IF WALLS COULD TALK...

Augmented space designed to enhance physical and social engagement.

Holly Chan

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A 120 point thesis submitted to the Victoria University of Wellington in partial fulfilment of the requirements for the degree of Master of Architecture (Professional).

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ABSTRACT

Key Words: Augmented Space, Built Environment, Human-Building Interaction, Interaction Design, Engagement

This thesis addresses the issue of the change in Human Interaction with the built environment. Over the past 20 years, technology has become increasingly prevalent in our lives. With the current advancements of mobile devices and social media, the public's attention is captured in the virtual environment. The mind has become separated from the physical realm and designers must now compete with technology for the public's attention.

This thesis explores the development of Augmented space, which involves overlaying the built environment with digital information. Digital media provides the opportunity to enhance physical space with the element of interaction, which results in a high level of user engagement.

Many architectural spaces are designed as passive space, serving no pragmatic purpose. Through the addition of digital media, emotional and reflective value can be added to the built form. If space is designed to be reactive, rather than passive, a dialogue can be formed between the user and the environment. This thesis explores how meaningful connection to place can be developed through the addition of interactive digital media.

There is an opportunity to change architecture as a practice to consider digital technology as a tool rather than a threat. This thesis proposes that digital media can be used to re-engage the public with the built environment and increase interaction with physical form with the development of augmented space. The body of research explores how digital media can become embedded in the built form and can be used as a form of materiality by the designer. As new interactions are formed with the built environment, the public can form meaningful relationships with space and create stronger emotional connections with the spaces they inhabit.

CONTENTS

EXTERNAL VIDEOS

As this thesis is based on the development of motion imagery, there is content which cannot be solely conveyed through still images. Throughout this thesis there are QR codes to access video content. To access, scan the QR code with the camera on your smart phone and click the pop-up link. Alternatively there is a list of external video links in the appendix section or use the flash-drive included.

INTRODUCTION

1.0

1.1

PROBLEM STATEMENT + OPPORTUNITY

Humans form meaningful connections with the built environment through the physical and social interactions within the spaces they inhabit. The built form has been *"created for as long as at least three hundred thousand years, and strikingly even in the earliest and simplest forms they were interactive and multifunctional"* (Alavi, et al., 2016). On a daily basis, society is in constant dialogue with the built environment. This dialogue allows us to alter the parameters of the space we occupy; turning on a light switch, opening a window, closing the curtain or even rearranging the furniture. We are affecting and altering our surroundings. These daily affordances give us control to create the ideal subjective comfort; creating physical, sensory or emotional pleasure in the spaces we occupy.

The public's everyday interactive experiences with the built environment are changing and will not look the same within the next 20 years. Over the last three decades, our world has become increasingly enriched with digital technology and information. In the past, technology was fixed to a particular location, and its effects were limited to specific spaces: the office, the television, the cinema. With the advancements of mobile phones, digital media is accessible throughout the day and in any location. Accessed through the doorway of a screen, the virtual world is separate from the physical environment.

We have come to engage near equally with the virtual environment as well as the physical one, living simultaneous lives within separate realities. While the body is located in the physical world, the mind has become split between the virtual and physical environment. Unable to fully apply itself to one, we have begun to move through physical space instinctively without engaging with the built form.

Designers are often confronted with addressing the competing interests of public attention. While the presence of technology and information increases, architecture as a practice must develop to combine virtual and physical capabilities. *"In an age of networked interactions, there are new digital technologies that the planning profession can use to connect and engage with citizens"* (Houghton, Foth, & Miller, 2015). Digital technology has the potential to enhance architecture with a higher level of interactivity, creating the opportunity for communities to develop meaningful connections with place. As Refik Anadol states; *"Despite what is seemingly a lack of social awareness as users concentrate on their screens, photogenic architecture and media content can provide opportunities to allow alternative interactions with people and environments"* (Anadol, 2020).

The refreshing and infinite scroll features of our mobile devices demand our constant attention. The level of engagement we have with our mobile devices can be adapted and applied to the built environment, developing physical social interactions rather than virtual ones. Engagement is the key to changing the public's relationship to architectural space; *"Engagement is something that can catalyze the many disparate thoughts of individuals in the community, bring them together into something meaningful, which can be developed for the benefit of the whole community"* (Houghton, Foth, & Miller, 2015).

Architects can begin to consider digital media as a form of materiality and a tool to enhance interaction with the built form. Comparable to how concrete or timber is used as a surface treatment, where material choice can change the atmosphere of a space, digital media can provide similar opportunities. Digital materiality is adaptable and thus the architect is not confined to choosing a material for the next 50 years but can alter the atmosphere of space depending on its current function. Digital media as part of the built form presents an alternative to the threat of technology to an architect's creative control, enabling the architect to establish what and how media is experienced within space.

Connection to place is more than just physical form, *"it is about the meaning and connection people have with that environment"* (Houghton, Foth & Miller, 2015). Digital media provides the opportunity to communicate intangible qualities of space and enhance connection with an environment. As seen in Refik Anadol's work, which is explored in later chapters, augmented space can create narratives of place, telling the story of a building; its history, how it is used or the social interactions that take place

within it. When these intangible qualities are communicated, individuals can begin to understand a sense of the space which encompasses them. They can identify themselves as part of a broader whole that makes up the daily interactions and movements of a building. These narratives create meaningful relationships with the community and enhance the connection to place.

This thesis explores how virtual and physical interaction can be combined to develop Augmented space and how it can be used to enhance public engagement. The research examines the implications, benefits and outcomes of augmented space and aims to develop a system to create a meaningful connection with a place.

1.2

RESEARCH QUESTION

In response to the contextual information, I frame the following design research question:

"How can physical action and virtual interaction be combined to engage the public with architectural space and create more meaningful connections to the built environment?"

1.3

AIMS + OBJECTIVES

This thesis aims to explore augmented space and how this can be developed to reconnect people to the physical environment.

Through design research, an interactive system will be created which utilises augmented technologies to enrich an architectural space.

The objectives of this thesis are as follows;

1. Investigate different augmented technologies, understand their strengths and weaknesses and explore how they can be immersed with physical space.
2. Develop an interactive system that enriches architecture and forms new relationships to the built form.
3. Apply this experience to a specific space and understand how it changes the perceived experience of the building.

1.4 SCOPE OF DESIGN RESEARCH

The research sits within the field of 'Human-Building Interaction'; *"Human-Building Interaction (HBI) frames Human-Computer Interaction(HCI) research and design within built environments"* (Alavi, et al., 2019). The research is focused on the development of Augmented Space and how the combination of virtual information and physical form can create new human interactions.

Animation design, AR (Augmented Reality) application design and installation design are explored to understand how augmented space can best be incorporated into the built environment.

To create an interactive experience that expresses a human narrative, real-world data will be used. The research will use real-time input data rather than collected and stored data. This research will not explore artificial intelligence or machine learning but does aim to create a tool which reacts to human input.

The user will affect the work but does not control the work. The research aims to create an experiential outcome rather than an interface; therefore, usability and interface design will be considered but not strictly applied.

The thesis will explore methods of digital design and how it can be embedded in the built environment in poetic mediums. The design research will combine both poetics and pragmatics but inclines toward practical application and the production of an architectural artifact. This thesis is not purely speculative but instead uses a practical application to encourage speculative thinking.

The research will not explore the semiotics of space, phenomenology or spatial perception. It is centered in a technical application rather than a theoretical approach.

The research intends to generate a digital experience within the parameters of the digital skills which can be acquired. The design research is initiated with no prior knowledge of scripting or coding, so the design research will be limited to the tools and skills that can be learnt within the research period.

The outcome of the design research will be a practical application of augmented space and an exploration of the possibilities of how it can be applied.

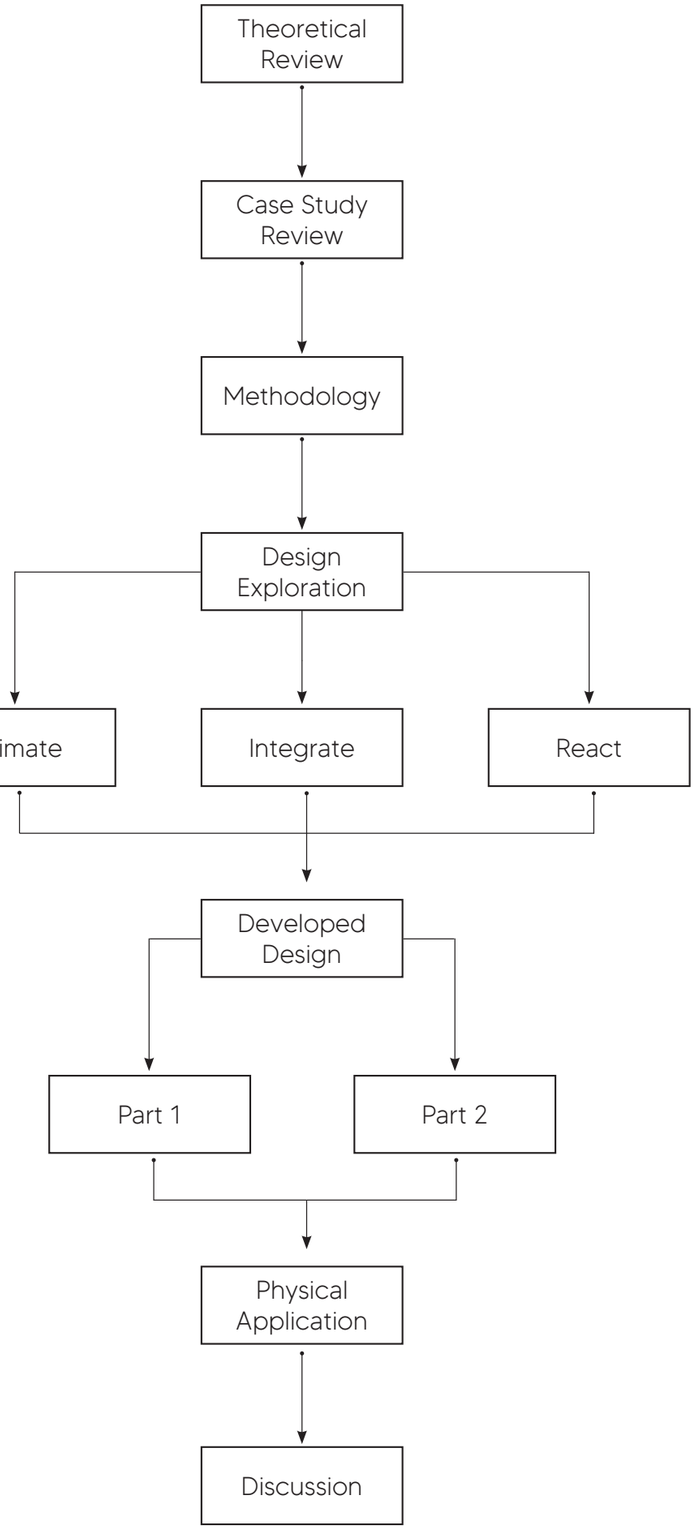

Figure 1: Thesis Structure

1.5

THESIS STRUCTURE

The following study begins by exploring relevant theoretical concepts in order to provide context for the research. Six relevant case studies are then examined to explore previous work in the area and understand areas for further investigation.

The design research methodology outlines a design framework which has been derived from the concepts of Emotional Design as defined by Donald A. Norman. The design framework will be used to evaluate the successfulness of the design explorations.

An initial design exploration is presented in 3 parts; animate, integrate and react. Animate explores the development of creating engaging digital media. Integrate examines how the media can be immersed with the physical environment and React explores how the media can adapt to human interaction.

The developed design chapter presents the refinement of the design using the tools and skills gained in the preliminary design process. The development of the design works towards creating a meaningful interactive experience.

The interactive systems are applied to two different physical environments; a threshold space and an urban alleyway. The practical application of the systems compares the benefits and outcomes of applying digital media to alternate environments.

The conclusion of the study discusses the findings of the design research, providing a critical reflection of the work and opportunities for further development of the investigation.

THEORETICAL REVIEW

2.0

2.1

INTRODUCTION

The literature review identifies the key ideas that are explored in this thesis. The review examines the context of augmented space and interaction design. The combination of these two concepts results in synesthetic architecture. This review outlines the opportunities of synesthetic architecture and will explore how it can be applied to enhance physical space. The design of synesthetic architecture will create a speculative design that will contemplate how digital media can be integrated into the physical environment to enhance public engagement.

2.2

AUGMENTED SPACE

Physical structure alone once captured the visual attention of the public. In today's technological culture, an individual's attention is immersed in the digital environment. The digital world is dynamic, evolving and provides us with constant social interaction. With digitisation having infiltrated all aspects of everyday life, the physical world is saturated with digital information.

Augmented space is a response to the separation of the physical and digital environment. Augmented space defines the relationship between physical environments and virtual information. As Lev Manovich writes in The Poetics of Augmented Space, augmented space is ***"The physical space overlaid with dynamically changing information"*** (Manovich, 2016). The concept explores how personal experience can be altered through the addition of multimedia information.

There is an opportunity through the creation of augmented space to ground the image and connect it to physical space. *"Augmented Space provides a challenge and an opportunity for many architects to rethink their practice since architecture will have to take into account the fact that virtual layers of contextual information will overlay the built space"* (Manovich, 2016).

The seamless integration of digital media into built form can enhance the level of user immersion and interaction. Transparency indicates *"an interface that is able to erase itself, making the user experience more immediate"* (Biggio, 2020). When describing her multimedia video installation at the Museum of Modern Art, Pipilotti Rist stated: *"The basic concept is to try not to destroy or be provocative to the architecture, but to melt in"* (Lavin, 2011). Augmented space aims to overlay the physical architecture, melting in, and becoming part of its structure.

Augmented space re-conceives architecture as a canvas, enhancing it by creating emotional connections and interactions with the public. While augmented space provides architects with opportunities to enhance their architecture, there is a question about its range of opportunity. If the digital information is static, for example, a looping animation, will the augmented space become mundane and non-engaging? Manovich's quote outlines *"dynamically changing information"* (Manovich, 2016) which will become key to developing an engaging experience.

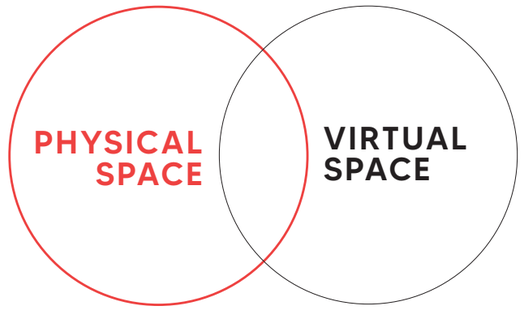

Figure 2: Augmented Space

2.3

SYNESTHETIC ARCHITECTURE

The term Synesthetic Architecture was coined by the digital media artist Refik Anadol. Anadol works with collecting site-specific data in order to generate digital data sculptures. His most well-known work, a projection onto the façade of the Walt Disney Concert Hall in Los Angeles, uses a collection of the LA philharmonics data to create digital media that presents the building's past.

The term Synesthetic Architecture takes the ideas from augmented space; combining physical space, digital information with the addition of machine learning. He defines the idea and its possibilities;
"Synaesthetic architecture, therefore, suggests that architects may enfold machine learning into building forms, not just creating but also redefining space through mixed media and interactive robotics. The age of machine intelligence will make our computers, our buildings and our cities more responsive and brain-like" (Anadol, 2020).

The idea presents an alternative to the threat of technology to an architect's creative control. Digital media can become a tool and a form of materiality to architects, similar to how architects would use concrete to enable the form. Digital media can be utilised to enable engagement, expression and interaction. The concept *"questions how we can augment and expand the possibilities for architecture itself. How can we interact with these tools as collaborators?"* (Anadol, 2020).

A similar term was framed by Sylvia Lavin in her book Kissing Architecture which explores the relationship between architecture and contemporary art. Her term 'Super Architecture' describes the result of adding digital media to architectural form. Resulting in works that *"not only superimpose themselves onto architecture but that intensify architectural effect… mingling one medium with another so that neither loses its specificity."* (Lavin, 2011).

While Anadol defines synesthetic architecture as the combination of physical space, digital information and machine learning, I will substitute the term machine learning with interaction. The design research will explore how the built form can become more responsive to human interaction, creating a membrane between built form and public space.

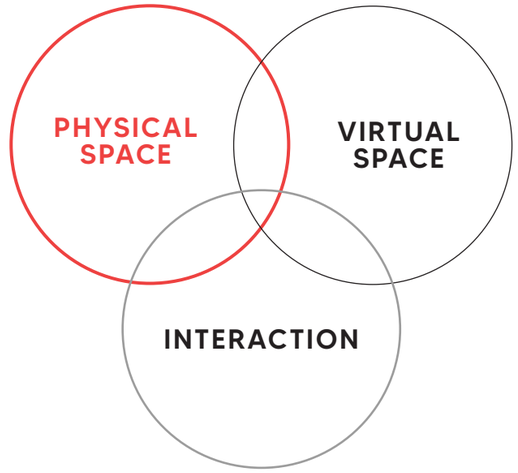

Figure 3: Synesthetic Architecture

2.4

INTERACTION

This research relies on an understanding of interaction. Interaction can be defined as the relationship between two objects, beings or substances. *"Although interactivity is sometimes associated exclusively with gaming, it has become increasingly important to the field of information visualization, as the ability of users to interact with data allows them the opportunity to explore meaningful relationships"* (Wessel & Sauda, 2012). In this research, interaction focuses on the relationship between people, digital technology and the built environment.

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Figure 4: Interaction Framework between a human and a system by Selcuk Artut.

Interaction introduces social dynamics into space. This research will investigate how people relate to built form; how they interact with each other and a building. The interaction with augmented space can provide an opportunity for designers to create a conversation between the inhabitants and a building. *"A building's surface is the most dynamic part of its character, and its openness to change continuously generates new interactions between people and the urban environment"* (Anadol, 2020).

2.4.1 HUMAN BUILDING INTERACTION

Human Building Interaction (HBI) is an interdisciplinary topic of Human-Computer Interaction (HCI) , framing it within the realms of the built environment. HBI "seeks to examine the involvement of HCI in studying and steering the evolution of built environments" (Alavi, et al., 2019). As our environments become increasingly saturated with digital technology, HBI aims to design digital media to become embedded in our physical environments.

HBI encompasses people, the built environment and computing. Bill Hillier originally defined HBI in his book 'Space is the Machine', stating;

"Built environments are a construction of physical elements that create and protect a space. Each of these two aspects, the physical and the spatial, carry a social value: the former by the shaping and decoration of elements (with functional or cultural significance), and the latter by providing spatial patterning of activities and relationships. Designing Human-Building Interaction, in that perspective, consists of providing interactive opportunities for the people to shape the physical, spatial, and social impacts of their built environment" (Hillier, 1996).

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Figure 5: Diagram illustrating the scope of HBI by Hamed S. Alvi et al.

His ideas are conveyed in the diagram above by Alvi, et al., included in their writings about the future possibilities of HBI. The diagram illustrates the areas of HBI and how they interlink. The looping circles represent *"people's experiences in built environments*

that integrate computing in various forms" (Alvi et al., 2019). These areas are linked by the elements that form the built environment; physical, spatial and social, as defined by Bill Hillier.

The intent of HBI is not to transform buildings into computers but to manipulate and craft interactive experiences within a building.

2.4.2 USABILITY

Interaction design is a human orientated activity. It is focused on human behaviour and how humans think, act and react to a certain intervention. Cooper, Reimann and Cronin in their book The Essentials of Interaction Design, discuss an approach to interaction design called the Goal-Directed method. This method *"is concerned most significantly with satisfying the needs and desires of the people who will interact with a product or service"* (Cooper, Cronin, & Reimann, 2007). They found that when a designer concentrated on the user's expectations, attitudes and behaviours, a more powerful and pleasurable experiential outcome was created.

While the design research does not work within the realms of application design, the intent is to create an artefact that is to be 'used' in a sense. The principles of interface design delve into the psychology and emotional reactions users have when engaging with digital systems. Interface design outlines conditions for ideal usability. While these conditions will not be applied strictly, it is useful to be aware of usability in order to create the desired experience; *"Every interaction designer would probably agree that usability clears the way for a more profound and complete user experience"* (Quanjer & Lamers, 2014).

Jakob Nielsen's '10 Usability Heuristics for User Interface Design' are outlined in the table below and will be applied within the design research in Chapter 5.3, in the exploration of creating interactive media.. These principles were developed in 1994 to create a framework for evaluating digital interface design. They have been used to evaluate websites, user interfaces and digital applications and *"in many cases they have been modified so that they can be applied in an ever-changing socio-technical environment"* (Gonzalez-Holland, Whitmer, Moralez, & Mouloua, 2017).

Only the relevant principles Nielsen outlined have been presented and have been discussed in relation to the design of Augmented space.

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Figure 6: Jakob Nielsens '10 Usability Heuristics for User Interface Design' in relation to the design of augmented space (Nielsen, 2020).

2.4.3 USER ENGAGEMENT

Interaction is the key difference between engagement in a mobile device and the built form. Our digital device provides us with visual stimulation that is constantly refreshing and updating. We can play and explore within the virtual world with endless possibilities to keep us engaged. We have an insatiable appetite to be constantly entertained that is not currently fulfilled within the real world.

The addition of interaction to augmented space adds another layer of user engagement that will enable the user to become an active participant in the experience. The participant will become the actor rather than just the spectator, or as Augusto Boal calls *"Spect-actors"* (Boal, 1985). Boal, an expert in performance and theatre, describes that when the participant becomes a 'Spec-actor' they are applying their own agency to the experience. The user can become actively involved in the production of narrative and meaning, this idea is further discussed in Part 2.6 of this chapter.

The concept does not only explore the interaction of the participant but also the experience of the other spect-actors within the space. A different experience is created for a user watching another spect-actor engaging with the media, thus enticing them to engage. Megan Alrutz discusses applied theatre experiences, stating *"However intentional (or not) their participation, in a sense, everyone who entered the gallery was simultaneously watching and being watched, performing and spectating, consciously and unconsciously producing and consuming narratives…"* (Alrutz, 2011).

Interaction has a proportional relationship to engagement; the more evolving and dynamic the experience is the higher the user engagement becomes. *"Thus through their high level of interaction and layering of information, Mixed Environments provide immediate feedback to its users"* (Schnabel, 2009). It is this feedback that will create an *"intangible pleasure"* (Dalton, Schnadelbach, Wilberg, & Varoudis, 2016) and form a memorable and meaningful experience for the viewer.

2.4.4 REFLECTIVE ENGAGEMENT

Meaningful interactions can also be explored through what Arnold Jan Quanjer calls reflective interfaces. Reflective interfaces are digital experiences that do not follow conventional interaction design. Commonly interfaces are designed to be instantaneous and reactive, created with the goal of effortless usability.

In his paper 'Make Me Think', Quanjer discusses Jakob Nielsen's Heuristics for Usability and alters them to enable reflective interaction. He discusses how methods such as time delay, which counteracts principle one, can be used to give the user time to reflect. Reflective interfaces are designed to encourage you to think and reconsider your actions. These interactions can be designed with *"deliberate slowness and friction [which] can encourage a user to make an extra effort and make him think"* (Quanjer, 2014).

Reflective interfaces use unconventional design methods to make the user feel uncomfortable or confused. This emotional response enables questioning and re-evaluation of the design they are experiencing.

2.5

SPECULATIVE DESIGN + PERFORMATIVE ARCHITECTURE

Speculative Design is a form of design research that encourages contemplation and questioning of conventional design. James Auger states that speculative design primarily serves two purposes: *"first to enable us to think about the future; second, to critique current practice"* (Auger, 2013). It uses the language of design, rather than the spoken word, to ask questions and provoke emotions. Speculative design aims to evoke the imagination of the viewer with the aim to start a conversation. Speculative designs can be used to inspire, entertain, critique, raise awareness and be used as a catalyst for change.

Speculative design ranges across all mediums of design and can be presented in many forms. They can present alternate realities, fictional environments, and possibilities of future worlds, cultures or behaviours. The aim is to provoke change in the thoughts and emotions of the viewer. Speculative designs can often make the viewer feel inspired, uncomfortable or confused. These emotions provoke thought and aim to leave a meaningful impression on the viewer.

Speculative design can be a powerful tool of communication and enables the designer to critique current practice. The key factor to enhancing the speculative effect is to manage the fictionality of the idea, *"if it strays too far into the future to present implausible concepts or alien technological habitats, the audience will not relate to the proposal resulting in a lack of engagement or connection"* (Auger, 2013). Designers must work within the realms of possible and plausible in order for people to engage with the ideas they are presenting. If a design strays too far outside the realms of possibility, the work becomes dismissed as fictional and is purely examined for entertainment.

Speculative design became increasingly popular in the 1960s. A movement of designers used speculative design experiments to comment on the role of architecture in social, political and urban culture. One of the most well-known groups, Archigram, used their design to critique consumerist society. *"Archigram wanted architecture to be as mobile, dynamic and 'pulsating'… as the society they saw around them. They proposed buildings that moved, that shone in the dark, that could be changed at their users will"* (Moore, 2018). Archigram wanted architecture to become more socially and politically engaged. Archizoom used similar mechanisms to comment on modern architecture, criticizing architecture for *"ignoring and aggravating environmental and social problems"* (Schneider & Till, n.d.).

Designers such as Haus Rucker Co, Coop Himmelblau and Cedric Price, explored concepts of performative architecture. *"Haus-Rucker-Co created performances where viewers became participants and could influence their own environments, becoming more than just passive onlookers"* (Schneider & Till, n.d.). Their project Oase No.7 (shown below), featured a large inflatable structure fixed to the side of a building. The idea was to create a space for play, reflection and relaxation within the urban environment. The design uses an individual's senses to alter their perception of reality. Coop Himmelblau similarly used the user's perceptions to explore their relationship to the built environment. The group produced interactive projects, such as Soft Space (1970), using viewers as actors within the environment.

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Figure 7: Sketch of Cedric Price's concept for Fun Palace.

Cedric Price, also a part of the 1960's speculative design movement, was an architect who examined the concept of architecture without built form. He philosophized that *"a building is not necessarily the best solution to a spatial problem"* (Schneider & Till, n.d.) and explored designs with a time-based approach. His speculative design The Fun Palace (shown above), explores the idea of creating adaptable and interactive architecture. The Fun Palace was designed for London theatre director Joan Littlewood, who outlined the brief as a theatre where the audience became the actors. *"As socially interactive*

architecture, the Fun Palace integrated concepts of technological interchangeability with social participation and improvisation" (Mathews, 2006). Price designed architecture as a machine, composed of parts that were at the disposal for individuals to change, alter and design. It was *"designed to be dismantled and reassembled"* (Schneider & Till, n.d.). The Fun Palace was human orientated design that examined the social dynamics of people within space. It provided an opportunity for people to escape mundane and routine life to create, play, learn and explore. The interventions primary purpose was to adapt and change to the users needs and emotions. Price explored the concepts of time within this project and thought of *"architecture in terms of events in time rather than objects in space"* (Mathews, 2006). The Fun Palace was an architecture of continuously changing events rather than being composed of built form.

Performative architecture gives the user a sense of agency and enables them to exercise their creativity within a space. While the architect still designs the mechanisms of the space, there is an opportunity for the user to inform the atmospheric qualities. The subsequent design research builds on a speculative design approach, questioning and critiquing the role of technology within the built environment. The design research aims to explore how technology can add enjoyment to space and immersed people in the physical environment.

2.6

SUMMARY

The Literature Review has outlined the key concepts that will be explored within the design research. The concepts explored share overlapping ideas and provide context within the scope of the research project. Certain concept-driven principles have been derived from the theoretical review and are as follows:

- The design should enhance the built environment through the creation of augmented space.
- The design should enhance the interaction between the public and the built form.
- The design should portray the intangible qualities of a space.
- The design should be an emotionally and visually engaging experience that is constantly changing and evolving.
- The design should intensify and alter the architectural effect of a threshold space.
- The user should facilitate the experience; becoming both the spectator and the actor.
- The experience should encourage speculative reflection. Critiquing technology but also reimagining how it can be applied in the built environment.

The following chapter explores multiple design precedents and identifies how the theoretical concepts have been applied within each project.

CASE STUDY REVIEW

3.0

3.1

COCOON

Factory Fifteen
2015

Cocoon is an immersive installation designed by multi-disciplinary design studio; Factory Fifteen. The firm, founded in 2011 by three British architecture graduates, focuses on immersive technologies and film-making. Their work includes architectural animation, branding and advertising, immersive technologies and film.

Cocoon, completed in 2015 for SAT (Society for Arts and Technology) Montreal, is an immersive video installation. The dynamic film is projected onto a 360° x 220° spherical dome, allowing the viewer to be fully immersed within the space and the film.

"Cocoon places the participants inside several shells of abstract and figurative architectural spaces, which slowly peel away. Cocoon believes architecture is not static, but is transitory, evolving and animated. Our city is our cocoon" (Factory Fifteen, Cocoon, 2015).

The designers have used animation along with sound and lighting design to create an immersive cinematic experience. The film deconstructs urban architecture in an abstract way, enticing the viewer to reconsider conventional architecture.

Not only is the visual display captivating but the construction of the installation is well executed. The physical scale of the work enhances the perception to the viewer. Rather than seeing the film on a two-dimensional surface, the viewer is surrounded by the animation. Depth has been incorporated into the visuals to enhance the reality and scale of the film. The size of the dome, 18m in diameter and 13m high, makes the viewer feel small and inconsequential. As the solid architectural form crumbles on top of the viewer, a contrast is created between solidity and the immaterial.

This project provides an alternative approach to Virtual Reality (VR) that is commonly used to create immersive filmic experiences. While VR is strong in its immersive qualities, it takes the viewer out of the physical world and places them within an alternate reality. The problem is that *"people often struggle to get beyond the concept to appreciate and engage with the ideas"* (Dunne & Raby, 2013). The accomplishment of this project is it augments physical space allowing users to continue to exist in their current environment. The users are able to feel immersed and connect with the ideas rather than discrediting as abstract and fictional.

The weakness of this project is it lacks in viewer engagement and interaction. The viewer is purely a spectator and takes no part in manipulating the outcome of the narrative. While they have the room to move around the space and change perspectives of the work, there is no interaction with the work and thus no dialogue with the participant.

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Figure 8: Factory Fifteen's Cocoon

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Figure 9: Factory Fifteen's Cocoon

3.2

E-BRUSH

Factory Fifteen
2019

E-brush, a project also by British media company Factory Fifteen, is an interactive artwork generator. The installation was developed for Nissan's Formula E Division series. The work represents dynamic energy and is manipulated through human interaction.

The participant's physical input influences the digital output. *"The idea is that your input leaves it's mark. Your body is the brush and the digital screens the canvas"* (Factory Fifteen, E-brush, 2019). Depending on what direction the individual moves affects the colours that are produced.

The user's information stays on the screen until it is wiped over by another participant. The artwork was exhibited in 12 different cities, each location having its own unique colour palette. The outcome is individual artworks that represent each city and the participants of the event.

This project is of similar characteristics to Mark Goulthorpe's Hyposurface from 2003. The installation exhibits a mechanical wall which reacts to people's physical interaction. Goulthorpe describes it as the world's first physically dynamic screen, combining information and form. Using an input of various physical parameters, such as touch, sound and weather, the wall ripples and moves. The work shows how architecture can become dynamic and adaptive to public engagement.

Factory Fifteen's E-brush explores similar ideas of Hyposurface but evolves them to utilise today's technologies. Both projects exercise the user as the facilitator of the design and enable them to become the actor within the space. The movement of the interventions enables performative architecture and imagines the possibility of reactive built form.

E-brush addresses the issue of lack in engagement that was discussed previously in Factory Fifteen's Cocoon. The project is a great example of user engagement and interaction. The limitations of the project are it only reacts to one set of variables; directional movement to colour. There is an opportunity to build up the layers of information to create a more complex simulation, as seen in Hyposurface.

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Figure 10: Factory Fifteen's E-Brush

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Figure 11: Factory Fifteen's E-Brush

3.3

WALT DISNEY CONCERT HALL DREAMS

Refik Anadol
2018

WDCH Dreams by Refik Anadol is a dynamic data visualisation projected onto the facade of Frank Gehry's Walt Disney Concert Hall. Commissioned by the Los Angeles Philharmonic to celebrate their 100th Anniversary, WDCH Dreams is one of Anadol's most ambitious and well-known works.

Refik Anadol is a digital media artist who explores the relationship between data, digital media and architecture. Anadol who coined the term Synesthetic Architecture (Chapter 2), takes large sets of raw data and uses machine algorithms to process the information, resulting in what he calls digital data sculptures. He poses the idea that virtual information along with machine intelligence can become a form of materiality in an architects tool kit. He states that architecture *"is at a turning point, now expanding the definition of 'space' to include realities that are otherwise alternate or virtual."* (Anadol, 2020).

In WDCH Dreams, Anadol takes 45 terabytes of data: composed of images, videos and sound clips, and processes the information using machine learning algorithms. *"The files were parsed into millions of data points that were then categorised by hundreds of attributes, by deep neural networks with the capacity to both remember the totality of the LA Philharmonic's 'memories' and create new connections between them"* (Anadol, 2020). The simulation creates connections between individual pieces of data, forming a narrative that reflects the building's past.

The culmination of the building memories combined with machine learning creates a 'consciousness' of the building, speculating on the future of the LA Philharmonic. The idea was to *"mimic how humans dream, processing memories to generate new combinations of images and ideas"* (Anadol, 2020).

The visualisation was projected onto the surface of the Walt Disney Concert Hall over a week-long period. Using 42 projectors, the digital media was mapped onto the building's facade, transforming the building into one dynamic data sculpture. Anadol explores how a flat facade can become its own three-dimensional space. This space doesn't need to serve a physical purpose but can rather show us intangible information which is not seen in the physical realm.

Anadol successfully exhibits how built form can become a canvas to digital media. Architecture does not need to stay in the static form of its original design, becoming a mundane form of our everyday lives, but can be used to facilitate the communication of intangible narratives. Anadol has highlighted the opportunity to enhance architecture with a digital layer of information. This layer can facilitate a meaningful dialogue between the public and built form, becoming an interface to the building.

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Figure 12: Refik Anadol's Walt Disney Concert Hall Dreams

3.4

EVERYDAY EXPERIMENTS

Space10 + IKEA
2020

Everyday Experiments is a project by research and design lab SPACE10. The project is an explorative study of how technology can be redefined within the home. In collaboration with IKEA, SPACE10 commissioned multiple design and technology studios to create 18 speculative projects which challenge how technology can be used within the home.

Some projects take a practical approach, such as 'Home Applications' by Bakken & Baeck which proposes a light bulb that indicates the air pollution level within a home, or 'Shelve It', an AR application which scans the walls to enable you to design the perfect shelf within your home. Other projects take a more playful approach such as FIELD's 'Extreme Measures' which questions 'What if an elephant could measure the size of your space?'. The project takes the metaphor "the elephant in the room" and adapts it into a tool to measure space. Using LiDAR scanning, the application inflates an elephant to any defined area; a room, the space under your bed or in a cupboard. The aim is to create a playful way to measure space intuitively rather than metrically.

'Fort Builder' also by FIELD, explores how technology can be used to create joy. Taking the concept of building forts in the living room as a child, the application enables you to take the objects in your home and virtually stack them up. The prototype allows you to build structures with your furniture, without the limitations of gravity, then let them topple to the ground at your will. The project is *"An ode to the simple pleasure of smashing things, without doing any real damage to mama's best vase. And an important reminder that being locked in at home is not a limitation to creativity."* (FIELD, 2020).

FIELD wanted to ground the prototype in human instinctive memory. By doing this the experience became intuitive and made the technology *"human, relatable and emotional". FIELD states "Most spaces in the home are designed by and for adults – building forts gives children a takeover moment to create their own safe spaces"* (FIELD, 2020). The project enables the user to reimagine the mundane and to exert the act of play within their home.

This experiment, in particular, is interesting as utilises modern technology without serving a utilitarian purpose. Space10 defined the goal of the experiments as a way to explore how technology in the home doesn't always *"mean doing something faster, or with more precision. It can simply provide a way to enjoy our homes more: infusing the spaces we have with joyous elements that make you feel happy, calm, or safe"* (Space10, 2020). The speculative nature of the experiments makes us question how technology has come to add pressure on our everyday lives. Alonso Homes, a collaborator in the experiments states that technology *"should free us to focus on the relationships, experiences, and activities that matter the most to us, by removing unnecessary complication"* (Space10, 2020).

Everyday Experiments provides an alternative approach to the design of digital technology. Rather than designing digital media with the intention to enhance a certain aspect of our lives, which often results in technology feeling like a burden: digital tools could be designed with the sole purpose of creating joy, beauty and play within the physical environment.

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Figure 13: Extreme Measures by FIELD

3.5

NEXEN UNIVERCITY ‘THE INFINITY WALL’

D’Strict
2019

Nexen UniverCity ‘The Infinity Wall’, is a project which clearly exhibits how threshold spaces can be enhanced with the addition of digital media. The installation was designed by Korean design studio District, a company that specialises in innovative digital spatial experiences.

‘The Infinity Wall’ was completed in 2019 and is a public media installation designed for Nexen Tires. The 30 by 7 meter long LED Screen is situated in the lobby space of Nexen Tires Research and Development centre in Seoul.

The visualisation is composed of four parts; Knock, Soaring, Combination and Climbing, each depicting a different visual language. Knock uses the language of water and fluidity, depicting a giant wave within a three-dimensional space. Soaring is composed of millions of animated cubes which move as one as they are displaced within the environment. Combination illustrates the human form transforming from a dust-like substance to liquid to concrete. Climbing turns the walls into a tessellated climbing structure that illustrates human figures jumping between them.

In all four parts, the fluidity and dynamic nature of the visualisations contrast with the static design and materiality of the lobby. The display transforms the flat wall into its own three-dimensional space. Creating the illusion of a window into another room. The scale and detail of the display create a mesmerising installation which changes the spatial experience of the lobby.

The design of the wall was driven by three principles; story mode, mood mode and message mode. Story mode drives the narrative design of the installation, communicating the core values and philosophies of Nexen Tires. Mood mode aims to *“create a highly emotionally charged atmosphere”* (District, 2019) and message mode adds a practical element to the installation. Including weather, time and news information into the visualisation, turning the display into a real-time ‘bulletin board’.

This project is a distinct example of how a threshold space can be enhanced with the addition of digital media. The intervention challenges and alters the user’s perception as they enter the building as well as changing their expectations and emotions of the subsequent spaces. The infinity wall shows how dynamic digital media can capture the attention of the public and ground them within their physical surroundings. The installation changes the threshold from a ‘passing through’ space to a space to be inhabited and enjoyed.

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Figure 14: Knock - The Infinity Wall

3.6

PRESENT CONTINUOUS PASTS

Dan Graham
1974

Present Continuous Pasts is a conceptual art piece by Dan Graham that aims to facilitate reflection on time and space. The piece is composed of a mirror, a camera and a monitor. As the viewer walks into the space they immediately see themselves in the mirror, reflecting 'the present'. The camera records the user within the space, capturing their reflection in the mirror. The monitor then plays back the recorded image with an eight-second time delay, displaying 'the past'. The user simultaneously sees their current self as well as their past self. Graham has created *"an infinite regress of time continuums within time continuums within time continuums"* (Francis & Pelzer, 2001).

Present Continuous Pasts is an installation where time has become the fourth dimension. Graham challenges the user's perception of time; disrupting time in space to compel the viewer to reconsider their surroundings. This delay in time enables what Arnold Jan Quanjer defines as a reflective interface; *"A reflective interface may be deliberately slow and induces delay. In this manner it creates more time to consider different options and thus enables reflection"* (Quanjer, 2013). Reflective interactions are important as they inspire speculative discussion. Raising questions and encouraging different interpretations of the space.

This piece also applies the theories of performative design. *"The spectator becomes a participant that completes the artwork while perceiving the past in the present"* (Quanjer, 2013). The user is not only viewing the artwork but as they are recorded and replayed, they are also becoming a part of the art itself. They are the 'Spec-actor', becoming actively involved in the production of narrative.

Through this piece, Graham has created what Till Boettger in her book Threshold Spaces defines as a time threshold; *"the installation provides insight into the time dimension of threshold experiences"* (Boettger, 2014). Thresholds are constructed around an individual's perception of space and are spaces that are moved through. As an individual moves from one point in space to another, they are creating distance over a period of time. Through his installation, Graham has created an unconventional perception of time, encouraging the viewer to reconsider how they have transitioned through the threshold. This is similar to how Price explored concepts of time in The Fun Palace creating an *"architecture in terms of events in time rather than objects in space"* (Mathews, 2006).

This project is particularly interesting due to the time of its creation; Present Continuous Pasts was exhibited in 1974. While it was a digital art piece, it was limited to the technologies of the current day. The simplicity of the piece is to be admired as it enables the user to create their own reflections and *"allows users control over the process of meaning making"* (Quanjer, 2013). With the development of contemporary technologies, there is an opportunity to develop and expand on Graham's concepts of time and space,

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Figure 15: Dan Grahams Present Continuous Pasts

3.7

SUMMARY

The case studies explored include projects that range from pure entertainment to interactive experiences. The case studies all include elements of narrative, speculation and aim to craft a specific experience for the viewer. The following principles have been derived from the case study review and are design-driven principles rather than concept-driven principles as seen previously in the literature review (Chapter 2.7):

- The design can be abstract in visualisation this will allow users to create their own interpretations of the work.
- The design must be visually captivating but must also be interactive so that the user constantly gains a unique experience.
- The design should not only rely on visual stimulation but also activate senses such as touch and sound.
- Time should be utilised as a fourth dimension to enable reflective interaction.
- The installation should have an element of depth to create an extension of the three-dimensional environment. This will avoid the creation of a two-dimension image projected onto a two-dimensional surface.
- The user must feel present in the physical whilst engaging with the virtual material.
- The installation of the experience is as important at the digital media - scale, location and construction should be considered.
- The design does not have to be conventionally practical but can enable a sense of play, joy or happiness.

METHODOLOGY

4.0

4.1

DESIGN PRINCIPLES

The major aim of this thesis is to explore the production of interactive augmented space. As well as the previously outlined design principles that were explored in the Theoretical Review and the Case Studies Review, principles of emotional design will also be briefly examined.

Emotional Design is a topic explored by Donald A. Norman in his book Emotional Design: Why we love (or hate) everyday things. In his book, he discusses how understanding human emotions when designing can result in better user experiences. He outlines three levels of brain processing; the visceral, the behavioural and the reflective, each targeted by different techniques and styles of design.

Visceral design is centered around aesthetics and grabbing the user's attention. The visceral processing level is an instinctive response, it is *"about the initial impact of a product, about its appearance, touch and feel"* (Norman, 2004).

The behavioural level of the brain regards how a product is used or experienced. In the scope of this research, the behavioural design is the experience of the interaction taking place. The design must function in a satisfying way to create a positive emotional experience.

The reflective level uses consciousness and thought to create the most effective emotional response. Norman describes the effects of the reflective level on design: *"It is only at the reflective level that consciousness and the highest levels of feeling, emotions and cognition reside. It is only here that the full impact of both thought and emotions are experienced"* (Norman, 2004). This thought process can be targeted to leave an impression on the viewer and enable the viewer to engage with the theoretical concepts of the design.

The three levels of emotional brain processing can be aligned to an augmented space design as follows:

Visceral design - Aesthetics, appearance and initial reaction
Behavioural design - The enjoyment and effectiveness of the interaction.
Reflective design - The emotional value and speculative discussion the design enables.

The following design criteria has been developed to assess the proceeding design research. The design criteria is separated into three parts to respond to the three levels of emotional design.

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	
1.2	The design should intensify and alter architectural effect.	
1.3	The design should be visually stimulating and engaging.	
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	
2.2	The system should be easily understood without explanation.	
2.3	The design should use and manipulate real world input.	
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	
3.2	The design should be presented in a thought provoking nature.	
3.3	The design should enable performative architecture.	

Figure 16: Design Evaluation Criteria based on Donald A. Normans Emotional Design

4.2 INSTRUMENTS OF DESIGN

The design that is being undertaken falls outside of the realms of conventional architectural design. Alternative tools and methods must be explored in order to execute the objectives of this research. The tools used explore the industries of game design, animation and interaction design. The use of these tools will aid to develop a meaningful augmented experience.

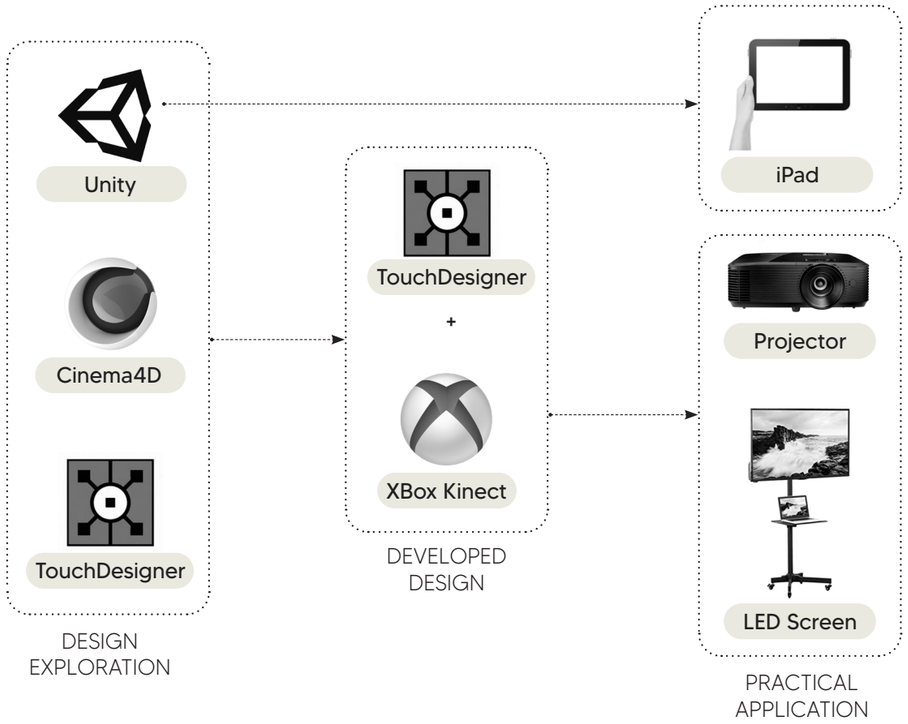


Figure 17: Workflow of Instruments of Design

Animation Software

Animation software is explored to aid the creation of visualizations which target the brain's visceral response. Cinema4D is the primary animation software used in design research. This program creates aesthetically pleasing animations that explore scale, weight and materiality.

Game Engine Software

Unity3D, a real time game engine software will be used to explore the spatial dynamics of the animations created. The Unity Augmented Reality toolkit is also used to explore the opportunities of augmented application design.

Visual Programming Software

Touch Designer is a visual programming tool which uses creative programming to manipulate real-time data into visual graphics. The software is used by a variety of creators to produce animations, interactive installations and multimedia content.

Input Sensor Devices

Microsoft's Xbox Kinect device is used to collect motion sensor data which is able to be manipulated in the visual programming software. The Kinect device is available in two versions, both of which have different capabilities. Version one and two have both been used in the design research.

Other input devices, such as microphones will be used to collect and manipulate audio data.

Display Tools

Different display methods are important to explore as it will alter the overall experience of the design. Display tools that will be tested include an iPad, LED screens and data projectors.

4.3

METHODOLOGY

This thesis applies the method of researching through design, as defined by Peter Downton in his book Design Research. Downton makes the argument that *"design is a way of inquiring, a way of producing knowing and knowledge; this means it is a way of researching"* (Downton, 2003). The method of researching through design results in the production of knowledge within a certain area. This knowledge is the outcome of testing, application and critical reflection.

The design research will begin with an explorative preliminary design phase. This will involve researching and experimenting with different tools and programmes to assist in the creation of augmented space. The purpose is to reflect on the strengths and weaknesses of different programmes, tools and systems in order to create a developed design.

The developed design phase will apply an iterative process, making design changes to develop a system that is engaging and meaningful. The design choices will be driven by the contextual theoretical and precedent research. Each design iteration will be evaluated against the Design Evaluation Criteria (4.2). Downton outlines the importance of critical reflection; *"reflective, critical approaches are woven through quality designing and constantly inform design decisions"* (Downton, 2003).

The main method of design in this thesis will be the process of Creative Coding. Creative coding is a type of computing programming that uses scripts to generate visual material. Rather than using conventional architectural language, creative coding uses computational language as a design medium. Creative coding is becoming increasingly used within the art and architecture community. *"Contemporary artists are using computers not only as an assistive apparatus, but as a collaborative platform to infiltrate far beyond their imagination and expressions"* (Artut, 2017). It is a design medium where the computer becomes a partner in the production of design and the act of crafting a code is a form of design in itself.

DESIGN EXPLORATION

5.0

OVERVIEW

The initial design phase is undertaken in an explorative nature. The purpose is to explore the parameters of the tools to aid in the creation of augmented space.

The initial design exploration is split into three parts; animate, integrate and react. Animate explores the creation of dynamic animations using Cinema 4D. Integrate explores how the virtual and physical realms can begin to intertwine. React introduces human interaction as a parameter of the design.

"We create spaces where the physical and non-physical merge; environments that invite people to play, reflect and connect"

(Space10, 2020)

5.1

ANIMATE

When we perceive something as "pretty," that judgment comes directly from the visceral level. In the world of design, "pretty" is generally frowned upon, denounced as petty, trite, or lacking depth and substance—but that is the designer's reflective level speaking (clearly trying to overcome an immediate visceral attraction). Because designers want their colleagues to recognize them as imaginative, creative, and deep, making something "pretty" or "cute" or "fun" is not well accepted. **But there is a place in our lives for such things, even if they are simple"**

(Norman, 2007).

This initial design study explores our immediate visceral response to design. Visceral design makes us feel a sense of enjoyment and satisfaction and has the ability to transgress time as the principles are *"wired in, consistent across people and cultures"* (Norman, 2004). Norman explains that aesthetics matter to people. Aesthetically pleasing designs generally have a greater effect; targeting the viewer's attention and emotions.

This following design exploration uses short animations to target the brain's visceral reactions. The tests begin to examine how virtual information can overlay the physical environment. What role virtual information can play in the physical environment and how it can add value.

Cinema4D is used as a design tool and enables the creation of high quality, dynamic animations. The software was chosen for concept exploration as it is an intuitive software which enables fast and high-quality outputs. The motion graphics tools in the software offer a range of features that enable weight, velocity and displacement to be explored.

The exploration links to the ideas presented in Space10's Everyday Experiments; that technology and digital media don't always have to make our lives faster or more efficient but can simply be a way of creating joy, excitement or engagement. As Norman states in the above quote, *"there is a place in our lives for such things, even if they are simple"* (Norman, 2004).

Exploration:

01

Video 1

This test uses motion graphic tools in Cinema 4D to explore movement and impact. Multiple objects are instanced and are displaced using the central ball object. The test creates a contrast between solid form and dislocated form. The animation is playful and the erratic movement of the ball is captivating to watch.

MOVEMENT + IMPACT

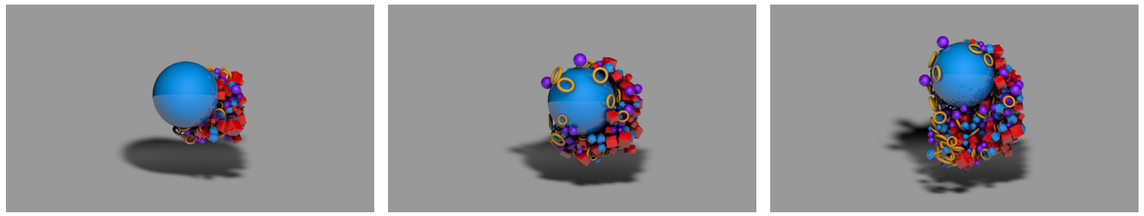


Figure 18: Movement and Impact Exploration

02

Video 2

This test uses a particle system which is shaped by a rotating turbulence. Five particle systems are generated from the same position, each represented by a different colour. As the particles move forwards, they are creating an impression that shows their movement. This test explores if the public's physical movement could create a virtual mark.

Exploration:

VIRTUAL IMPRESSION

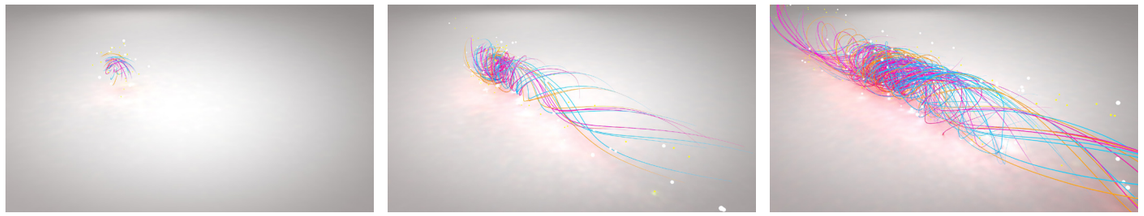


Figure 19: Virtual Impression Exploration

Figure 20: Concept of Animation in Site

03

Video 3

Exploration:

ORDER TO DISORDER

This exploration, similar to Exploration 01, explores the contrast of order and disorder. Four coloured spheres are multiplied to form a cube shape. The cube, which rotates on an axis, is displaced by a turbulence effector. Transforming the ordered cube form into chaos. The spheres bounce around and then contract back to the original form. The movement of the objects is abrupt and entertaining to watch. The animation explores the idea that the nature of movement could be influenced by a real-world input, e.g. could the movement of the spares align with the speed or direction of the user.

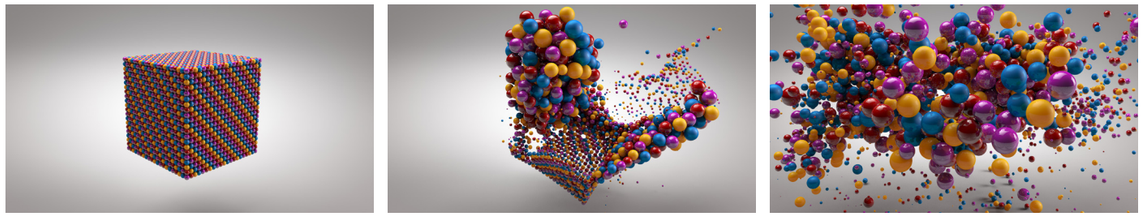


Figure 21: Order to Disorder Exploration

04

Video 4

This test explores impact and fragmentation. The animation exhibits how an object can be fragmented by the impact of another. This exploration uses a tool called the Voronoi Fracture, which can be used to break shatter and crumble objects. This test explores the idea of using virtual tools to explore how real-world forms can be built and dismantled.

Exploration:

FRAGMENTATION

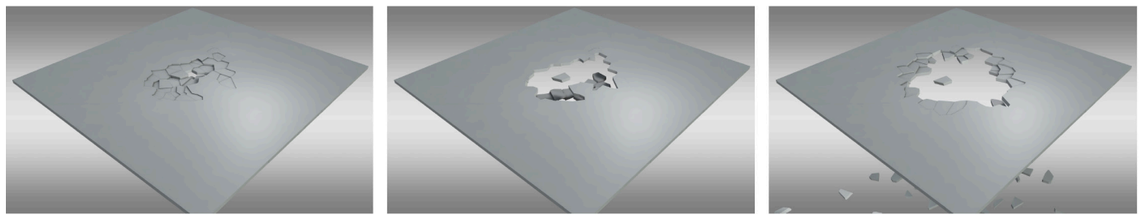


Figure 22: Fragmentation Exploration

Figure 24: Weight and Materiality Exploration

05

Video 5

This exploration looks at how the surface of objects can be gradually transformed over time. The beveled edge of the form gradually increases to enable the surface to change appearance. The test examines how the surface treatment of the built form could change with human influence or over time. The test questions if buildings could react to environmental changes for example; time of day or weather.

Exploration:

SURFACE TRANSFORMATION

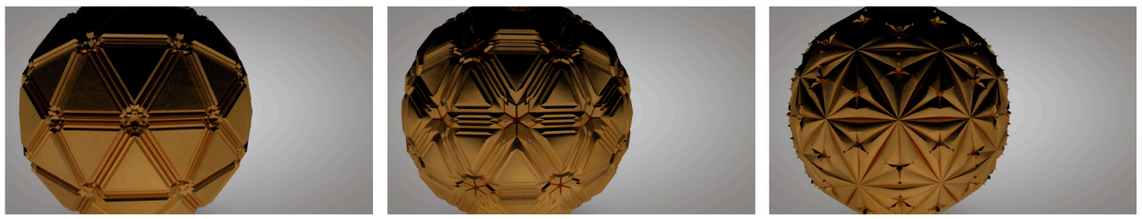


Figure 23: Surface Transformation

06

Video 6

This animation explores light and materiality. Rectangular cubes are stacked to make a building like structure. A linear displacement field is moved horizontally over the cubes. As the displacement field moves down the cubes change form; from cubes to spheres. The materiality changes from solid to transparent. The animation explores the contrast between solidity and immaterial qualities.

Exploration:

WEIGHT + MATERIALITY

Figure 25: Weight and Materiality Series

07

Video 7

Exploring the concepts of displacement and reaction, this test is composed of a wall of rectangular cubes. An invisible sphere is moving around and through the wall. As the sphere moves the cubes are being displaced and rotated. The use of colour and materiality of the animation highlights the displaced orientation of the objects. This test explores if physical touch could displace virtual information - could the displaced area represent human presence?

Exploration:

DISPLACEMENT + REACTION

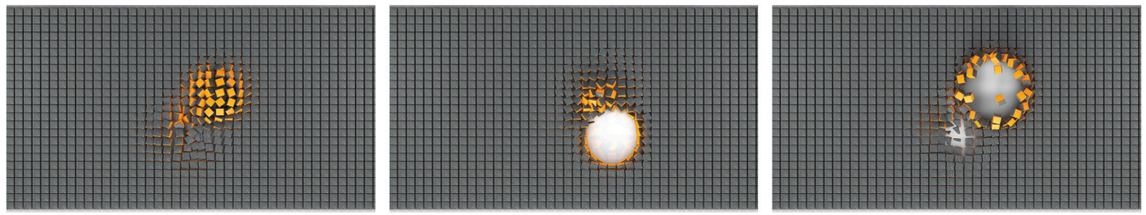


Figure 26: Displacement and Reaction Series

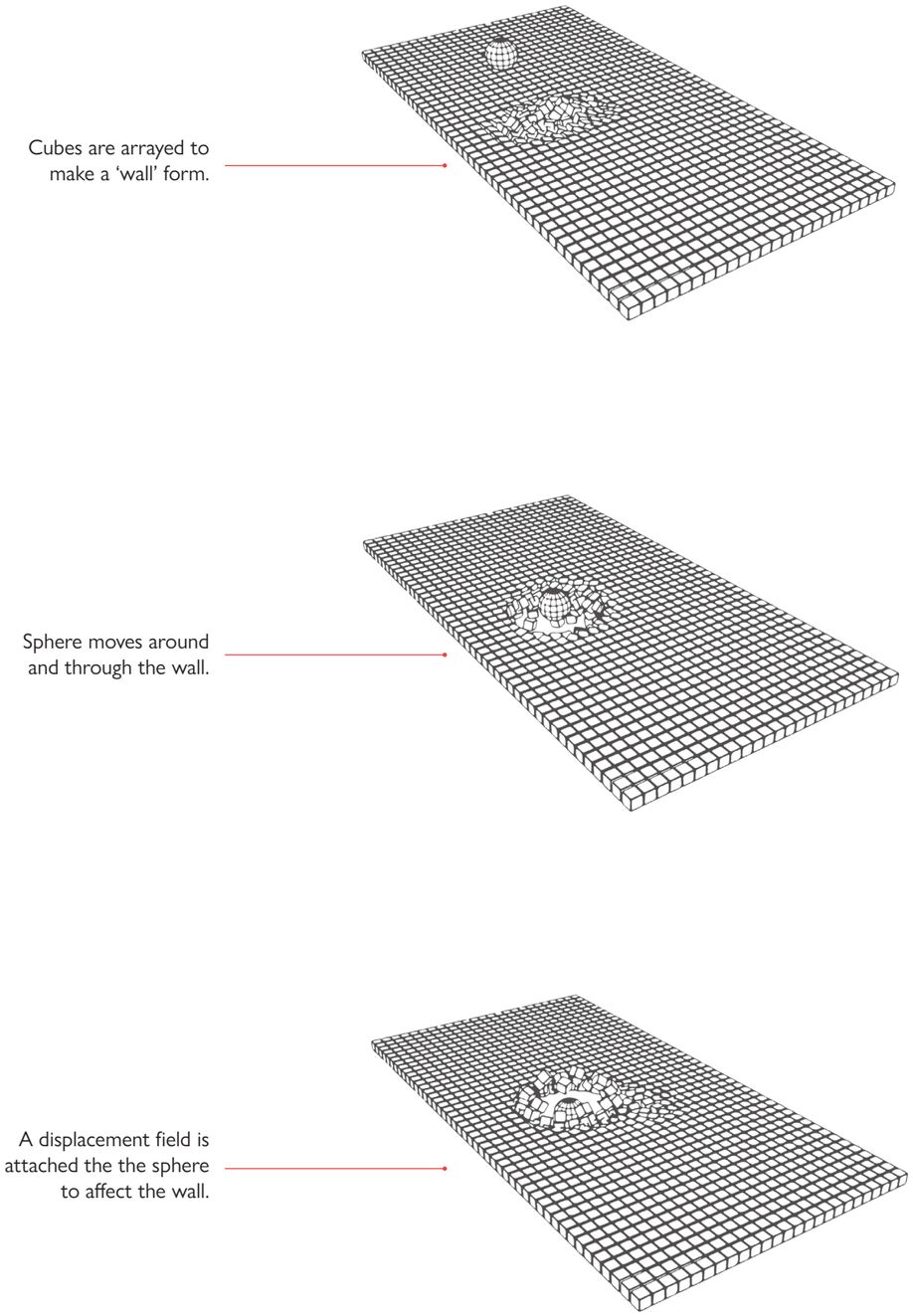


Figure 27: Displacement Diagram

08

Video 8

Exploration:

MOVEMENT + IMPRESSION

The exploration is one of the most successful in the series due to its materiality and nature of movement. Tube forms are arrayed over an undulating surface, which has a noise displacer applied. As the surface moves, the tubes move and rotate. A shader is applied to the tubes which defines a colour gradient. The higher the tubes are displaced, the lighter colour they will appear. The test will be used as a concept in the Design Development (6.1). This test continues the ideas from Test 6 - exploring if a wall or surface can react to human presence and touch.

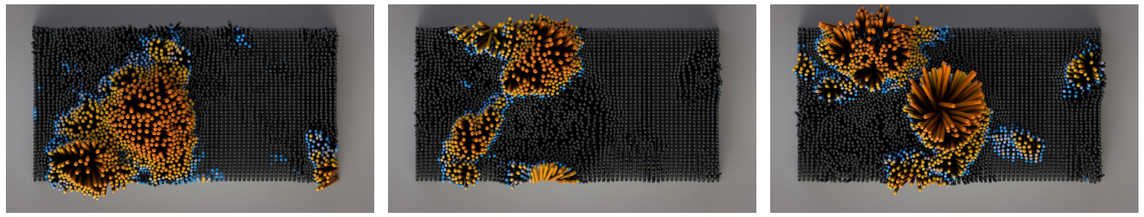


Figure 28: Movement and Impression Series

Figure 29: Concept of intervention in site.

09

Video 5

This test explores how sound can become an additional parameter to affecting virtual information. In this animation, a sound track is added to the simulation. The frequency of the sound affects the size and positions of the spheres. The test explores if real-world sound collection could create a visualization of the physical atmosphere.

Exploration:

SOUND + REACTION

Figure 30: Sound and Reaction Series

10

Video 10

The exploration uses materiality to explore the concept of reflection. The animation is simple and is composed of a deformed sphere with a reflective material applied. The sphere rotates around, warping the real-world reflection. The exploration questions how abstraction of the real-world makes the viewer question reality.

Exploration:

REFLECTION

Figure 31: Reflection Series

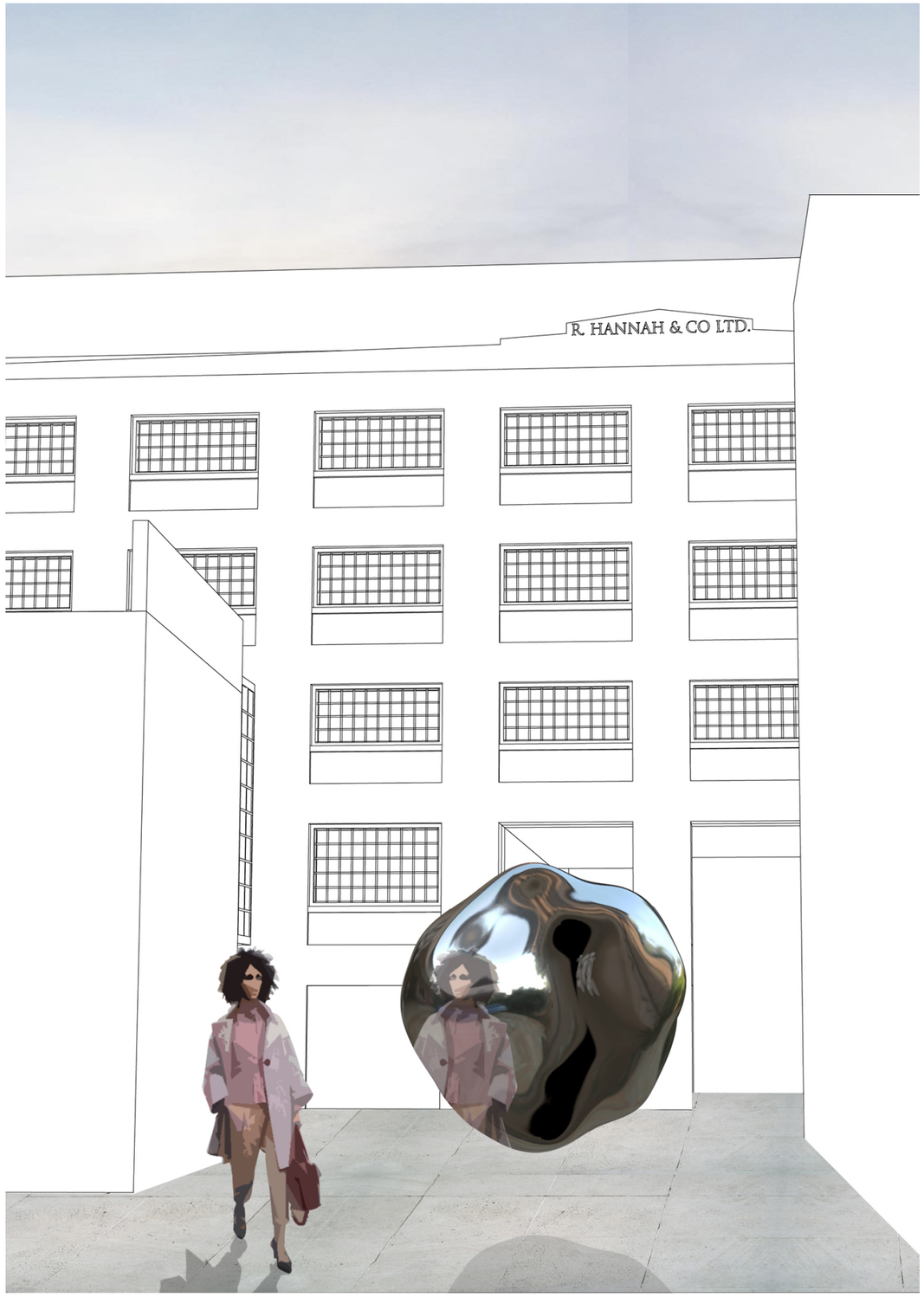


Figure 32: Reflection Intervention in site.

REFLECTION

These explorations successfully explore the poetic aspect of virtual information. While the animations are visually pleasing they do not directly represent anything within the physical world or interact with physical space. The testing raises the question if the animations could either represent intangible aspects of physical space or animate the built form itself. The tests show that animation and movement can serve as what James Auger defines as a 'perceptual bridge'. If these animations visualise data of the physical world they can create a bridge, existing *"between the audience's perception of their world and the fictional element of the concept"* (Auger, 2013).

EVALUATION

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	X
1.2	The design should intensify and alter architectural effect.	
1.3	The design should be visually stimulating and engaging.	X
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	
2.2	The system should be easily understood without explanation.	X
2.3	The design should use and manipulate real world input.	
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	
3.2	The design should be presented in a thought provoking nature.	
3.3	The design should enable performative architecture.	

VIRTUAL INFORMATION

PHYSICAL SPACE

=

AUGMENTED SPACE

5.2

INTEGRATE

This exploration introduces Norman's concept of Behavioural Design, which is based around four principles; *"function, understandability, usability and physical feel"* (Norman, 2004). Behavioral design explores how something is used. This design exploration investigates the possibilities of how augmented space can be executed and experienced.

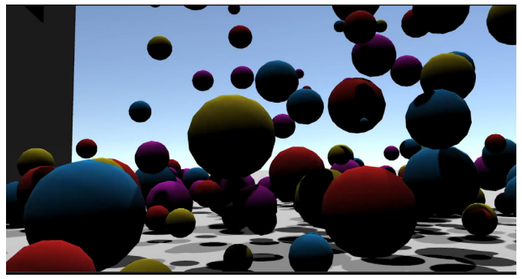
This design exploration aims to integrate the digital information into the physical environment, resulting in the creation of Augmented Space. The game engine Unity is used as a design tool. As a gaming software, the programme enables the simulation of real world environments.
This exploration introduces human interaction in the form of a player within the game environment. Enabling the animations to be walked through and around. This section also introduces Unity AR Foundation which is an Augmented Reality toolkit. The use of the tool kit explores the medium in which the virtual information will be communicated through.

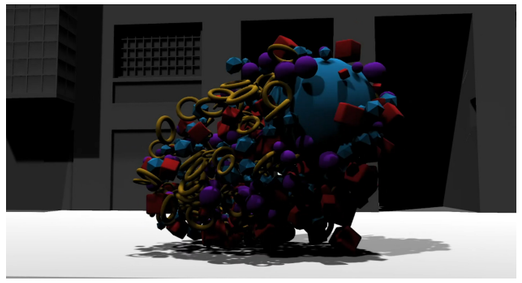
ANIMATION + UNITY

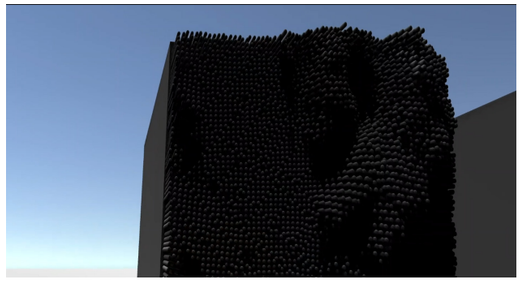
This test explores how the animations feel at human scale and in three dimensional form. Previously the Cinema 4D animations were viewed in static form on a two-dimensional screen. By placing the animations into the game engine, each animation is able to be walked through and around.

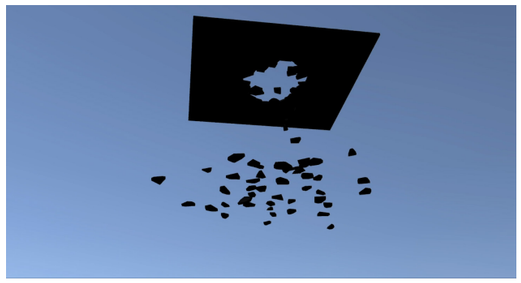
The game scene examines the virtual information in an urban context. Questioning if the public could interact with virtual layers of information as they walk through the city. The game scene is composed of a 3D model which represents Leed Street, in Wellington. The 3D geometry has collision dynamics applied so that the animations can react to the physical elements. A First Person Controller (FPC) has been added to enable a player to walk around the environment. The animations have been placed within the scene, exploring how virtual information interacts with the built environment.

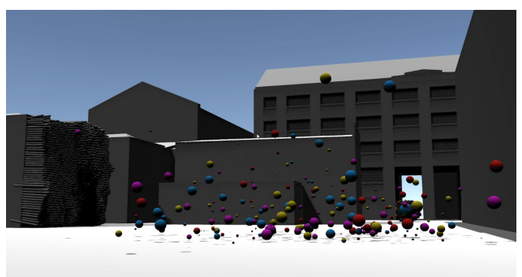
Figure 33: Cinema4D Animations in Unity Game Engine.











Video 11

UNITY AR FOUNDATION

Unity AR Foundation is a developer toolkit provided by Unity to aid in the development of Augmented Reality Applications. The toolkit enables developers to build applications and deploy to a variety of devices. The package is available for Android, iOS, Magic Leap and HoloLens. This design exploration tests the programme using an iOS build and trailing the application on an Apple iPad.

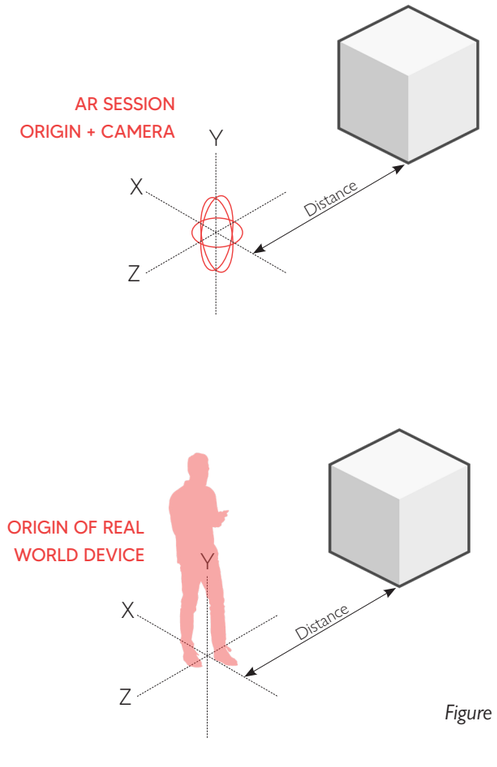


Figure 34: AR Session Illustration

AR SESSION: Controls the lifecycle of an AR experience.

AR SESSION ORIGIN: Translates real world movement to Unity world space coordinates. AR devices track devices in 'session space', the origin translates the devices movement into the game engine.

AR CAMERA:

Offers controllable features for the device's camera, available features include light estimation and facing direction. Light estimation alters the lighting of the virtual environment to adjust to the real world light conditions. Facing Direction enables 'world' or 'user' options. World being the back camera of the device and user being the front camera.

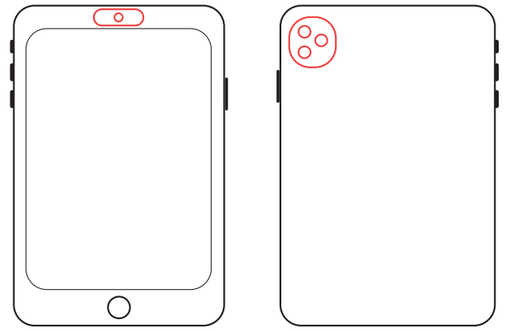
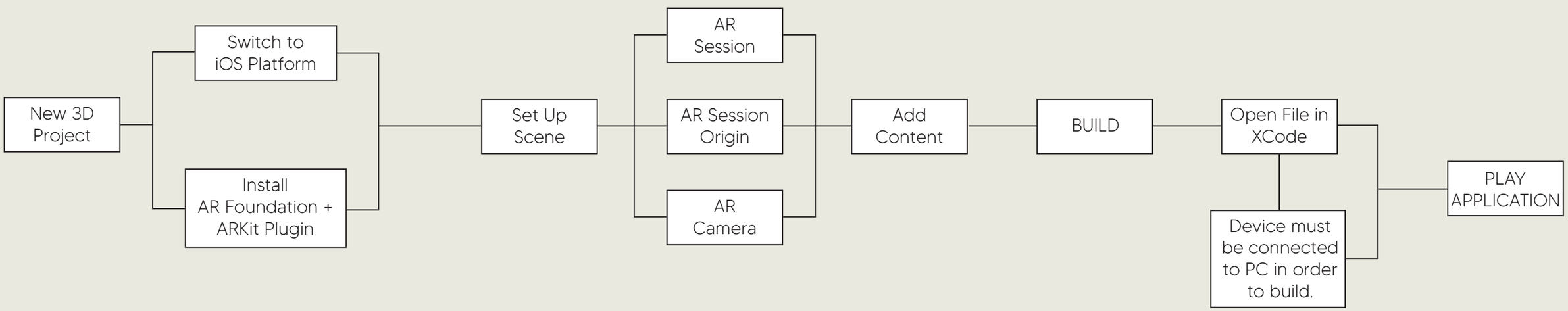


Figure 35: iPad Camera Orientation

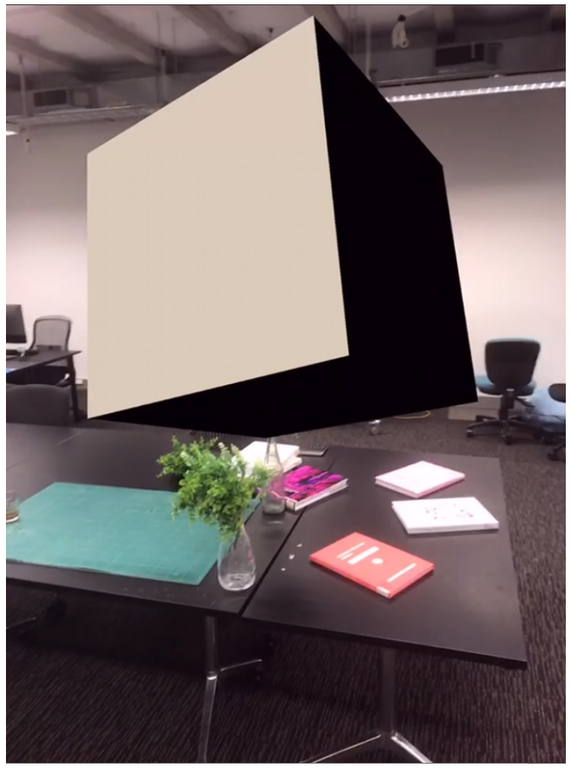
Figure 36: AR Pipeline

AR PIPELINE



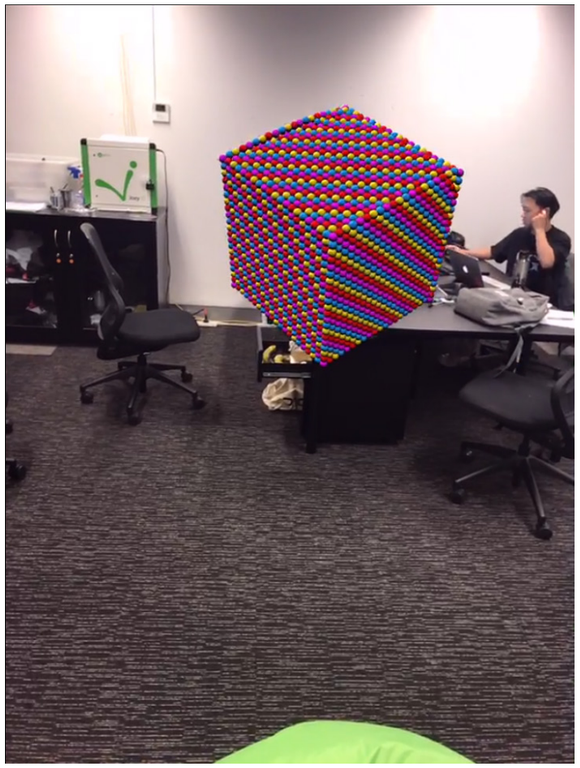
UNITY AR FOUNDATION TESTS

These explorations use the Unity AR Foundation to integrate the virtual information into the physical environment. Using the AR pipeline as previously outlined, the animations are added to the scene. The application is then deployed onto an iPad and the user can experience the virtual information in their current environment. The user understands a sense of scale and is able to walk through and around the digital media. The tests present the issue of depth of field and placement. When a virtual object is placed in space, real world objects are either behind or in front of it. As seen in Test 3, where the ground is crumbling, the user's feet are underneath the ground. Thus breaking the illusion of reality.



1.

Video 12

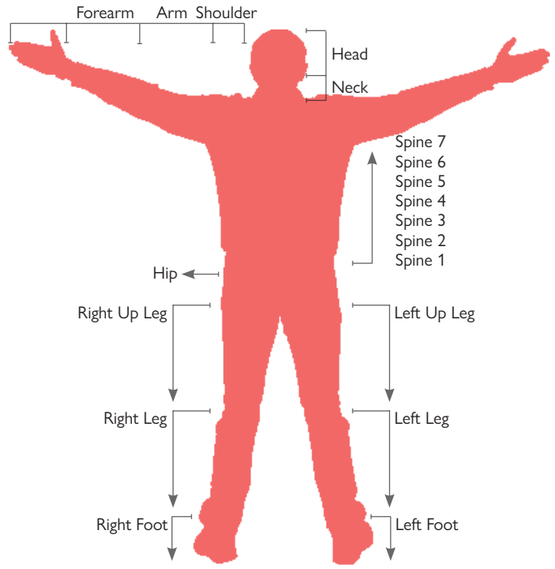


2.

Video 13

3.

Video 14

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    Root = 0, // parent: <none> [-1]
    Hips = 1, // parent: Root [0]
    LeftUpLeg = 2, // parent: Hips [1]
    LeftLeg = 3, // parent: LeftUpLeg [2]
    LeftFoot = 4, // parent: LeftLeg [3]
    LeftToes = 5, // parent: LeftFoot [4]
    LeftToesEnd = 6, // parent: LeftToes [5]
    RightUpLeg = 7, // parent: Hips [1]
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    RightFoot = 9, // parent: RightLeg [8]
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}
```

Figure 37: Code that enables body tracking. Each joint is defined with a related position.

UNITY AR FOUNDATION BODY TRACKING

The body tracking feature is part of the AR Foundation toolkit. The feature uses the device's camera to recognise physical human body joints, applying 2D and 3D visuals to the body in virtual space. The system uses a code that defines each joint. Each definition has an associated world-space position and geometry assigned, enabling the virtual object to align to the physical body.

The first test uses the Unity prefab to assign a robot geometry to the physical body. The second test explores how custom visuals can be generated and applied. A simple line skeleton has been produced, but more complex skeletons could be created. The tests were undertaken to explore if physical human presence could effect, displace or alter the virtual animations.

TEST 1

TEST 2

Video 15

REFLECTION

These explorations were successful in understanding the technical methods of creating augmented space. Useful techniques were discovered using Unity and the AR Foundation package. A main benefit from this process was understanding how Human Body tracking works, this information will be applied in later design explorations. The design explorations present the possibilities of creating an augmented application to be viewed through a mobile device, the weakness of this, is that the simulation can only be experienced by one viewer at a time.

EVALUATION

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	X
1.2	The design should intensify and alter architectural effect.	
1.3	The design should be visually stimulating and engaging.	X
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	X
2.2	The system should be easily understood without explanation.	X
2.3	The design should use and manipulate real world input.	
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	
3.2	The design should be presented in a thought provoking nature.	
3.3	The design should enable performative architecture.	

“Designing Human-Building Interaction, in that perspective, consists of providing interactive opportunities for the people to shape the physical, spatial, and social impacts of their built environment.”

(Hillier, 1996)

5.3

REACT

The previous design explorations; animate and integrate, provided useful insights into the creation of augmented space, exploring visceral and behavioural design processes. Objective 2.1, outlined in the design Framework (4.1), requires that the design should have a high level of interactivity in order to create an effective behavioural design. Unexpected reaction of the system is important within the research as it aims to enhance user engagement with the built environment.

Interactivity requires human body tracking in order to manipulate digital information. The system must understand where the user is located, to be able to translate their actions into virtual space. While body tracking was briefly explored in part 5.2, using Unity AR Foundation Body Tracking, an alternative method has been explored in the following exploration.

TouchDesigner is utilized as a design tool in this section. The design tests explore interactivity in its basic form; tracking the human body and actions to express the real-world environment through virtual abstraction. This process is enabled through a Microsoft Kinect device. The motion sensor device tracks a user’s body and the environments around them, translating the information into data which can be manipulated within the programming software.

This section focuses less on aesthetics and more on behavioural design techniques, exploring how a system is used and the effectiveness of different mechanisms. This section explores the principles of usability, Jakon Nielsens ‘10 Usability Heuristics’, as defined in Section 2.4.2. The usability principles are applied within this design exploration as follows:

- The system should react in a way so users are made aware of the interaction between themselves and the simulation.
- The system should be relatable and human orientated in order to evoke an emotional response.
- The user should understand that they are affecting the system. Mechanisms to start over should be included.
- The system should be easily read and understood.
- The system should be intuitive and should be able to be utilised without instruction.
- Anyone should be able to use the system.
- The design should not be overly complex so that the users struggle to understand the concept or ideas.

TOUCH DESIGNER + KINECT BASIC PRINCIPLES

TOUCH DESIGNER

Touch Designer is a visual programming software which uses creative coding to manipulate data into graphic visualisations. Touch Designer is a node based programme. A network of components is created; *"where each component computes an output based on data it receives as an input. Different than text based programming, the flow of execution is explicitly visualised which provides a clear feedback of the algorithm"* (Cannaerts, 2016). Operators are used to form a node network, these operators are split into six different categories; Components, Texture, Channel, Surface, Material and Data.

It is important to note that each operator, or node, has an input and an output. The function of the node is to change the data between the input and the output.

The basic components that make up a Touch Designer and Kinect node network are shown below. The Kinect sensor data is input into the program. This can provide motion data in colour, depth or player index settings. The Kinect image then needs to be processed in order to extract the desired data, this can include turning the Kinect data image into a vector image or numerical parameters. These parameters can then be input into the geometry or visualisation parameters to affect the output image.

BASIC CONCEPT OF A TD + KINECT PIPELINE

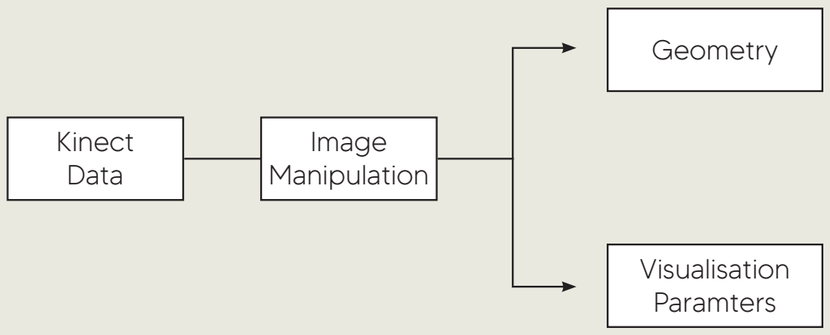


Figure 38: TouchDesigner and Kinect Pipeline

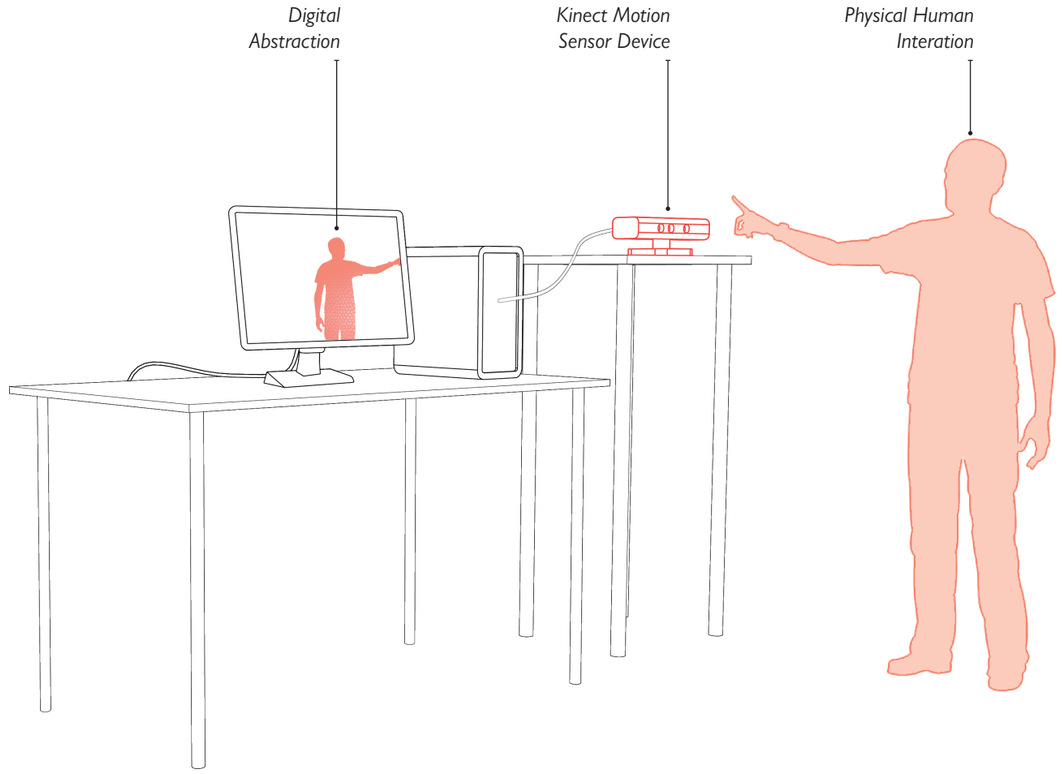


Figure 39: Illustration presenting the relationship between user, kinect and system.

The following design explorations present diagrams that communicate the basic network of each system. These diagrams do not show the full node network that creates the code but shows the principles of how the code is constructed which results in a visual image.

TOUCH DESIGNER OPERATORS

COMP's
Components

Components are functional operators and feature nodes such as cameras, lighs and buttons.

TOP's
Texture Operators

TOP's enable the manipualtion of image based data and can alter alter image properties e.g. change the black level of a video image.

SOP's
Surface Operators

SOP's are nodes which generate three-dimensional form , such as cubes, spheres, tubes etc.

CHOP's
Channel Operators

CHOP's enable the processing of motion or audio data. The data is conveyed in curves or channel form.

Figure 40: TouchDesigner Operator Explanation

FLOW EMITTER

This exploration uses a Flow Emitter node as a central competent for producing the visual imagery. A flow emitter is a *"volumetric fluid-based simulation of a burning gas system"* (Derivative, Nvidia Flow TOP, 2020). As illustrated in the diagram below, the kinect image is input into the system and is processed to become the silhouette of the user. This silhouette is used as the shape input from which the gas system generates its particles. A colour gradient is applied and a gravity input affects the displacement of the particles around the user.

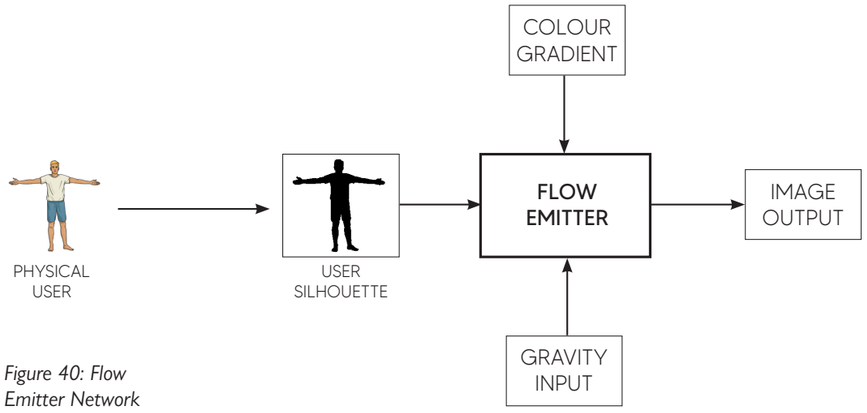


Figure 40: Flow Emitter Network

This initial test was undertaken to explore the method of inputting sensor imagery and manipulating it into a visual image. The image created is successful in its aesthetic outcomes and effectively shows the physical presence in virtual space.

Video 16

Figure 41: Flow Emitter Test

TUBE INSTANCING

This test explores the recreation of Animate (5.1) Test 08 in TouchDesigner. Instancing is a term that defines the replication of objects in a certain direction, similar to the array command in Rhino. Instancing is a tool in Touch Designer which enables a singular geometry to be replicated in two directions; X and Y, and translated or displaced along the Z-axis. This tool enables manipulation of translation, rotation, scale, pivot, texture and colour of the instanced geometry.

This test does not incorporate Kinect sensor data but rather explores how geometry can be manipulated by data channels. Shown below, data channels are generated by a grid, a noise displacer and a colour gradient. This produces the tx, ty and tz coordinates that the tube is instanced by. The rotation channel affects the rotation of the tube and the RGB channels affect the colour of the tubes. This method was an effective test of displacing geometry and will be applied later in Chapter 6 (6.1).

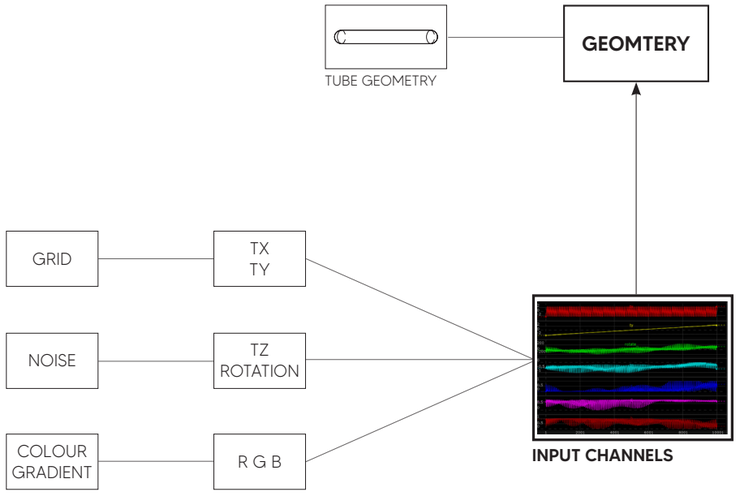


Figure 42: Tube Instancing Network

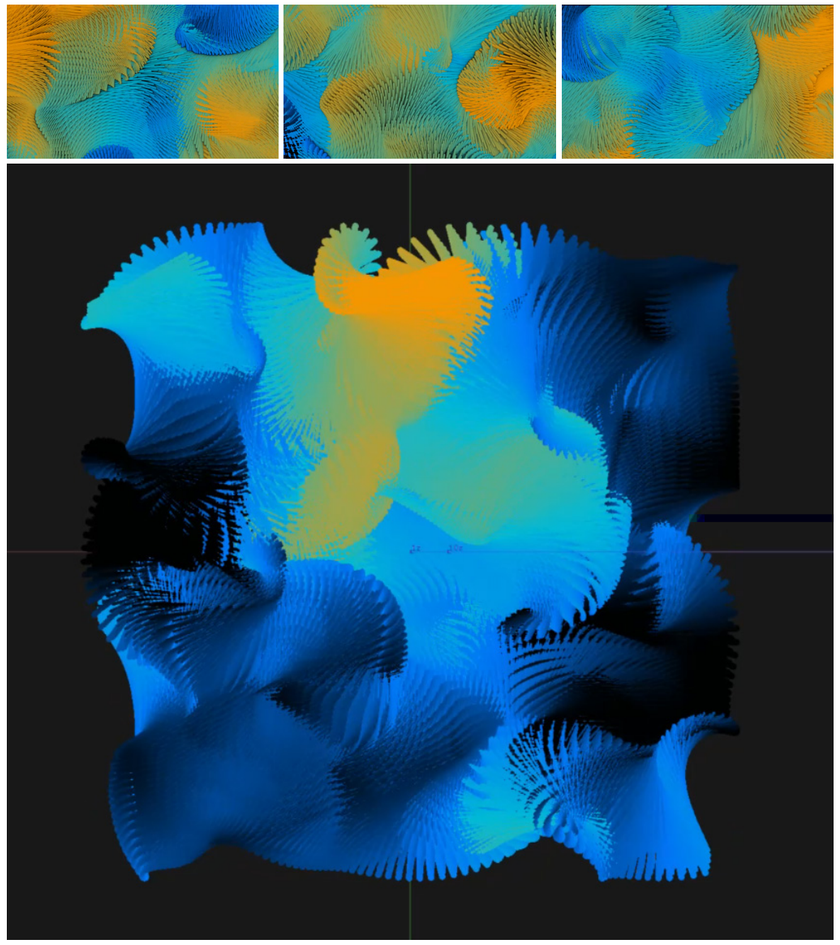


Figure 43: Tube Instancing Test

Video 17

BODY DISPLACER

This test is composed of a similar network to the previous Tube Instancing Test. In this exploration, Kinect data has been input to generate the RGB channels, thus reflecting the interaction in the physical environment. The tx, ty and tz co-ordinates are still generated by a grid and noise displacement. The input channels affect the instanced cube geometry; as the user moves the display reflects their silhouette.

The colour input and feedback loop was the most useful successful element of this test. A feedback loop is a method in Touch Designer which creates a blur effect of the image, it effectively leaves a trace of the user's movement on the screen. In this exploration, the colour gradient and feedback are aligned. As the user moves their body leaves a trace on the screen which is represented through colour. The body's current position is represented in a blue tone and the previous positions are conveyed through purple tones.

Effectively the user's body is leaving a digital trace on the virtual environment. This exploration introduces the concepts of time that is explored in Dan Graham's project, Previous Continuous Pasts.

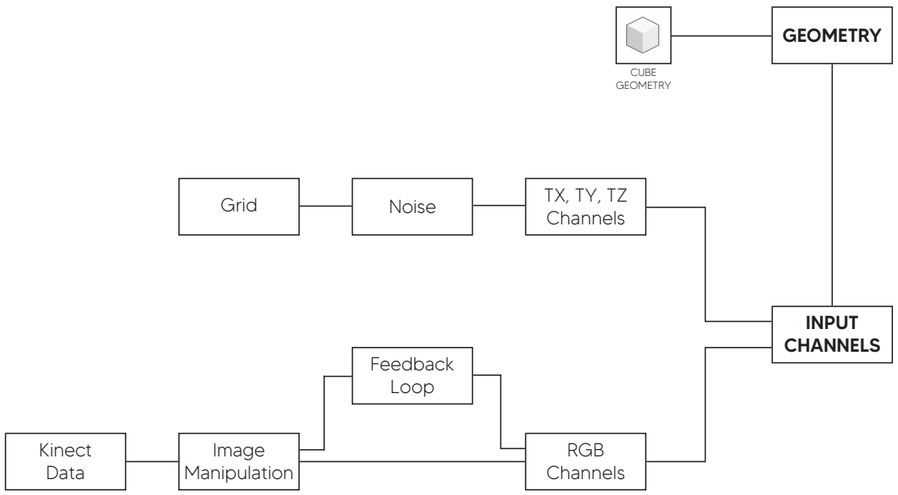


Figure 44: Body Displacer Network

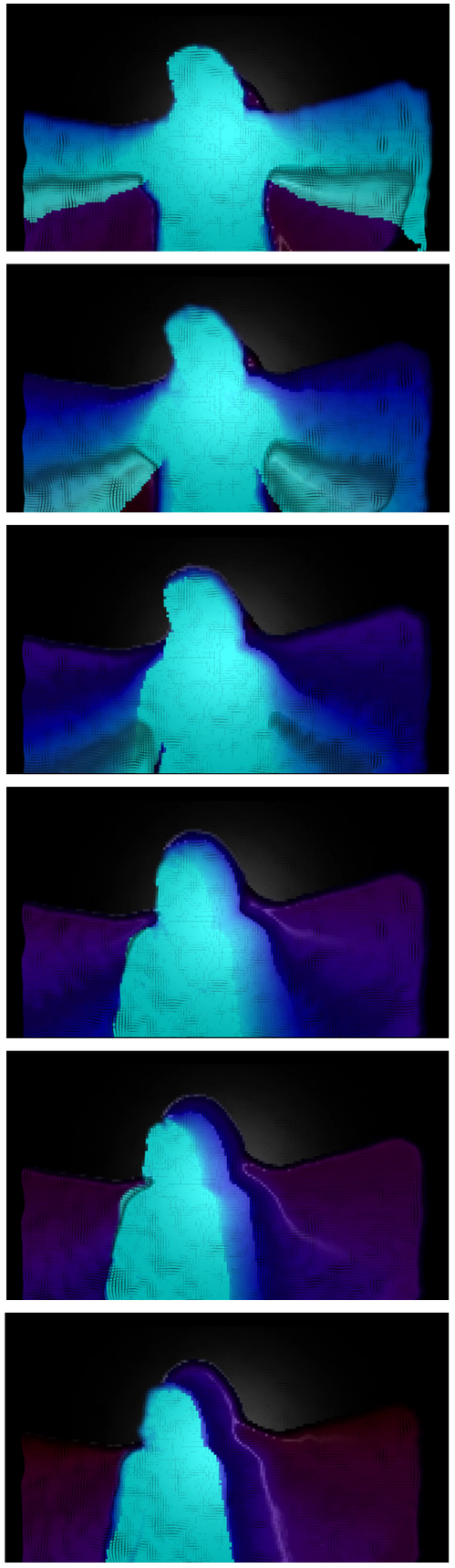


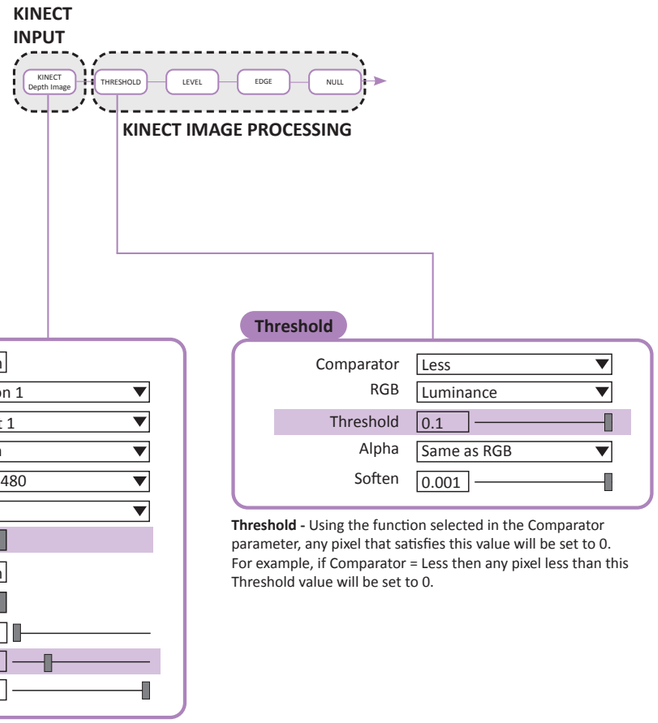
Figure 45: Body Displacer Test

Video 18

HAND DISPLACER

This exploration uses the same node network as the previous test; Body Displacer but changes the depth of the reaction area. Rather than the displayed image reflecting the user's whole body, the image only picks up the user's hand impression. The Reaction Area can be adjusted to any desired width by manipulating the 'Threshold' and 'Too Far' values.

This exploration was interesting as the experience created the illusion of emulating the sense of touch, aiming to meet Criteria 1.1 of engaging the sense of touch and sound. The user feels as if they are touching and physically altering the digital information with their hand, even though they are not physically touching anything.



Near Depth Mode - Enables near mode for the depth camera, which allows the depth camera to see objects as close as 40cm to the camera (instead of the default 80cm).

Too Far Value - For depth pixeld that are too far to resolve, this pixel will be output instead.

Threshold - Using the function selected in the Comparator parameter, any pixel that satisfies this value will be set to 0. For example, if Comparator = Less then any pixel less than this Threshold value will be set to 0.

Figure 46: Breakdown of effect of values on Reaction Area

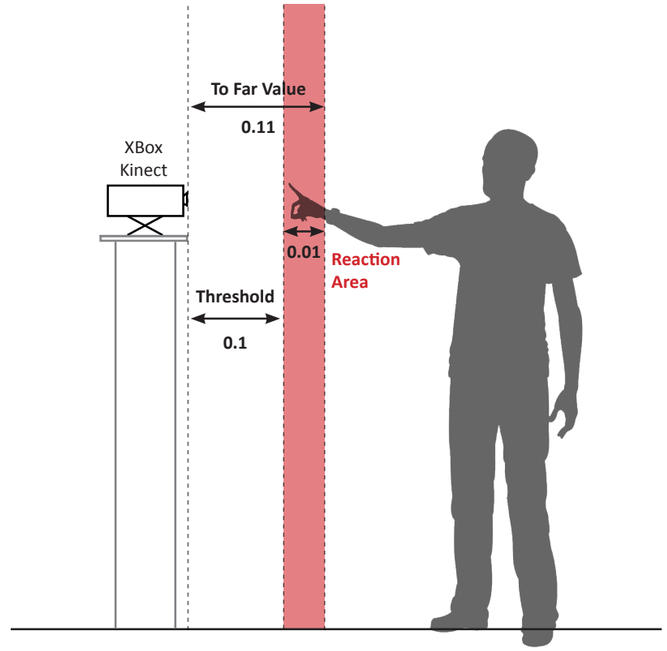


Figure 47: Diagram Illustrating values effect of physical space.

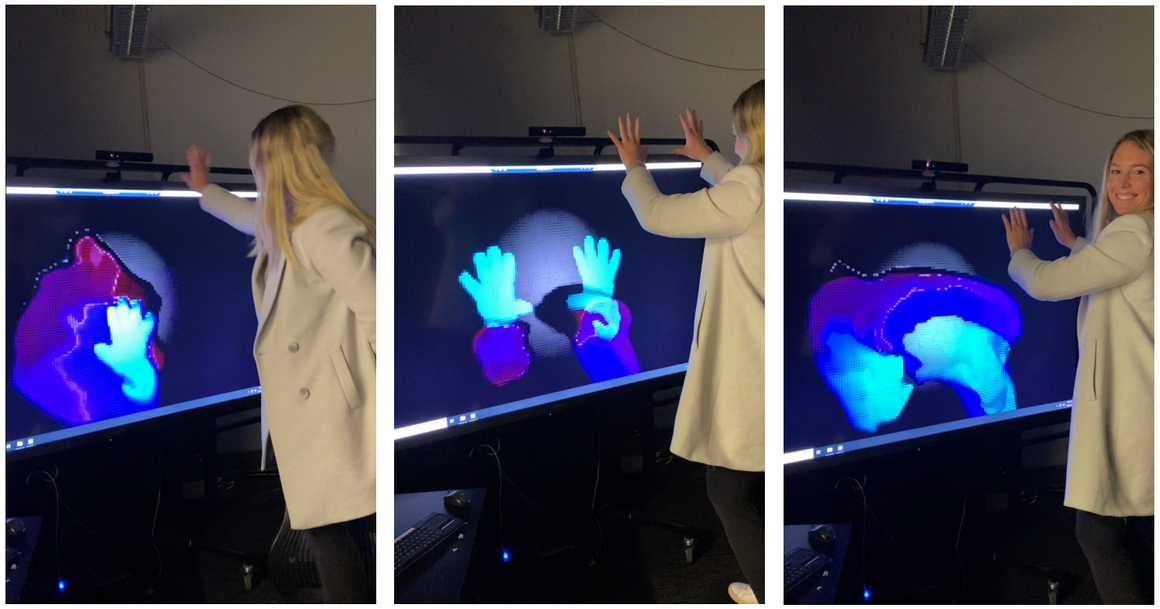


Figure 48: Hand Displacer in use.

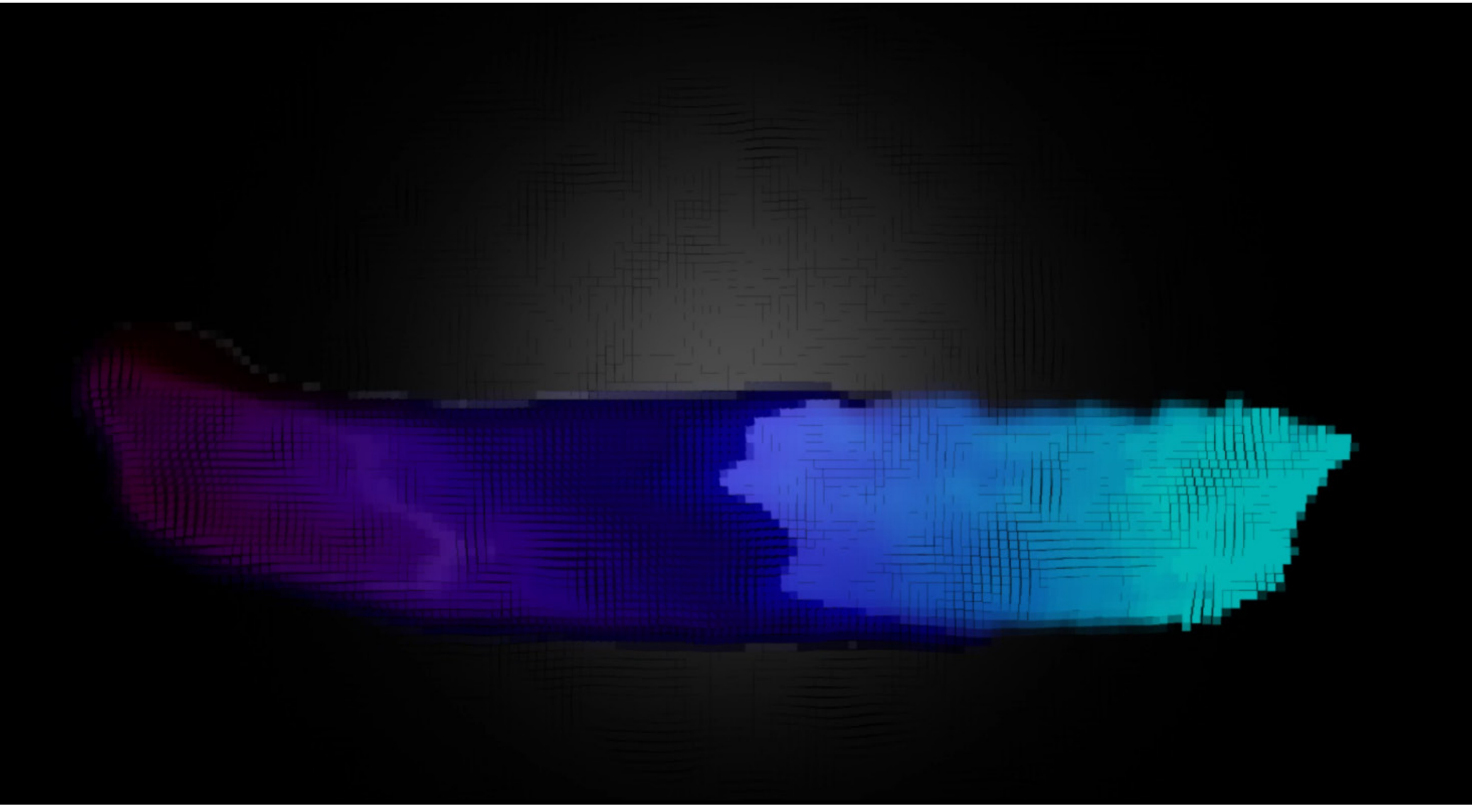


Figure 49: Hand Displacer

Video 19

BODY TRACKING

Body tracking was briefly explored in section 5.3.4, using Unity AR Foundation. This test examines using body tracking tools in TouchDesigner. Body tracking methods are enabled by Channel Operators or otherwise known as CHOP's. Texture operators (TOP's), which have been used in previous tests, manipulate image data. Whereas CHOP's are operators which manipulate data in the form of a curve or channel, as exhibited below.

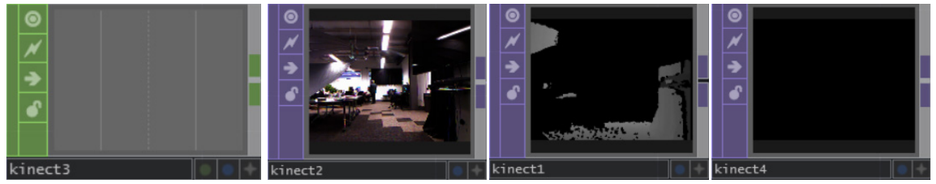
KINECT CHOP

A Kinect CHOP, similar to the Unity Body Tracking System (5.3.4), extracts a user's body joints and translates it to a numerical value within the program. As shown in Figure X, when there is no user on the screen, no data is shown. When a user is present, Kinect CHOP data is available. Kinect CHOP data provides a tx, ty and tz position for each body joint of each player. Kinect Version 1 can track up to two players, where Kinect Version 2 can track up to six players.

*	p1/upperarm_r:tx	p1/foot_r:tz	p2/upperarm_r:tx	p2/foot_r:tz
p1_id	p1/upperarm_r:ty	p2_id	p2/upperarm_r:ty	p3_id
p1:tx	p1/upperarm_r:tz	p2:tx	p2/upperarm_r:tz	p3:tx
p1:ty	p1/forearm_r:tx	p2:ty	p2/forearm_r:tx	p3:ty
p1:tz	p1/forearm_r:ty	p2:tz	p2/forearm_r:ty	p3:tz
p1/root:tx	p1/forearm_r:tz	p2/root:tx	p2/forearm_r:tz	p4_id
p1/root:ty	p1/hand_r:tx	p2/root:ty	p2/hand_r:tx	p4:tx
p1/root:tz	p1/hand_r:ty	p2/root:tz	p2/hand_r:ty	p4:ty
p1/spine1:tx	p1/hand_r:tz	p2/spine1:tx	p2/hand_r:tz	p4:tz
p1/spine1:ty	p1/pelvis_l:tx	p2/spine1:ty	p2/pelvis_l:tx	p5_id
p1/spine1:tz	p1/pelvis_l:ty	p2/spine1:tz	p2/pelvis_l:ty	p5:tx
p1/spine2:tx	p1/pelvis_l:tz	p2/spine2:tx	p2/pelvis_l:tz	p5:ty
p1/spine2:ty	p1/thigh_l:tx	p2/spine2:ty	p2/thigh_l:tx	p5:tz
p1/spine2:tz	p1/thigh_l:ty	p2/spine2:tz	p2/thigh_l:ty	p6_id
p1/neck:tx	p1/thigh_l:tz	p2/neck:tx	p2/thigh_l:tz	p6:tx
p1/neck:ty	p1/shin_l:tx	p2/neck:ty	p2/shin_l:tx	p6:ty
p1/neck:tz	p1/shin_l:ty	p2/neck:tz	p2/shin_l:ty	p6:tz
p1/clavicle_l:tx	p1/shin_l:tz	p2/clavicle_l:tx	p2/shin_l:tz	
p1/clavicle_l:ty	p1/foot_l:tx	p2/clavicle_l:ty	p2/foot_l:tx	
p1/clavicle_l:tz	p1/foot_l:ty	p2/clavicle_l:tz	p2/foot_l:ty	
p1/upperarm_l:tx	p1/foot_l:tz	p2/upperarm_l:tx	p2/foot_l:tz	
p1/upperarm_l:ty	p1/pelvis_r:tx	p2/upperarm_l:ty	p2/pelvis_r:tx	
p1/upperarm_l:tz	p1/pelvis_r:ty	p2/upperarm_l:tz	p2/pelvis_r:ty	
p1/forearm_l:tx	p1/pelvis_r:tz	p2/forearm_l:tx	p2/pelvis_r:tz	
p1/forearm_l:ty	p1/thigh_r:tx	p2/forearm_l:ty	p2/thigh_r:tx	
p1/forearm_l:tz	p1/thigh_r:ty	p2/forearm_l:tz	p2/thigh_r:ty	
p1/hand_l:tx	p1/thigh_r:tz	p2/hand_l:tx	p2/thigh_r:tz	
p1/hand_l:ty	p1/shin_r:tx	p2/hand_l:ty	p2/shin_r:tx	
p1/hand_l:tz	p1/shin_r:ty	p2/hand_l:tz	p2/shin_r:ty	
p1/clavicle_r:tx	p1/shin_r:tz	p2/clavicle_r:tx	p2/shin_r:tz	
p1/clavicle_r:ty	p1/foot_r:tx	p2/clavicle_r:ty	p2/foot_r:tx	
p1/clavicle_r:tz	p1/foot_r:ty	p2/clavicle_r:tz	p2/foot_r:ty	

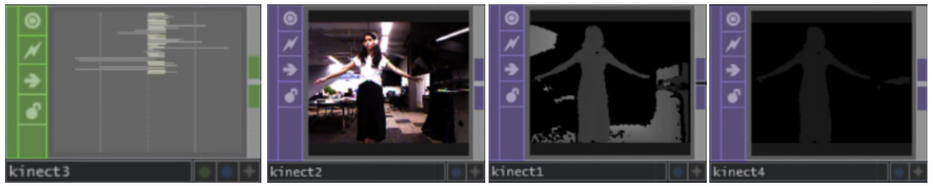
Figure 50: CHOP Player Data

KINECT NODES WITH NO USER



KINECT CHOP | KINECT TOP - COLOUR | KINECT TOP - DEPTH | KINECT TOP - PLAYER INDEX

KINECT NODES WITH USER



KINECT CHOP | KINECT TOP - COLOUR | KINECT TOP - DEPTH | KINECT TOP - PLAYER INDEX

TEST 1

The program allows you to take a CHOP value and input it as a reference in another node's parameters. This can be seen applied in test one. The player's right-hand x position has been input into the circles x position, and so on with the y positions of both hands. This means that as the player moves their right hand the red circle moves and as they move their left hand the white circle moves.

Video 20

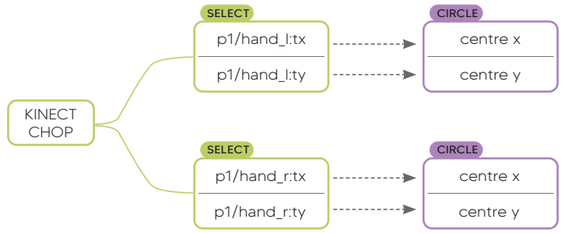
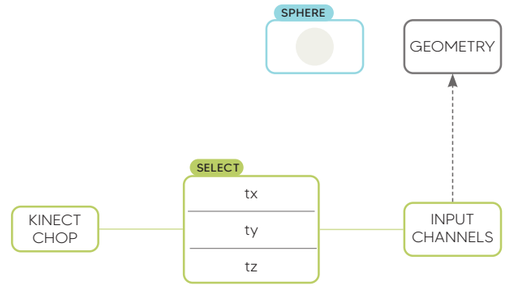


Figure 51: Kinect Hand Recognition

TEST 2

Test two uses a similar method to apply a sphere geometry to each joint of the player. The tx, ty and tz values are input into the geometry nodes Translate x, Translate Y and Translate Z parameters. This means that when the player moves the sphere will move with the assigned joint.

These tests are significant as it exhibits how to manipulate player-specific data to align with different visualisations.



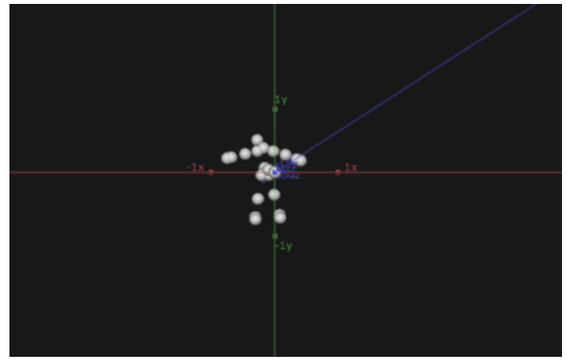


Figure 52: Kinect Body Joint Recognition

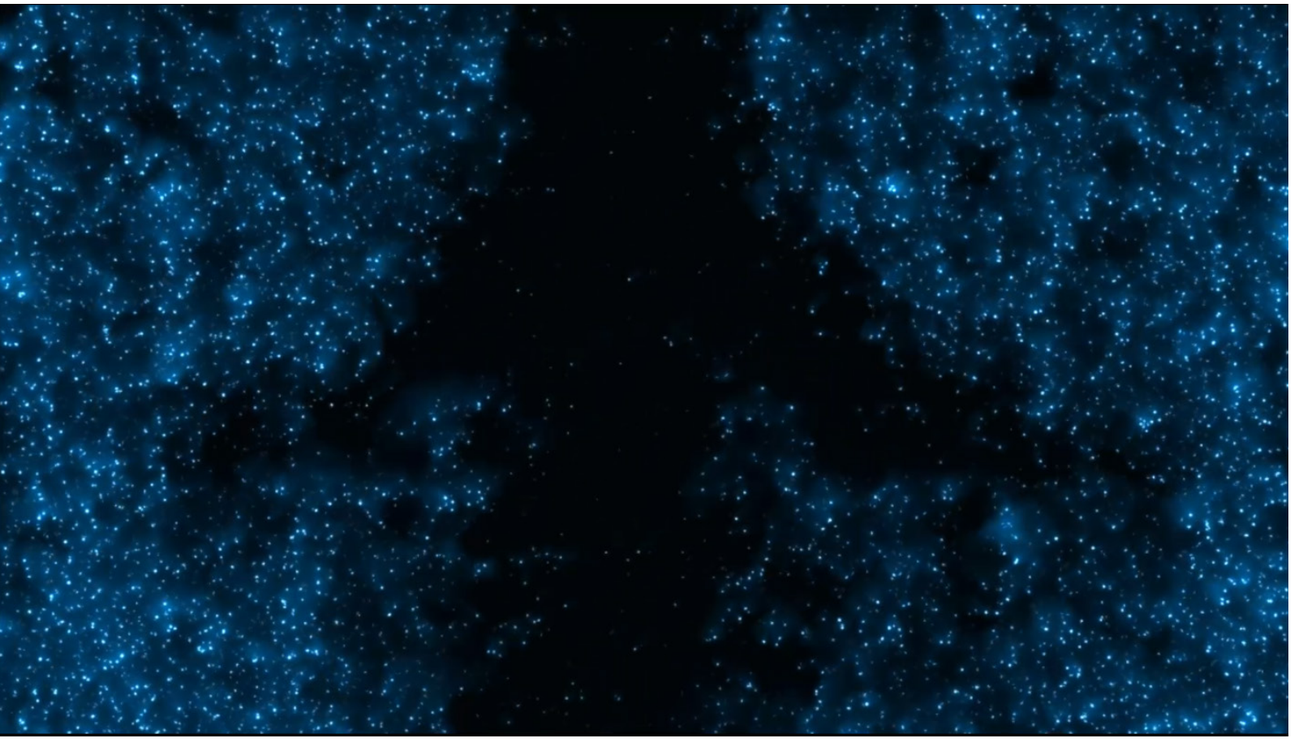


Figure 53: Particle Displacer System

PARTICLE SYSTEMS

Video 21

A Particle Node is used to create and control the parameters of a particle system simulation. Particle systems can be created in Touch Designer and can have effective aesthetic outcomes. Controllable parameters within the particle system include the number of particles, particle size, life period and mass. Forces such as wind and turbulence can be applied to displace and control the movement of the particles. The system input is composed of two parts; the geometry in which the particles are generated from and the geometry in which they are displaced by. The particles generator could be geometry such as a grid, a square or even a noise field. The displacer input is where Kinect data can be added so that the user can displace the movement of particles.

The system for Test 1 (above image) is illustrated in the below diagram. The diagram illustrates a simple particle system with a grid generator and a Kinet as a displacer. Feedback and colour is added to enhance aesthetic quality.

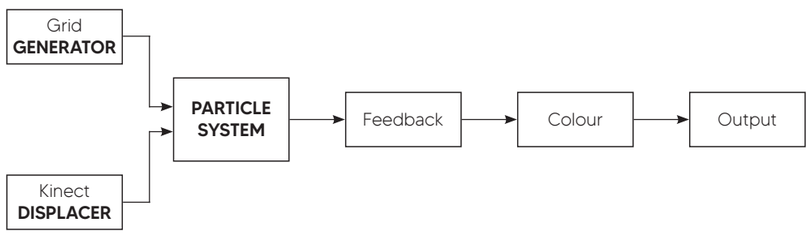


Figure 54: Basic Particle System Network

TEST 2: **PARTICLE ATTRACTORS**

This exploration uses a combination of particle system techniques and manipulation of Kinect CHOP data. The experiment creates a particle system and uses the player's hand movement to influence the movement of the particles. Using the Kinect CHOP data, the player's right-hand X and Y position is defined. These values are then inputted into the X and Y parameters of a sphere. This sphere acts as the particle attractor. As the user moves their hand around the particles are drawn to the location of the hand.

Figure 55: Node Network of a Particle Attractor System

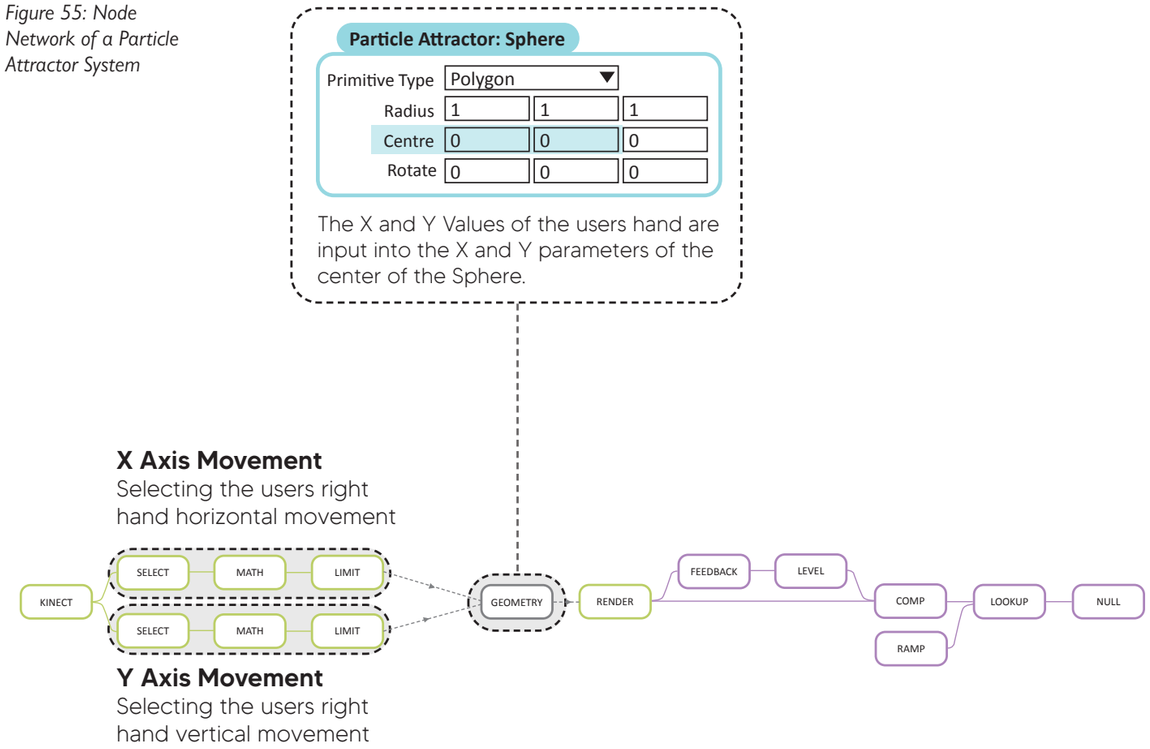
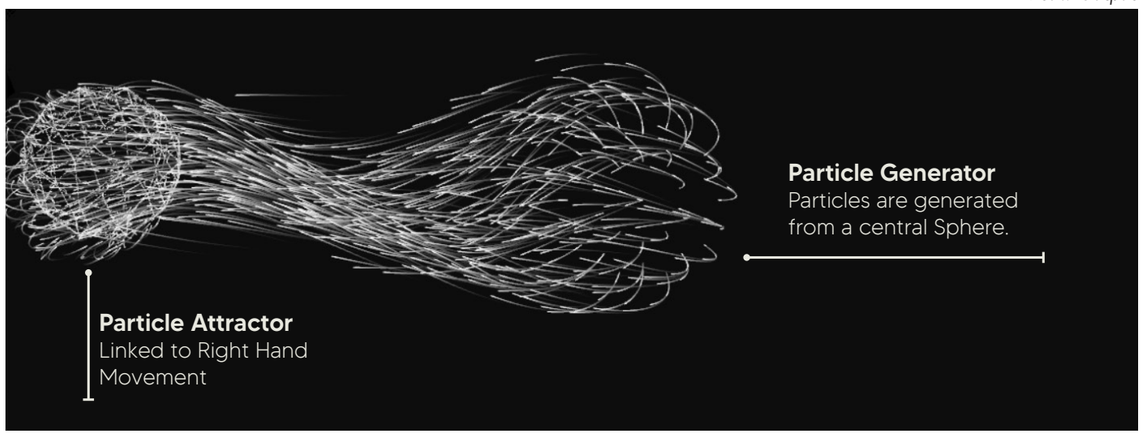


Figure 56: Particle Attractor Visual Output



TEST 3: **PARTICLE SOUND SYSTEM**

This exploration introduces the parameter of sound into the experience, aiming to fulfil Criteria 1.1 of engaging other senses such as touch and sound. In this experiment, a soundtrack is an input into the system, providing audio data channels to be manipulated. The high-frequency and low-frequency channels are extracted. These data channels are input into the particles systems parameters to manipulate its movement according to the sound, this can be exhibited in Video 22. The high-frequency sound channel influences the Drag parameter of the particle system and the low-frequency sound channel influences the turbulence speed of the particles.

The outcome of this experiment is highly successful in its aesthetic qualities. The simulation is captivating and the flow of the particles with the soundtrack creates a poetic experience. The movement of the particles also emphasizes that the particles are occupying their own space and enhances the depth of the visualisation. The viewer is not looking at a two-dimensional screen, but rather a virtual space in itself.

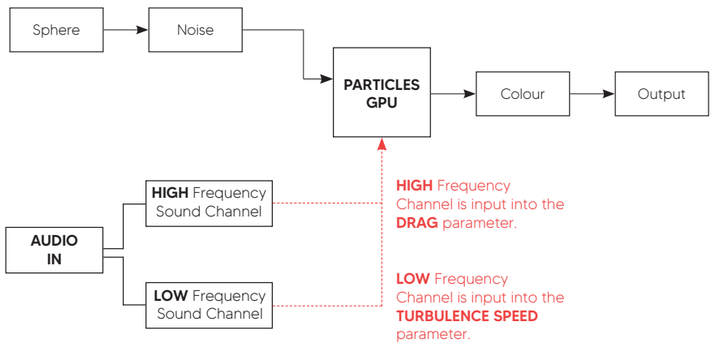


Figure 57: Basic Network illustrating Sound Channels.

Video 22

Variations of Sounds and Colours

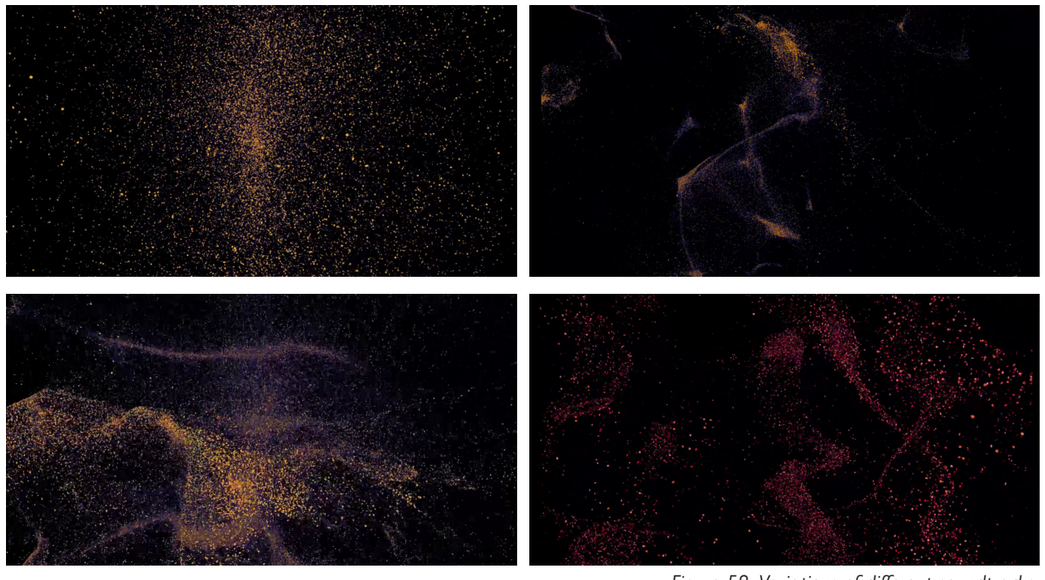


Figure 58: Variations of different soundtracks affecting Particle Systems.

TEST 4: **COMBINING SOUNDS**

This exploration uses the same system as previously but takes two different visualisations and combines them together. The visualisations have different soundtracks, colours and varied external forces. This test explores the question of if the visualisations could represent other spaces sounds and thus visually representing the atmosphere of a space. There are multiple opportunities to be explored from this test. If the audio is linked to a physical location, picking up the sound of footsteps and peoples voices, the display would then represent the atmosphere of a space. As different spaces sounds are overlaid, the display could act as an interface to the building providing an insight into different atmospheres in different areas.

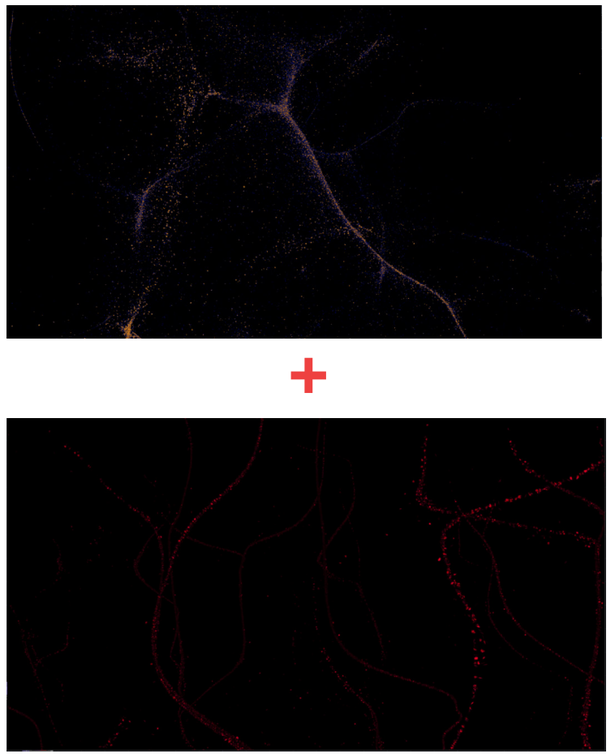


Figure 59: Two particle sytems being combined.

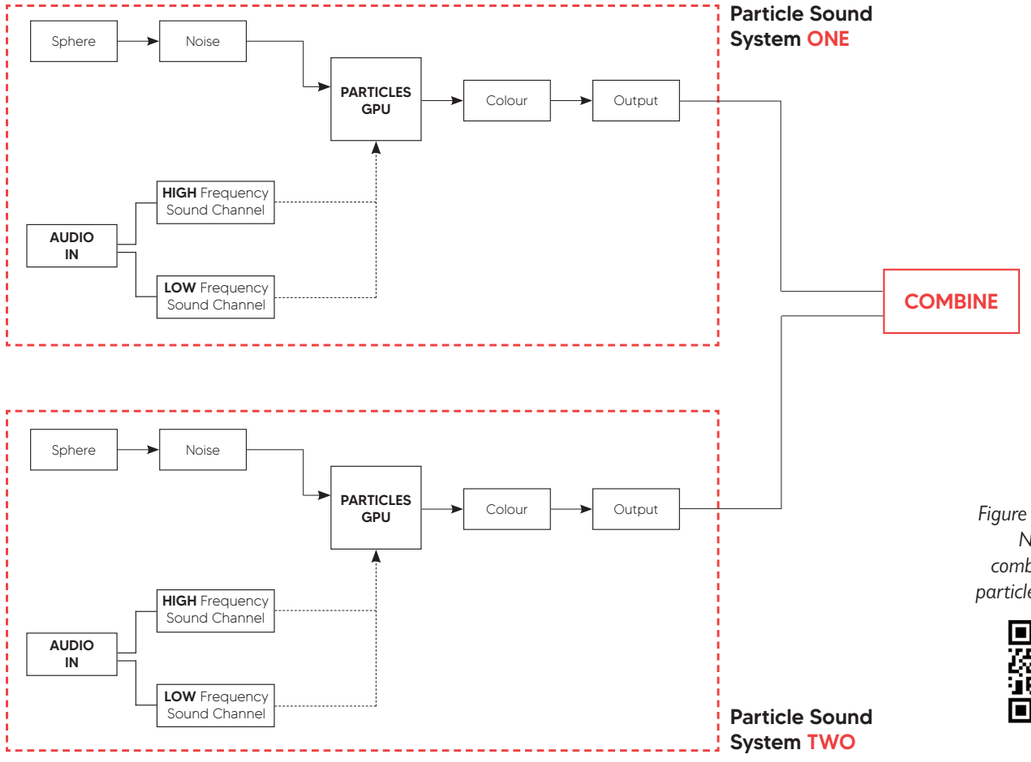


Figure 60: Node Network of combining two particle systems.

Video 23

PARTICLE SOUND SYSTEM

COMBINING SOUNDS

VISUALISING
ATMOSPHERE

TOUCH DESIGNER SOFTWARE

Figure 61: Result of Test 4: Combination of two Particle Systems

REACT

TEST 4

REFLECTION

React was a successful design exploration that examined the techniques in creating interactive digital media through the use of TouchDesigner. TouchDesigner as a program was intuitive to learn and its strengths lie in its ability to manipulate parameters at each step of code. The design explorations in React, served as a learning experience into the processes of creative programming. The various tests provided coding frameworks that can be altered to form a developed design.

While the exploration has outlined the creation of digital artefacts, there is an opportunity to craft the visual aesthetics to enhance visceral reactions. Each test generally serves one purpose; creating an animation, displaying body movement or representing sound. There is an opportunity to build up and overlay the mechanisms into one experience. Creating a complex simulation that is engaging and encourages reflection.

Overall the preliminary design explorations have been successful in understanding the mechanisms to create augmented space. While the animations in Cinema 4D and the experiments using Unity do not serve a direct benefit to the design outcome, they have aided in the process of understanding. Thus still providing value to the design research. The prior tests in this chapter are still valid techniques of augmented space and could be further developed in alternate research.

TouchDesigner has proven the most effective software to aid in the development of the design outcome. The preliminary design explorations have provided the tools and techniques to create a developed design, which will be explored in subsequent chapters.

EVALUATION

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	X
1.2	The design should intensify and alter architectural effect.	
1.3	The design should be visually stimulating and engaging.	X
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	X
2.2	The system should be easily understood without explanation.	X
2.3	The design should use and manipulate real world input.	X
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	X
3.2	The design should be presented in a thought provoking nature.	
3.3	The design should enable performative architecture.	X

DESIGN DEVELOPMENT

6.0

6.1

PART ONE

The design development builds on the techniques and tools identified in the preliminary design exploration. The design development follows an iterative process which uses the successful TouchDesigner mechanisms to form a singular simulation. The simulation is designed as an interactive media which enables the creation of augmented space. The experience aims to enhance physical space with meaningful digital media; immersing the public in the physical environment.

Not all the mechanisms discovered in the design exploration have been applied but specific tools have been developed to align with principles that enhance the simulation. These principles are defined on the following page and aid in the creation of a complex and multilayered simulation.

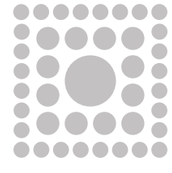
We perceive space through the experience of our senses; sight, sound and touch. *"Perception is an active process through which we make sense of the world around us"* (Lawson, 2001). Traditionally senses are an inward motion and are produced by external elements. When we see, images enter our brain through our eyes. We hear sounds around us and we perceive space by moving through it. The following design development examines an alternative to the conventional sensory experience of space, exploring how our senses can be used to produce atmosphere rather than just experience it. The interactive design aims to encourage the user to use their senses; sound and touch, to activate the architectural experience.

The following design development is based on a simple framework; human input to computational output. Each iteration of the design development outlines an aim, composed of a human activity resulting in a digital reaction. This relationship creates a dialogue between the user and the system, which when applied in the physical environment, creates a dialogue between the individual and the building's surface.

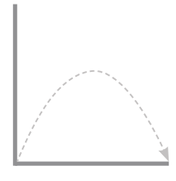
The following design exploration takes an iterative approach which explores the following principles:

FORM + AESTHETICS

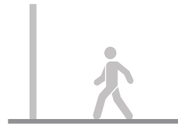
DEPTH



SCALE



TIME + VELOCITY



TRANSLATION

SOUND

DENSITY

Figure 62: Parameters by which the design is developed.

FORM + AESTHETICS

6.1.1

Form and Aesthetics were present principles in the design exploration experiments but were not the focus of the tests. This design moves towards a 'post-digital' stage where rather than focusing on technical methods "*the discourse has given rise to new discussions about aesthetics, affects and sensations*" (Retson, 2016).

This development is initiated through a combination of ideas from three design explorations as illustrated on the following page.

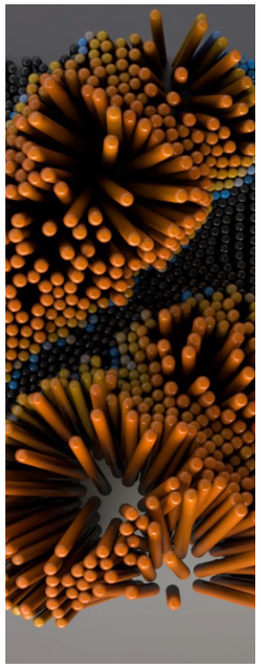
5.2.8 - The Cinema4D explored movement and expression and was successful as it explored the possibility of 3D form reacting to human impression. The test was successful in aesthetics and form and will be the basis for aesthetic exploration.

5.4.3 - Used TouchDesigner to emulate forms and movement simulation that can be seen in the Cinema4D test (5.2.8). This exploration does not include Kinect user input data.

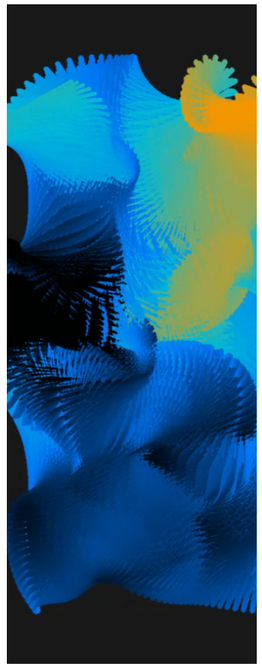
5.4.4 - Was a successful TouchDesigner Test as it used Kinect user data input to displace geometry and applied a colour gradient to the displaced area.

This design exploration forms an initial code that displaces an instanced tube geometry using Kinect user input data. The code combines the two touch designer tests (5.4.3 + 5.4.4) to create an output that is similar to the Cinema4D test (5.2.8).

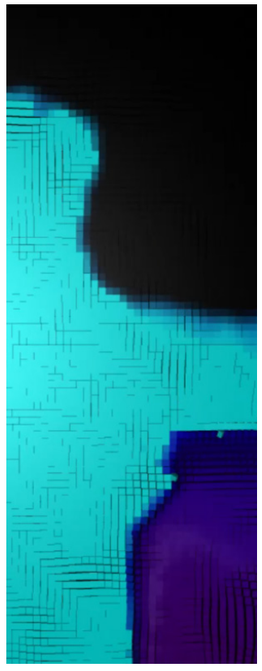
Figure 63: The previous designs which are combined to establish the system.



EXPLORATION
5.2.8



EXPLORATION
5.4.3

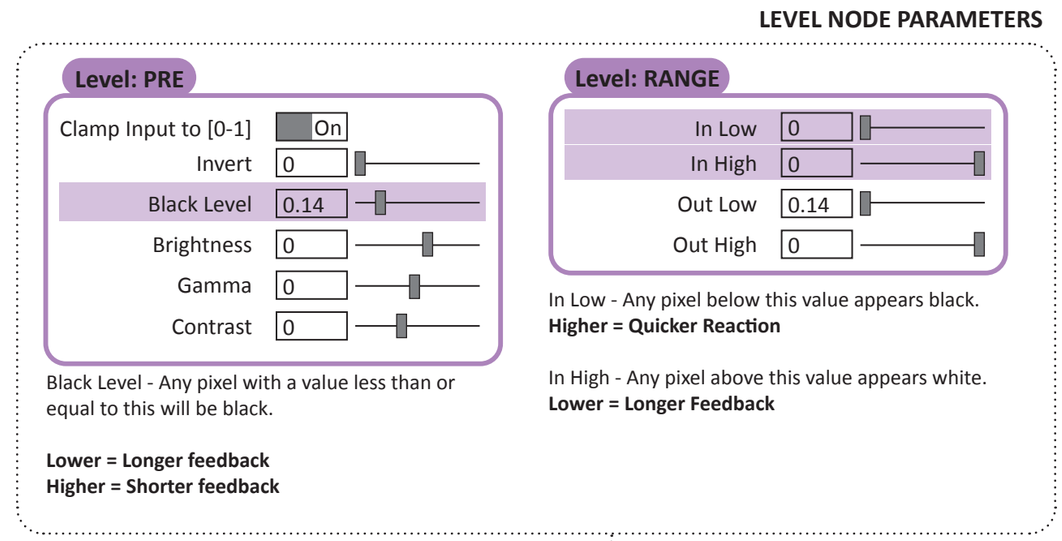


EXPLORATION
5.4.4

FORM

The initial code is constructed in the following method, and is illustrated in the node network diagram.

- Kinect depth data input
- Image data is processed to users input becomes a silhouette
- Feedback loop is added so a 'digital trace' is left. The time the digital trace lasts can be manipulated through the level node parameters, as shown below.
- From the kinect data, R, G and B channels are defined. These are input into the geometry nodes RGB parameters.
- X and Y channels are defined by a grid. These are input into the Translate X and Translate Y parameters in the geometry node.
- The instanced geometry is a tube form which composes the surface.



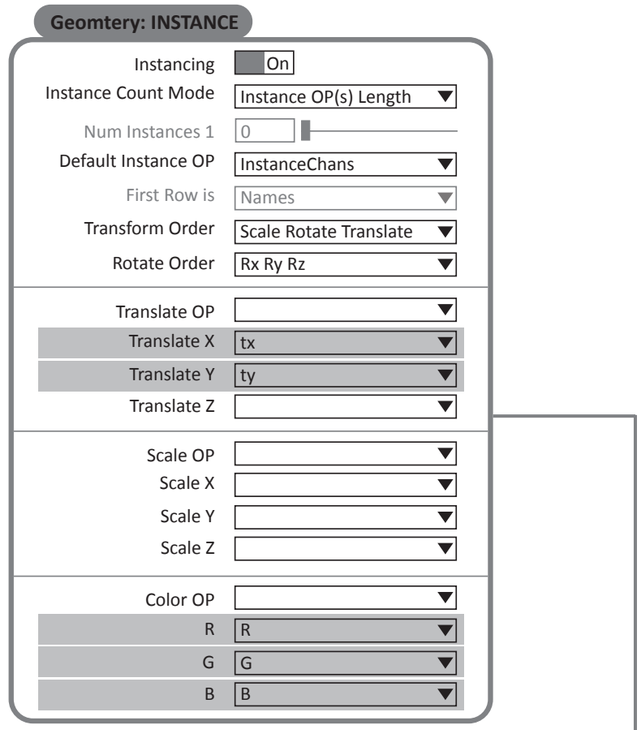


Figure 64: Authors own TouchDesigner Script.

“The emphasis shifts from process to the final object and its qualities. The object is delimited and defined by a surface, often richly articulated, textured, complex or carved out. The surface produces an edge, boundary or figure defining the object. Sometimes this surface is voluptuous and smooth, sometimes rippled and irregular, sometimes in tension, sometimes loose.”

RETSIN, 2016

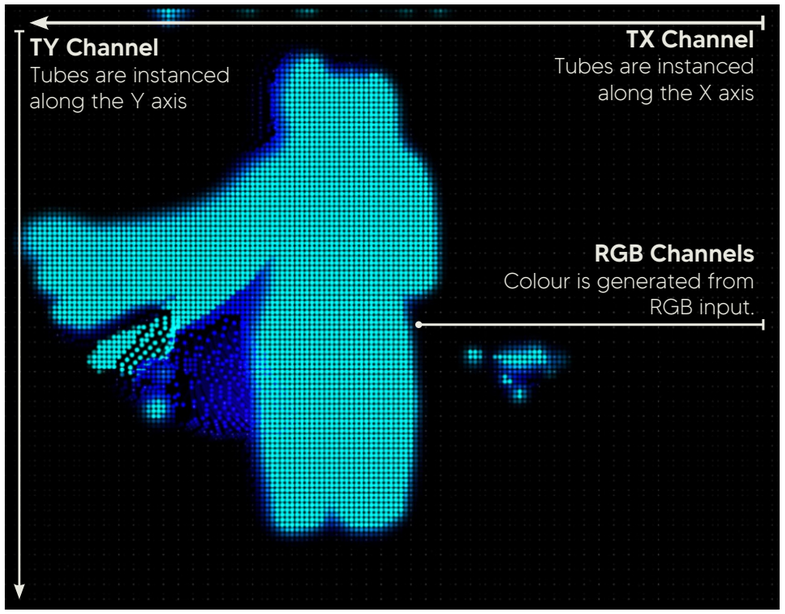


Figure 65: Visual Outcome of Initial Development.

Video 24

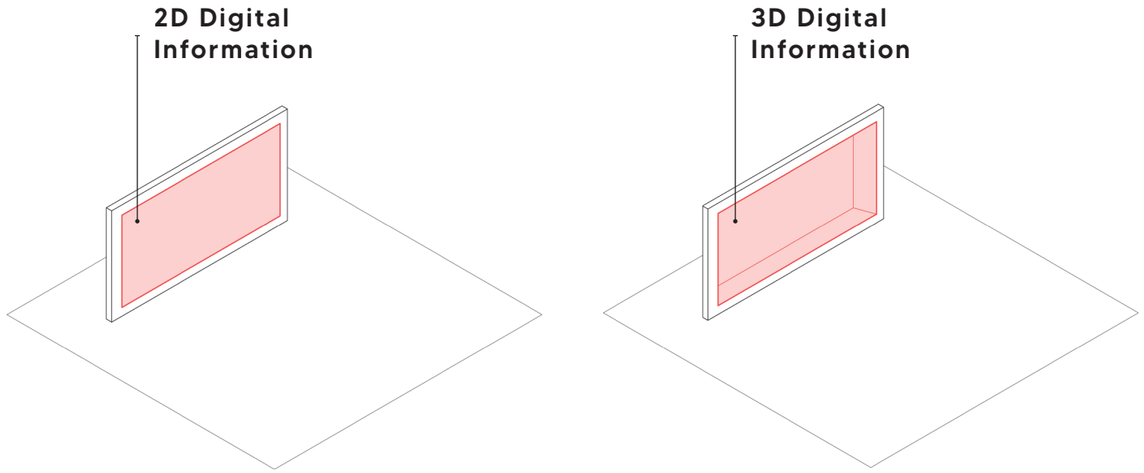


Figure 66: Illustration showing depth of Image on a surface.

DEPTH

6.1.2

The exploration of depth involves developing a virtual spatial experience. In the creation of augmented space, the virtual information overlays the physical environment. If the virtual information is to be displayed on a surface or a screen, it is important to avoid creating a two-dimensional digital surface that sits on a two-dimensional physical surface. This idea has been successfully achieved in Nexen UniverCity's Infinity wall (3.5). Depth must be developed in order to give the installation a spatial quality.

Figure 67: Ascending and Descending M.C Escher.

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Zeynep Cinar discusses the concept of depth in relation to Paradoxical Architecture, exploring how a two-dimensional image can create the illusion of three-dimensional space. "An image, although has qualities of three-dimensional elements is always an image and although it depicts reality can only be a surface of that reality, which actually solidifies its paradoxical nature of not exactly knowing if this is real or just an optical illusion" (Cinar, 2017). Variation of scale can also be used to create the illusion of space which is explored in part 6.1.3. This concept can be exemplified in M.C Escher's 'Ascending and Descending' (1960) where the images depict an impossible reality but the depth and logic in the image justify the possibility.

Joe Rohde, the Senior Vice-President and Executive designer at Walt Disney, discusses how depth can be utilised to create the illusion of space and how it can aid in the communication of narrative. He exemplifies the concept in the classic Bibiena design for a proscenium stage (Fig.67) "where the illusion of depth is an established convention. But it is equally true in any narrative environment. Space consists of what is seen, felt and heard by the individual and whatever additional imaginary space is implied by what they experience. Voices coming from beyond a wall imply place and action on the other side of the wall" (Rohde, 2010).

Depth is important to aid in the creation of an illusion of space. Through emulating spatial qualities, a narrative can be developed which can "exist primarily to convey meaningful communication and signification, that is emotion and ideas" (Rohde, 2010). The development of spatial narrative enables the achievement of Design Criteria Three which explores the reflective design and emotional value.

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Figure 68: Bibiena Design for a Proscenium Stage.

COLOUR + DEPTH

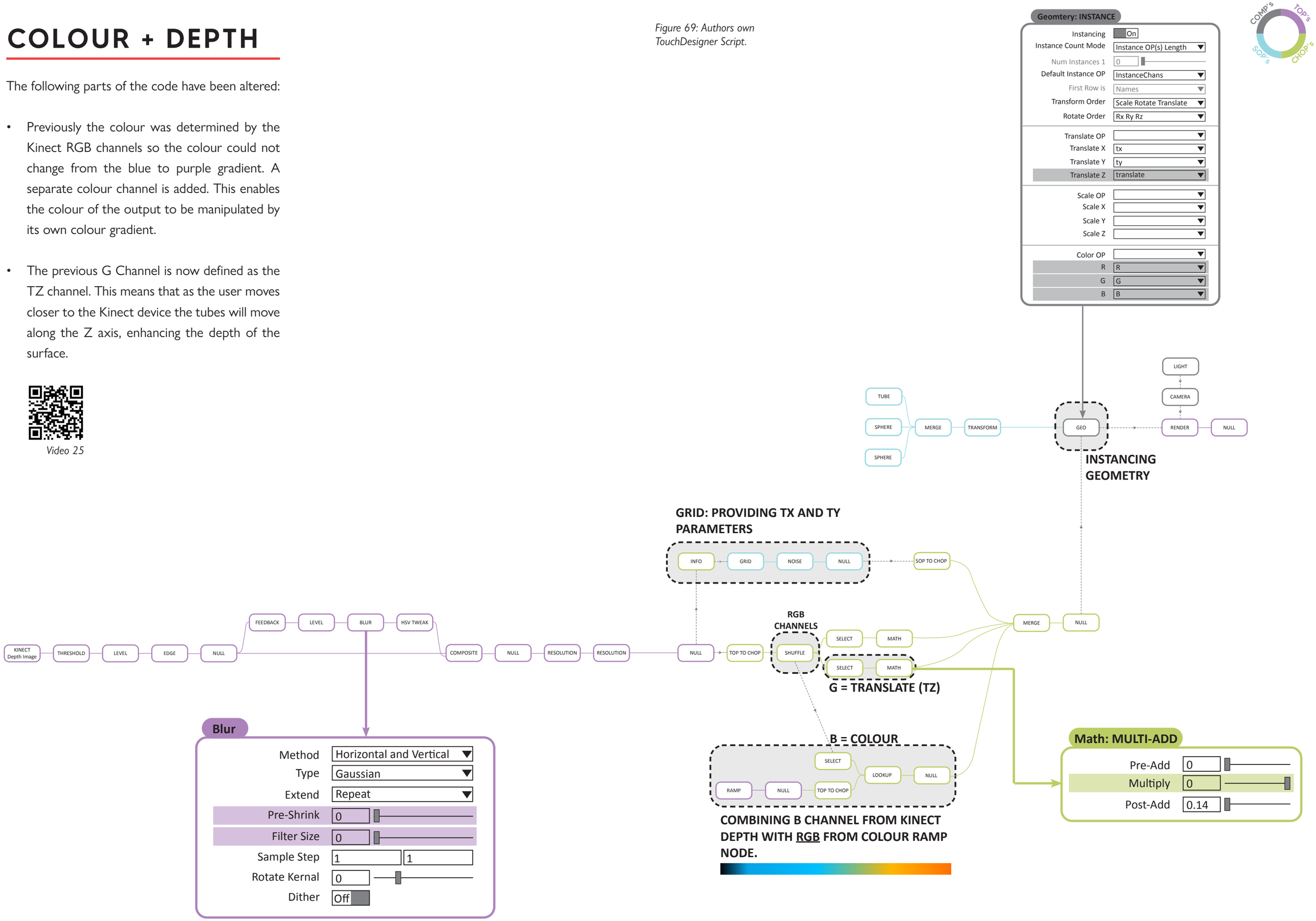
The following parts of the code have been altered:

- Previously the colour was determined by the Kinect RGB channels so the colour could not change from the blue to purple gradient. A separate colour channel is added. This enables the colour of the output to be manipulated by its own colour gradient.

- The previous G Channel is now defined as the TZ channel. This means that as the user moves closer to the Kinect device the tubes will move along the Z axis, enhancing the depth of the surface.

Video 25

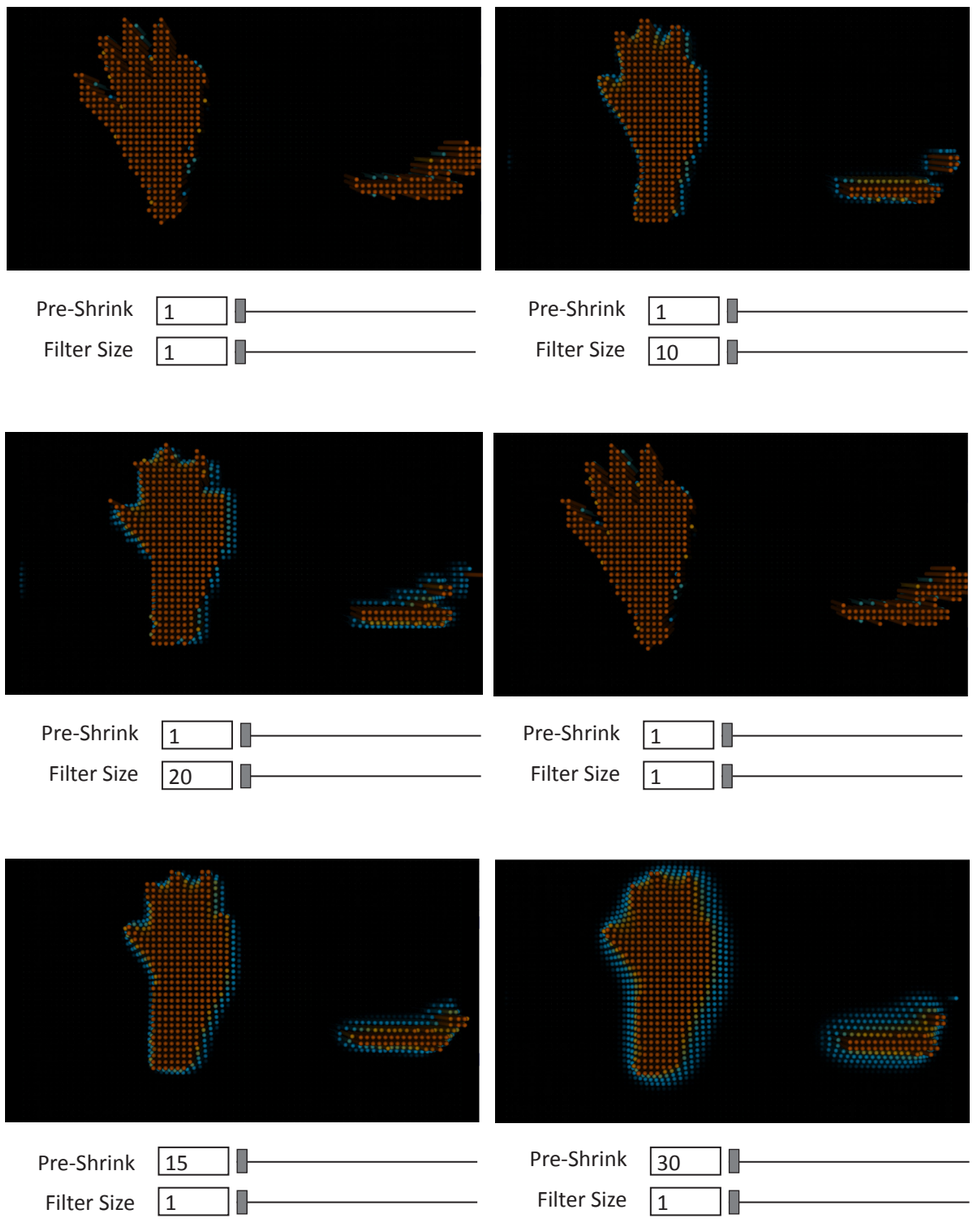
Figure 69: Authors own TouchDesigner Script.



GRADIENT OF DEPTH

The ‘Pre-shrink’ and ‘Filter size’ parameters in the Blur node are adjusted. The Pre-Shrink “reduces the image resolution before applying the blur” (Derivative, Blur TOP, 2020) and the Filter Size affects “the amount of blur in the pixels” (Derivative, Blur TOP, 2020). Effectively the adjustment of the parameters will alter the number of blue cells around the hand. It also creates a softer gradient in Z-axis translation of the cells. These effects are experimented with below.

Figure 70: Variations in gradient of depth.



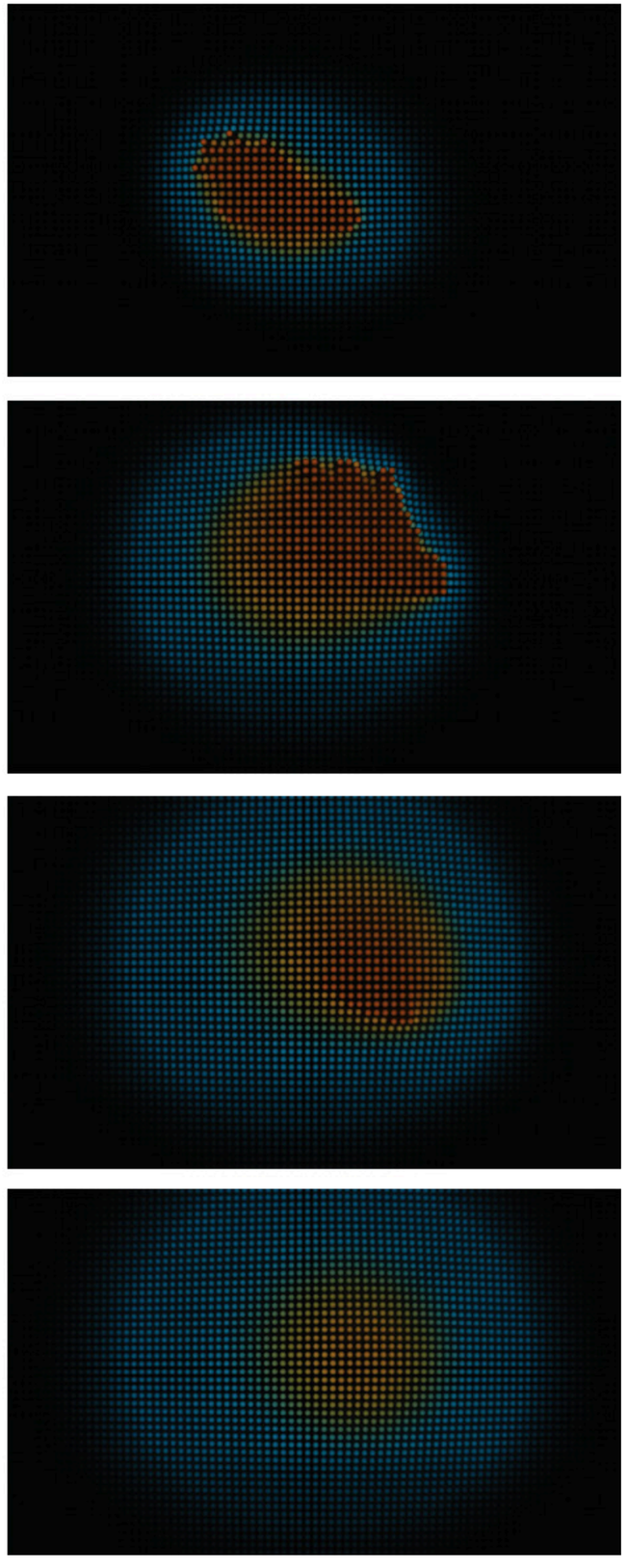


Figure 71: Series with above settings.

The change in parameters means that the more actively the user interacts with the surface, the longer the colour will last. User engagement proportionally relates to digital impression.

Video 26

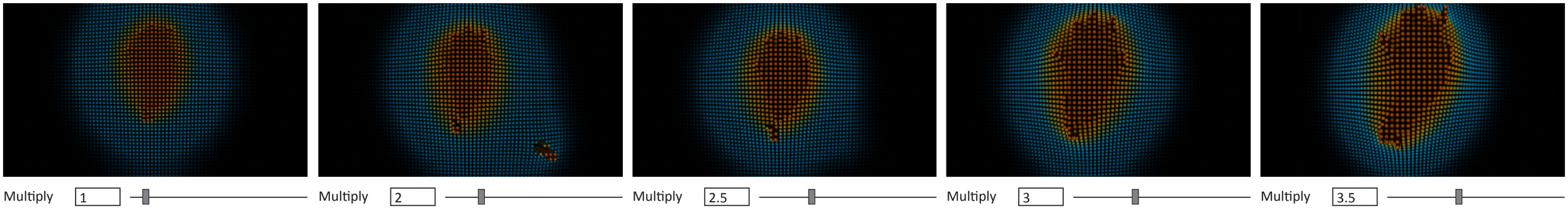
ENHANCING DEPTH

The multiply channel is then adjusted so that the depth translation is multiplied by a certain value. Experimentation of multiply levels can be seen below.

The higher multiplication is more successful as it enhances the depth of physical impression.

Figure 72: Multiplication of Depth

Video 27



DEPTH

6.1.2

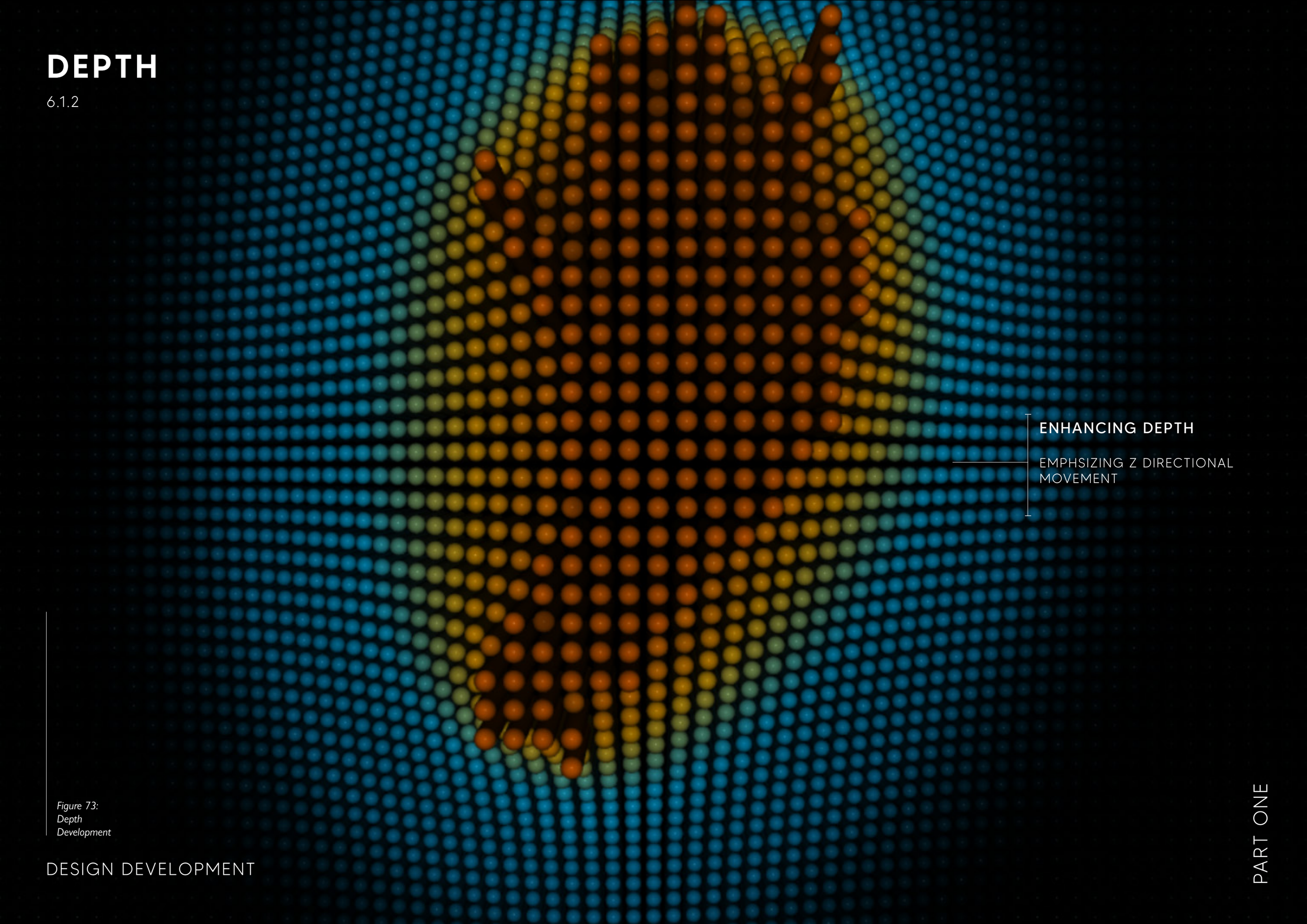


Figure 73: Depth Development

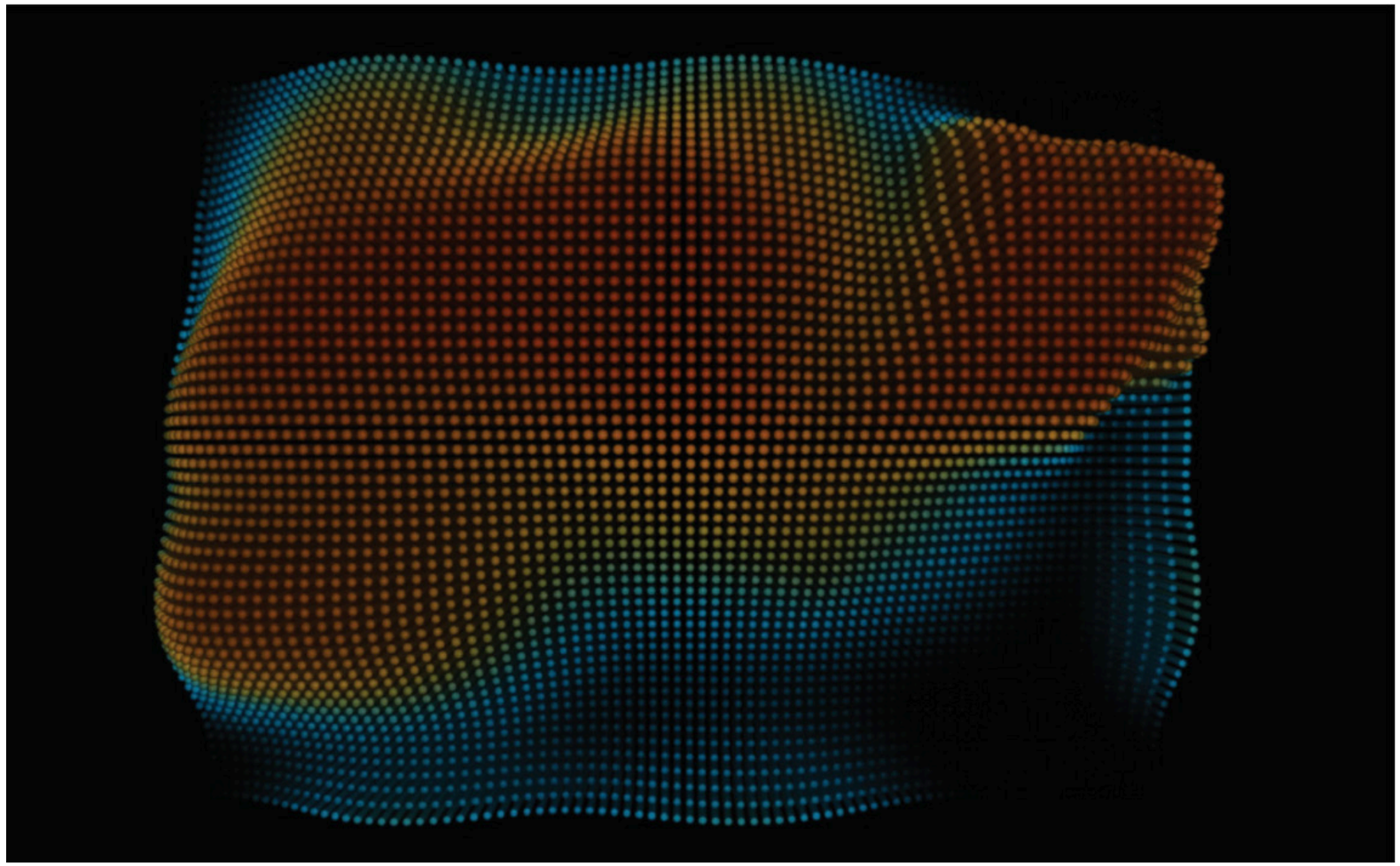


Figure 74: Scale Development.

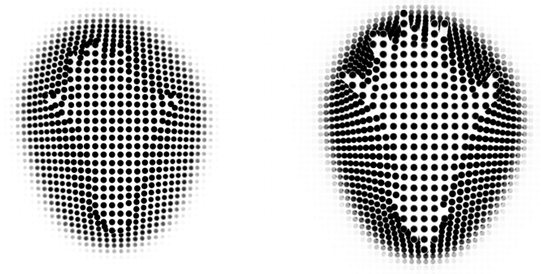
Video 28

SCALE

6.1.3

The scale has been developed to further emphasize the sense of depth and thus intensify the illusion of space, as explored in part 6.1.2. The cells displaced by the user's impression are scaled in the X, Y and Z directions. The X and Y directions are scaled proportionally by a scale factor of 0.8 and the Z direction is scaled by a factor of 0.5. Explorations of the manipulation of scale are exhibited on the following page.

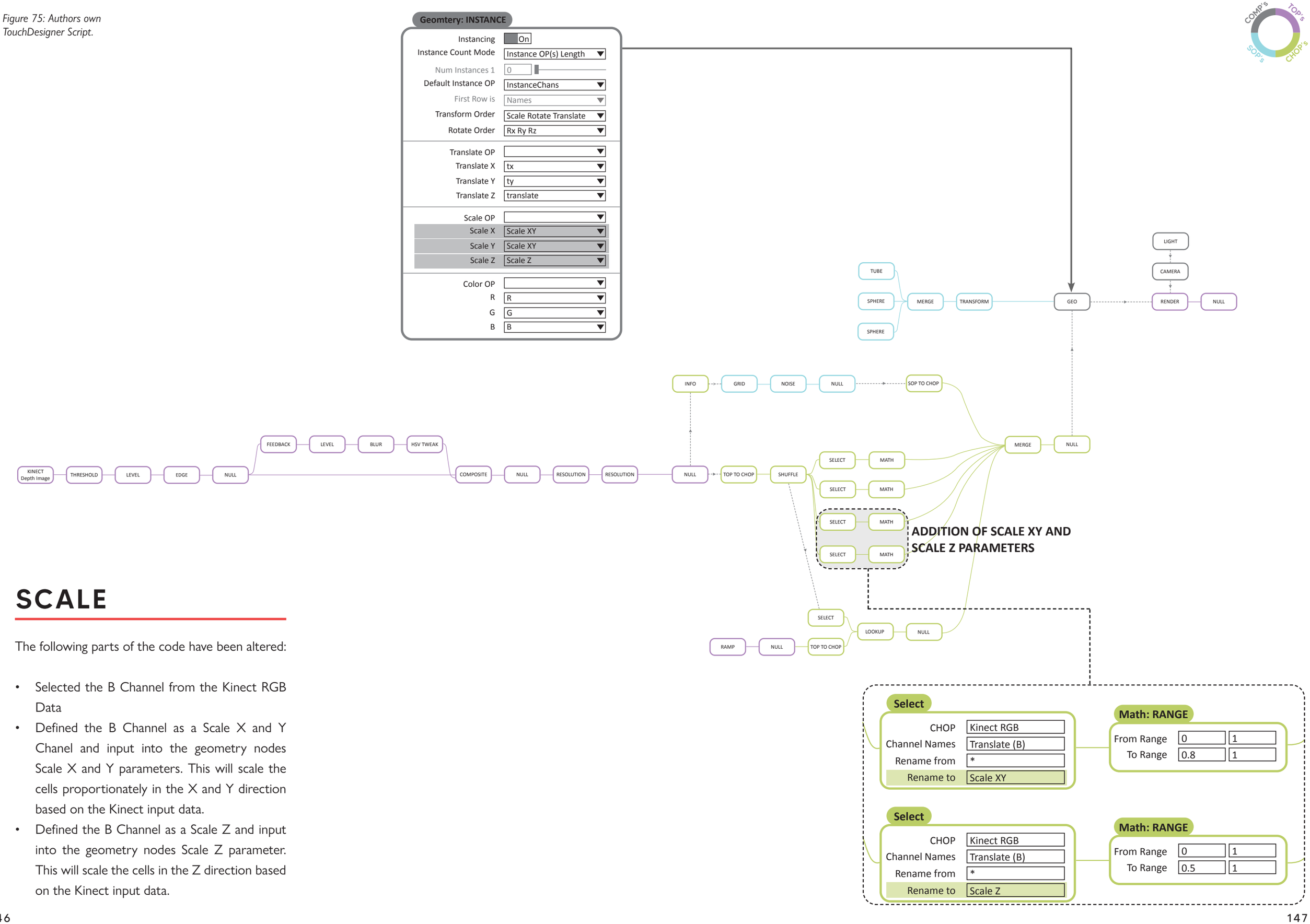
The addition of a variation in scale between the displaced cells and the static cells emphasizes the user's impression on the surface. This development enables the behavioural design criteria, advancing the enjoyment and effectiveness of the interaction.



NO SCALE APPLIED

SCALE APPLIED

Figure 75: Authors own TouchDesigner Script.



SCALE

The following parts of the code have been altered:

- Selected the B Channel from the Kinect RGB Data
- Defined the B Channel as a Scale X and Y Chanel and input into the geometry nodes Scale X and Y parameters. This will scale the cells proportionately in the X and Y direction based on the Kinect input data.
- Defined the B Channel as a Scale Z and input into the geometry nodes Scale Z parameter. This will scale the cells in the Z direction based on the Kinect input data.

VELOCITY + TIME

6.1.4

Video 29

A relationship between the user's velocity and the feedback time has been formed through the manipulation of CHOP data. Velocity can be defined as the distance travelled over time elapsed. The distance travelled is defined by subtracting the user's current position from their previous position. The speed value is then defined by applying a slope node. Essentially dividing the distance travelled over the time elapsed.

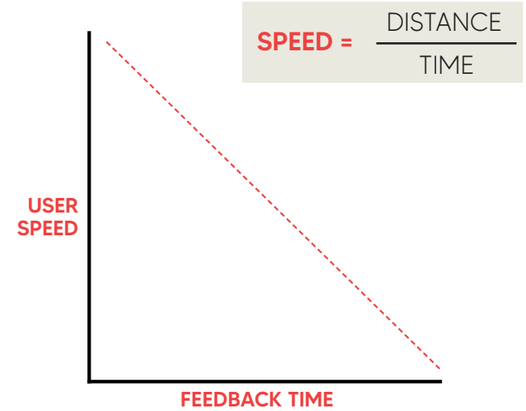


Figure 76: Relationship of User speed to Feedback Time.

The velocity value is input into the black level of the feedback loop. If the user's speed is fast the image disappears quickly and the reaction is instantaneous. If their speed is slow and their presence long, the feedback is slower and their digital mark will stay on the wall for longer.

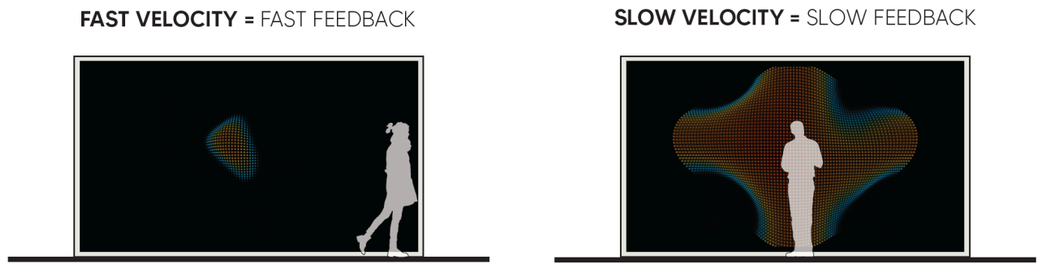


Figure 77: Feedback to visual output

The mechanism creates a relationship between past users and current users. When a past user has had a long engagement with the space their mark will remain for the next user to experience, enabling reflection considering the past inhabitants of a space.

The mechanism increases the unpredictability of interaction. "If space is formed by predefined knowledge in architecture will the experience of that space always be the same from the viewers … point of view?" (Cinar,2017). As identified in the case study review (Chapter 3), if the digital media is a predefined, looping animation, the viewer's engagement will decrease over time. This mechanism aims to create unique interactions every time a user engages with the intervention.

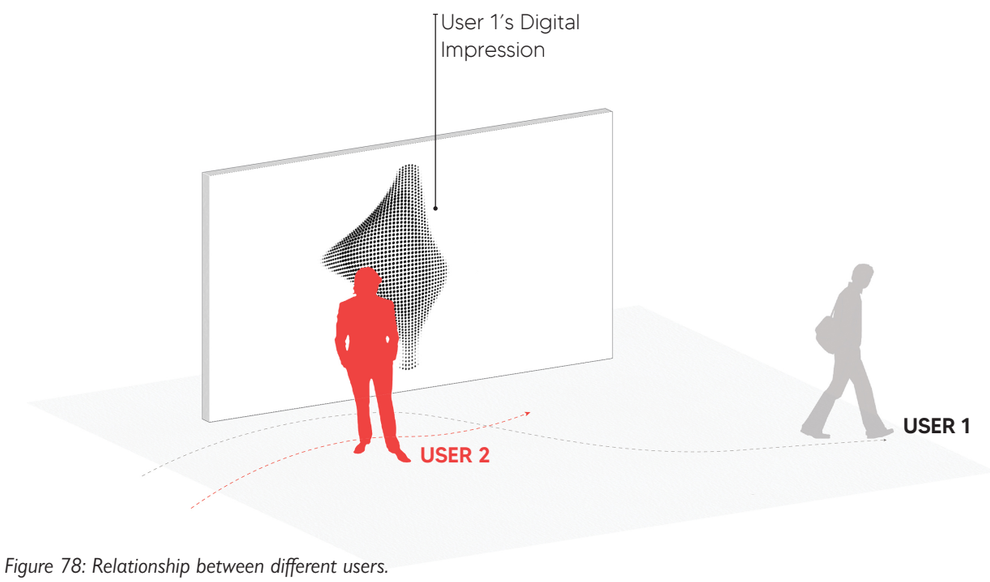
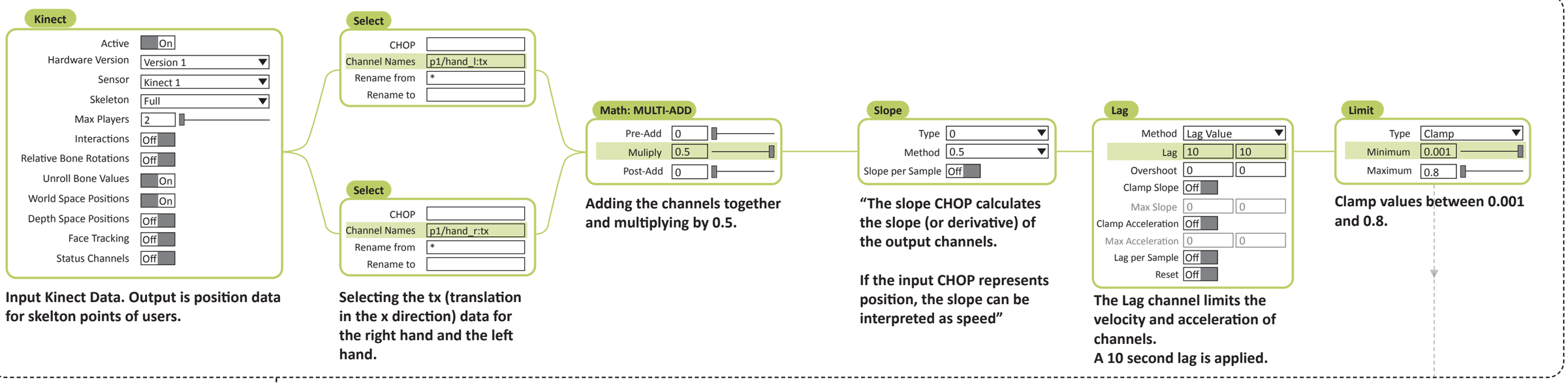
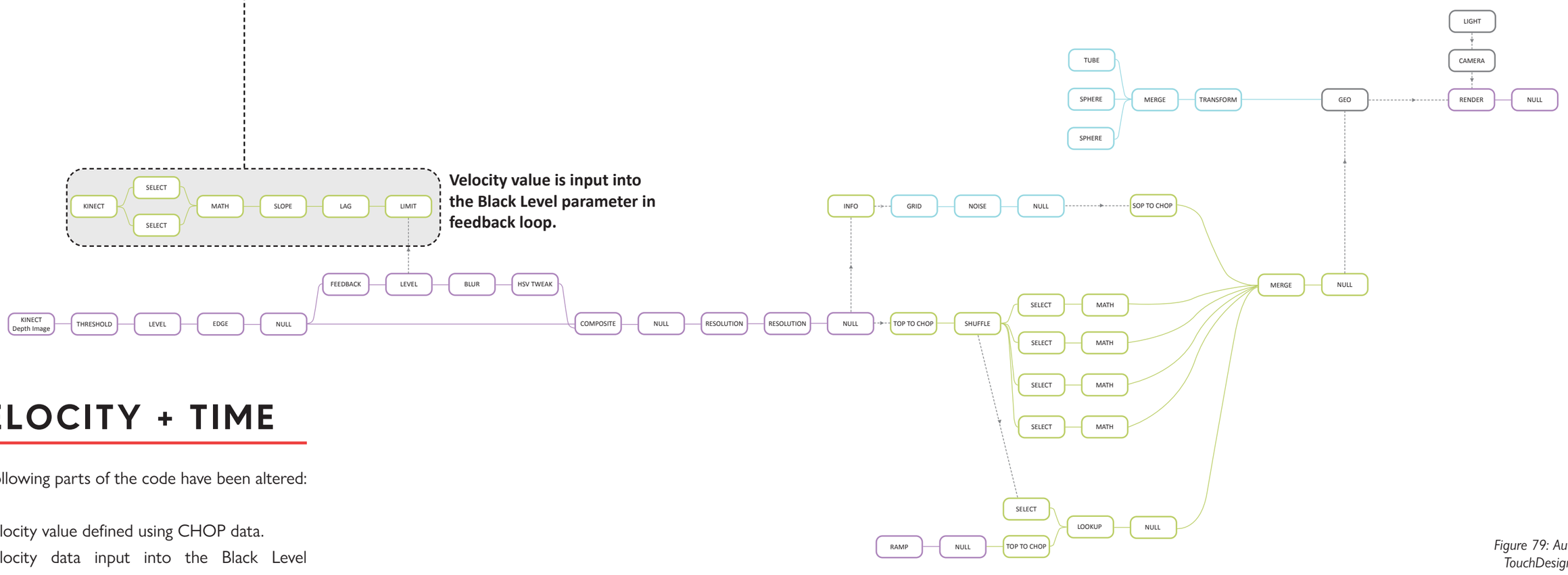


Figure 78: Relationship between different users.

DEFINING VELOCITY VALUE





VELOCITY + TIME

The following parts of the code have been altered:

- Velocity value defined using CHOP data.
- Velocity data input into the Black Level parameter in the feedback loop.

Figure 79: Authors own TouchDesigner Script.

TRANSLATION

6.1.6

This development establishes a relationship between the user's proximity to the surface and the time of feedback. This mechanism expands on the concepts of the previous development (6.1.4), aiming to manipulate the code's parameters so that the experience is unique depending on what actions are performed.

A trail node has been added to the code which includes a Cache Size parameter. This parameter manipulates "the number of frames to keep cached in available memory" (Derivative, Trail SOP, 2020). The higher the cache size results in longer feedback, and vice-versa. When the Z position value is input into the cache size parameter, the closer the user is to the surface the more instantaneous the interaction will become. The further away, the mark will be longer.

This mechanism applies the methods of behavioural design in a conditional approach. If the user has a high level of interaction and thus physical presence the system is responsive and easy to use.

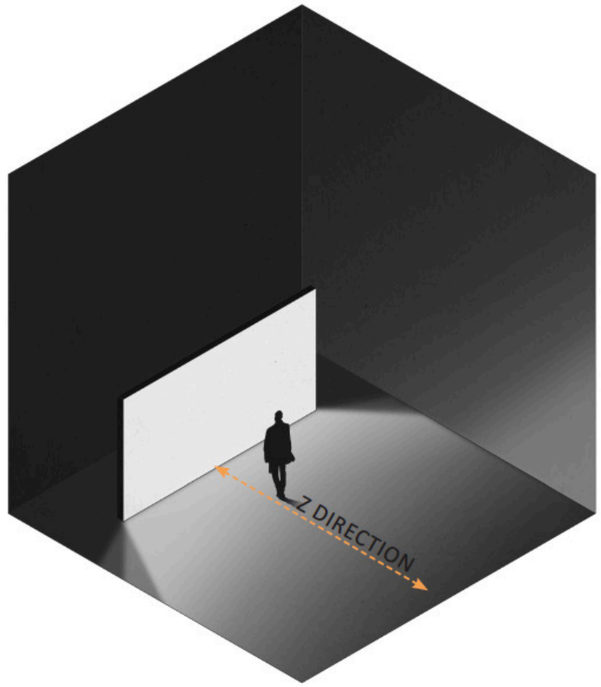
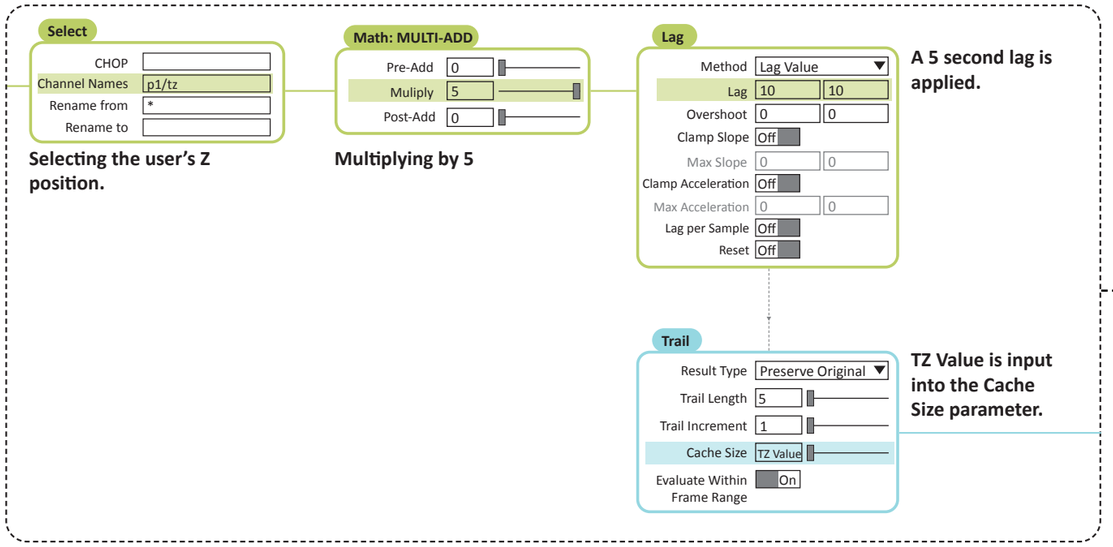


Figure 80: Relationship between Z Translation and Cache Size



DEFINING Z POSITION

TRANSLATION

The following parts of the code have been altered:

- The Z position of the user has been selected from the Kinect CHOP node.
- A trail node has been added.
- The Z position value is input into the Cache Size parameter of the Trail Node.

Figure 81: Authors own TouchDesigner Script.

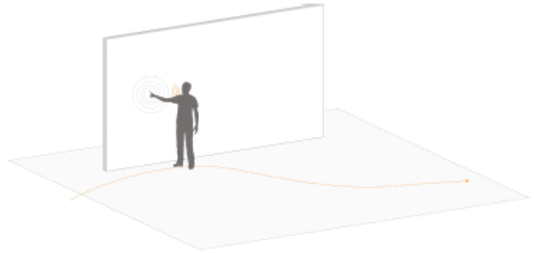
SOUND

6.1.6

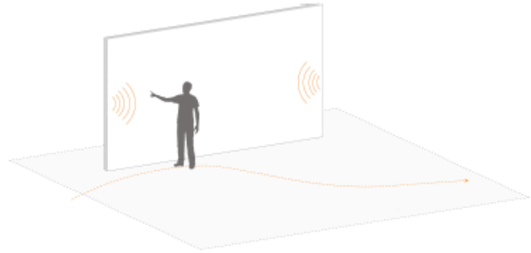
Sound has been incorporated into the design in a multi-layered approach and offers complexity to the system. The sound manipulation was derived from Design Exploration 5.4.7, where a soundtrack was used to manipulate particles. In this development, a microphone audio device has been input into the system in order to use the physical space's sound to manipulate the visual output.

The sound data is manipulated to create a high frequency and low-frequency sound channel. These channel values are input into the 'Rotate Z' and 'Pivot Z' parameters within the geometry. This programming results in movement of the cells along the Z-axis when a sound is made. For instance, if the user claps, the tubes move forwards toward the user. The higher and longer the sound, the more the tubes are translated in the Z direction.

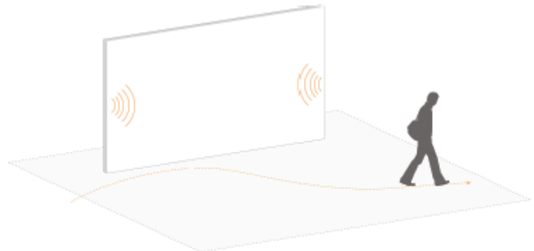
The second manipulation of sound is the delay in the output of sound. When a sound is made, it is played back to the user with a 5 second, 10 second and 30-second delay. This concept builds on the ideas of Dan Graham's Present Continuous Pasts (3.6) and incorporates time as a fourth dimension. The user will hear themselves in the past while continuing to experience the present. The 30-second delay is designed to enable future users to hear the sound made by past inhabitants of the space, similar to the feedback mechanism designed in 6.1.4. The purposeful time delay of sound enables a reflective interface as earlier defined in section 2.4.4.



User one will output sound. The wall will react with a physical displacement of the geometery.



The user will then hear the echo of the sound 5 seconds later.



The second echo of the original sound will be 10 seconds later.

The third echo of the sound will play 30 seconds later, when the user has left the area. Following users will hear the sound and will gain an insight into the past and who has been there before.

Figure 82: Designed Sound experience.

Video 30

SOUND

The following parts of the code have been altered:

- Audio Device input is added.
- High frequency and low frequency channels are defined
- High frequency channel is input into the Rotate Z parameter of the geometry.
- Low frequency channel is input into the Pivot Z parameter of the geometry.
- A 5 second, 10 second and 30 second delay is applied to the audio output.

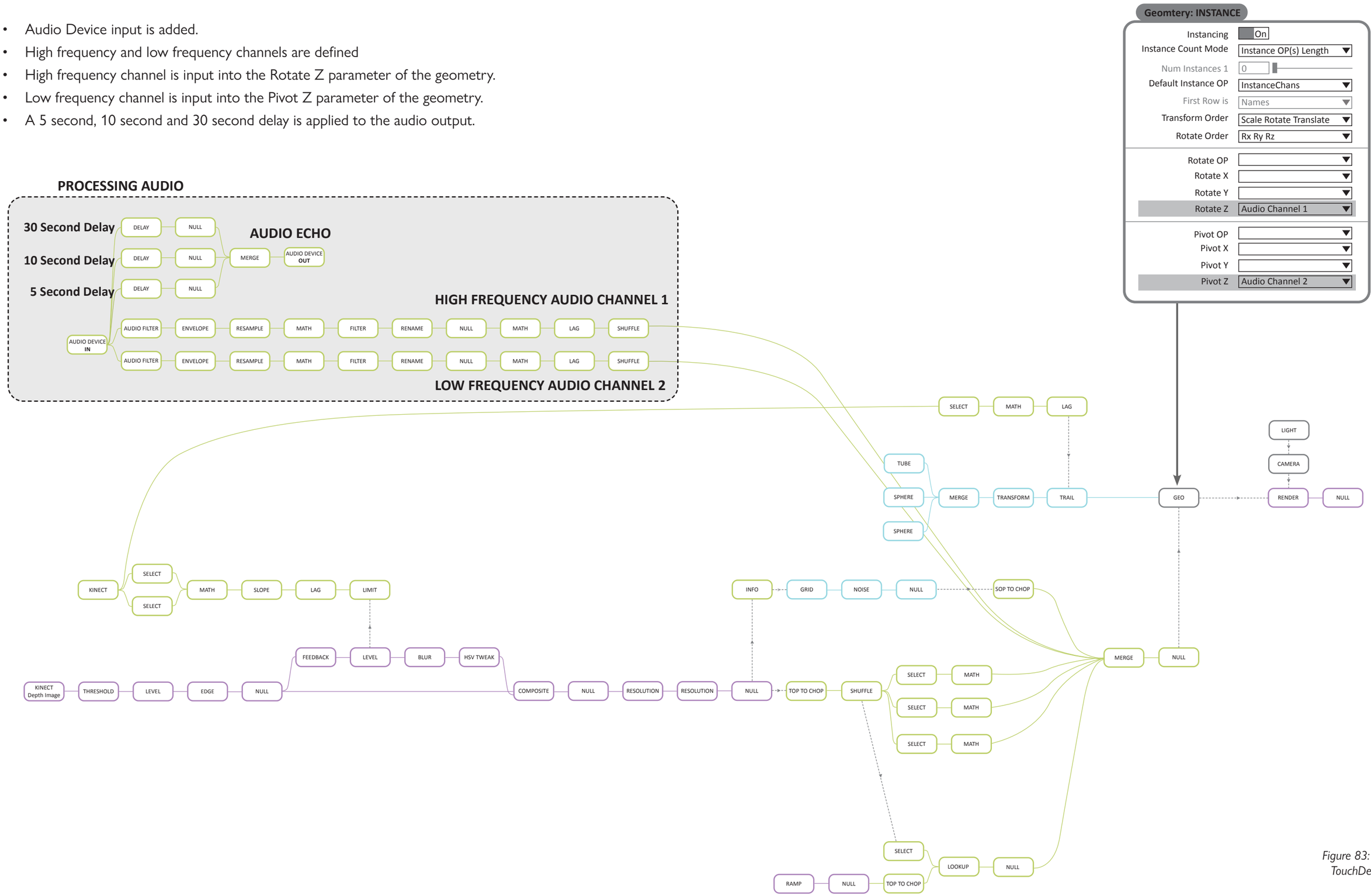


Figure 83: Authors own TouchDesigner Script.

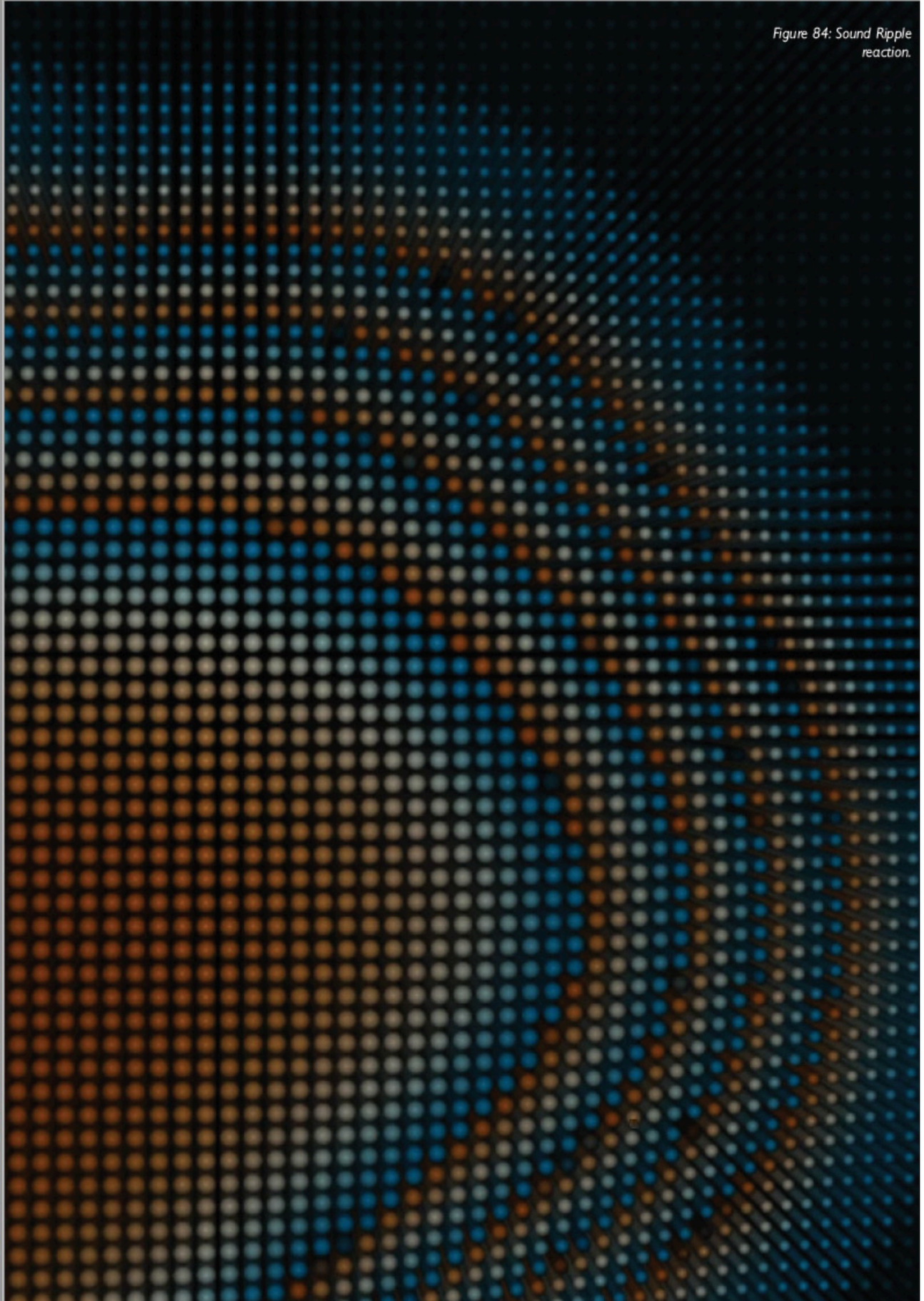


Figure 84: Sound Ripple reaction.

SOUND RIPPLE

A sound ripple has been included to emphasize the visual reaction to sound. In order to create a sound ripple, a Python text script has been added to the High Frequency sound channel. The script defines that if the value of the sound changes above 3, the period of the colour gradient equals 0.2. If the value is not above 3, the period remains at 1.0.

The period defines the length of the colour gradient. If the period is at 1.0, the colour gradient is at full length. When the value is 0.2, it is twenty percent of the original size. Meaning there are five colour gradients repeated, resulting in a ripple effect.

```
var1 = op('limit3')[0]
def onValueChange(channel, sampleIndex, val, prev):
        if var1  > 3:
                op('ramp4').par.period = 0.2
        else:
                op('ramp4').par.period = 1
        return
```

Initiating the script when the value of the High frequency channel changes.

If the value is over 3 (Sound present) the period equals 0.2

If the value is **NOT** over 3 the period equals 1

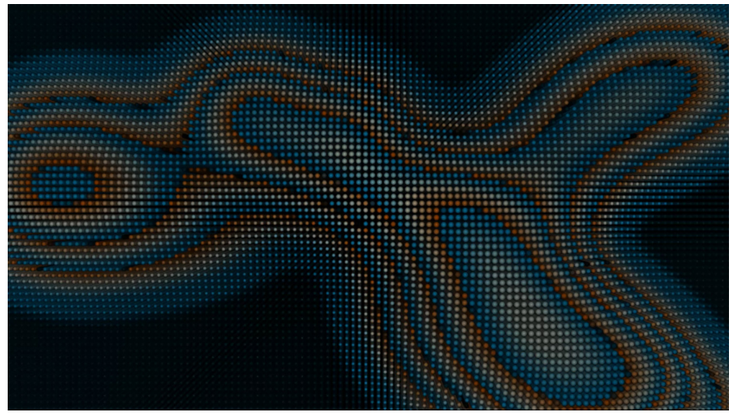


Figure 85: Sound Ripple reaction.

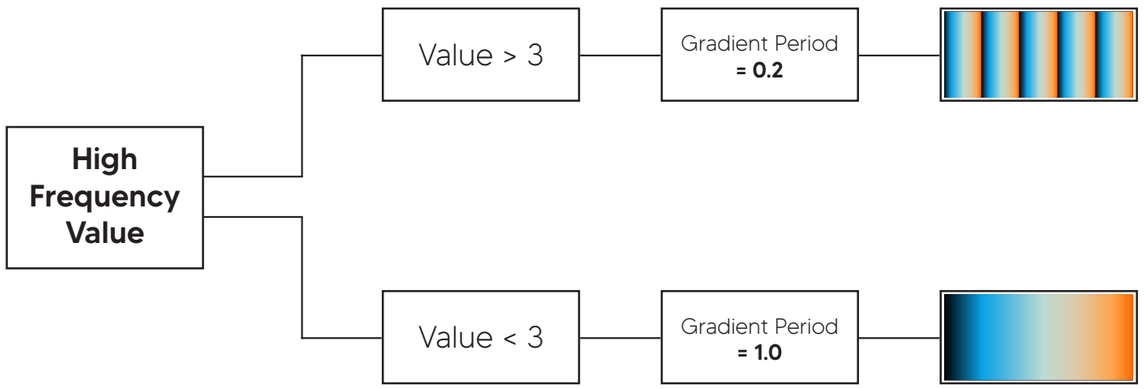


Figure 86: Sound Value in relation to colour gradient period.

Video 31

DENISTY

6.1.6

Video 32

This development is designed to reflect human presence within the space. Density explores how the system can react when multiple users are present. Initially this development creates a relationship between the number of people to colour. The code is developed so the simulations colour will change gradient depending on if there is one user present or two.

A script has been added in a similar method to the previous sound ripple development. If the second player is present then the RGB parameters in the geometry node are changed to the second gradients RGB channels. The effects of this are shown below.

While this is a successful mechanism and visually represents a change in presence, the transition between colours is static and not conveyed in a poetic manner. Instead a more subtle approach has been taken, where user presence is translated to a change in saturation.

In this approach, as illustrated on the following page, the more users present, the brighter the installation becomes. Using the Kinect CHOP data, up to six people can be recognised which correlates to six different levels of brightness. There is a direct relation between presence and visual output. The wall is reacting to the human atmosphere within the space.

ONE USER

TWO USERS

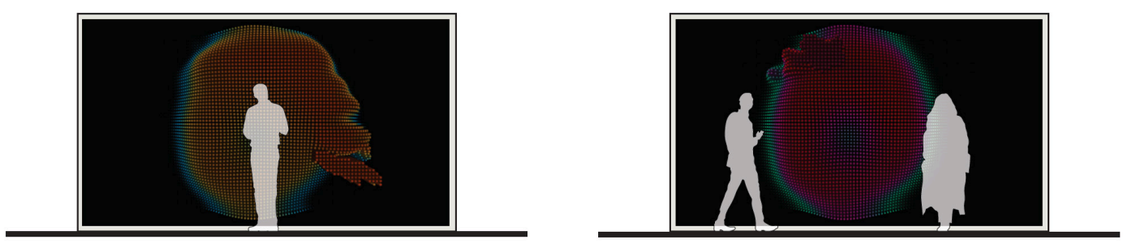
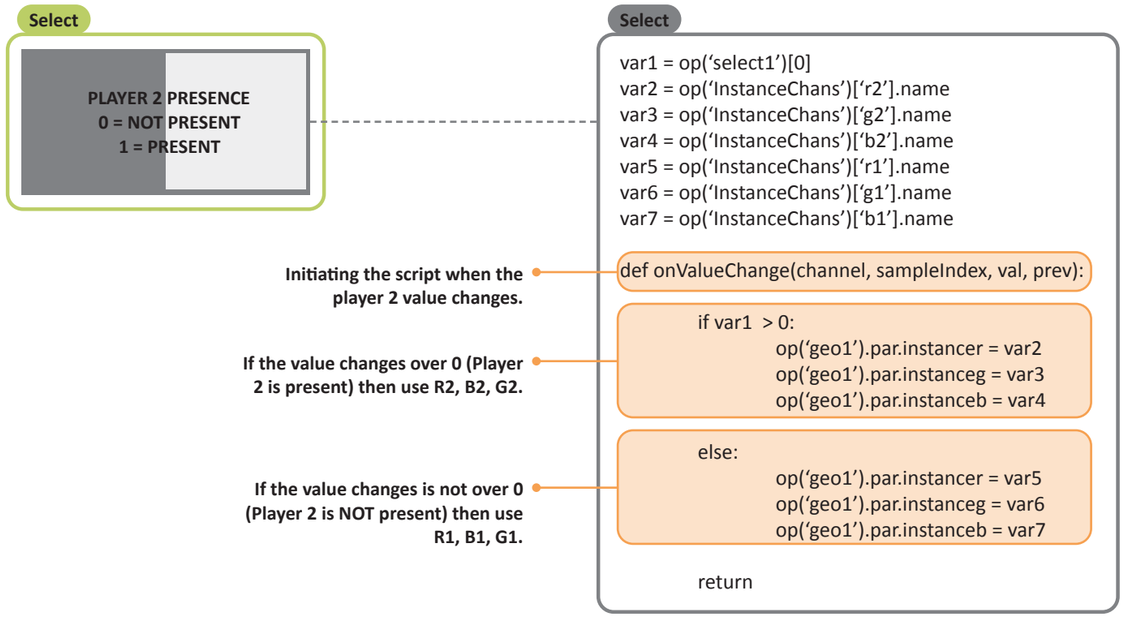


Figure 87: Colour reacting to number of people

NUMBER OF PEOPLE TO COLOUR

Script Breakdown



NUMBER OF PEOPLE TO SATURATION

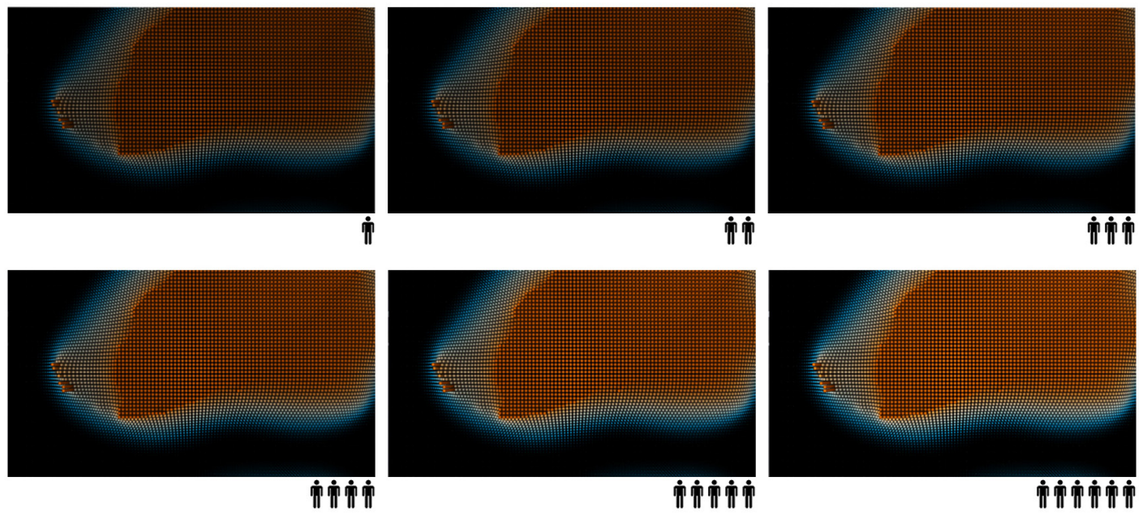


Figure 88: Saturation reacting to number of people

REFLECTION

Part 1 of the design development successfully creates a simulation that can be incorporated into the physical environment to create augmented space. The construction of the system in physical space will be explored in Chapter 7.

The design outcome applies all three emotional design principles. The design is aesthetically pleasing, targeting an initial visceral response of the user. The mechanisms that are designed into the system enable an effective and enjoyable experience. The system is not a defined motion image, but a visualisation which is enabled by user interaction; the user is becoming the actor of the space. The mechanisms have been designed in a manner to encourage reflective thinking and speculative discussion. Features such as Velocity and Time (6.1.4), the Sound Delay (6.1.6) and Density (6.1.7) enable the system to react in a way to entice the user to reconsider conventions of time and space. The multilayered approach taken enables the system to become a complex experience which the user will need to engage with to fully understand the mechanics.

EVALUATION

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	X
1.2	The design should intensify and alter architectural effect.	X
1.3	The design should be visually stimulating and engaging.	X
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	X
2.2	The system should be easily understood without explanation.	X
2.3	The design should use and manipulate real world input.	X
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	X
3.2	The design should be presented in a thought provoking nature.	
3.3	The design should enable performative architecture.	X

This content is unavailable. Please consult the figure list for further details.

Figure 89: Refik Anadols Machine Hallucinations Data Sculpture.

PART TWO

6.2

The following design development uses similar mechanisms that were used Part 1 but explores an alternate aesthetic composition to build the interactive system.

In the previous design development, the system is communicated in pixel like composition and the aesthetic is very digital. When reflecting on Refik Anadol's digital data sculptures as explored in Chapter 3.3, his work whilst digital, is communicated in soft and natural aesthetic language. This can be exhibited in the above image from his project Machine Hallucinations. In this example, Anadol has generated a detailed data sculpture using an immense particle system. The colour palette used and the soft formation of the particles creates a visualisation that does not feel technological or digital, but rather communicates a system which is natural and organic.

One of the objectives of the research is to immerse people into the physical landscape. If technology is being used to facilitate this objective, then it should not increase digital pressure on the users life. The system should be designed in a way where it is not perceived as 'another screen' but rather a refreshing and reflective interface. By developing a system which has a natural aesthetic, the work can be interpreted in a poetic manner, rather than in a digitized form.

The following design exploration uses a multilayered particle system to visualise different spatial elements. The system includes 4 different particle systems, each enacting different mechanisms, which overlay each other. The outcome is a visualisation which creates an abstract communication of the spatial atmosphere.

The exploration is a less complex system than the initial development. Through focusing on combining reactive and delayed mechanisms, the design is more open to be interpreted by the user. The design outcome results in a poetic system that is aimed at engaging the users reflective and emotional responses.

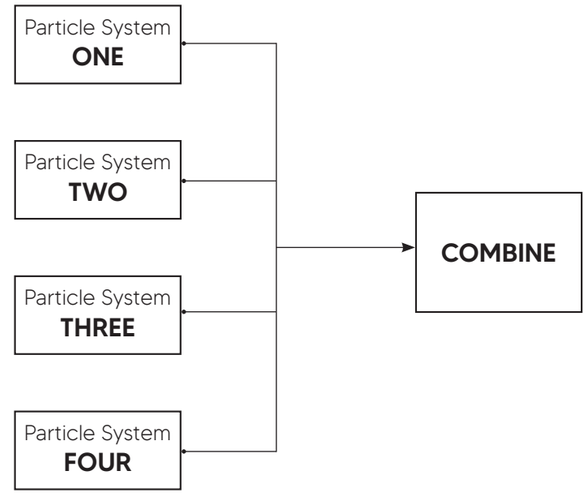
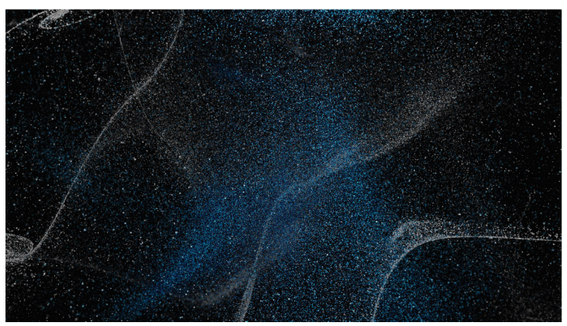
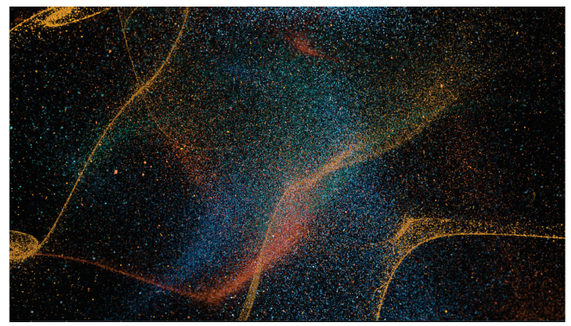


Figure 90: Multil-ayered particle system that will be used in Part Two

Figure 91: Aesthetic Explorations of Combining Particle Systems.





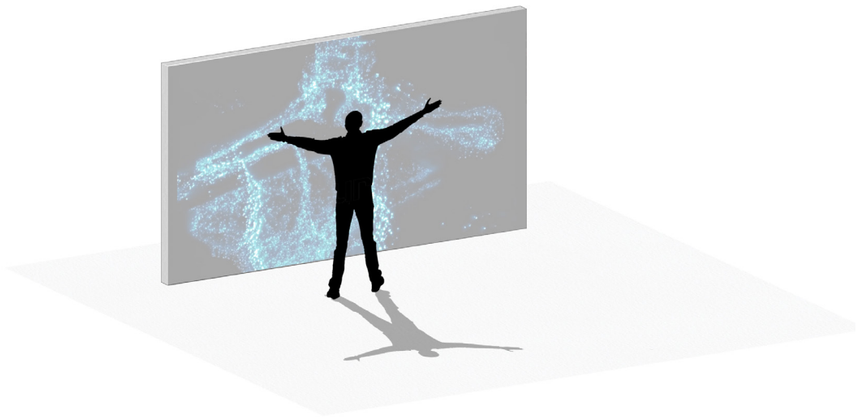


Figure 92: Illustration of user producing an outline of particles.

USER PRODUCES PARTCILES

6.2.1

Video 33

As outlined in the particle system explorations in Chapter 5 (5.4.7), a particle system has two inputs. The first being the geometry that generates the particles and the second being the geometry that displaces the particles.

This design development is initiated by the creation of a mechanism where the user produces the particles. The Kinect data is input into the system and is manipulated to form an outline of the user in three-dimensional world space. This outline forms the geometry which is input into the particle system as the particle generator.

The mechanism has multiple successful aspects. As seen in Video 33 the outline of the user does not appear instantly and the system captures the outline at timed intervals or when the user has been still for a certain amount of time. The individual's mark is becoming embedded into virtual space. The particle system has external forces applied, as time transgresses the remnants of the user's imprint slowly dilutes into digital space.

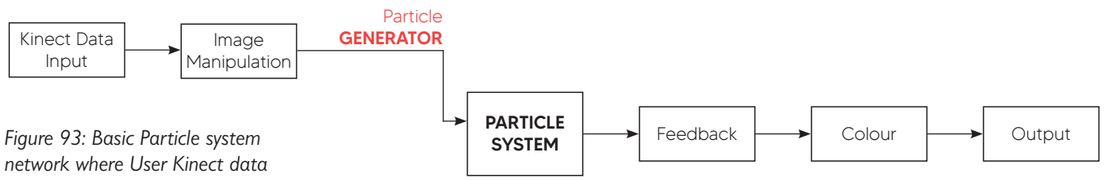


Figure 93: Basic Particle system network where User Kinect data produces particles.

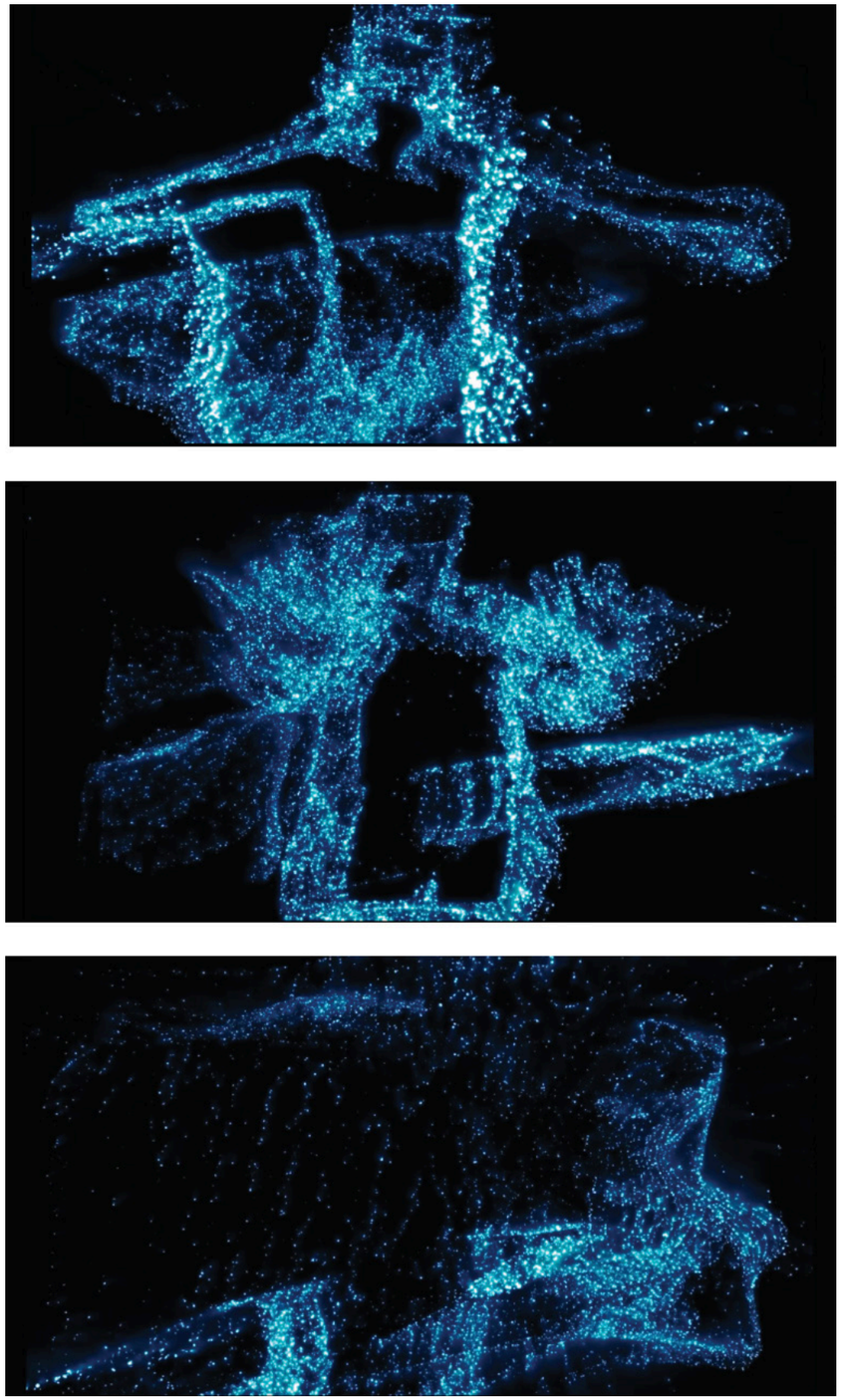


Figure 94: Series of user producing particles.

USER DISPLACES PARTICLES

6.2.2

Video 34

The second mechanism uses the Kinect user data to displace the particles. Similar to the last mechanism, the Kinect user data is input into the system. The image is manipulated to form a silhouette of the user which is instead inputted into the particle system as the particle displacer. A sphere, which is displaced by a noise field, is input as the particle generator.

As the user's motion is captured the particles are displaced and create a shadow-like visualisation. This mechanism is instantaneous but subtle. When combined with the previous mechanism (6.2.1), the system simultaneously captures the user's shadow and their outline. The effect creates the narrative that the longer the user is present, the more solid their digital trace becomes. The system explores how presence can be solidified at different points in time.

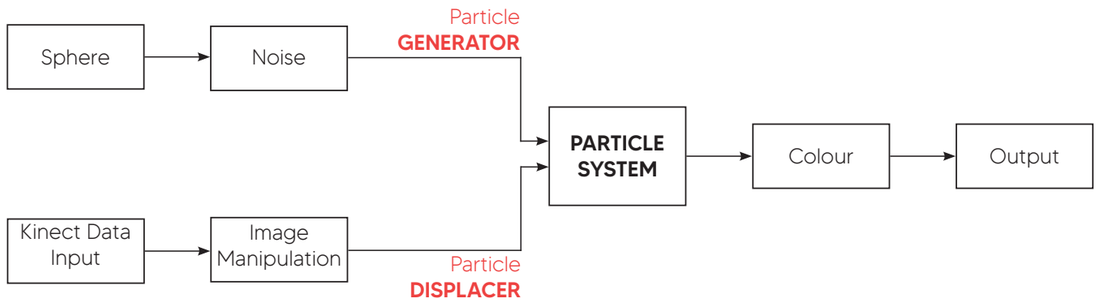


Figure 95: Basic Particle system network where User Kinect data displaces particles is added.

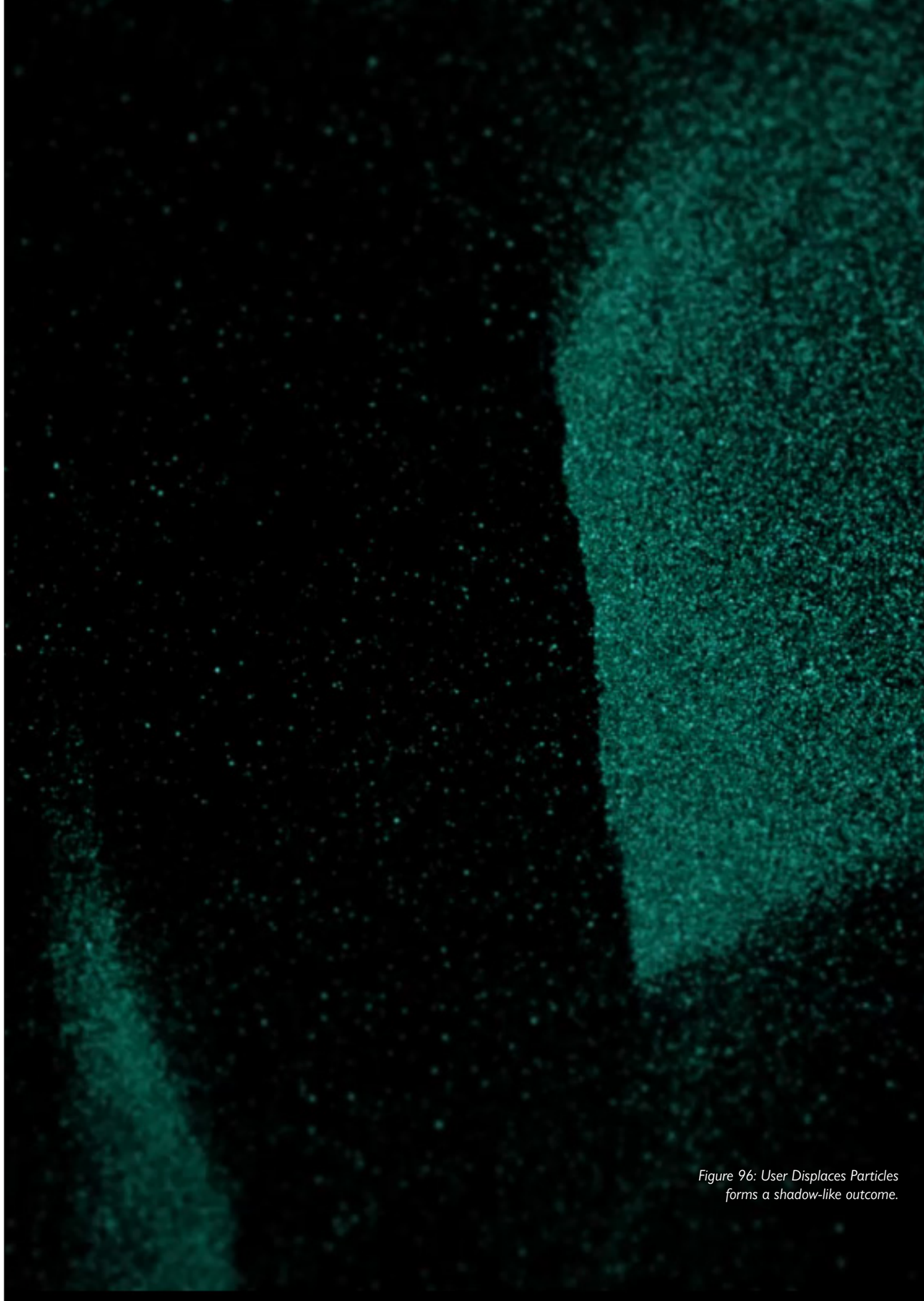


Figure 96: User Displaces Particles forms a shadow-like outcome.

PART TWO

MULTI-LAYERED PARTICLE SYSTEM

USER PRODUCES PARTICLES

USER DISPLACES PARTICLES

Video 35

Figure 97: Combination of two particle systems.

PARTICLES VISUALISE SOUND

6.2.3

Video 36

This mechanism introduces the element of sound into the simulation. Using the techniques derived in section 5.4.7, high and low sound frequencies are input into the drag and turbulence speed of the particle system. This enables the particles to react to sound. If the sound is a loud clap, the particles will jolt quickly. The more constant and continuous the sound, for example, music or continuous stream of voices, the more fluid the particles system becomes.

Sound creates an atmosphere in a space. A library is quiet and still, whereas an atrium tends to be a loud and busy atmosphere. The sound particles visualise the sound of the space and thus communicate the atmosphere. This element provides an interesting opportunity for designing for hearing impaired individuals, where they could see what the sound of the space is. The system becomes an interface to the intangible qualities of a building.

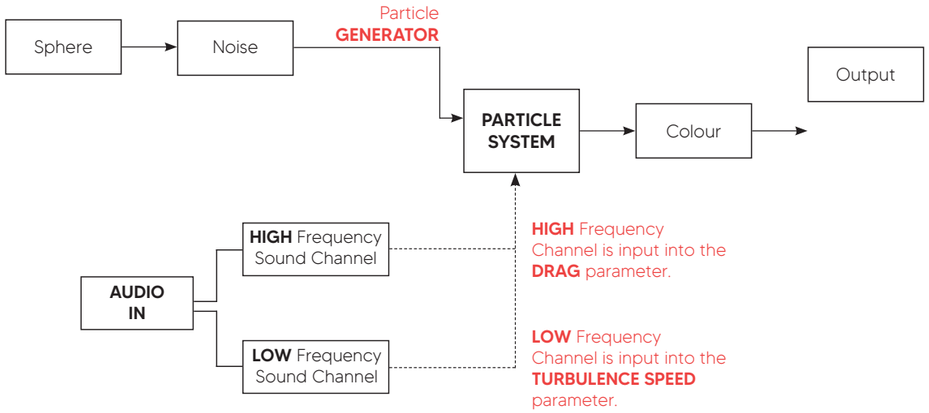


Figure 98: Network to produce particle sytem which reacts to sound.

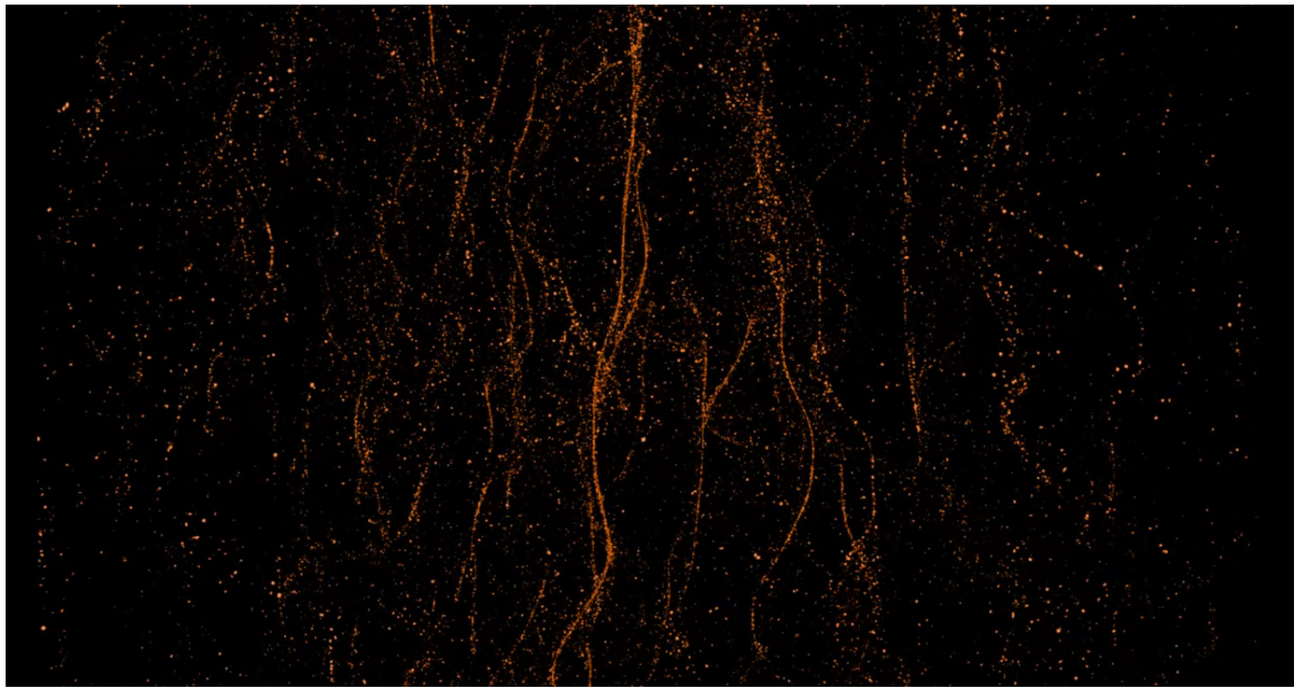


Figure 99: Particle syst

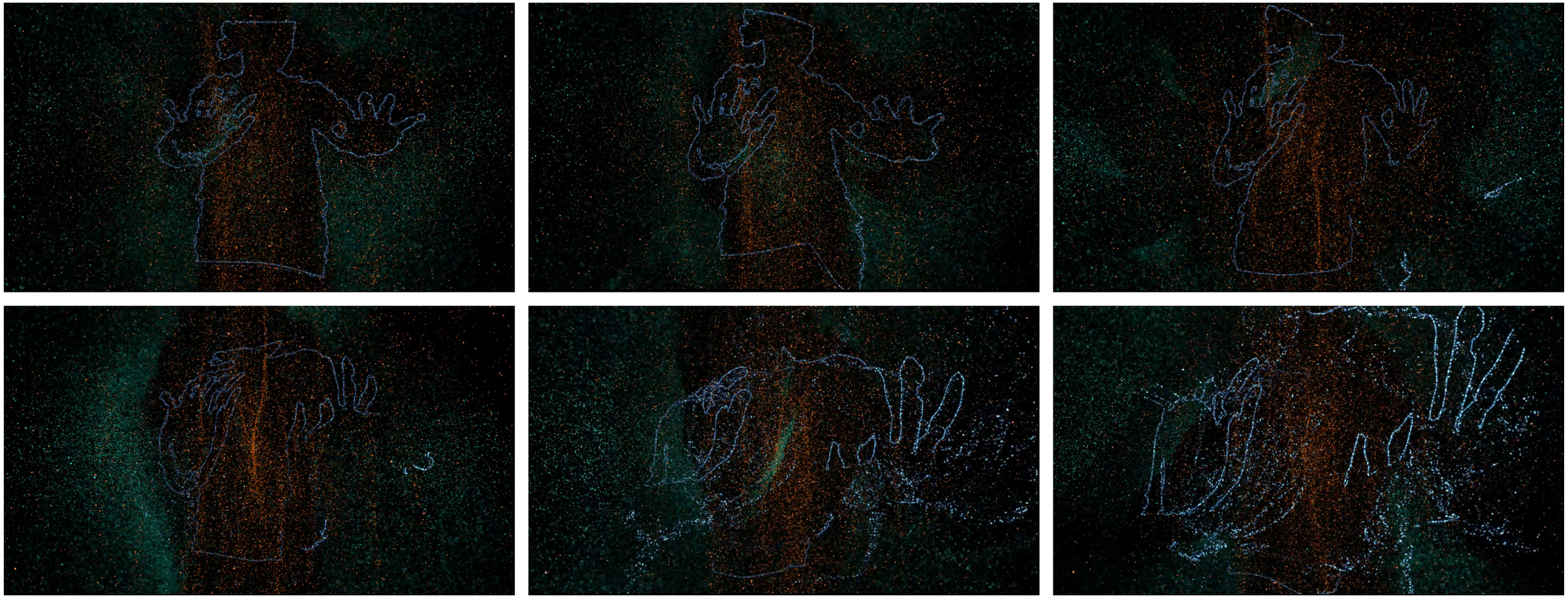


Figure 100: Combination of three particle systems.

Video 37

SECOND USER PRODUCES PARTICLES

6.2.4

Video 38

The last mechanism which is embedded into the system is the representation of a second user. A Python script has been used to develop this system, which defines if the second user is present or not. If the second user is present, an alternate particle system of user-generated particles is displayed. These yellow particles contrast with the original blue particles and fade in and out as the second user enters and leaves the captured area.

As we move through the world with our attention captivated in the virtual environment of our mobile devices, we often don't register the presence of another individual. This mechanism is designed to signify the presence of another individual, even if the first user cannot see the other person, the digital wall visualises their presence. This mechanism examines how the built environment can play a role enhancing our social awareness.

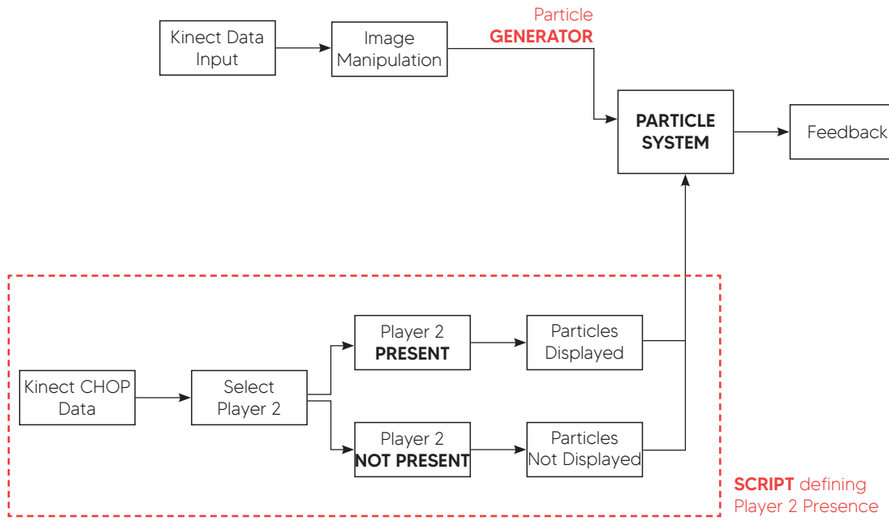


Figure 101: Network is adjusted to change to presense of second user.

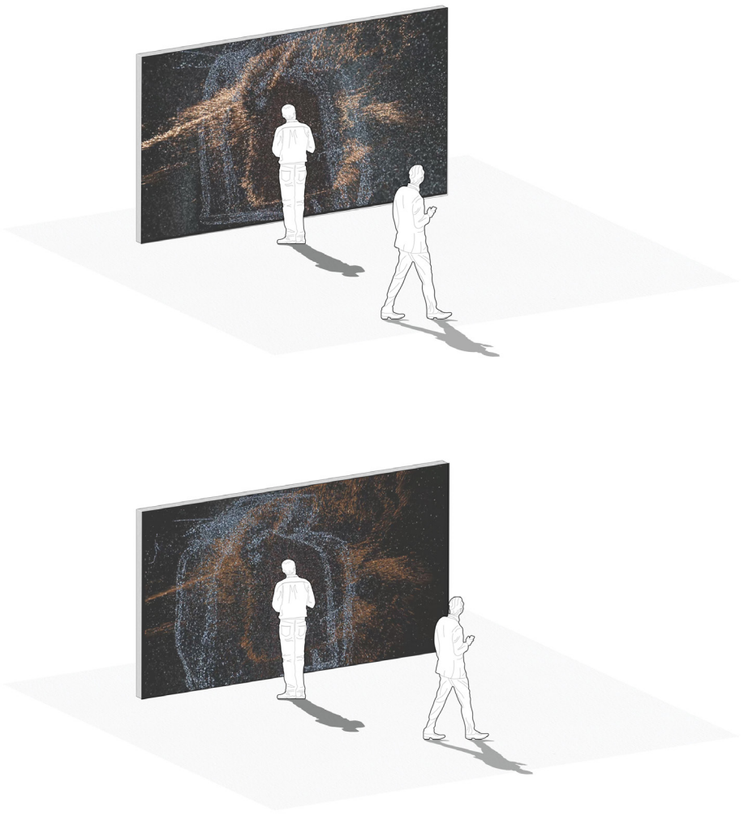
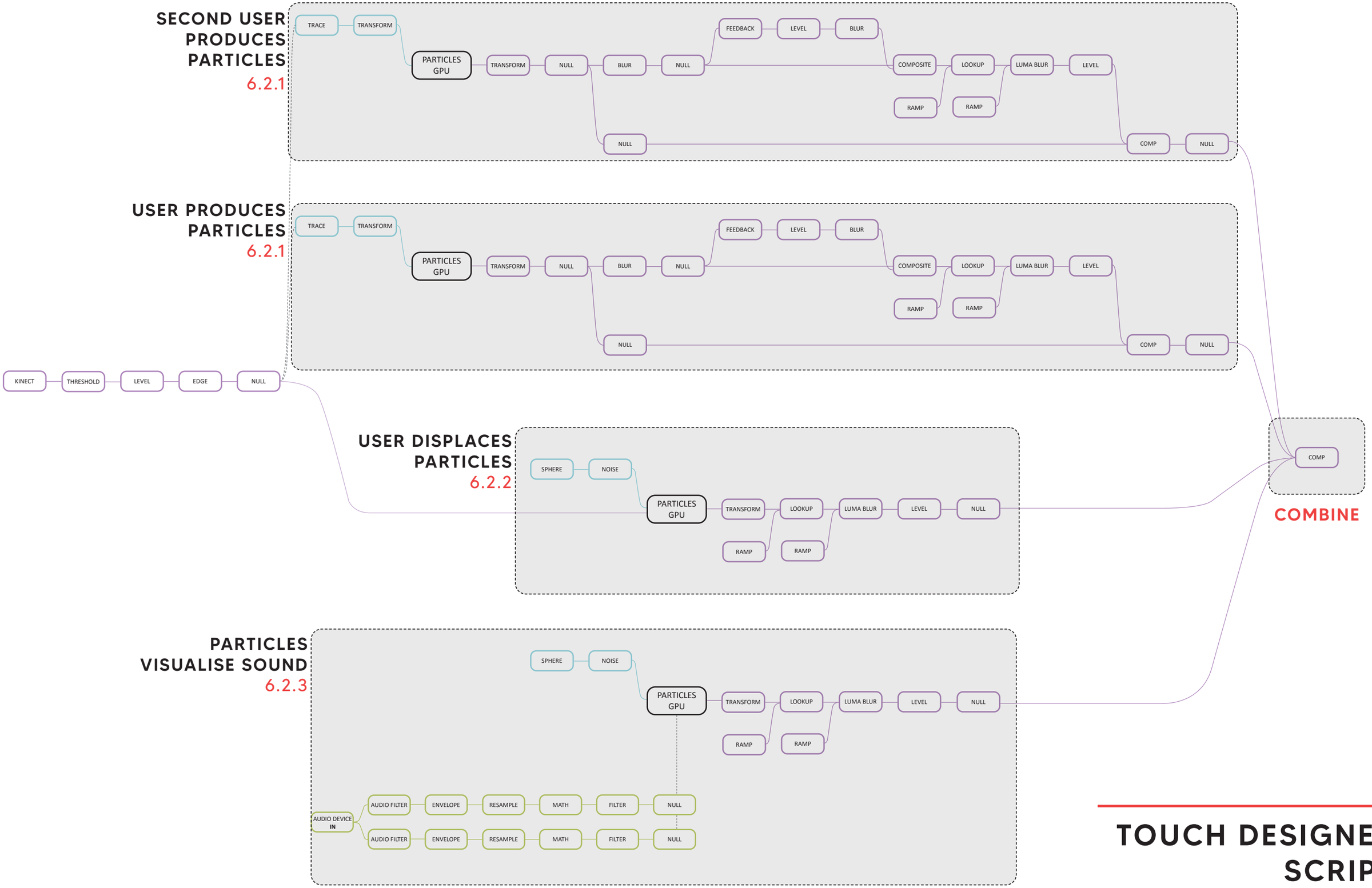


Figure 102: Feature is designed to enhance social awareness of other individuals.

Figure 103: Final TouchDesigner script for Part Two



TOUCH DESIGNER SCRIPT

PART TWO

INTERACTIVE OUTCOME

6.2.4

Figure 104: Part Two Design Outcome.

PRACTICAL APPLICATION

7.0

The research question aimed to explore how physical and virtual interactions can be combined to engage the public with the built environment. The virtual interactions have been established in previous chapters, in the following exploration the system is now ‘embedded’ into the physical context. “Embedded interaction refers to the transition in interface design from command line interfaces… to fully physically embedded systems” (Wessel & Sauda, 2012). While the system can be applied to any location, this chapter explores the application in two different physical environments. This creates an opportunity to investigate alternate applications and compare the benefits and outcomes of each physical setting.

The first application explores how digital media can enhance and alter the experience of a threshold space. In particular the threshold space of the Victoria University Architecture and Design Campus. The second application explores the opportunities of using the interactive media to activate unused urban space. Lukes Lane, was chosen for this application. The alleyway is vacant urban space in Wellington CBD which provides the opportunity to be activated and increase safety with the integration of a digital media installation.

Both applications explore how digital information can activate passive space. Aiming to create a sense of connection to place and engagement with the built form. This chapter is presented to examine the benefits and outcomes of designing augmented environments. Specifically examining how the designed system can integrate seamlessly into the physical realm.

$$\frac{\text{VIRTUAL INFORMATION}}{\text{PHYSICAL SPACE}} = \textbf{AUGMENTED SPACE}$$

Figure 105: Map of Te Aro, Wellington showing two sites of application

7.1

THRESHOLD

Threshold spaces are transition points in architecture which create a connection between architectural spaces. Thresholds are dual in nature; they are not connected or separate, public or private, open or closed. “On a threshold, one is neither inside nor outside. A threshold is simultaneously a place, a boundary, a transition, and an obstacle” (Janson & Tigges, 2014). There is a lack of permanence and ownership of place in a threshold.

Traditionally threshold spaces would demand attention, in the form of a step or door sill, and would influence a change of behaviour in the user. In today’s world, many are designed as mundane architectural conventions. Becoming so familiar, that we move through them instinctively with no recognition of transition of place. This unconscious transition is further exacerbated by the distraction of the virtual environment in our mobile devices. People who unconsciously pass through thresholds “no longer know the difference between inside and outside, but exist in a permanent in-between; no longer experience boundaries, but only possible margins; no longer experience transition, but only a continual passing through” (Stalder, 2009).

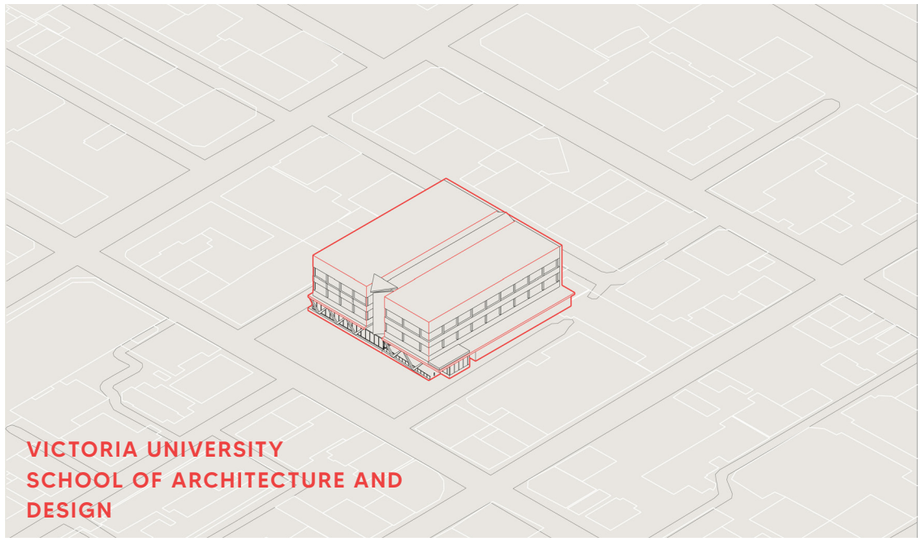
A threshold, is a space that must be passed through as entering a building, providing the ideal opportunity to create a targeted augmented experience. Digital media can capture the public’s attention, enticing them to slow down, stop and engage in a place which is designed for passing through. The intervention will encourage people to look up from their screens, to stop, to play, to enjoy before entering the building and starting their day. The benefits of a digital threshold have been exhibited in section 3.5 in Nexen UniverCity’s Infinity Wall.

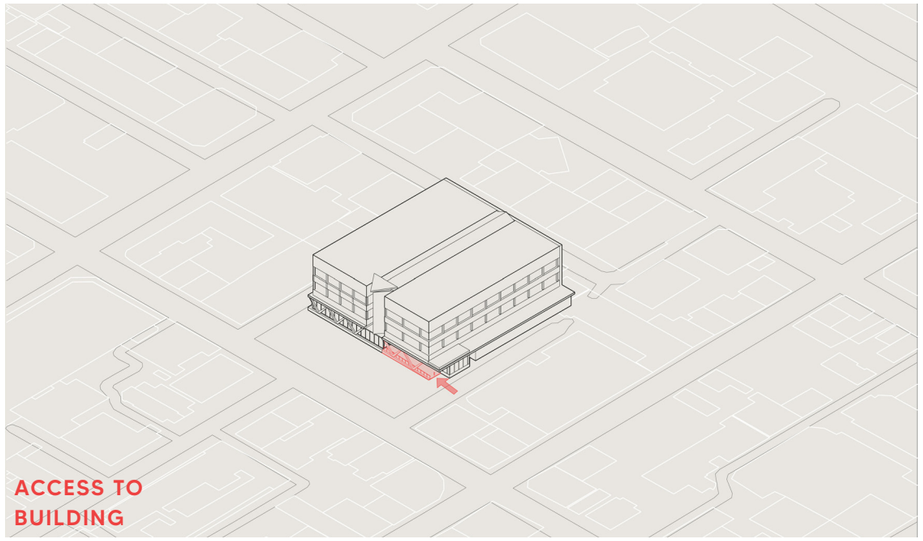
The immense scale and dynamic animations of the LED screen capture the attention of the public and change the atmosphere of the Lobby. An augmented threshold can create a small moment in time and space where people can become reimmersed within the physical environment.

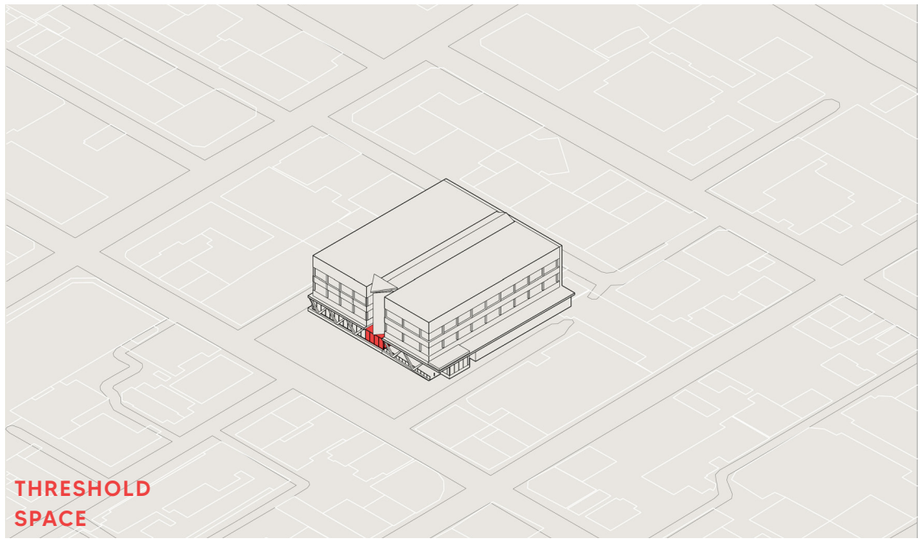
Thresholds act as a “preface to perception of architectural space” (Boettger, 2014). They provide context and an indication of the spaces to succeed them. The addition of virtual information can enhance the experience of passing between Space A and Space B and in doing so, alter the users perception as they enter Space B. As digital systems can be easily manipulated, there is an opportunity to control and alter the atmosphere of entering a building, without changing structural or material aspects.

The chosen threshold is the threshold space of the Victoria University Architecture and Design Campus. The building is accessed through a ramp which leads to a small threshold space, which is preceded by the public atrium. This threshold is designed as a space in itself but possesses no specific programme or use. The space is purely designed to be passed through. The following exploration examines how this space can be enhanced with the addition of an interactive virtual layer and how this can alter the experience of entering the building.

Figure 106: Victoria University School of Architecture and Design







THRESHOLD SPACE

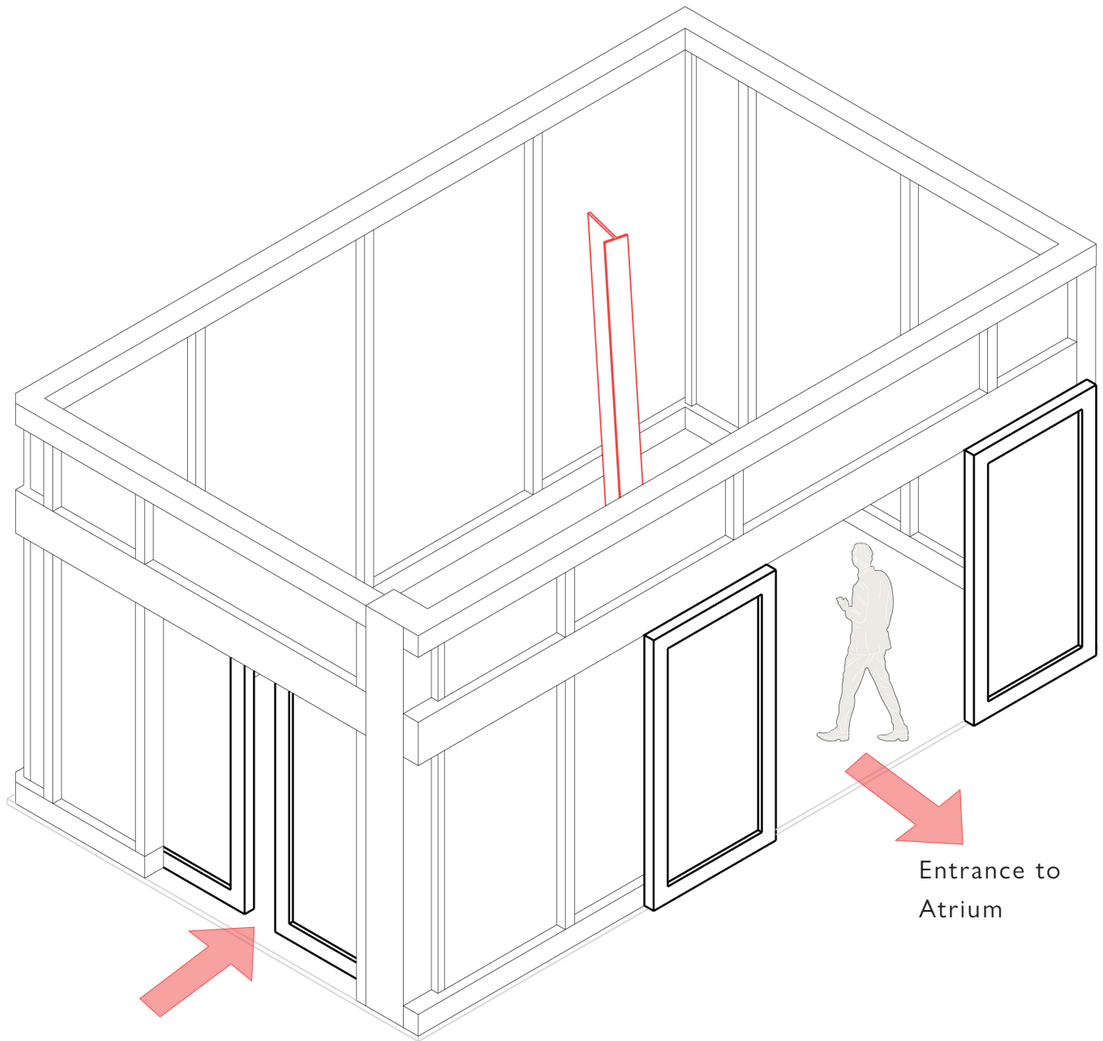
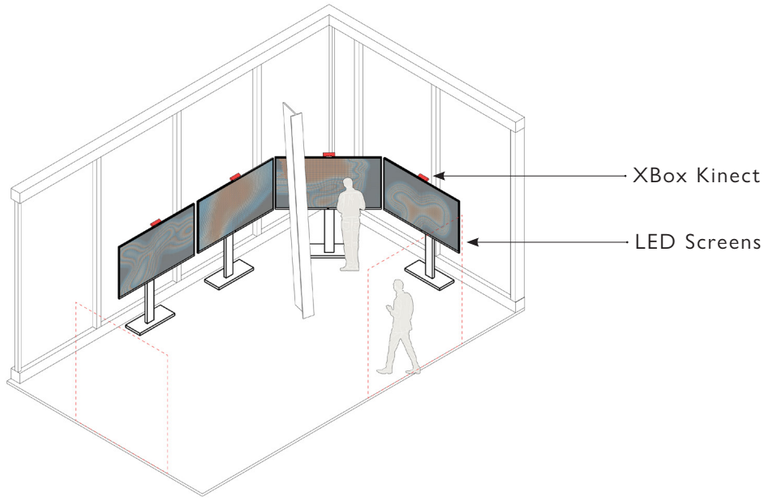
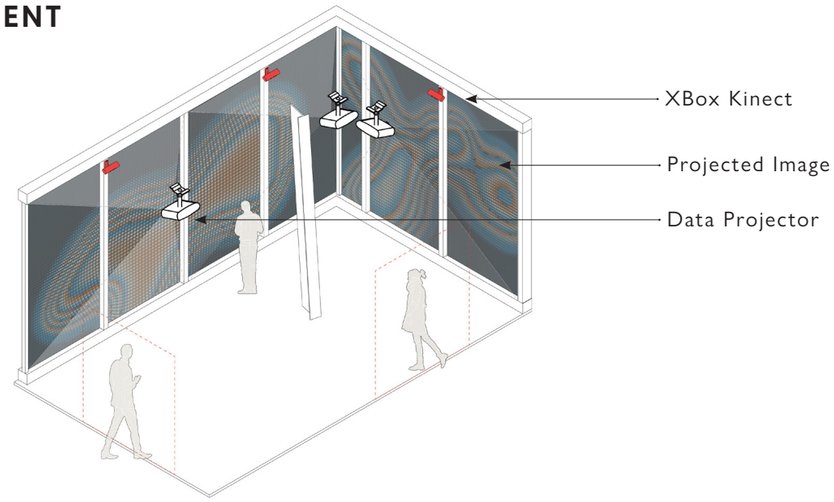


Figure 107: Current Threshold Space

TEMPORARY INTEGRATION



SEMI-PERMANENT INTEGRATION



PERMANENT INTEGRATION

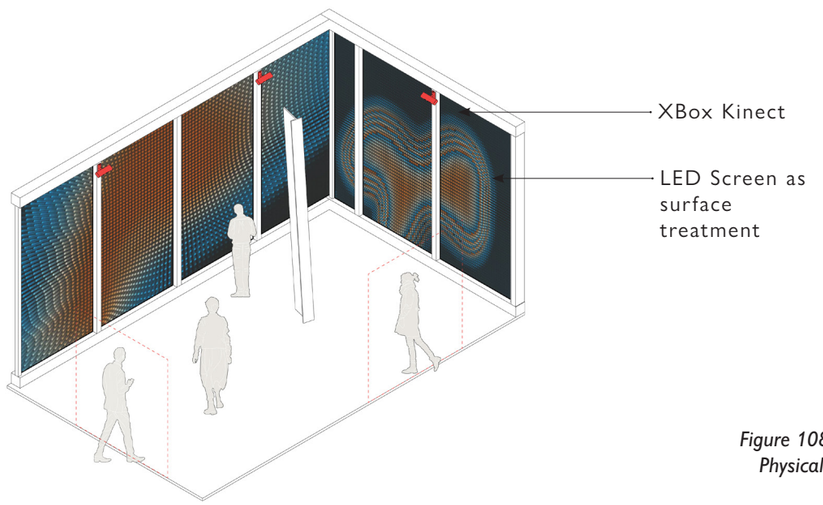
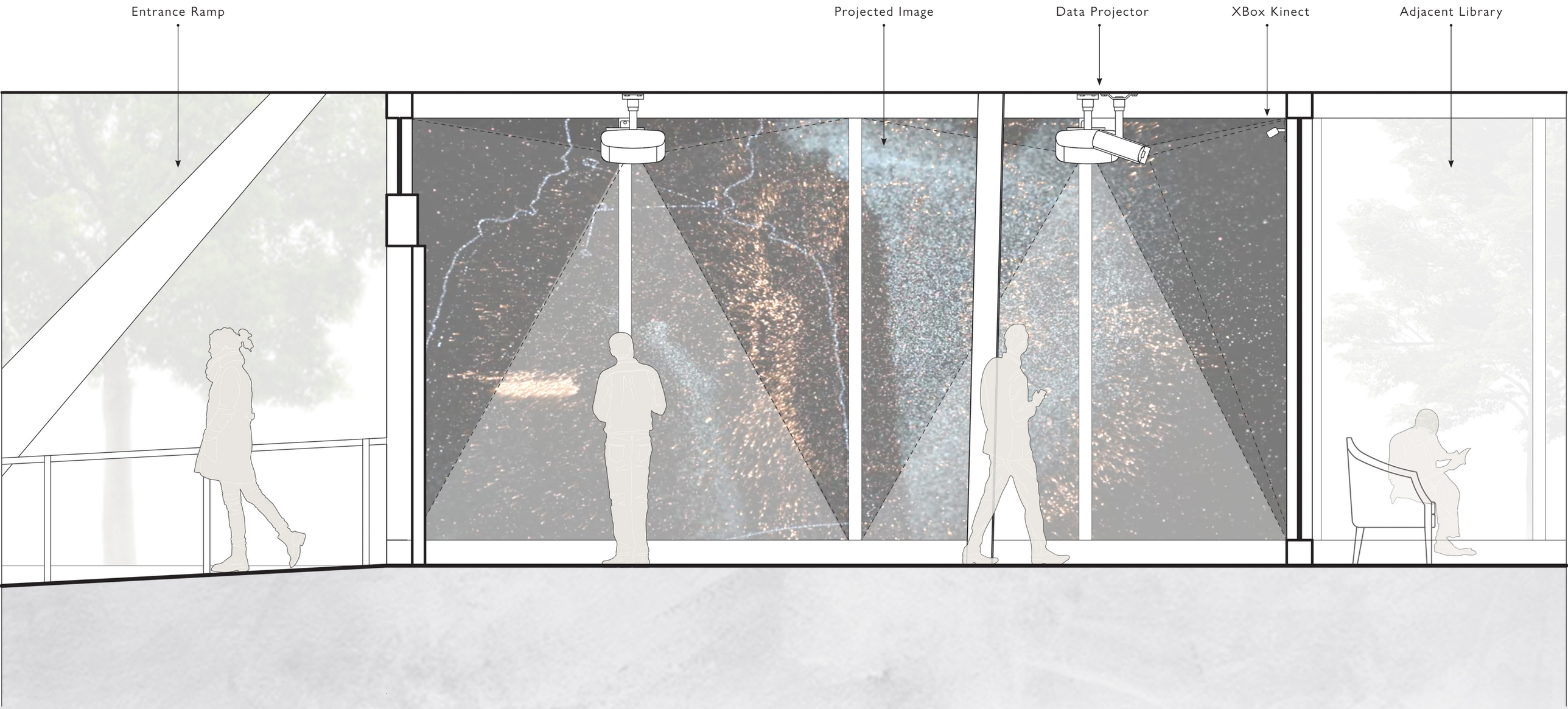


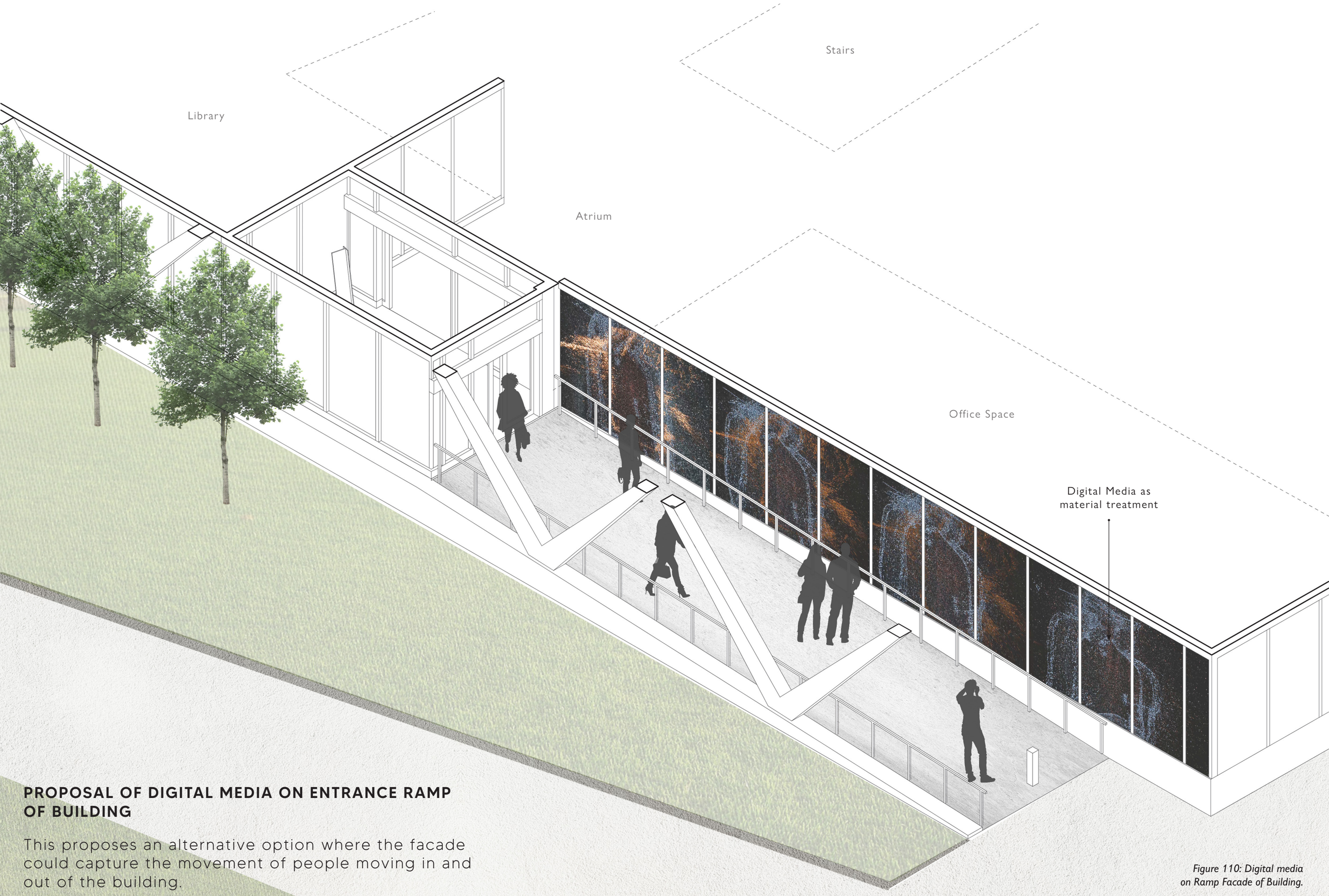
Figure 108: Options of Physical Integration.



SECTION OF THRESHOLD SPACE

Part Two Design outcome projected on windows.

Figure 109: Section of Threshold.



PROPOSAL OF DIGITAL MEDIA ON ENTRANCE RAMP OF BUILDING

This proposes an alternative option where the facade could capture the movement of people moving in and out of the building.

Figure 110: Digital media on Ramp Facade of Building.

Figure 111: Temporary Augmented Threshold Space.

7.2

URBAN ACTIVATION

Urban activation is a topic which is well researched and explored. Unused urban spaces, such as alleyways, car parks or public parks, can encourage unwanted behaviour and compromise feelings of safety. These spaces often serve no pragmatic purpose and lack a sense of place. This can be seen in the alleyway of Lukes Lane in Wellington CBD. The laneway possesses no defining characteristic or programme, lack of lighting and occupation result in the space feeling unpleasant and unsafe.

“For such spaces to better engage people and take advantage of virtual and physical capabilities, they must be adaptive to the people in them, incorporating not just passive displays but also interactivity in a particular place as a form of socially-intelligent computing” (Wessel & Sauda, 2012).

There is an opportunity to activate the laneway through the use of a digital interactive installation. The intervention proposes placing the interactive system within the alleyway using LED screens in the window of the adjacent building. The installation will bring light to the space, enticing people to play and interact, resulting in the alley becoming populated with human activity. Through embedded digital media, the alleyway can become enlivened with social presence and light, increasing the sense of safety.

The installation proposed for this space aims to stimulate and enliven the laneway, providing a public interface which can give the public “the ability to create and communicate meaning through their interaction with the system” (Wessel & Suada, 2012).

Video 39

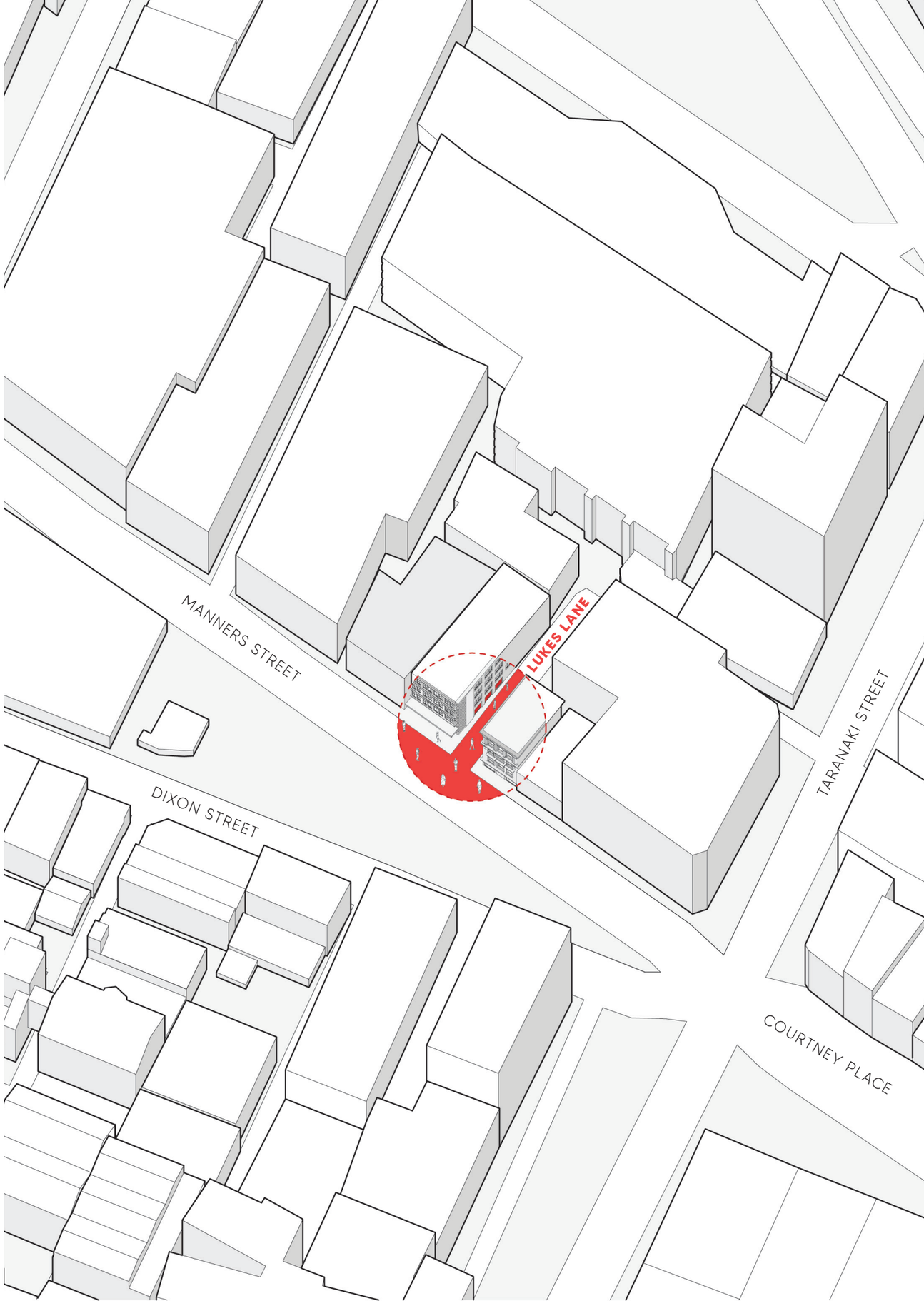


Figure 113: Using digital media to activate an Urban Alleyway.

Figure 114: Section of Lukes Lane.

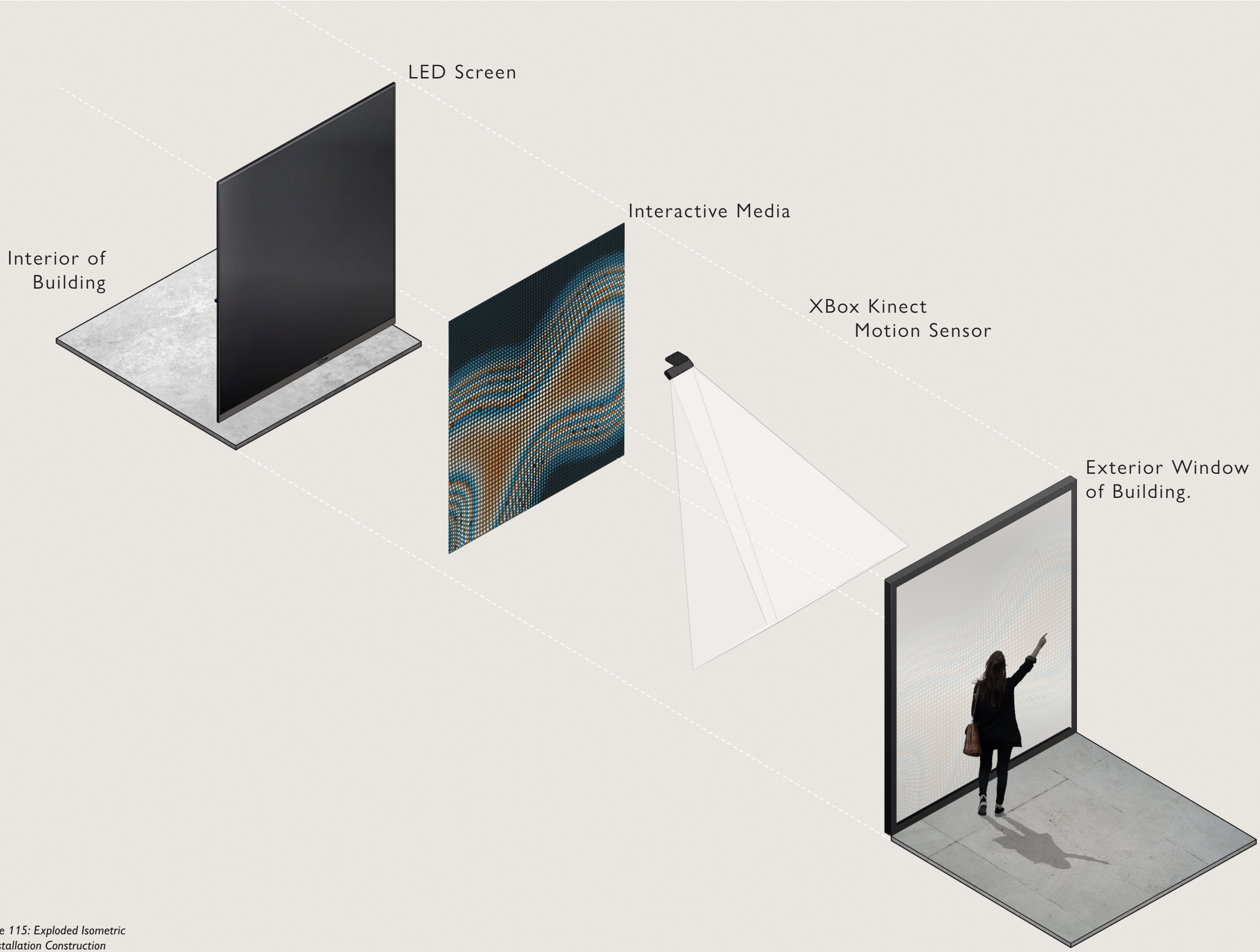


Figure 115: Exploded Isometric of Installation Construction

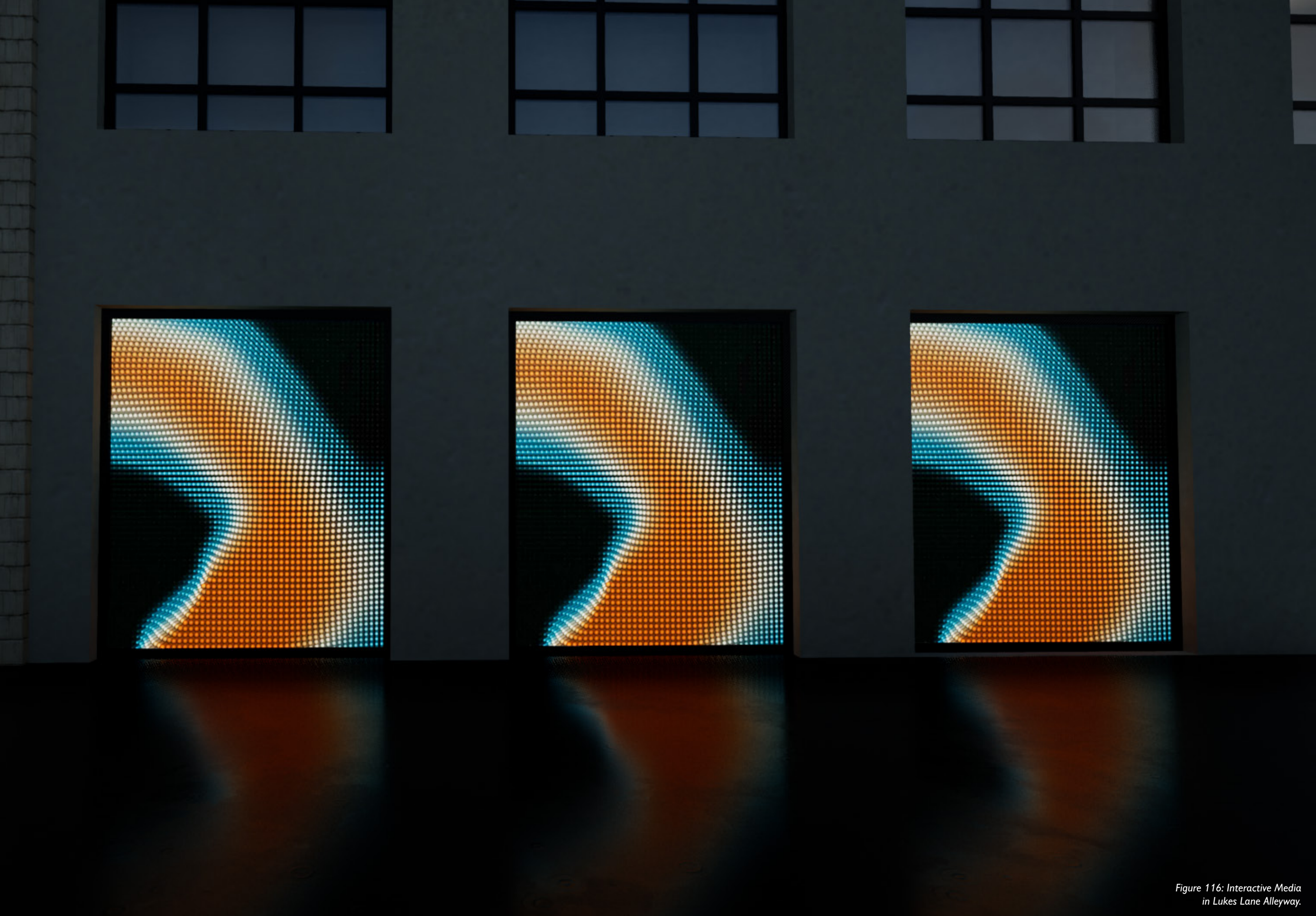


Figure 116: Interactive Media in Lukes Lane Alleyway.

Figure 117: Interactive Media in Lukes Lane Alleyway.

7.3

SUMMARY

This body of design-based research has explored the application of interactive digital media to physical space, presenting a potential for digital media to propagate both social interactions and architectural connections. The research shows that physical and virtual elements can be developed to encourage conversations between the public and the built environment. The application of digital systems can enhance the built form and activate passive space.

The application of the system to a threshold environment concludes that the addition of a digital system alters the experience of entering a building. The system adds social and cultural value to the space, and encourages people to move more consciously through space. The system creates the opportunity for users to reflect on their movement in and out of the building and in relation to other users of the building.

The threshold application also raised the insight of how the system is constructed in space; the construction can range from temporary to permanent. The exploration concluded that the more embedded the digital system becomes in the space, the more successfully it can be interpreted by the user.

The urban activation application served a different purpose to the Threshold application, exploring how the system can be used to increase safety and activate space. The urban alleyway application raises the question if the system can be specifically crafted to track individuals movement to enhance safety, but counteractively also raises the issue of ethics and social monitoring. The urban alleyway application is currently being considered as a possibility to be implemented in the site by Wellington City Council. The exploration shows the value of the system creating new interactions with space which would not previously exist.

EVALUATION

Design Evaluation		
1.0	**Visceral Criteria**	**Completion**
1.1	The digital media should be aesthetically pleasing as well as engaging other senses such as touch and sound.	X
1.2	The design should intensify and alter architectural effect.	X
1.3	The design should be visually stimulating and engaging.	X
2.0	**Behavioural Criteria**	
2.1	The design should include a high level of interactivity.	X
2.2	The system should be easily understood without explanation.	X
2.3	The design should use and manipulate real world input.	X
3.0	**Reflective Criteria**	
3.1	The design should communicate the intangible qualities of space.	X
3.2	The design should be presented in a thought provoking nature.	X
3.3	The design should enable performative architecture.	X

Figure 118: Physical Installation of System at Victoria Univeristy end of year Exhbition.

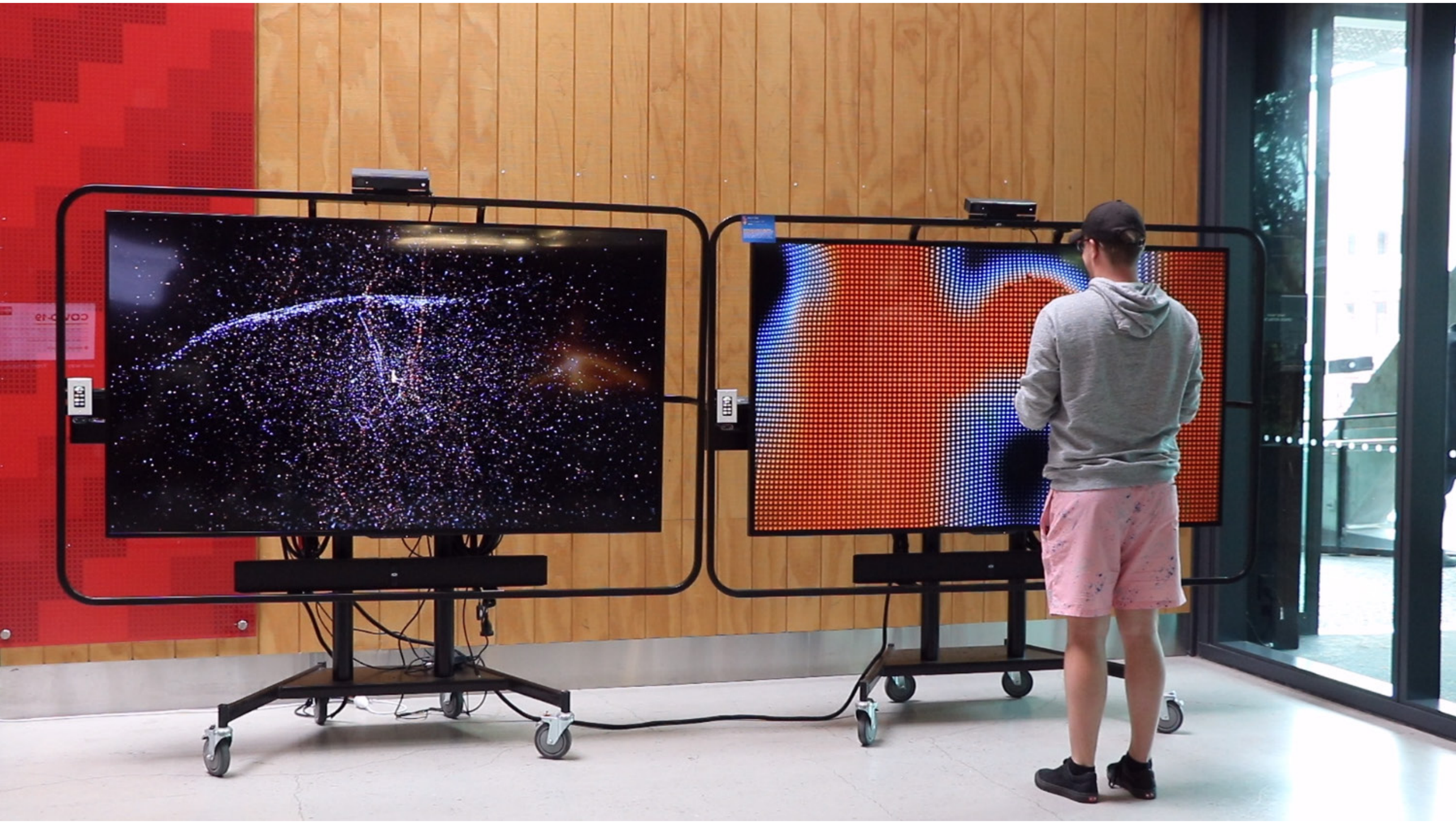


Figure 119: Physical Installation of System at Victoria Univeristy end of year Exhbition.

DISCUSSION

8.0

8.1

DISCUSSION

This body of research sought to explore if interactive digital media can play a role in enhancing public engagement with the built form. The research was undertaken in response to a lack of public attention to architectural space due to the development of mobile technology. The opportunity has been identified by multiple practitioners that architecture as a practice should be developed to include digital media as part of the built form. As a result of the contextual information, the research question was framed:

“How can physical action and virtual interaction be combined to engage the public with architectural space and create more meaningful connections to the built environment?”

The aims and objectives of the research proposed the investigation of the methods and technologies available to create augmented space. This was executed in the design exploration where Cinema4D, Unity and TouchDesigner were used to explore the parameters of creating an augmented system. While the experiments with Cinema4D and Unity did not directly aid the design outcome, the tests provided technical understandings which assisted in the Design Development phase.

The design development phase generated two interactive systems which create new interactions with architectural space. The third objective was achieved through the application of the system to two different spatial environments; a threshold space and an urban laneway. The practical application provided the opportunity to examine the opportunities and benefits of applying the system to different architectural environments.

A key insight gained from the research is that interactivity is a critical element in the development of a virtual system, without the element of interaction the system risks becoming a mundane feature in everyday life. As exhibited in the case studies ‘Cocoon’ and ‘The Infinity Wall’, a pre-recorded animation is only engaging for a certain amount of time. This is exhibited in the design exploration, Animate (5.2), where Cinema4D was used to create abstract animations. The videos target the user’s immediate visceral responses but due to lack of interaction, the engagement level decreases quickly. Through giving the user the ability to control the experience and craft the narrative, concepts of performative architecture (2.5) are applied. Performative architecture gives the user a sense of agency and enables them to exercise their creativity within a space. Interaction opens the opportunity for the built form to become reactive, enabling the inhabitants to play a significant role in shaping the atmosphere of space.

The physical application highlighted key learning regarding how the virtual system is embedded in physical space. In the exploration of a Threshold space (7.2), multiple installation methods were examined: concluding that the application of augmented space can range from temporary to permanent, which can alter the overall effect of the intervention. It is evaluated that augmented space is more successful when it is fully embedded into the architectural structure and form, thus is perceived as part of the building, which enables enhanced interaction with the architecture itself.

The systems developed to provide an opportunity for the architect to enable the public to have new and unique interactions every time they inhabit a space. The research speculates the possibility of digital media as a form of materiality which creates the opportunity to flexibly craft atmosphere. Virtual interaction encourages physical activity within the public, enhancing engagement and forming meaningful relationships to space.

8.2

CRITICAL REFLECTION

The potential for architects to apply digital media as a form of materiality was outlined as an opportunity in the research. An effective digital system and physical application was explored and provides proof of concept. There is a shortcoming in the research to develop a framework for incorporating digital systems as part of practice. The research shows how a digital system can be applied to an already constructed space but there is an opportunity to investigate how the virtual information can be embedded into the design as part of the preliminary initiation of a building design. Further advancements of the research could outline how digital materiality can be applied in practice and utilized in building construction.

TouchDesigner was the software chosen as it could be utilized to create the desired interactive outcomes. While Augmented Reality applications were briefly explored in Chapter 5.3, further research could apply the design principles outlined in this thesis to the creation of an Augmented Reality application. The interactive principles could be explored using an alternate method of AR application design in Unity. The progression of the design research could result in an application which provides an alternate perspective of how virtuality can enhance public interaction with physical space.

The design research resulted in two interactive systems being developed that create visual representations of physical actions. Further developments of the design research could explore systems which are more tailored to specific human characteristics. Questioning if a building's interface could adapt to a user's age, height or gender. This speculation of further development also highlights the difference in data used within the system. The systems both use real-time input data to manipulate the visual outcome. The addition of stored data or collected could enhance the complexity of the system, this can be seen in Refik Anadols work where he manipulated a buildings historical data, or in Mark Goulthorpes Hyposurface, where weather data is defined as an input parameter. The addition of external data channels provide the opportunity to increase the complexity of the system and thus create a more complex reflection of the work.

8.3

CONCLUSION

This body of research has explored how interactive digital media can be embedded in architectural space to encourage new interactions between the public and the built environment. The creation of a digital interactive system provides proof of concept which can be implemented in any built environment. The exploration of the system in two alternative architectural spaces explores the different outcomes and benefits of contrasting applications. The system has proven effective as it is now being considered for physical implementation by a property developer in collaboration with Wellington City Council.

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9.0

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APPENDIX

10.0

FIGURES

Figures not listed here are created by the author.

Figure 4 Artut, S. (2017). Incorporation of computational creativity in arts education: Creative coding as an art course. SHS web of conferences, Vol. 37, 1028.

Figure 5 Alavi, H. S., Churchill, E., Wiberg, M., Lalanne, D., Dalsgaard, P., Fatah gen Schieck, A., & Rogers, Y. (2019). Introduction to Human-Building Interaction (HBI): Interfacing HCI with Architecture and Urban Design. ACM transactions on computer-human interaction, Vol.26, 1-10.

Figure 7 Price, C. (1959-1691). Fun Palace for Joan Littlewood Project, Stratford East, London, England (Perspective). Retrieved from Museum of Modern Art: https://www.moma.org/collection/works/842

Figure 8 Fifteen, F. (2015). Cocoon. Retrieved from Factory Fifteen: http://www.factoryfifteen.com/project/cocoon

Figure 9 Fifteen, F. (2015). Cocoon. Retrieved from Factory Fifteen: http://www.factoryfifteen.com/project/cocoon

Figure 10 Fifteen, F. (2019). E-Brush. Retrieved from Factory Fifteen: http://www.factoryfifteen.com/project/ebrush

Figure 11 Fifteen, F. (2019). E-Brush. Retrieved from Factory Fifteen: http://www.factoryfifteen.com/project/ebrush

Figure 12 Anadol, R. (2018). Walt Disney Concert Hall Dreams. Retrieved from Refik Anadol: https://refikanadol.com/works/wdch-dreams/

Figure 13 Space10. (2020). Everday Experiments. Retrieved from Space10: https://space10.com/project/everyday-experiments/

Figure 14 District. (2019, September 5). Nexen Univercity “The Infinity Wall”. Retrieved from Vimeo: https://vimeo.com/357990150

Figure 15 Graham, D. (1974). Dan Graham’s Artworks. Retrieved from Lisson Gallery: https://www.lissongallery.com/artists/dan-graham/artworks

Figure 67 Cinar, Z. (2017, June 29). Paradoxical Architecture. Retrieved from Zeynep Cinar: https://www.zeynepcinar.com/writings/

Figure 68 Bibiena, G. (18th Century). Design for a Stage Set with a Monumental Arcaded Courtyard. Retrieved from Met Museum: https://www.metmuseum.org/art/collection/search/377854

Figure 89 Anadol, R. (2020, June 01). Machine Hallucinations: ISS Dreams. Retrieved from Refik Anadol: https://refikanadol.com/works/1775-2/

EXTERNAL VIDEO LINKS

Video 1 https://youtu.be/rdbmgJRsuac

Video 2 https://youtu.be/7YuWV020Yns

Video 3 https://youtu.be/j_HfEA2nFg8

Video 4 https://youtu.be/_fdTn9QzsDA

Video 5 https://youtu.be/clg5tDDpUfg

Video 6 https://youtu.be/r6zvRZLetoQ

Video 7 https://youtu.be/FMMKUy4o39A

Video 8 https://youtu.be/6yJ2EHkAmCU

Video 9 https://youtu.be/0dUFPpIIDpU

Video 10 https://youtu.be/I_iP31kc804

Video 11 https://youtu.be/firVDkfCwbs

Video 12 https://youtu.be/dID5XpLnR14

Video 13 https://youtu.be/zcZdgxU1Kpw

Video 14 https://youtu.be/sjpkoD3yhio

Video 15 https://youtu.be/UMD1C1xi4n0

Video 16 https://youtu.be/p60WZQK9T3o

Video 17 https://youtu.be/ndts7irYC6s

Video 18 https://youtu.be/E_Dro2vfq8A

Video 19 https://youtu.be/468mYQ5Fy2U

Video 20 https://youtu.be/0gxr4lrMLAU

Video 21 https://youtu.be/KQaQS-fhkKU

Video 22 https://youtu.be/V8_mmrMkAbQ

Video 23 https://youtu.be/8RIXIgxbTsA

Video 24 https://youtu.be/nnYuFW4dTpU

Video 25 https://youtu.be/HVdeEMhy-wE

Video 26 https://youtu.be/wQXgW7rSGE0

Video 27 https://youtu.be/ZvlzSKZKOr0

Video 28 https://youtu.be/MYUihJ1J820

Video 29 https://youtu.be/24d1L0iG0_w

Video 30 https://youtu.be/Ys-NU8We84g

Video 31 https://youtu.be/9Y_4tUXxNAc

Video 32 https://youtu.be/SRlinsKQLcM

Video 33 https://youtu.be/538NrO3wFVw

Video 34 https://youtu.be/6nfSP9ITYU4

Video 35 https://youtu.be/n56NHzUXuik

Video 36 https://youtu.be/NI4Wx-RMprw

Video 37 https://youtu.be/Pwq6WC0_O34

Video 38 https://youtu.be/1GKvPuLEFH0

Video 39 https://youtu.be/FAtgupffVbA