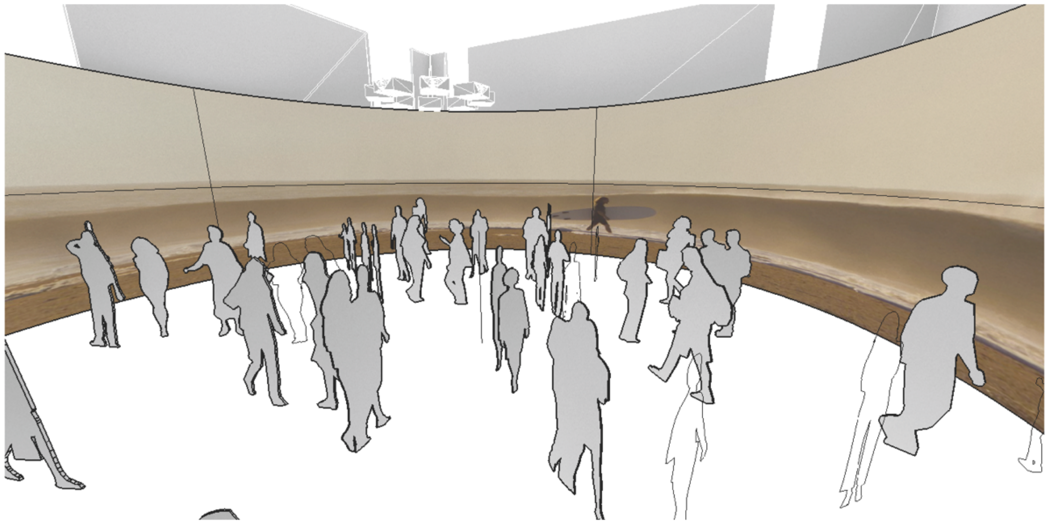


Figure 5.8 Allo2 - Concept - a rendering inside the cylindrical screen viewing waves

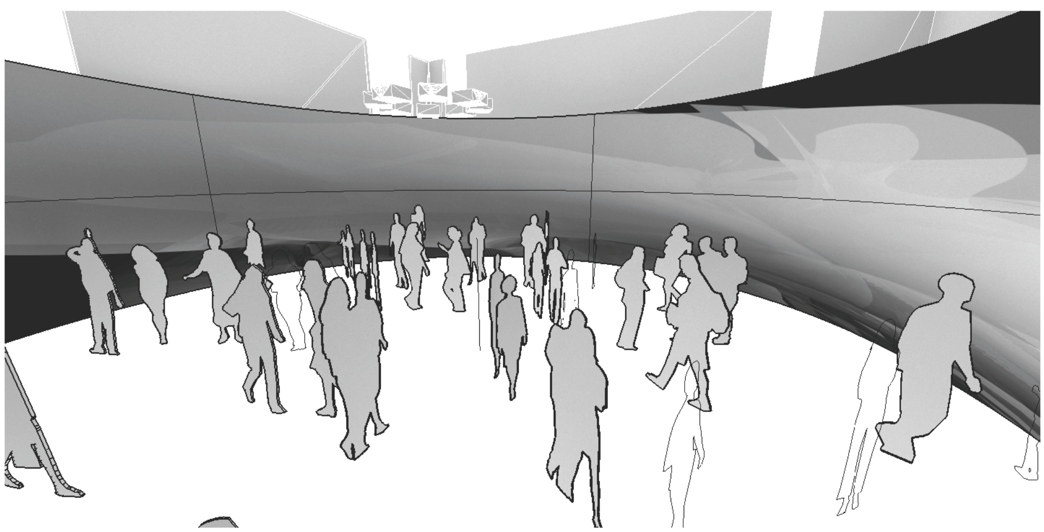


Figure 5.9 Allo2 - Concept - a rendering inside the cylindrical screen the blue atom

The ultimate installation that I would like to design deals with bringing the atom to monumental scale as seen in the picture below.

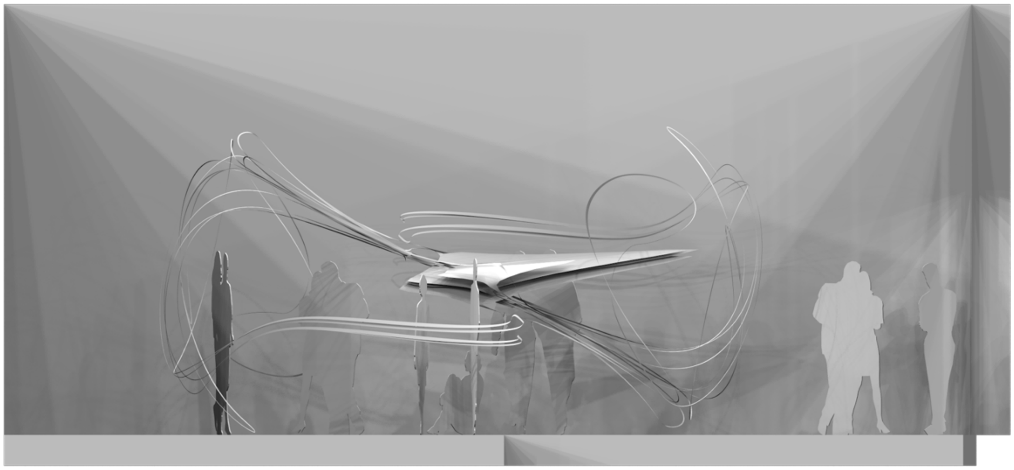


Figure 5.10 *Probably/Possibly?* - The Dream, a concept design for MOXI, side

Other important future directions include building an integrated software system for *NMA* and incorporating complexity theory with finer resolution on all spatiotemporal scales in my media works.

I end this dissertation with a quote that magnifies the ambition of the research:

"An image by Heraclitus was the starting point of this book. As it draws to a close, the image appears before me: the lyre, which consecrates man and thus gives him a place in the cosmos; the bow, which shoots him beyond himself. All poetic creation is historical; every poem is a longing to deny succession and to establish an enduring realm.

…Man wants to be one with his creations, to unite with himself and with his fellows: to be the world without ceasing to be himself. Our poetry is consciousness of the separation and attempts to unite that which was separated." (Octavio Paz, 1955, translated 2009) [240]

Figure 5.11 ***Probably/Possibly?)*** **- The Dream, a concept design for MOXI, back view**

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[239] T. S. Kuhn, The Structure of Scientific Revolutions. University of Chicago Press, 1970.

[240] O. Paz, The Bow and the Lyre: The Poem, The Poetic Revelation, Poetry and History. University of Texas Press, 2009.

Appendix

7.1 Leonardo | ISAST: AlloSphere Research Team: SIGGRAPH 2020

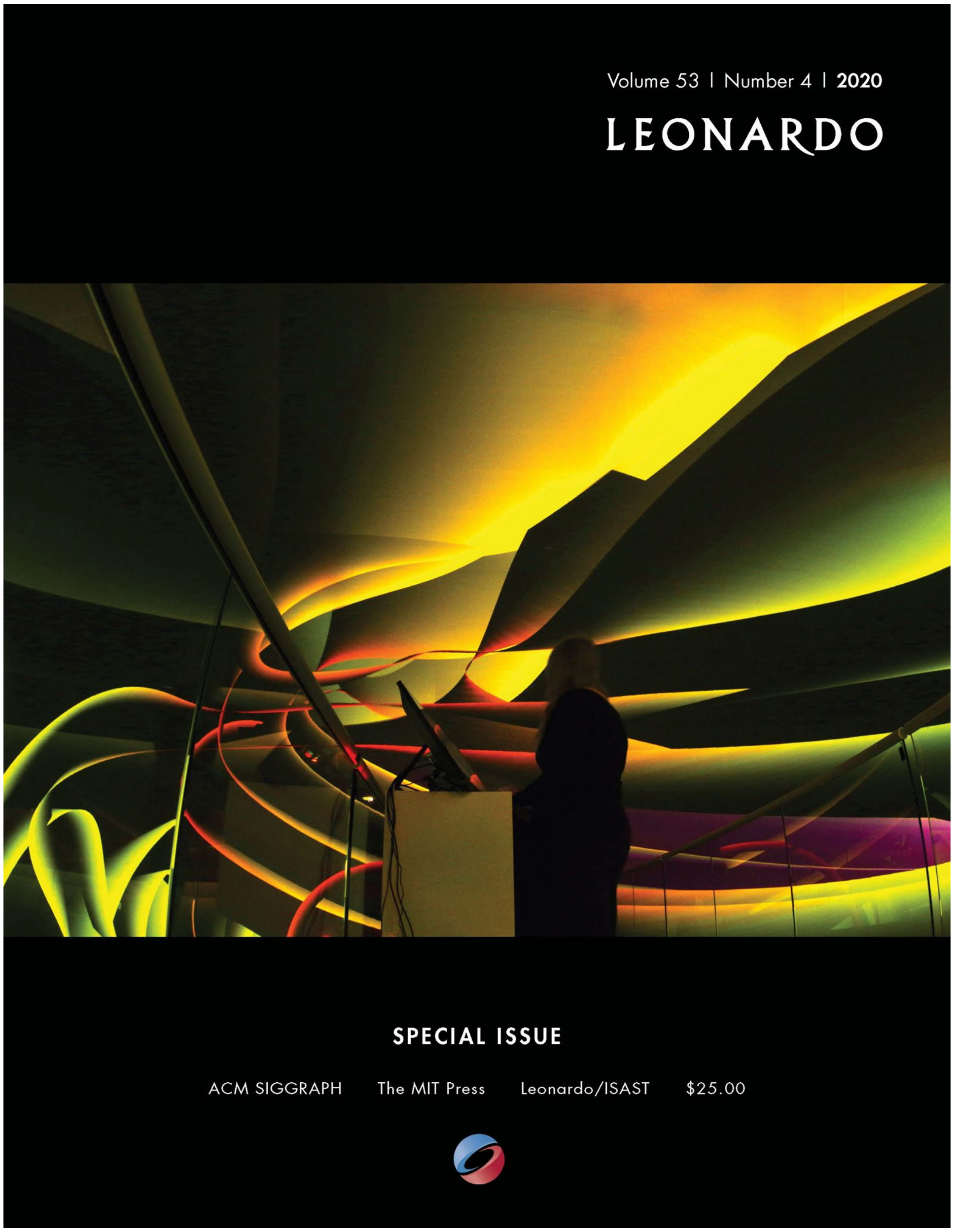


Figure 7.1 MYRIOI

Leonardo | LEAF at CAA: New Media Architectures - CAA Conference 2021

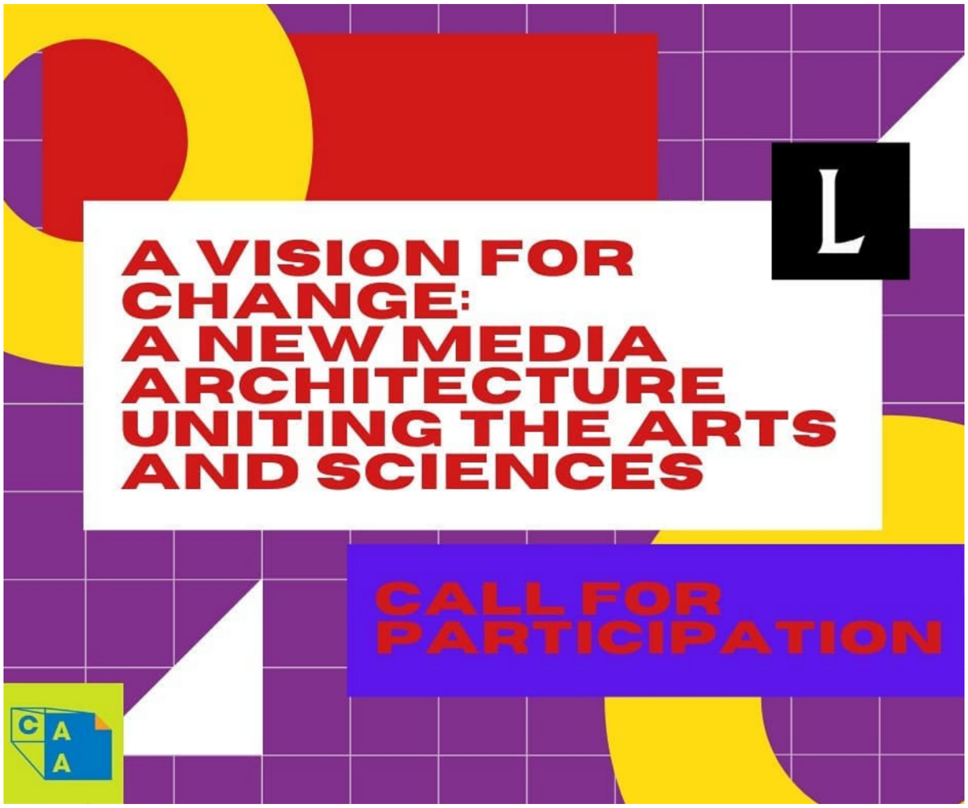


Figure 7.2 CAA Panel

Leonardo | Research Collaborative: A New Vision for Change at Ars Electronica 2021

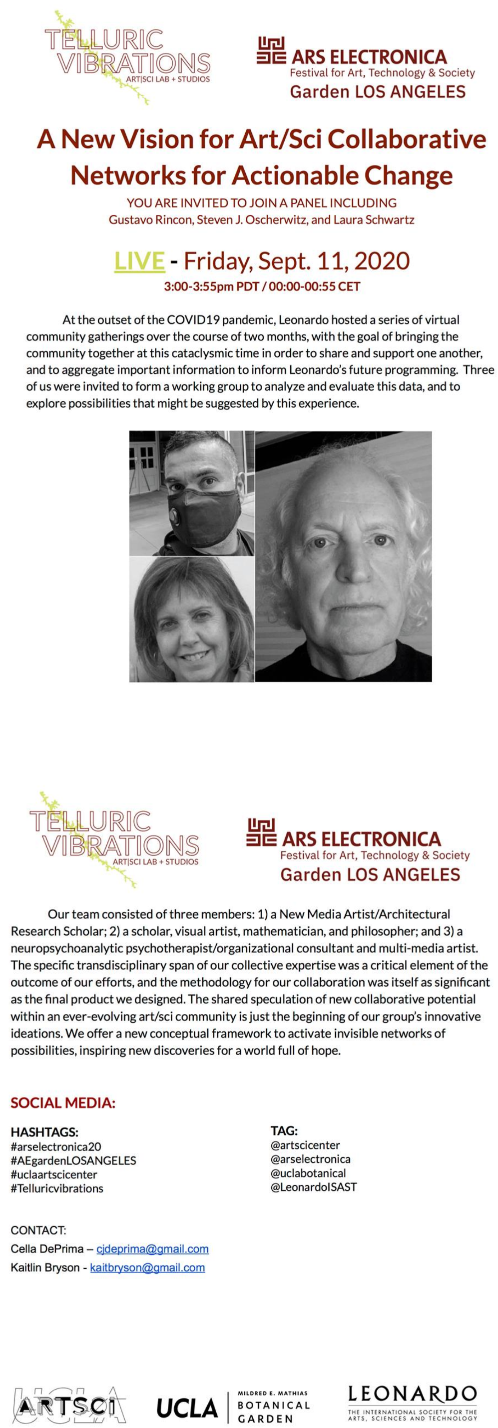


Figure 7.3 CAA Panel

7.2 Publications: (Selected)

The Effects of Visual Realism on Search Tasks in Mixed Reality Simulation

Cha Lee, Gustavo A. Rincon, Greg Meyer, Tobias Höllerer, and Doug A. Bowman

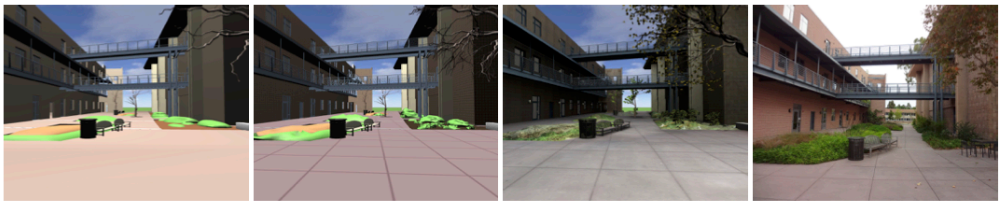


Fig. 1. From left to right are the low, medium, and high levels of visual realism, and a photograph of the real-world location used for the real AR condition.

Abstract—In this paper, we investigate the validity of Mixed Reality (MR) Simulation by conducting an experiment studying the effects of the visual realism of the simulated environment on various search tasks in Augmented Reality (AR). MR Simulation is a practical approach to conducting controlled and repeatable user experiments in MR, including AR. This approach uses a high-fidelity Virtual Reality (VR) display system to simulate a wide range of equal or lower fidelity displays from the MR continuum, for the express purpose of conducting user experiments. For the experiment, we created three virtual models of a real-world location, each with a different perceived level of visual realism. We designed and executed an AR experiment using the real-world location and repeated the experiment within VR using the three virtual models we created. The experiment looked into how fast users could search for both physical and virtual information that was present in the scene. Our experiment demonstrates the usefulness of MR Simulation and provides early evidence for the validity of MR Simulation with respect to AR search tasks performed in immersive VR.

Index Terms—MR Simulation, visual realism, augmented reality.

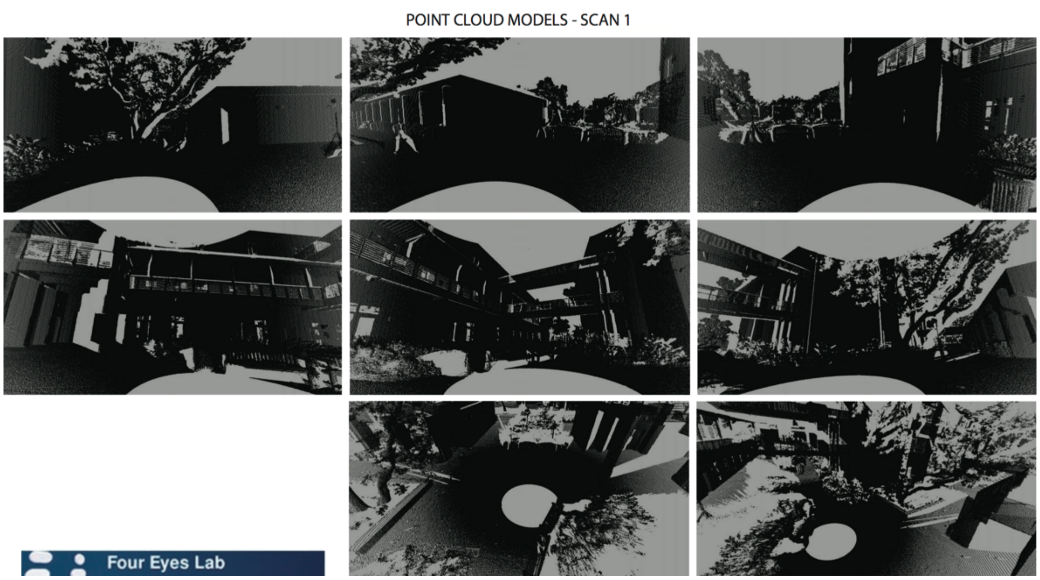
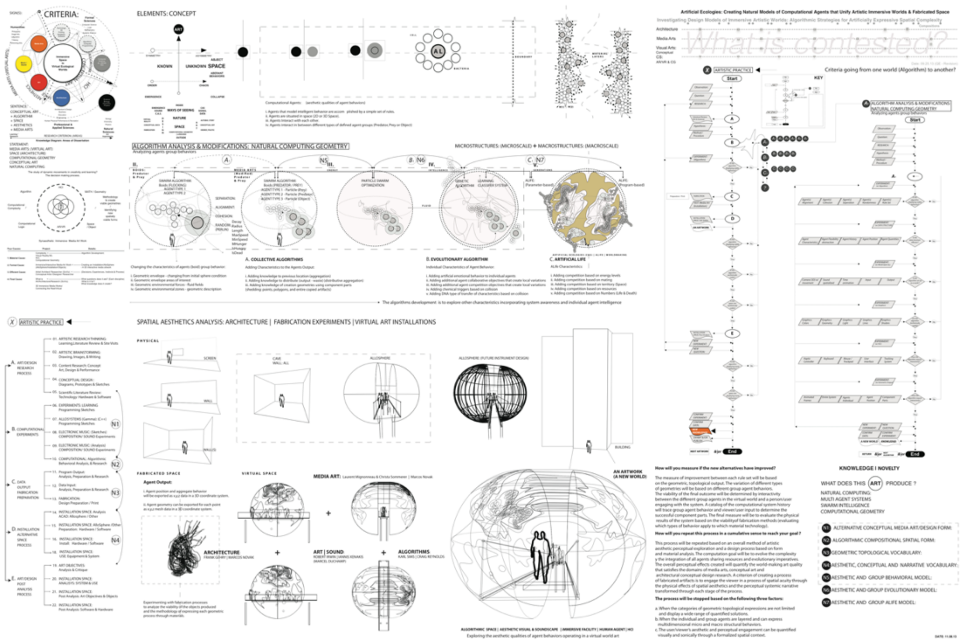


Figure 7.4 Four Eyes Lab Paper

7.3 Diagrams: (Selected)

Diagram 01: Algorithm, Worldmaking, & Instrument Design - 2014



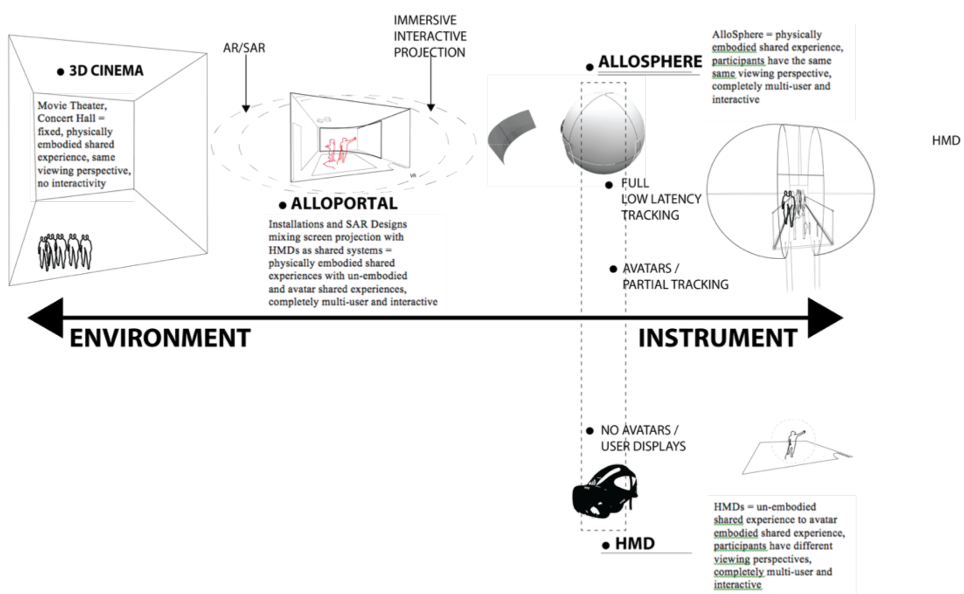


Figure 7.5 NMA Research Diagram

Diagram 02: A New Media Architectures –

A Comprehensive History - In Progress – 2019

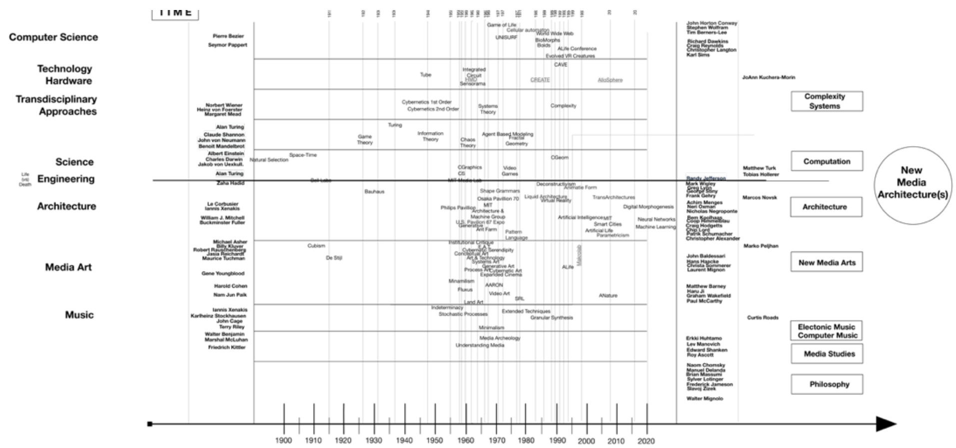


Figure 7.6 NMA History Diagram

A Comprehensive History Process of finding *NMA*

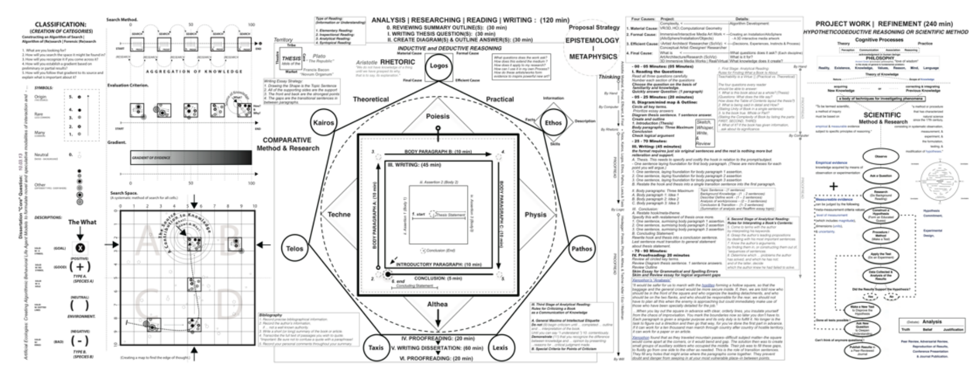


Figure 7.7 NMA Research Diagram

7.4 Exhibitions: Curated

AlloSphere and Mosher Foundation Funded Research:

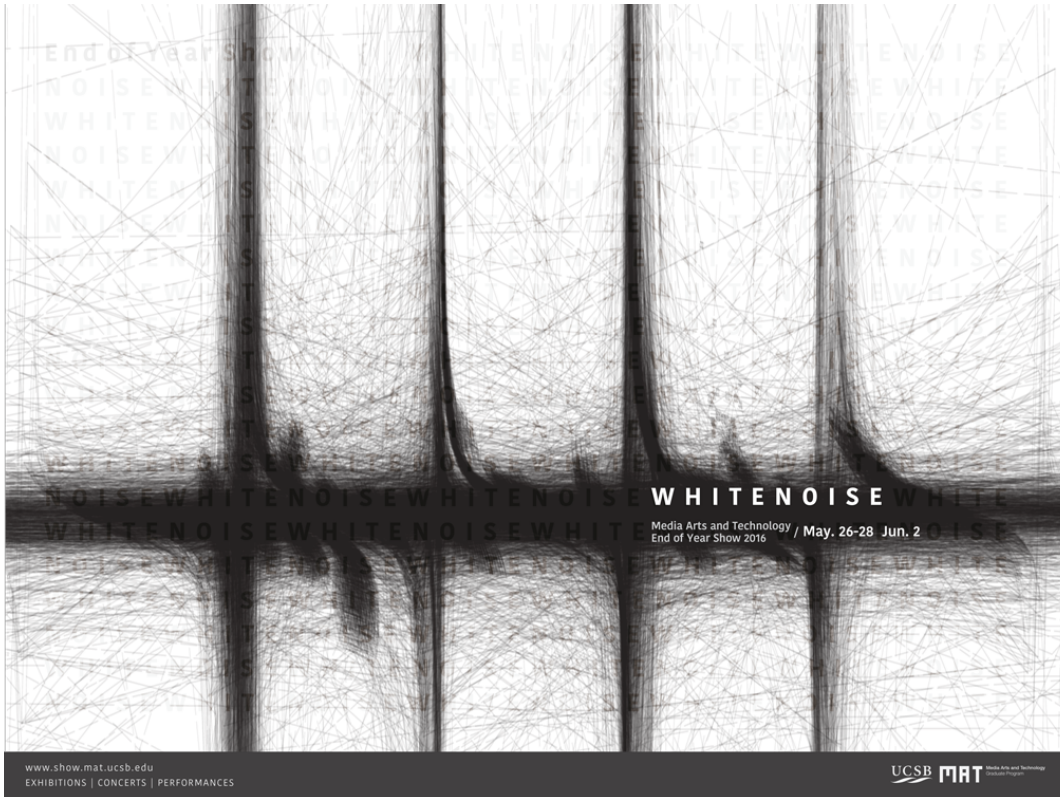


Figure 7.8 White Noise Poster

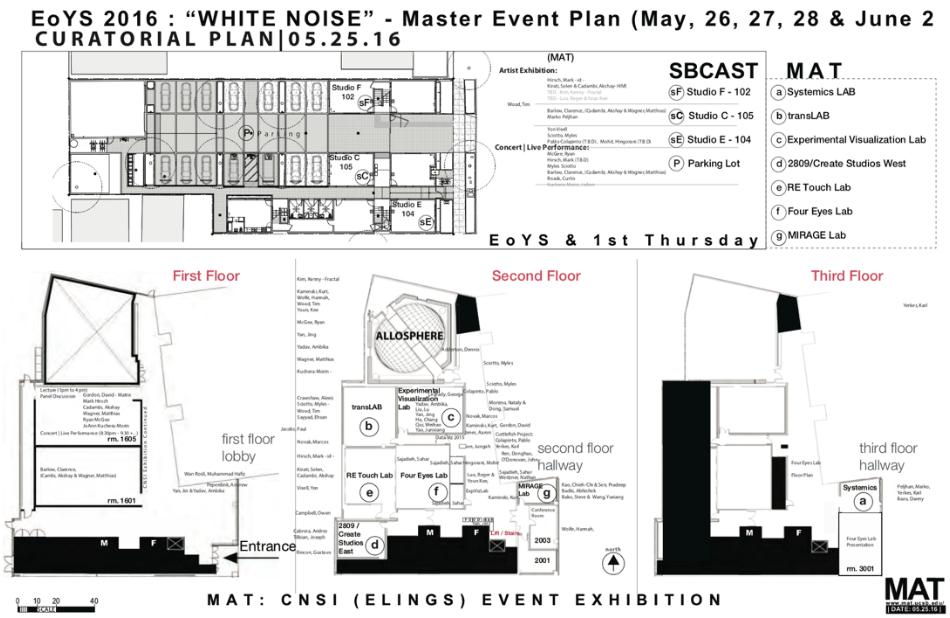


Figure 7.9 White Noise - Event Plan

Figure 7.10 White Noise - Event photo - SBCAST of F. Myles Sciotto's exhibition

Figure 7.11 White Noise – Panel Discussion – all MAT faculty

Accessed on July 18, 2020. https://www.mat.ucsb.edu/eoys2016/

Figure 7.12 White Noise – opening event - Day 1

Figure 7.13 White Noise – opening event - Day 2

Figure 7.14 White Noise – opening event - Day 1 - AlloSphere

Figure 7.15 White Noise – opening event - Day 1 - AlloSphere tour with Dr. Kuchera-Morin

1

FOR IMMEDIATE RELEASE
Date: 05.12.2016

CONTACT:
Gustavo Alfonso Rincon
eoys2016@mat.ucsb.edu
http://show.mat.ucsb.edu
(805) 893-5244

White Noise
2016 End of Year Show (EoYS)

The Media Arts and Technology Program (MAT) at UCSB will present "MAT EoYS 2016: White Noise," their annual End-of-Year-Show, on May 26, 27, 28 & June 2, 2016.

The EoYS "White Noise" exhibition will feature demonstrations, installations, performances, and concerts by over 50 student and faculty works from the MAT, AlloSphere Research Facility, Experimental Visualization Lab, Four Eyes Lab, MIRAGE Lab, RE Touch Lab, Systemics Lab, and transLAB. The media and research works represent transdisciplinary subjects and span areas such as computational perception, computer vision, computer graphics & imaging, haptics, robotics, virtual reality, augmented reality, conceptual art, digital humanities, mechanics of touch, real & virtual, human-robot interaction, data visualization, generative sound, generative design, scientific visualization, field research, sensor networks, remote sensing, and experimental music. Visitors to the EoYS will have the opportunity to take a guided tour of the Allosphere, the only immersive research instrument/lab of its kind in the world.

International curator and media artist Zhang Ga (CN/US) will be giving the opening lecture on Friday afternoon. He is Professor of Media Art at CAFA, China Central Academy of Fine Arts, and Associate Professor at the School of Art, Media, and Technology, The New School, Parsons.

A special panel discussion will follow on the theme of "White Noise" and the "Future of Media Arts Research: Education, Practice, and Scientific Discovery." Panel participants include international guests Zhang Ga and Andreas Schlegel and MAT Professors JoAnn Kuchera-Morin, George Legrady, Marcos Novak, Marko Peljhan, and Matthew Turk. The panel will be moderated by MAT Professor Yon Visell.

The opening remarks of the White Noise exhibition will be given by MAT Program Chair, Professor George Legrady, a recent recipient of the 2016 John Simon Guggenheim Memorial Fellowship.

Figure 7.16 White Noise – Press release, pg. 1

The 2016 MAT EoYS is supported by Rod C. Alferness, Dean of the College of Engineering, and John Majewski, Dean of the Humanities and Fine Arts. Special thanks to the Office of the Executive Vice Chancellor David Marshall. Our educational outreach is made possible by the generous support of the Robert W. Deutsch Foundation and the Mosher Foundation. We thank Alan Macy, Founder of SBCAST (the Santa Barbara Center for Art, Science, and Technology). Special thanks also to Craig J. Hawker, Director of CNSI (the California NanoSystems Institute) and Dow Materials Institute, and Faculty Director of the UCSB MRL (Materials Research Lab).

Why “White Noise”:

White noise— a noise containing all frequencies presented in equal proportion— represents all possibilities in equal likelihood. As this year’s theme, it represents the blank canvas— it’s the marble awaiting the sculptor to bring these possibilities to life. At MAT, our research is like white noise in that it contains “signals” from every field. As technologists and artists, we weave through this diverse research in novel ways, creating new works that transcend the present way we view the world. Our show is the product of this process, and we invite all to join us in its celebration.

What/Where/When:

Location One - CNSI - Address & Event Schedule:

California NanoSystems Institute (CNSI), Elings Hall
University of California, Santa Barbara
Santa Barbara, California, 93106

Educational Outreach
CNSI, Elings Hall
Thursday, May 26th, 1:00pm – 4:00pm

Opening Lecture and Panel Event
CNSI, Elings Hall, Room 2016
Friday, May 27th, 1:00pm – 4:00pm

EoYS “White Noise” Exhibition
CNSI, Elings Hall, throughout
Friday, May 27th, 5:00pm – 9:00pm

Critique Sessions
CNSI, Elings Hall
Saturday, May 28th, 9:00am – 12:00pm & 1:00pm – 4:00pm

Figure 7.17 White Noise – Press release, pg. 2

Location Two - SBCAST - Address & Event Schedule:

SBCAST
(Santa Barbara Center for Art, Science and Technology)
513 Garden Street
Santa Barbara, CA 93101

EoYS at SBCAST
SBCAST, Downtown Santa Barbara
Saturday, May 28th, 6:00pm – 9:00pm

EoYS "First Thursday" at SBCAST
SBCAST, Downtown Santa Barbara
Thursday, June 2nd, 5:30pm – 10:00pm

Further Details:

All events are free and open to the public. If you have any further questions, please contact the main office of the Media Arts and Technology Program.

For events at CNSI, all-day parking and short-term parking (payable at pay stations) are available in Lot 10. The campus map is available at http://www.aw.id.ucsb.edu/maps/.

For events at SBCAST, street parking is available.
The map is available at http://sbcast.org/contact/.

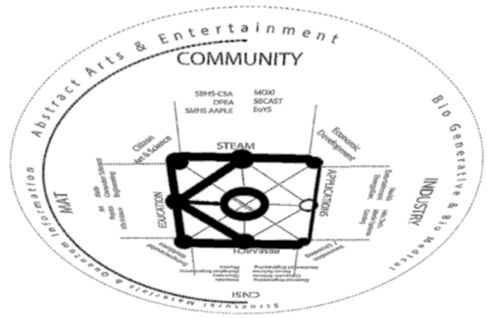
Programs are subject to change. Please consult the EoYS 2016 website at http://show.mat.ucsb.edu.

Main Office:

MAT
Media Arts and Technology Program
University of California, Santa Barbara
3309 Phelps Hall
Santa Barbara, California, 93106-6065

Phone: (805) 893-5244
General email inquiries: info(at)mat.ucsb.edu

Figure 7.18 White Noise – Press release, pg. 3



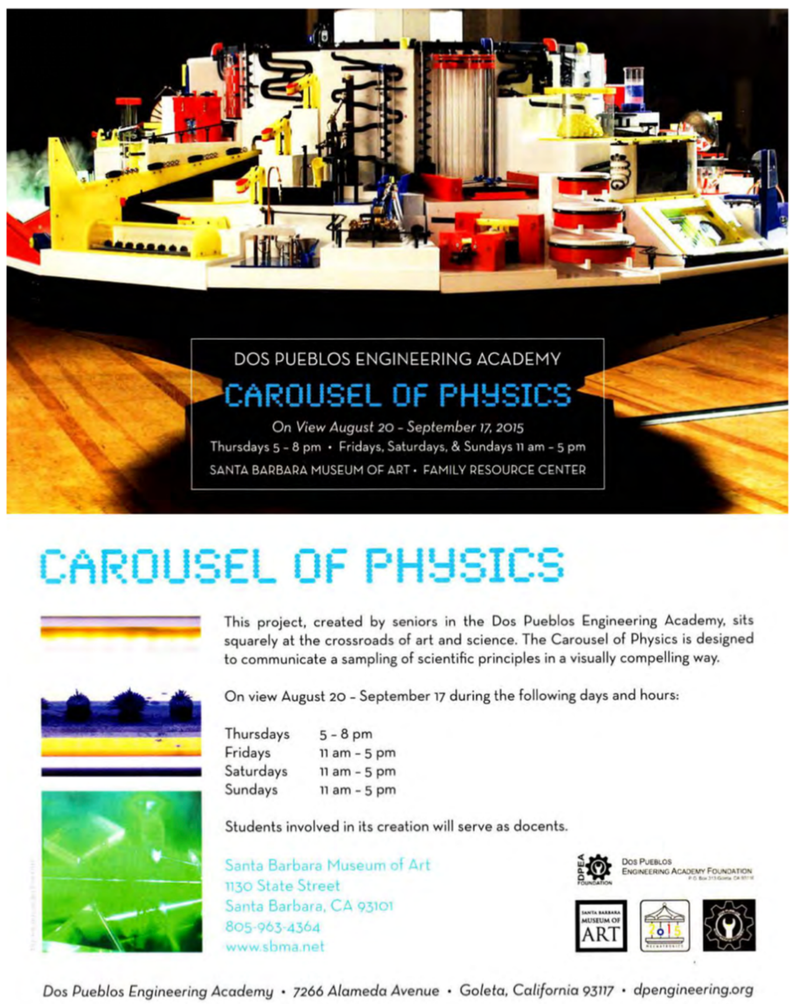
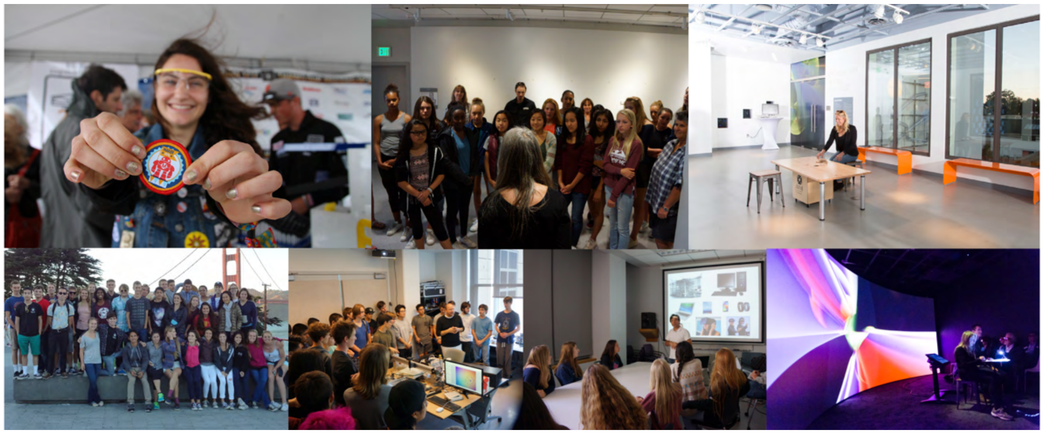


Figure 7.19 Carousel of Physics – Dos Pueblos Engineering Academy (DPEA)



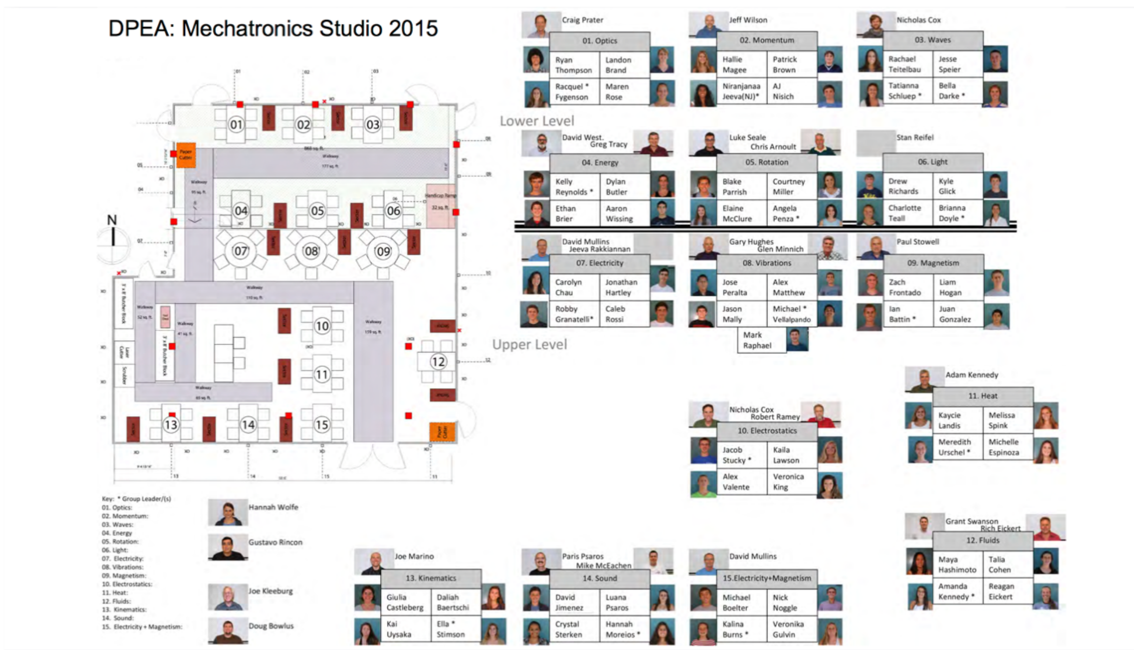


Figure 7.20 Carousel of Physics – DPEA and the Mosher Foundation

AWMAS 2020:

Figure 7.21 Alliance of Women of Media Arts & Sciences (AWMAS)

Figure 7.22 AWMAS – G. Rincon's Exhibition main view

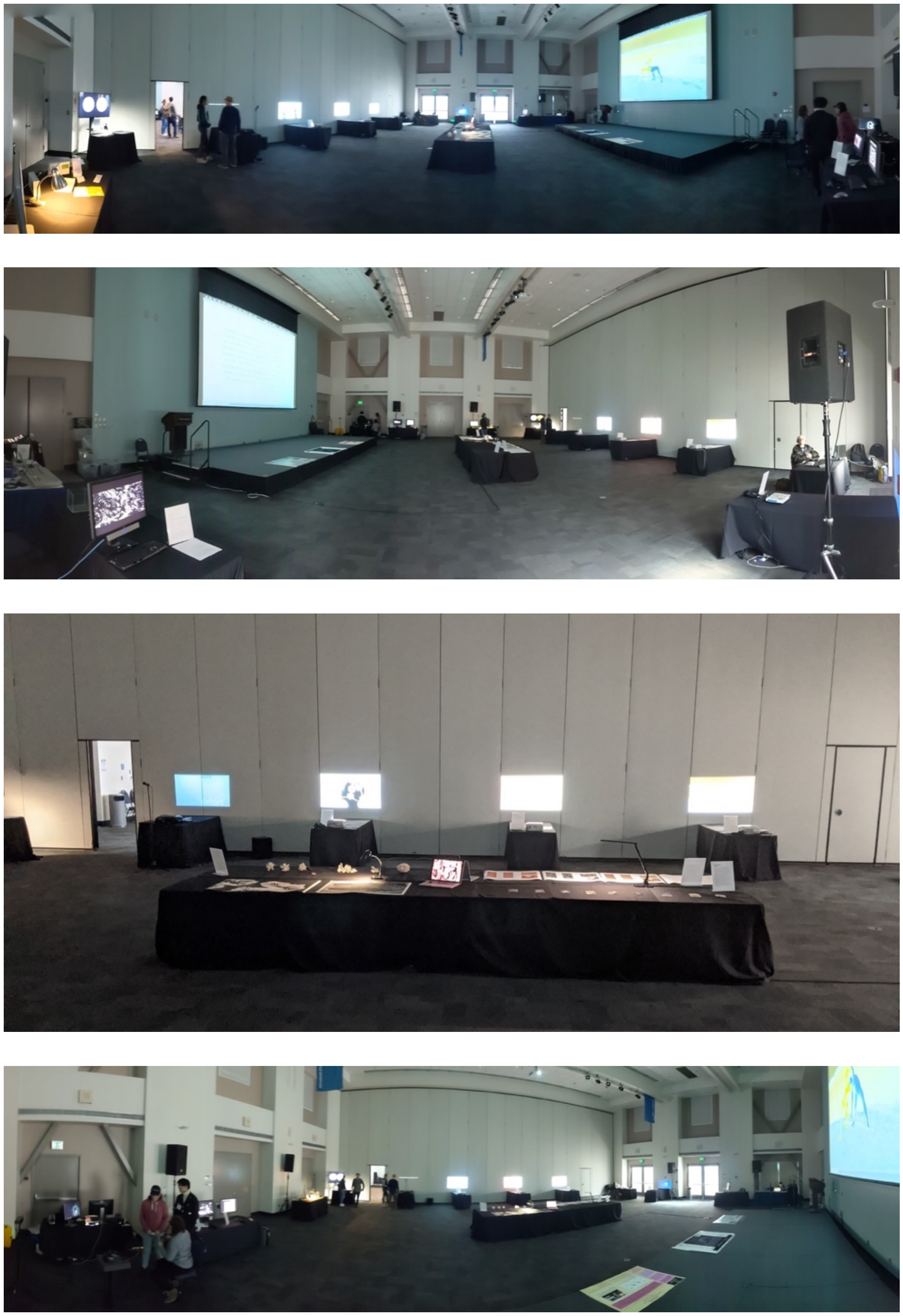


Figure 7.23 AWMAS – G. Rincon's Exhibition design views

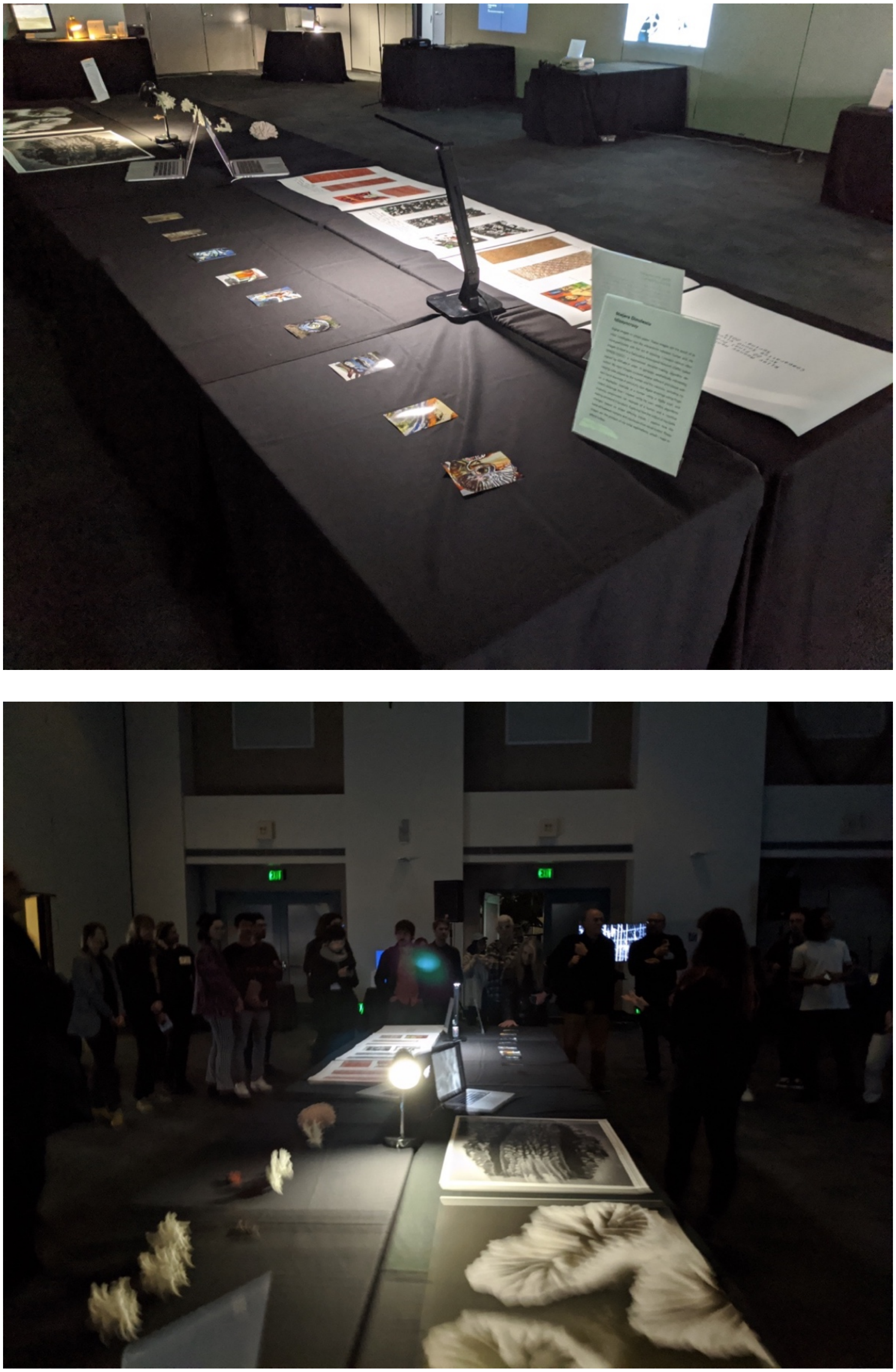


Figure 7.24 AWMAS – G. Rincon's Exhibition design detail views

Alliance of Women in Media Arts and Sciences (AWMAS) 2020

FOR IMMEDIATE RELEASE

AWMAS 2020 - Art Gallery Exhibition
at the Corwin Pavilion, University of California, Santa Barbara

AWMAS
Alliance of Women in Media Arts and Sciences

The UC Santa Barbara-based Alliance of Women in Media Arts and Sciences (AWMAS) will hold its third annual conference this week Feb. 5-7 at the Corwin Pavilion. With the goal of celebrating and promoting innovation by women in the burgeoning transdisciplinary space between science and media arts, the conference this year will focus on the theme of "Integration."

"Integration" is based on academic research and artistic works by women through transdisciplinary and interdisciplinary connections between the technical sciences and other applied sciences that influence new media art. The main goal behind this conference is to provide a platform for the exchange of ideas and experiences emerging from the intersection of science and applied art. Emphasis is placed on the various aspects of the mutual benefits of the integration and interaction between science and media arts.

Attracting leading female engineers, artists, scientists and educators from all over the world, the conference has become a thriving hub for the exchange of ideas, philosophy, research, and art. The conference is led by AWMAS founder Lena Mathew, a doctoral student in UCSB's Media Arts & Technology graduate program, along with a team of curators from UCSB, and other institutions.

As part of AWMAS 2020, an exhibition of audiovisual art installations will be presented in the Corwin Pavilion, with guided tours by the artists at 5 pm on the first day (Feb. 5th), and self-guided tours on the following days. This will serve as the backdrop for an exciting series of lectures, paper and poster presentations, and a workshop on programming for the creation of experimental computer music. The conference will culminate in a free multimedia concert on the evening of the final day.

Figure 7.25 Alliance of Women of Media Arts & Sciences – Press Release pg. 1

The full schedule can be found here: https://awmas2020.wixsite.com/home/program.

Artists

Sam Bourgault and Emma Forgues
Stejara Dinulescu
Maru Garcia
Elizabeth Hambleton
Riley Henningsen
Nana Klith Hougaard
Xindy Kang
Christina McPhee
Weilu Ge and Kelon Cen
Sophie Nebeker
Lauren Ruiz
Sahar Sajadieh
Tiffany Trenda
Rachel Wolfe
Yin Yu
Weidi Zhang

Curatorial Team

Sam Bourgault
Rodney DuPlessis
Kio Griffith
Elizabeth Hambleton
Gustavo Rincon
Sahar Sajadieh

AWMAS
Alliance of Women in Media Arts and Sciences

Dates (*Exhibition opening: Wednesday, February 5th, 2020, 5:00pm – 7:00pm)

Wednesday, February 5th, 2020, 1:00 pm - 5:00 pm, Art Gallery
Thursday, February 6th, 2020, 10:00 am - 5:00 pm, Art Gallery
Friday, February 7th, 2020, 10:00 pm - 1:00 pm, Art Gallery

Location

Corwin Pavilion
University of California, Santa Barbara
Santa Barbara, California, 93106

Contact
All Curators
awmas.exhibition@gmail.com

Special Thanks: Media Arts and Technology Program (MAT), Music Department, The Center for Research in Electronic Art Technology (CREATE), transLab, & Experimental Visualization Lab

Figure 7.26 Alliance of Women of Media Arts & Sciences – Press Release pg. 2

7.5 Exhibition Invitation: (Selected)

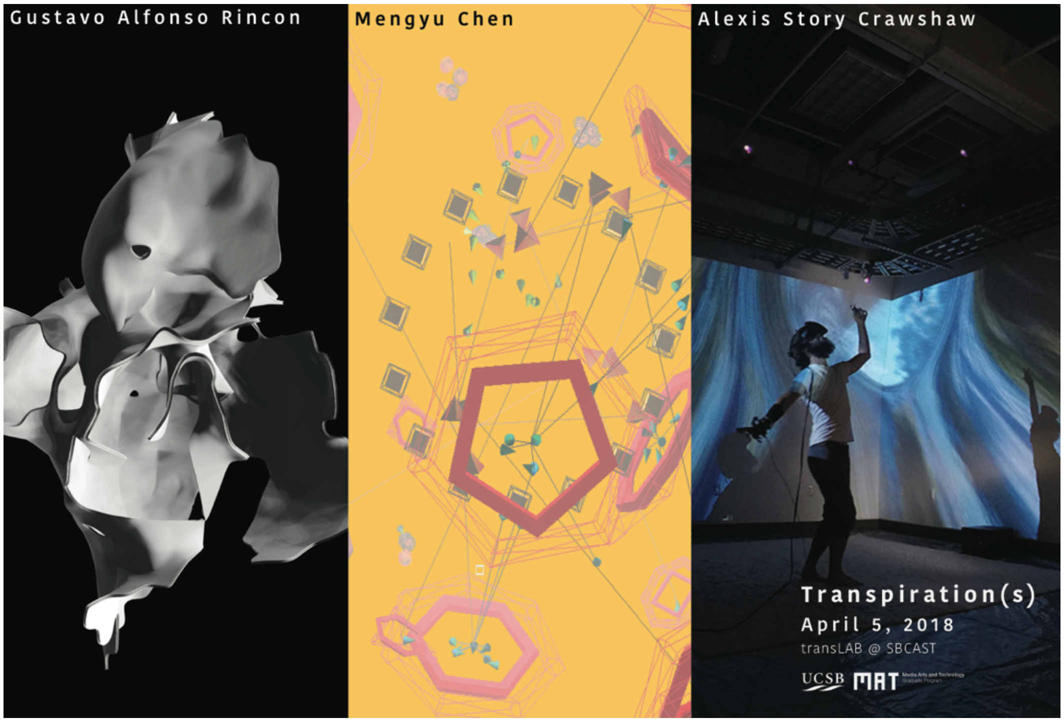


Figure 7.27 NMA – Invitation to the exhibition in Transpiration(s) - SBCAST