

# Virtual Paradise

Augmented Reality as Building Material

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Figure 01

## Editor's Note

This thesis is based on a fear of technology growing at a never-ending rate. It seems that within today's world, tech companies have more power than politicians, and know more about ourselves than we do. Our personal lives and information are beginning to be stored on servers all across the globe and sold to the highest bidder. At the same time, Virtual Reality (VR) is becoming a highly profitable and believable technology. Films, such as "The Matrix" and "Ready Player One", discuss a world in which our lives are lived within a virtual world and this virtual world is more important to us than the physical world.

Over the past decade, we have seen growth for action against climate change. At the same time, we have seen politicians choose to ignore cries for help from the community and push off the issue until it is too late. Some believe that VR may be a way for us to live normal lives when it is too dangerous to go outside. In this sense, we are creating an issue and creating a solution that does not solve the issue at large. Through industry trends in this VR space, it seems that mixed reality is becoming a more popular idea in which this virtualization happens

through a lens and is projected over our existing world. This allows for interaction in everyday space. This is similar to augmented reality (AR) with the added layer of interaction with virtual objects.

This thesis was conducted through the tactics of a conventional style of research through existing publications on the matter and a series of physical studies. The compilation of this thesis is meant to be unbiased to the growth of technology. The research presented is meant to create discussions on how this growth of technology can be molded into a useful tool for architects to use as a way of heightening architectural experience.

-Joe Loria



## THESIS ABSTRACT

This thesis focuses on an ever-growing and expanding field of augmented reality and discovering who will have to design these systems. Throughout the Covid-19 pandemic, industries have focused on online and virtualization of everyday systems. These systems are as simple as online shopping to Facebook's focus on the "Metaverse". Virtualization is beginning to make its way into our everyday lives at an increasing rate and as this becomes an augmented system, we will need to design these systems into our buildings. Some of the goals of this research were to discover a world where augmented reality has integrated with society. This has turned into discovering the types of virtual systems that could be integrated into the architecture. In a sense, these systems become part of our building materials. The methodology of this study has been split between classic reading, writing research, and research by making. The experience created for this research is inspired by the topic and open-source software used to create location-based AR. This thesis finds that within the design process, virtualization is already included, and this could be easily intercepted into structures

with BIM modeling. It allows for the virtual representation of a project to live on and communicate information about itself to its users. This study overall has worked to lay the groundwork for a future of architecture in which these systems could be implemented. It allows architects to think about the virtual entities we make as more than representation and could allow us to create truly inspiring work that isn't physical.



## THESIS STATEMENT

Since the mid-twentieth century, the world has seen an overwhelming increase in the use of technology in our daily lives. This can be seen through what seems like a necessity to own a smartphone or computer. Our daily lives are being shared and reacted to constantly online, over saturation of news articles of differing opinions at the touch of a button, and an expectation to always be kept up to date on the latest drama. Technology's widespread use and ever-growing popularity create the opportunity for virtual heroes and villains in our day-to-day life. Today we see a push toward full virtualization of our lives through the use of Meta's (Facebook) Metaverse and real worlds tests of augmented reality presentations of ads and experiences brought through the Covid-19 pandemic and virtualization of daily lives. This shows that the expansion of technology in our lives does not plan on stopping anytime soon and will most likely grow larger as time goes on.

Previously stated regarding Meta's (Facebook) Metaverse, this full virtualization of our lives does not plan on staying private. Virtual and augmented reality are

beginning to allow companies more investment in our daily lives without us noticing overmuch change. Not all implementations of this technology can be harmful. This technology can create helpful teaching and learning scenarios and truly enhance the architectural experience.

These two sides of a virtual coin create questions of what a world where technology has worked its way into most spaces of our life looks like. Some may say that this idea of the Metaverse could help us in the case of climate change where going outside may be too dangerous. This would only create solutions to problems we created, rather than fix the issue at its core while keeping us separated from living a real life. Others may see augmented reality as a better solution in which virtual elements are introduced into our daily lives in reality allowing us to see and interact with these things physically. The fear of AR comes with the understanding that virtual objects do not physically take up space, and thus can be deployed anywhere with little effort. This would mean that advertisements, posters, news, etc. can be broadcast anywhere in the world easily and

be harder to suppress than just turning off a device.

This thesis plans to show and create design guidelines around this topic of technology integration, specifically augmented reality installation within our daily lives. This thesis will create instances physically and theoretically to show ways in which this technology can help us, discuss the harms around the expansion of these installations, and create a set of rules around how to contain this work and let it Thrive

This research has led in a direction of augmented reality as a predecessor to virtual reality. Much of what is publicized is this concept of web 3.0, the blockchain, and the metaverse. In the background, VR is already being used for tasks of simulation. This simulation looks toward bringing these experiences into the real world. Augmented reality is not a new and future concept by any means, but is something that is in its infancy and will grow like a parasite if not controlled properly.

The main critique of this thesis is the viewpoint of virtual reality

being more accessible than the metaverse. The metaverse is this concept that has been all over media outlets. It has become the sole innovative goal of Facebook. NFTs have been selling “land” and accessories to be used in this future metaverse. This craze for virtual/non-fungible items can seem absurd to those who are not taking part in the trend. NFTs are marketing art in a similar way to stocks and cryptocurrency, all while there is a global warming crisis that this new blockchain contributes to. All of this technology works toward creating a decentralized system that in itself is centralized on a specific goal. The amount of energy that is required to power these systems as well as a contributing factor to the opposing argument of this technology.

The largest limitation of this study is access to this technology. While there is technology being created that can create experiences similar to this it is, in addition to being expensive, still in its infancy and limited to what it can do. Examples of this technology is Mixed Reality goggles and Microsoft HoloLens. Currently, it is difficult to ground virtual objects in the real world- it will not be that way forever.

## THESIS STATEMENT

Another limitation of this study is the lack of public research regarding Augmented reality. Much of this research is confidential from companies working on this technology, though there have been some open source projects which have been helpful.

This thesis concludes that architecture and technology have begun a sort of merger beginning in the mid-1980s. This is from the creation of software tools such as CAD which allow architects to create virtual projects that could be created within the real world. It is at this point that the virtual interpretation of a project “dies” and the physical takes its place. Considering the work that goes into creating extremely detailed virtual structures, this seems like a waste. The solution to this is to allow the virtual to live on and attach to the physical.





# INTRODUCTION

# Introduction

This thesis investigates the virtual world and gathers information on the current status of Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) with the goal of demonstrating what the future could hold for this technology and ourselves. The broad area of study will be examining the architect's role in a technologically advanced society. A society in which the end-user interacts with both virtual and physical entities daily. This society would cause architects to begin designing both the physical building but also its virtual counterpart. More specifically, this thesis examines the field of augmented reality and its use within architecture. Through this, the thesis considers the psychological effects of interacting and living within the virtual realm. This thesis also considers how augmented reality can be manipulated for a worse outcome for society- similar to cellphone and social media addictions, unwanted targeted advertising, and selling of user data in our current world.

The theoretical basis for this research comes from articles throughout the Covid-19 pandemic discussing the mass increased use of virtual reality through cheap consumer headsets such as the

Oculus Quest 2, which is one of the most popular consumer-grade VR headsets on the market. Virtual reality has become a staple of technology within this current time and an escape from the four walls of our homes. This technology allows for the user to be placed in a virtual world which can seem similar in scale to our world creating experiences available or greater than the physical world. These new frontiers into this virtual realm create a sense of fear for the future such shown in movies like The Matrix, Inception, and Ready Player One.

## Precedence



Figure 1.1

Mars House – Krista Kim  
(Fig. 1.1).

Mars house is an NFT House designed by Krista Kim. The home is not physical by any nature and can only be viewed through images, video, or virtual reality. The house was sold for \$514,557.79 via Ether (a form of cryptocurrency) in exchange for the 3D files of the “Home”. (Kolirin) The article states that the designer had designed the “house” for the metaverse. (Kolirin) The system of NFTs and cryptocurrency are both run on

what is known as the “Blockchain,” a series of computers all verifying encrypted transactions for cryptocurrency. Similarly, NFT art such as the first 5000 digital arts of Bepple’s one a day series of abstract digital art has sold for approximately 69 million dollars in Bitcoin (Currency) making him one of the top 3 most valuable living artists.

## Refill - Code on Canvas (Fig. 1.2)

Refill is an art installation based in Sydney, Australia for the 2014 Lights Festival, which incorporates a recycling bin with augmented reality. The system scans the object that you are recycling and creates a virtual image of that scan before disposing of the object. (Code on Canvas) The Box also contains a set of projectors that shine on the adjacent building. After the object is dropped into the bin, the projector shows the object falling down the side of the building while

bouncing off walls and doors with realistic physics. (Code on Canvas) this gives the illusion that the object is collected on the building and shows the pile-up of recycled material on the wall.



Figure 1.2



## Precedence



Figure 1.3

Niagara's power transformed -  
Thinkwell Group (fig. 1.3)

Thinkwell Group is dedicated to creating inviting, interesting, and interactive projection installations. This precedent uses a series of projectors and motion capture sensors to create an interactive display of imagery through the Niagara Park Power Station. This installation used projection to change space, extend space, and allow the users to modify the space based on their movement.

The projection lasted approx. 40

min in length before repeating and span for approximately 600 feet in length. The projections were meant to tell the history of Niagara and also show how the power station used the falls to generate electricity.

## Berl-Berl - Jakob Kudsk

Berl-Berl is a popular Nightclub in Berlin Germany. The Nightclub is situated in an old abandoned warehouse keeping the aesthetic of the old deserted and degrading walls. This installation used a series of mirrors and projections to change the space from a warehouse of 4 walls into an expansion of outdoor exotic worlds. The projections of these worlds are displayed on the walls of the warehouse, and mirrors are placed on the ground to extend these images downward.

Aside from the moving images, the installation does not interact with the users through gives a look into how virtual and physical can work together to create a meaningful and expansive space.



Figure 1.4

## Precedence



Figure 1.5

### AR Installation - Code on Canvas (fig. 1.5)

This installation by Code on Canvas uses AR to transform a publicly used space into a realistically

Mandalorian Set - Disney  
(Fig. 1.6)

moves through the set as well as changes based on camera placement within the set.

The Mandalorian is a Star Wars based series on Disney+ which follows a Mandalorian on his adventures in a galaxy “far far away.” The set design of this show uses a series of color accurate, bright, and massive LED Screens. This paired with a team of special effect artists working real-time in Unreal Engine creates an expanded universe for filming. This turns the filming set into a virtual reality experience where it follows the Mandalorian as he



Figure 1.6



# History of VR & AR

StereoScope - early 1900's

The stereoscope is a device created in the early 1900s in which the user would look through an oculus that would separate each eye and onto a set of photos slightly different to create the illusion of 3D

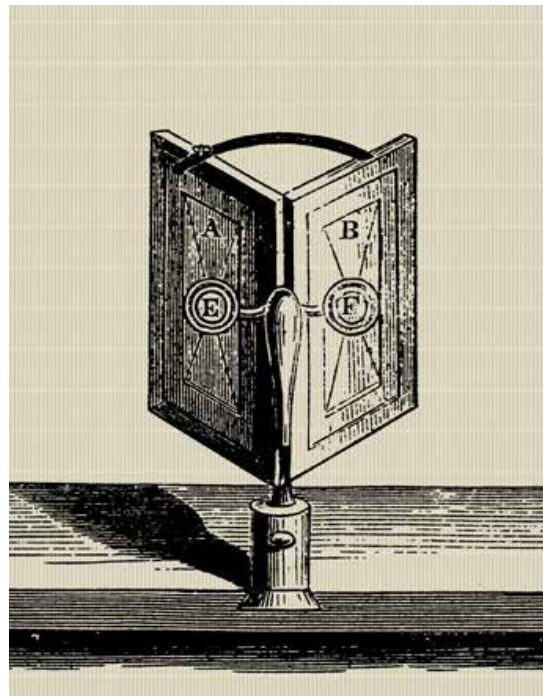


Figure 1.7

Sensorama - Morton Heilig (1950's)

The Sensorama is the first known form of VR in which the user would sit in a cockpit and view a first-person video of a motorcycle driving through New York. The device included surround sound speakers, fans to simulate wind, odor emitters to create a sense of smell, and a motorized seat that would move based on the motorcycle. Unlike how VR is generally used for video games, Morton Heilig created this as a better way for users to experience theater.



Figure 1.8



Figure 1.9

### Sword of Damocles - Ivan Sutherland (1960s)

Sword of Damocles is the first wearable VR headset. The headset allowed the user to be put in a 3D virtual space and view 3D objects. The Headset was extremely heavy and had to be suspended from the ceiling, creating limited mobility. Due to its shape, it was given the nickname Sword of Damocles.



Figure 1.10

### VITL Helmet - 1970's

In the late 1970s the United States Air Force developed fighter helmets with integrated technology allowing the pilot to have more information and see targets

## History of VR & AR

Video Place - 1985

Video Place was an installation using a video camera and a projection screen to put someone's motion and silhouette into VR. The camera tracked the user's movements and would translate that to virtual objects within the screen.

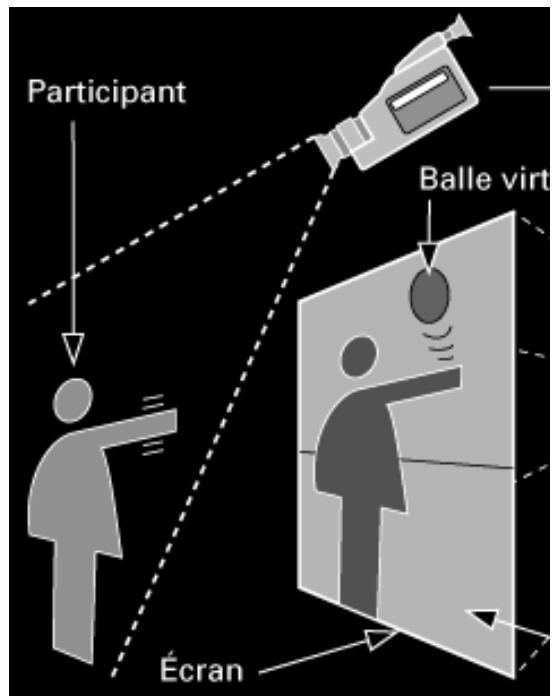


Figure 1.11

Nintendo Virtual Boy - Nintendo Inc. (1995)

The Nintendo Virtual Boy was one of the first consumer VR devices. The Virtual Boy allowed the user to play specific games in a virtual space and interact with virtual spaces through the use of a controller.



Figure 1.12

## Consumer Grade VR Headsets - Early 2010's



Figure 1.13

Consumer VR headsets started becoming available in the early 2010s. The headsets were targeted at gaming and professional work. Many architecture firms have been investing in this type of technology to more easily show clients design ideas and spaces rather than explain these through basic drawings.



Figure 1.14

## AR Apps and experiences -

Over the last 10 years, we have experienced a massive shift toward more accessible, powerful, and smaller technological hardware. Through this, AR has become a talking point for many tech companies. Our smartphones allow us to use this form of tech and integrate it into the real world. From catching Pokémon in the park to viewing Ikea furniture in your home through their Augmented reality features. Technology has allowed for further integration of technology and everyday life.



## History of VR & AR

### Facebook's Metaverse - 2021

Facebook (now Meta) announced its plans to start building the Metaverse. A fully virtual reality world in which we could live and explore similar to our real world.



Figure 1.15

## Editor's Note: Issue of the Metaverse

In late 2021, Facebook changed its name to Meta signaling a full force ahead strategy into building what they are calling "The Metaverse". In a brief video, Meta showed their early ideas of the metaverse and how people can interact with each other virtually on a 1:1 scale in person. This idea of a fully virtual world brings an idea of fear to many people and reminds many of movies such as The Matrix, Ready Player One, Jumanji, Sword Art Online, etc. All of which have wild and exciting virtual worlds which drastically and mostly negatively affect the real world. Though most peoples faith in Meta and the VR industry to pull this off seems lower than these companies would prefer. Thus, a more technologically integrated society where Virtual and Existing elements come together seems much more feasible.

Thus, this research will not focus on creating an experience similar to the metaverse. Though, there is much we can learn from Meta's stride toward pushing this Technology/Experience that can be used in this research to further our mindset of the existing world and technology. This study is focusing on augmented reality as a tool and

materiality that can be used within existing space and the future built environment. This technology differs from virtual reality in that it allows for real-life interactions between ourselves and virtual entities.



**OBJECTIVES AND PURPOSE**

## Purpose of Research

As seen in the history of VR, the growth and accessibility to this technology has grown at a rapid and alarming rate. Especially during the Covid-19 pandemic, in 2020 the Oculus Quest 2 became the most popular consumer VR headset allowing many more people to experience this tech and contribute to the development of this technology. During this time, many VR video games, large and small, had come out pushing the boundaries of what people originally thought VR could do. Titles, such as Valve's Half-life Alyx, The Walking Dead, etc. One of Valve's lead engineers came out in an interview discussing ideas and plans for how we can create a VR experience without the use of headsets, and rather using radio waves to transmit experiences into people's minds. He stated that this was something that a small team at Valve was actively working on and researching.

Meta (previously known as Facebook) has begun working on what they are calling "The Metaverse". Similarly changing the company's name to show its push toward a new era of VR for Facebook as Meta. Meta's focus has turned to creating fully virtual worlds that are exceptionally similar to

ours. From rumors and interviews, it seems that Meta is looking into creating Virtual Cities in which we can all live and discussing how the Metaverse can become a place for us all to possibly someday spend most of our time. This research strives to find ways that the virtual environment can be integrated into our existing society and discover existing technology that can make this dream come to life.

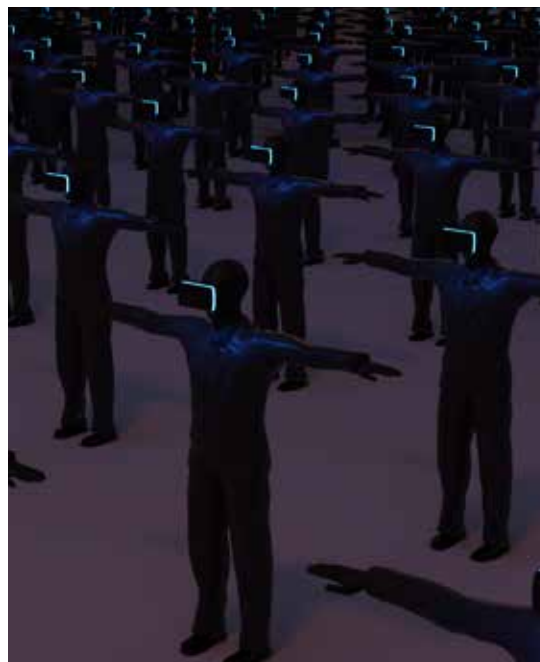


Figure 2.1

## Purpose of Research

The broad area of study for my work is the architect's role in a technologically advanced society in which we all interact with physical and virtual spaces/environments.

My specific research is in the field of integrating virtual reality and augmented reality into the architectural experience. I have been looking into the psychological effects of virtual elements and interactions within the real world, as well as the physiological effects of living in a fully virtual world such as we lived through the pandemic. Through this, I would like to find ways architects in the future can design spaces to include these virtual and interactive elements.

As a result of my project, I would like to achieve a set of design guidelines around integrating technology into architectural experiences.

The theoretical basis for my topic comes from articles that surfaced during covid-19 and the rise of virtual reality through the pandemic. These articles and news stories talked about how the VR industry has been experimenting with pushing VR into full simulation with real-world haptic feedback and 1:1 scale experience when compared to the real-world. These explorations into virtual space

created a sense of fear in me and made me think of movies like The Matrix and Inception, and how this technology could disconnect us from society and each other.

Since much of the computer industry is very focused on creating consumer VR/AR programs and experiences, there are many articles and research done on the topic. I've been starting my research on what constitutes VR and AR as well as looking into what are the objects that can bridge the gap between real and virtual spaces.

Some of the research questions I have are: what is the architect's role in a technologically advanced and integrated society? What is the implication of integrating technology into architecture? What are potential guidelines for creating integrated spaces?

The evidence gathered for this research will consist of a literature review, a real-world experience recorded, and theoretical experiments.

This research is necessary because there is a shift in many industries to move to partially or fully virtual workloads. Similar to how the architecture of a building affects its use, the architecture of future worlds may need to



Figure 2.2

incorporate this new use case.



**CYBRIDS**



# What is Augmented Reality

When an architecture project is presented to a client, the client sometimes falls in love with the quickly sketched and dramatic version rather than the realistic 3D model that would be put in front of them. The loss of dramatization and beauty that may happen when taking a concept and making it real is similar to AR and real life. Are these 3D figures that are superimposed into our real-world still false objects that are dramatized from what can be done, or are we living in a false world? Or are we living in an artistic world? Does augmented reality allow us

to “step into a painting” and live in that world? What is augmented reality?

By definition, augmented reality (AR) is an interactive technology that modifies physical surroundings with superimposed virtual elements.

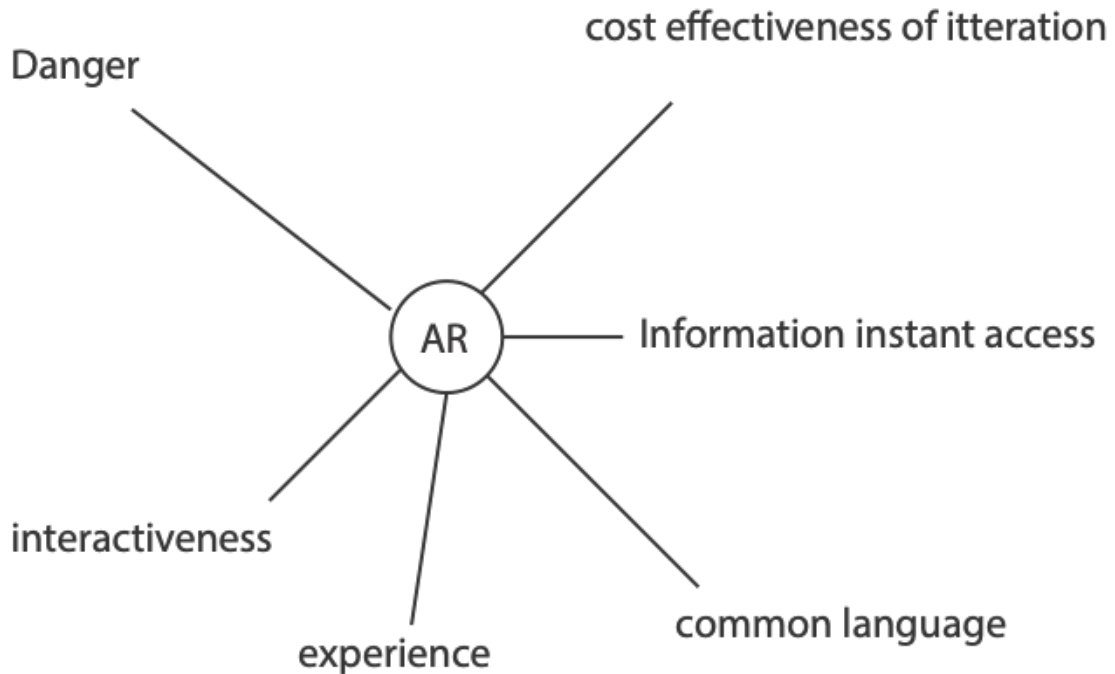


Figure 3.1



# Augmented Reality

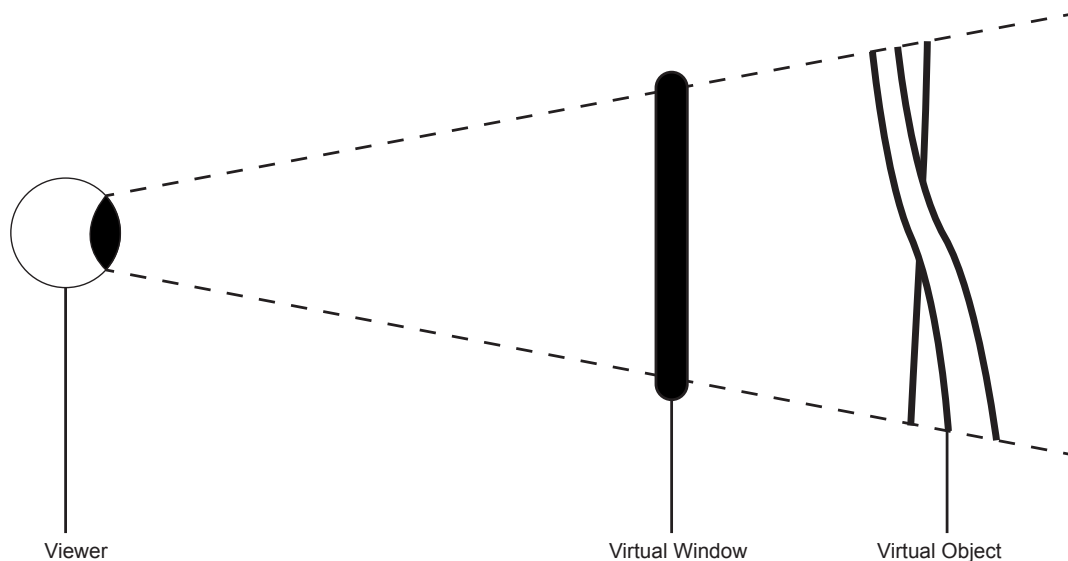


Figure 3.2

Augmented reality, in the most basic of terms, is the imposing of virtual elements into a space to make them seem real. This has been seen time and time again most recently through the use of smartphones. The smartphone allows the user to have AR capabilities anywhere. This is done through the use of a camera and as we'll call it: a virtual window. The virtual window is the space in which we can view the virtual world. Over the past century, there have been small scale developments in the use and function of AR. This has been a sort of bleed-down of

developments in VR.

If augmented reality and virtual reality are intertwined from developments of each other, then that brings us back to the question of what augmented reality is. If we look at virtual reality alone, it strives to stimulate our senses through the use of simulating an environment. It can make the space we are in seem so believable that we lose touch with reality and conform to the laws of that reality. When virtual reality is made to mimic reality it becomes a simulation of an existing

environment allowing the user to modify and explore the real site in a virtual world without the consequences of changing it in the real world. and lastly, Augmented Reality is the by-product of these changes to the virtual simulation in which we make the changes and impose these onto the real world through the use of Augmented Reality.

as videogames and 360-degree videos. Through similar applications, this can become informative by creating a space in which the user can learn and experiment with real-world physics and simulated material.

Both of these technologies are experiential in nature and can be informative. The technology, especially now, has been used for experience in applications such

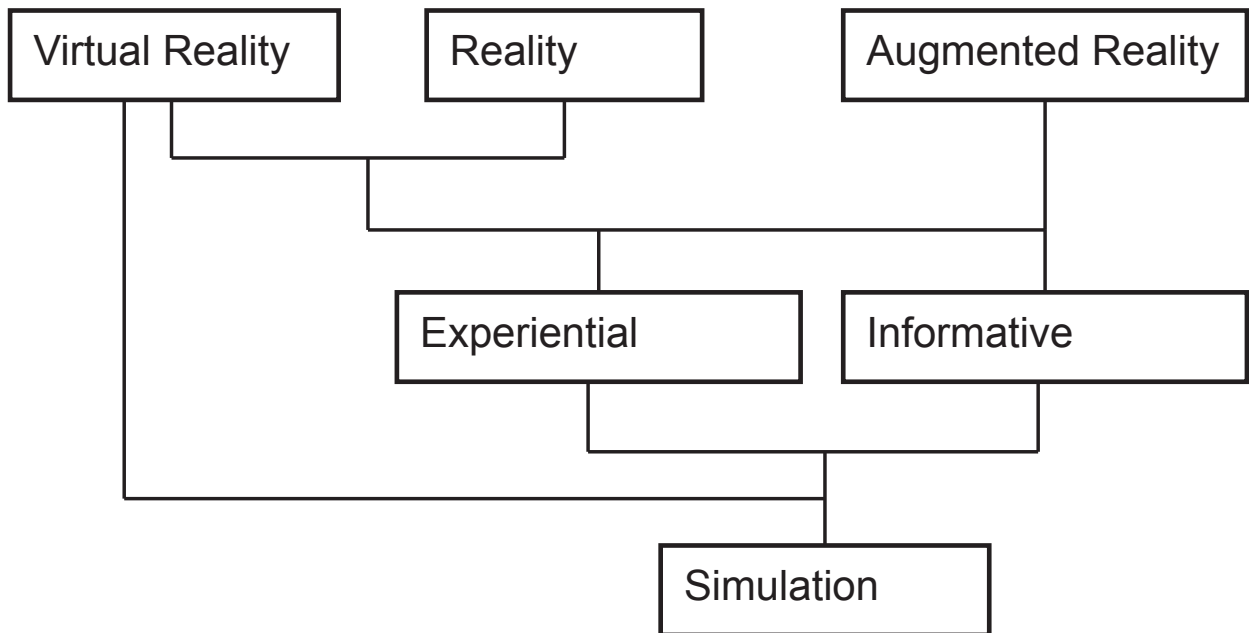


Figure 3.3

## Augmented Reality

So where does this lead us? If all virtual elements are just simulations of our existing world, then how do we begin to integrate them into our lives? One way can be through the use of AI integration into new buildings. AI has the power to completely make the function, egress, use, and labor of a building automated. Allowing a machine to control a structure allows for a further understanding and efficiency while within the building. Imagine a day in the future in which parking consisted of following lights the building set up for you to lead you to the closest open space. Walking into the building, you would be directed by AR arrows that point you in the direction you need to go rather than looking through maps and sitting in a room perfectly comfortable because the building will automatically adjust the climate controls near you to better suit your preference.





Figure 3.4

# Cybrids

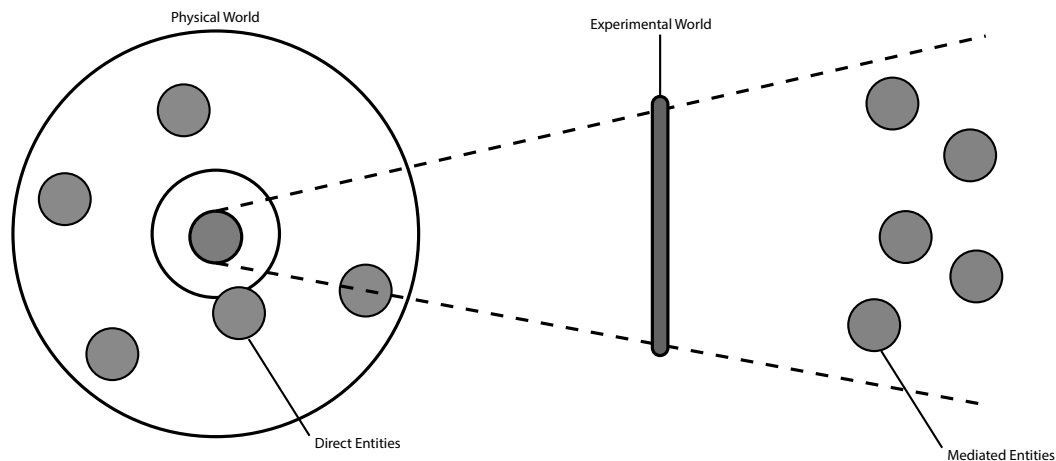


Diagram created by editor - derived from: Anders, Peter. "Cybrid Principles: Guidelines for Merging Physical and Cyber Spaces".

Figure 3.5

Earlier this thesis discussed the Idea that Virtual elements only live within the reality of a virtual window and thus do not affect the real world other than visually. This makes them purely simulated. Let's look at this through a different lens. Within our physical world, we contain these "direct entities". These **Direct Entities** are objects which we can physically touch and manipulate. These are objects that can physically impact us and our lives and that are meant to be physically interacted with. Virtually these entities are considered "mediated entities".

**Mediated Entities** are objects that are representations of direct entities. These are objects created in a virtual environment and are not subject to physical interaction, autorotation, or manipulation. These objects can only be manipulated, viewed, and changed in the "experimental world".

The **Experimental World** is the virtual canvas on which anything is possible. Similar to critics of Meta, they believe that this virtual world is purely experimental as it is not subject to the laws of physics such as the physical. These Ideas come from Peter Anders

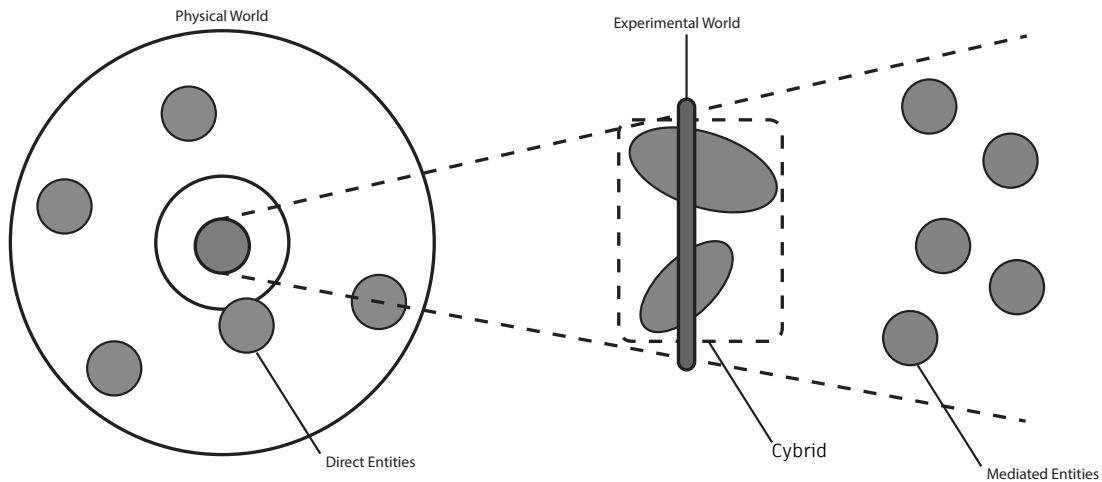


Diagram created by editor - derived from: Anders, Peter. "Cybrid Principles: Guidelines for Merging Physical and Cyber Spaces".

Figure 3.6

and his research into the concept of Cybrids. Anders believes that in our world we have these direct entities and on the other side of a virtual window there are mediated entities, though he discusses this idea of a third type called the Cybrid. Cybrids are objects that bridge this gap between the Direct entitled and mediated entities. Cybrids are not fully physical nor are they fully virtual. In a sense, they are both. The basis of what makes something a **Cybrid** is:

-that it is affected by physical Interaction and Virtual interaction.

-Changes made to it in the physical world are correlated to the virtual world.

-Changes made to it in the virtual world are made in the physical.

-The Cybrid affects both the physical surrounding and virtual surrounding world.

## Creating the Cybrid

The idea of the Cybrid is not set in stone, similar to that of augmented reality and virtual reality. These objects are very much theoretical, though we can see them coming to light more and more with advances in technology, and technology becoming cheaper for consumers. This can be seen in applications such as Mario Kart Live, Concepts for Futuristic Vehicles, and concepts for contactless buttons during the pandemic. So, how do we create this?

According to the criteria for Cybrids, the first of which is that the object is affected by both virtual and physical interaction. One way of testing this is through the phenomenon of Video Feedback. **Video Feedback** is a technique of positioning a camera toward a screen displaying the live video recording from the camera. In a sense, the camera is recording itself similar to sharing a shared screen on a desktop. This creates an infinite tunnel into the screen and will send the recording of any object placed between the 2 down the virtual tunnel. The interesting part of this is when the camera is tilted and the tunnel begins to spin. This distorts any object placed within this space and creates a

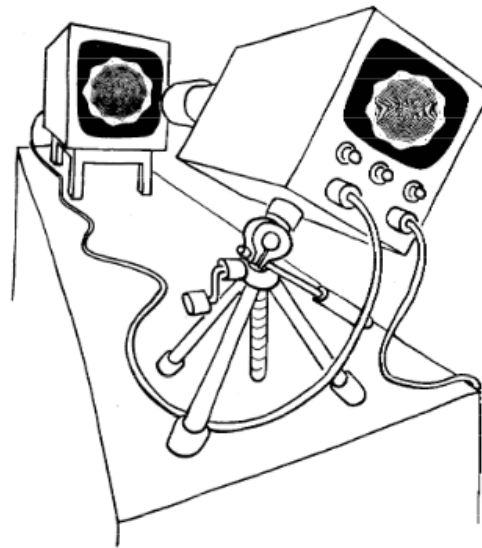


Figure 3.7

loop of live animation through human interaction. This allows any user to manipulate the virtual objects and for the virtual objects to manipulate how the user will interact with them.



Figure 3.8





Figure 3.9



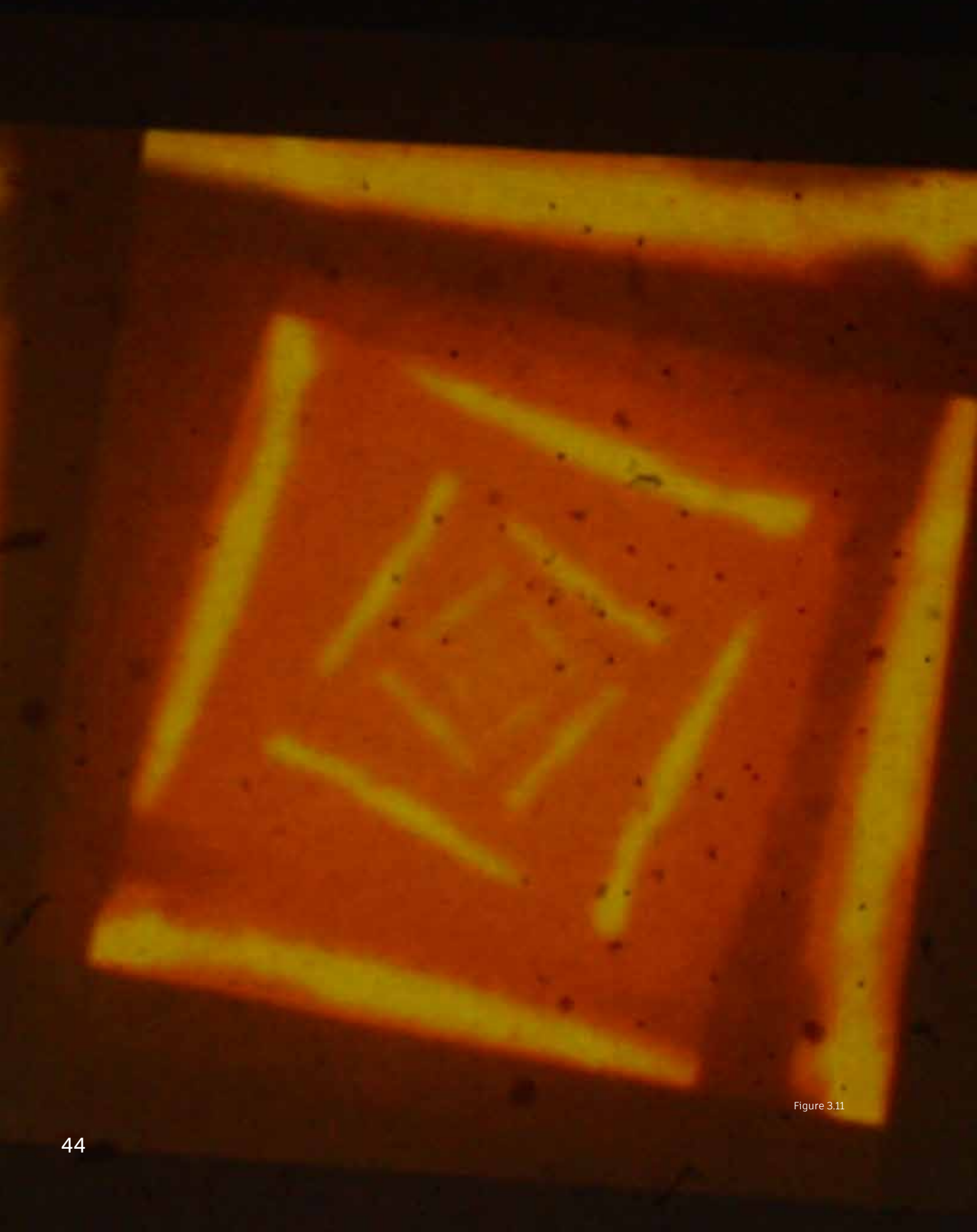


Figure 3.11

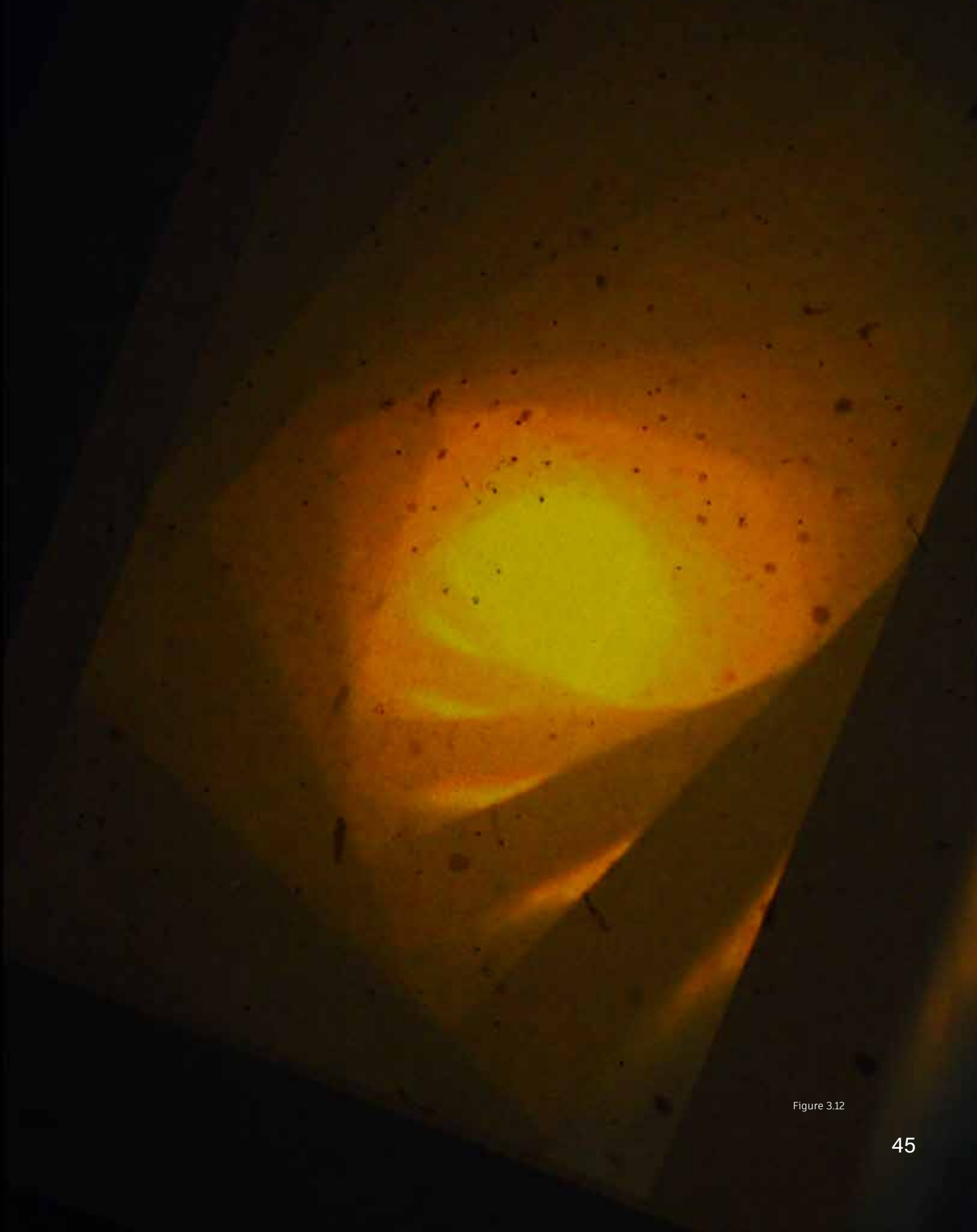


Figure 3.12

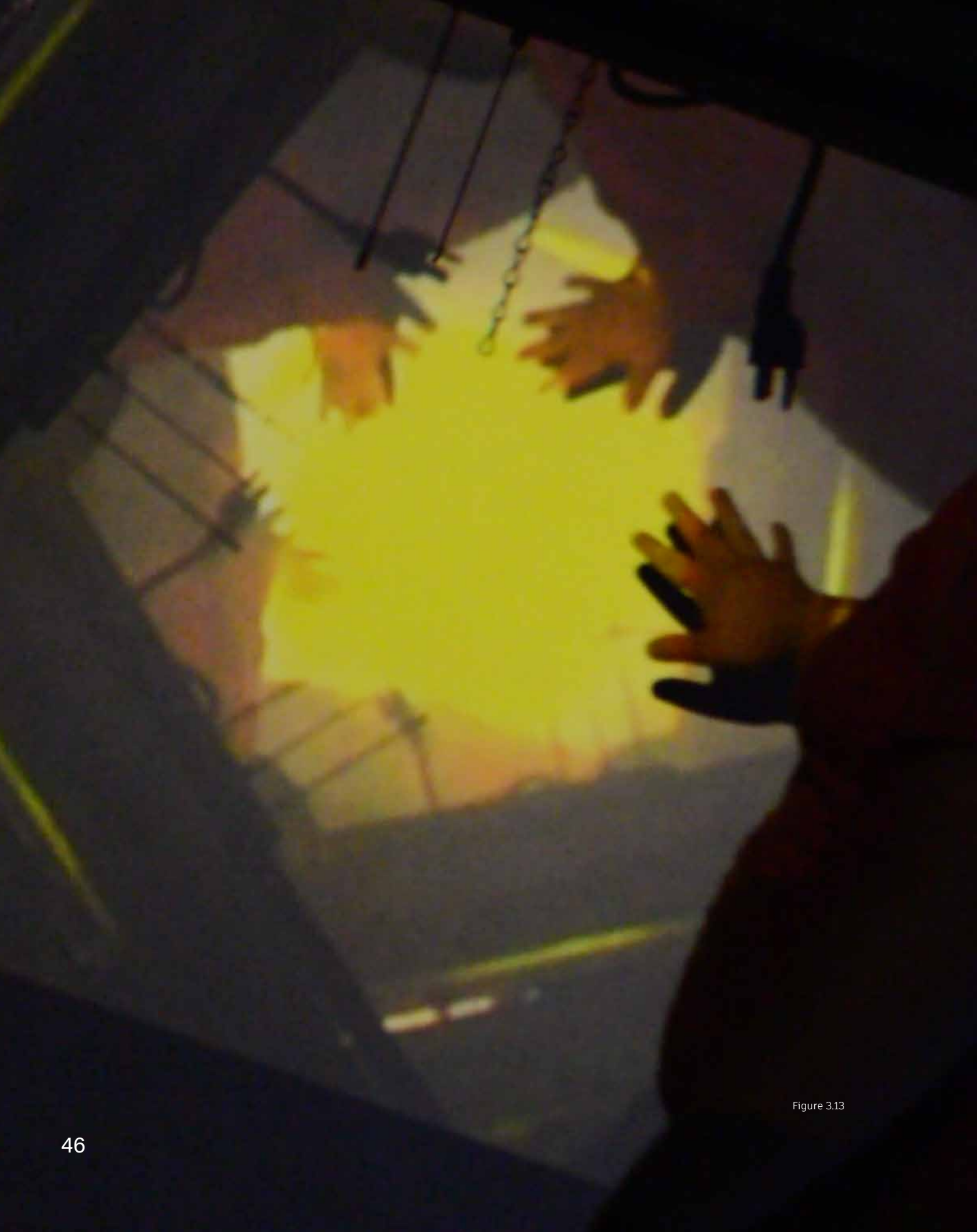


Figure 3.13



Figure 3.14



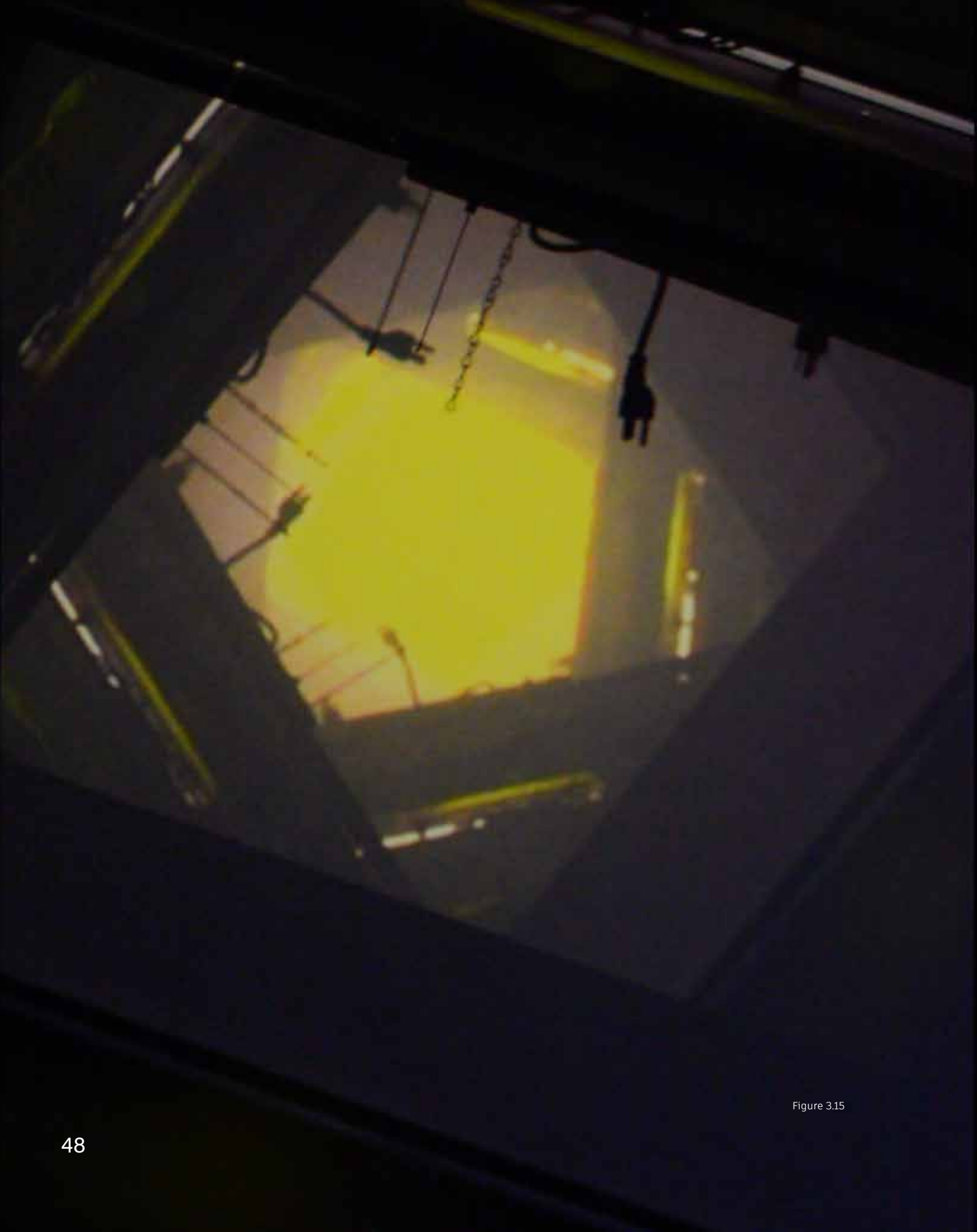


Figure 3.15







## Technological Interaction

As seen in Fig. 3.07-3.17 this technique can be used to create incredible virtual images that combine virtual and physical repetition of objects. The next step of this is to discover human interaction with technology.

## Perform Unconscious

Looking into how we as humans interact with AR projections is most efficiently done with the use of physical interaction with AR, Studies, and Reflections. This research worked with fellow cohort **Tiffany Dang** to create an installation within the “Hotbox” on the first floor of the University of Detroit Mercy School of Architecture. The installation consisted of a combination of performance tailored design and augmented reality to change the existing space. The Installation was set up as such: a stage was set up which included a single seat,

a table with props, and a screen (Mimicking a living room setup). Projected onto the wall adjacent to the user was a video loop of an unknown actress who would come into the scene and interact and react to the user. At the same time, the user is looking at the screen which is displaying the feedback of their “Performance” in the installation stage. In this instance they are the actors and are performing unconsciously.

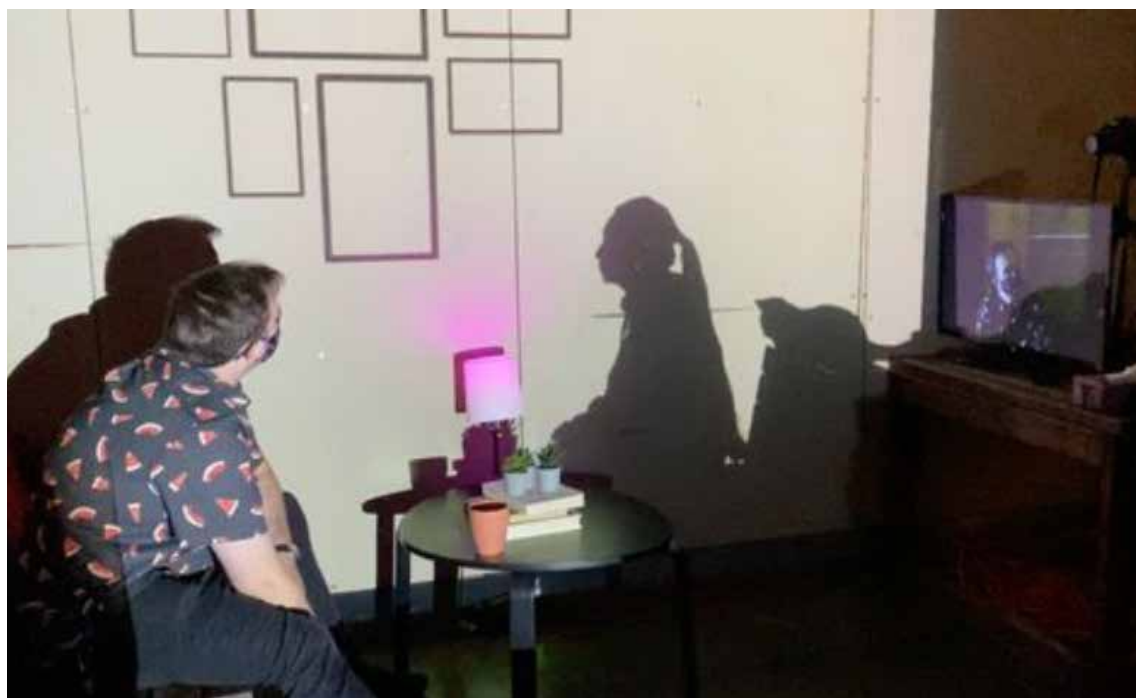


Figure 3.18



PERFORM  
**UNCONSCIOUS**  
COMING TO A THEATER NEAR YOU!  
OCTOBER 20, 2021

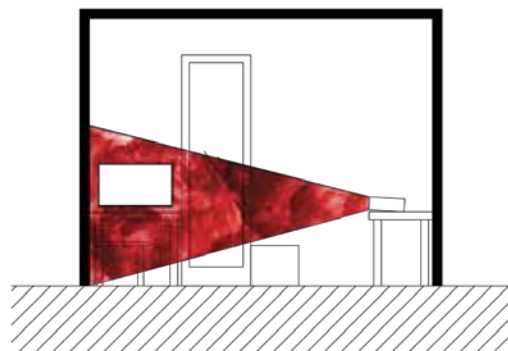
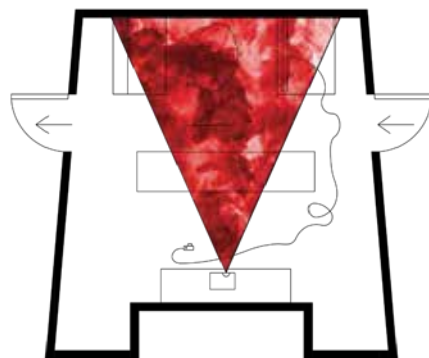


Figure 3.19



Figure 3.20



Figure 3.25



Figure 3.21



Figure 3.26



Figure 3.22



Figure 3.27



Figure 3.23



Figure 3.28



Figure 3.24



Figure 3.29

## Perform Unconscious: The Cast

From this, we create our cast of actors and actresses. These people were unconsciously performing in a space created for interaction between people and technology and studying how that interaction works. In the end, most of the actors/actresses decided to interact with the shadowy figure. The process of a person entering the room would consist of wonder from hearing the loud laughs, screams, cries, etc. from the Unknown Shadowy Actress. They would slowly walk in front of the projector and sit down. When most people saw their faces on the screen they froze. That seemed to be the most terrifying part for most people. Many described the feeling as frightening and scary, while some described it as weird and uncomfortable. It created a sense of surveillance within the installation that was unforeseen and forced the new actor/actress to actively perform knowing they are performing in this space.





VIRTUAL PARASITES

## VIRTUAL PARASITES

Augmented reality, as previously stated, is the projection of virtual elements onto physical objects or spaces. Parasites are organisms that attach themselves to a host which steals resources for its livelihood. Studying this technology called AR.js, I learned about the attachment of Virtual reality to our existing world and allowed me to learn about how AR truly works. AR is a transitional lens that places virtual objects or environments into our world and allows us to manipulate them. This requires the object to have some sort of base within our reality. ARs allow for the creation of a base

and implementation of the virtual parasites onto physical objects. On the right, we see a large black square that has been printed. This object is physical in nature. It can be manipulated like any other piece of paper though when looking through a virtual lens a virtual object is planted onto the image. The image becomes its physical base point to which our virtual parasite is attached, as the physical object is manipulated, the virtual object follows.

## AR.js

The intertwining of Augmented Reality and our world one day may become a staple of reality. Cybrids, being both physical and virtual, opens up a pandora's box for a theory on how existing objects can become Cybrids. One way for this is through the use of location Based Augmented Reality. **Location-Based Augmented Reality** is an AR strategy in which virtual objects are imprinted onto an existing space or object in the physical world. This is most commonly referred to as AR.js which is the label the most famous of the projects was started under. The image on the right is part of this project. It was created by Jerome Etienne and uses programming to imprint a 3D Model onto the Physical image.

Scan the code, load the webpage and point the camera back at the Large Black Square.



Image retrieved from: Etienne, Jerome. "Creating Augmented Reality with Ar.js and A-Frame - A-Frame." A, <https://aframe.io/blog/arjs/>.

4.01

## AR.js

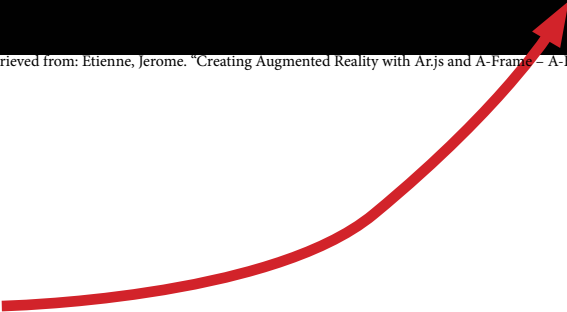
AR.js are programmed to serve one main function: combine physical and virtual. This allows for the creation of a Cybrid which is a Physical Object tethered to a Virtual object and that Virtual Object tethered back to the Physical Object. Within this scenario, there are 2 main objects at play. We have our Virtual, which is programmed within virtual XYZ space. All objects in Virtual space are subject to these XYZ constraints and thus are still present when moving these objects into the real world, which is a general base point for many 3D modelers is the (0,0) coordinate. This is where Target comes into play. The target is the Image on the right. Its sole purpose is to act as the (0,0) base point grounded in reality for the virtual Object to attach.



Image retrieved from: Etienne, Jerome. "Creating Augmented Reality with Ar.js and A-Frame." A-Frame, <https://aframe.io/blog/arjs/>.

4.02

**Target**



## How is this made?

This is made through the use of Python, JavaScript, and HTML. On the right, we see the simplest form of code that creates this installation. In the beginning, we start up the website and search for the Target image and model. The code tells the phone camera to search for a specific "Target" and once that target is found it is told to place our 3D model relative to the physical image. Line 07 shows the position in virtual space translated to the physical (0,0) point that is our physical target.



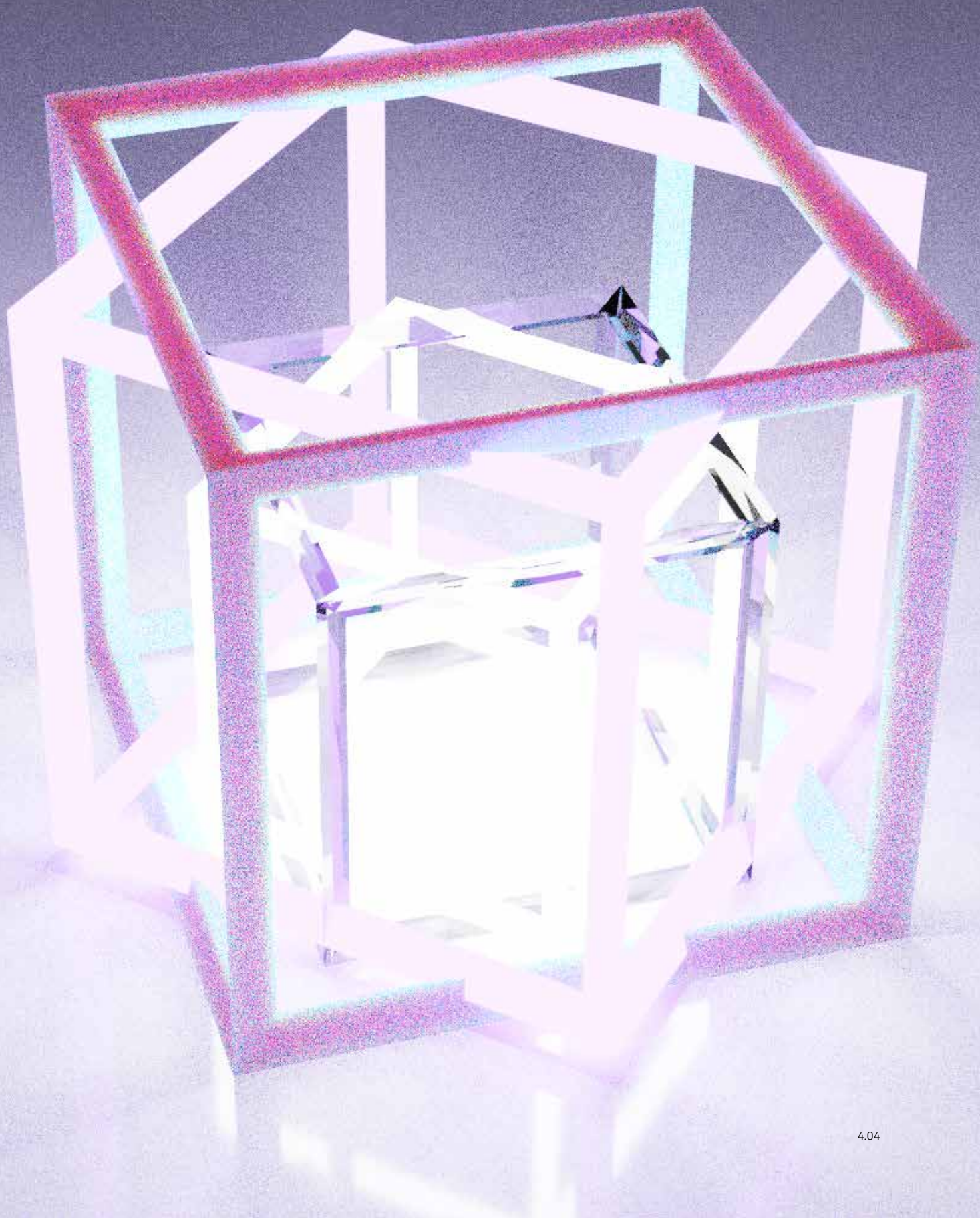
# html Output

```
01| <A-frame>  
02| <script src="https://aframe.io/releases/0.6.0/aframe.min.js"></script>  
03| <A-Frame>  
04| <script src="https://jeromeetienne.github.io/AR.js/aframe/build/aframe-ar.  
js"></script>  
05| <body style='margin : 0px; overflow: hidden;'>  
06| <a-scene embedded arjs>  
07| <a-box position='0 0.5 0' material='opacity: 0.5;'></a-box>  
08| <a-marker-camera preset='hiro'></a-marker-camera>  
09| </a-scene>  
10| </body>  
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43|
```

Code retrieved from: Etienne, Jerome. "Creating Augmented Reality with Ar.js and A-Frame - A-Frame." A, <https://aframe.io/blog/arjs/>.

## Virtual Parasites

The future of our world and the profession of architecture could one day look very different. Similarly, we, as architects, could be expected to design both the physical and virtual of our world. Will Virtual Parasites consume our world? This Thesis refers to this location-based Technology as **Virtual Parasites**. A **Parasite** is an organism that lives on or in a host organism and gets its food from or at the expense of its host. These parasites feed off of our existing world and use our resources to stay alive. At the current moment in time yes, they only live within the virtual world and are superimposed onto the Physical World (**AR**) Though it may not be long until this technology develops to such an advanced state that we struggle to distinguish the difference between physical and virtual. Until these Virtual Parasites become one with our world and grow from the nutrients of our lives.







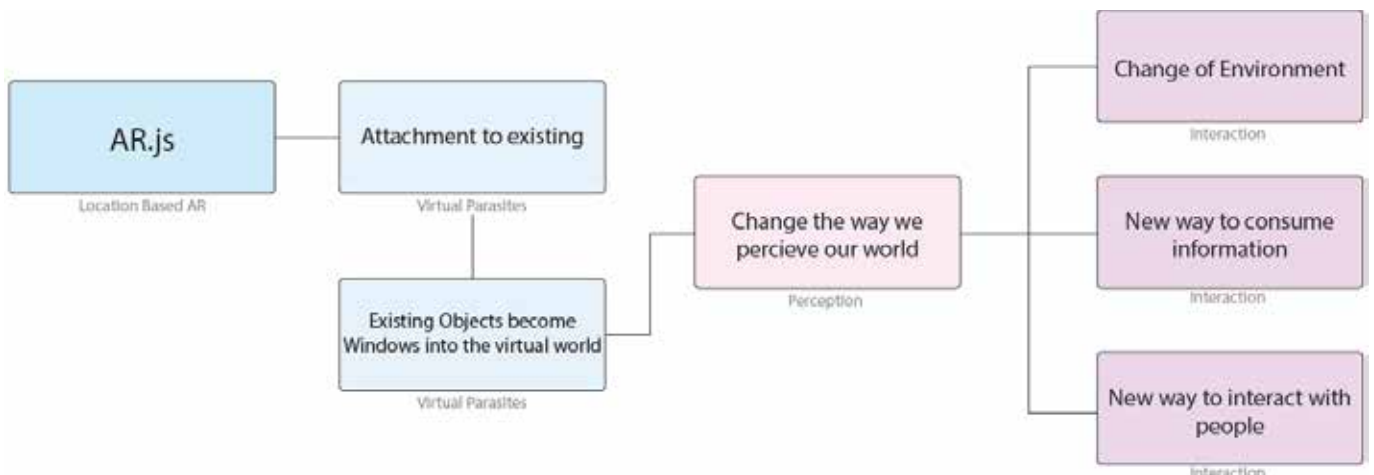
# INTEGRATION

# INTEGRATION

Location-Based AR creates this Attachment of Virtual objects to our existing world and allows these virtual objects to become a part of our reality. These Objects become interactive in the same way as **Direct Entities** though with the same characteristics as **Mediated Entities**. Through interaction and inclusion in public spaces and everyday life, they have the chance to change how we perceive our world. This has the opportunity to change our environment, change how we consume information, and completely change how we interact with other people and the world.

Integration into our world takes time and thus this thesis is not laying out an easy and quick solution to streamline the process. The goal of this thesis is to create a set of guidelines that will help

future architects and designers to integrate this type of technology ethically into their work. This thesis will discuss the Mutation of the built environment into a built and virtualized environment. This thesis is titled '**Virtual Paradise: Augmented Reality as Building Material**'. Within this, we must discuss the connection that Augmented Reality has to Building Material.



# MATERIALITY

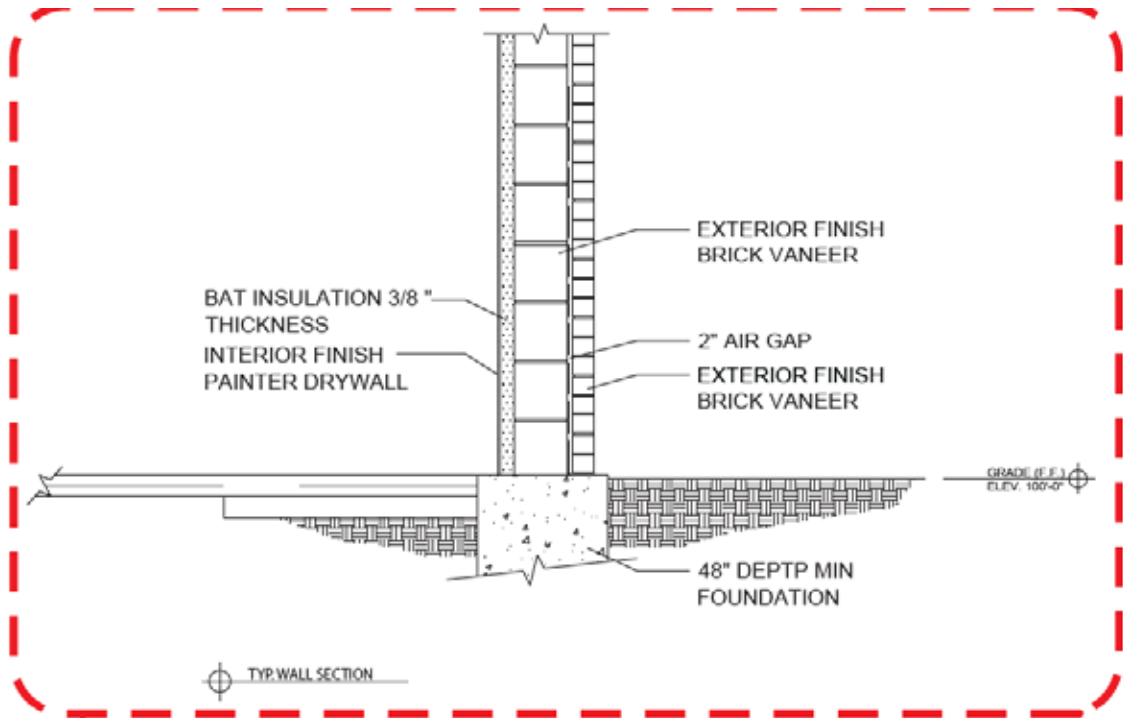
Building Material is generally understood to be the components that make up the construction of a building. Within the architecture office, we generally refer to the visual materials that the user would touch and see. These are things such as; decorative CMU blocks, brick, EFIS, Vinyl Siding, etc. As architects, we use these materials to express design on the exterior or a project. Interior designers will use paint, laminate, and different types of flooring to accentuate the experience within the built environment. These Materials have different attributes of which some may be for better grip on a gym floor, easy cleaning, or better feeling when touching surfaces. Exterior Materials are made to be weather resistant and perform similarly in hot and cold changing climates. These materials Serve a visual and performative role in more ways than one. Materials are meant to be cost-effective, in most cases, and beautiful with little repair costs, if parts fail.

Though, materials do not need to be Static. Building systems such as the HVAC, Electrical, Plumbing, and Heating area are all Building Materials that are not static. Things such as televisions,

projectors, information walls, and emerging technology are all aspects of modern design that are non-static Building Materials that are implemented into the design of a building. These design decisions are meant to be messed with by the users and changed with the building. This is the opposite of standard building design which included static walls and pathways with the only interaction being doorways and windows. It is these Dynamic systems that Augmented reality falls into.

Augmented reality as Building Material is meant to fit into this category of Dynamic and Interactable Building Features. Augmented Reality can be molded and shaped to fit into any space or use case. This allows for Flex spaces to be much more usable and changeable. Though compared to adding screens into a room, Augmented reality can be designed by the architect as a changeable system. This can be done from anything such as changing how existing materials appear or function to add a new layer interaction to these static objects.

The first way a person may go about designing AR is to look at the



5.02

## What is Necessary

current building wall construction and think... 'What can be replaced?'. This same designer could look at the wall section and say that "The structure is the only part of this project's construction". Thus, all other portions of the design such as the drywall, finisher, and the exterior brick facade could become virtual versions of these systems. While this is possible for AR it is not the best use case and could be harmful to design. These systems should not become replacements for conventional ways of design, but they should become enhancements for the

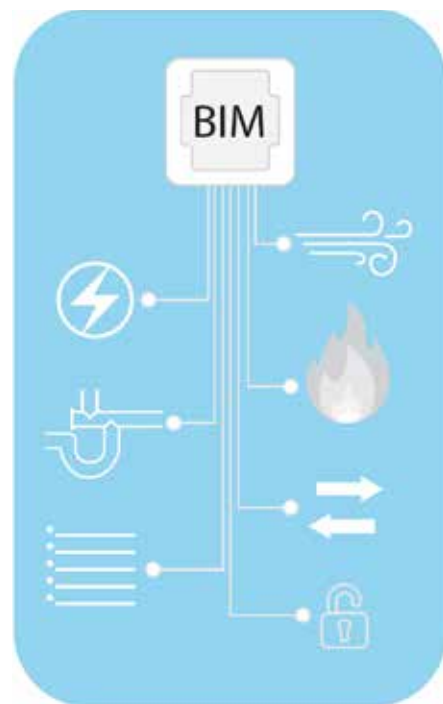
existing tactics of design. Building Materials and Building Systems must work together to create the architectural experience that all designers hope for while not overcoming each other. Though this creates a question of "how is this integrated into the design process?".

# BIM

BIM Modeling in architecture is generally referred to as a digital representation of a physical product that is to be built. BIM is a Building Information Model which consists of a 3D virtual model that contains all information regarding construction, finishing, equipment, etc. required by the contractors to construct the finished building. In a sense, this is a 3D variant of architectural plans created to make construction more streamlined. These BIM Models contain information such as the overall structure of a building, Layouts of rooms and corridors, and information on wall construction and materiality. These models also include the specifics and layouts in a 1:1 scale of all electrical, plumbing, mechanical, fire suppression, and any other special system that is to be integrated into the building whether for code of owner specification. These models are created and used over a period of months to years and after a project's completion, they are stored and used for reference. These models in a sense, die as the new physical interpretation lives on. Though this does not have to be the case. Some architectural firms have begun adding future facility management to the BIM

Model and allowing it to contain future maintenance information. This is just one way that The BIM Modeling lifeline is being extended today.

Further integration of the BIM Model could see a use for **Facility Management**. This would see the BIM Model living on as the Central Intelligence of a building creating a fully interactive environment for Architectural Experience, Efficiency, and streamlined Maintenance and System Control. The BIM model would be responsible for understanding where people are



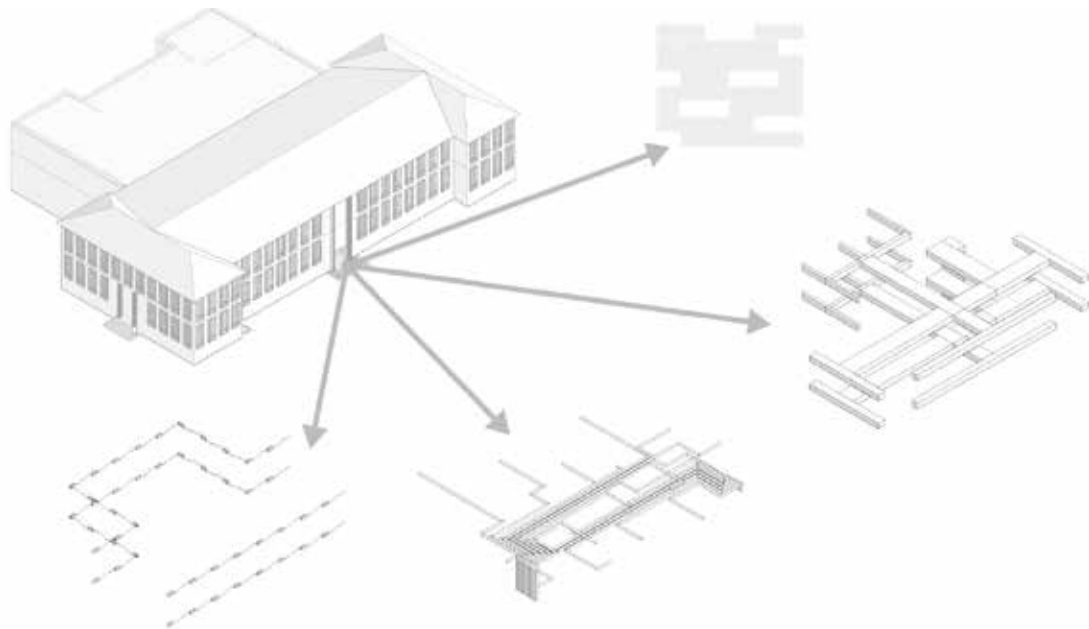
5.03



in the building and adjusting the systems accordingly. This could be done by automatically turning off lights and HVAC in rooms that are not being used at the moment, or changing climate controls based on the preferences of the persons within a space. This would even extend to changing information kiosks to display the most important information regarding a person's reason for entering the structure, such as directions or times for an appointment. This would create an enhanced experience for each user of the space allowing for a more personal connection with the built

environment.

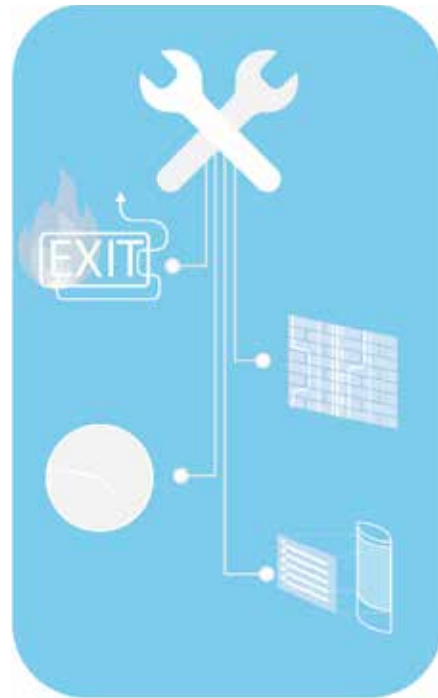
The BIM Model, as stated previously, is a Virtual extension of a Physical Model, and the Physical Model becomes the Physical Extension of the BIM Model. Earlier this thesis discussed the Cybrid which contains these similar properties. A **Cybrid** is an object which shares aspects with the physical and virtual world becoming a similar mesh within both realities. The BIM model in this thesis' opinion is an existing technology that would allow for easier integration into a building's Central intelligence.



5.04

## BIM

The idea of a building having its Central intelligence brings up some questions: What responsibilities would this system have? How would this benefit the users? and how would this affect those responsible for the building's upkeep? (i.e. janitorial, maintenance, managerial, etc.) This technology overall would be responsible for the existing Dynamic systems of the building. These include Systems of Climate Control, Lighting, Wayfinding, and Information Display which are already present within most Architectural Designs. The system would also control newly added Augmented Reality features to enhance systems such as wayfinding and Information Display. This would allow for specific information to be displayed at kiosks on a per person basis. This would also allow for parking structures to show where open spots exist for better parking experience or in the case of an emergency such as a fire it could show personnel the safest and fastest exit way and show firemen where the fire exists to assist in the control of such extremes. For maintenance, the BIM model would log any damage done to



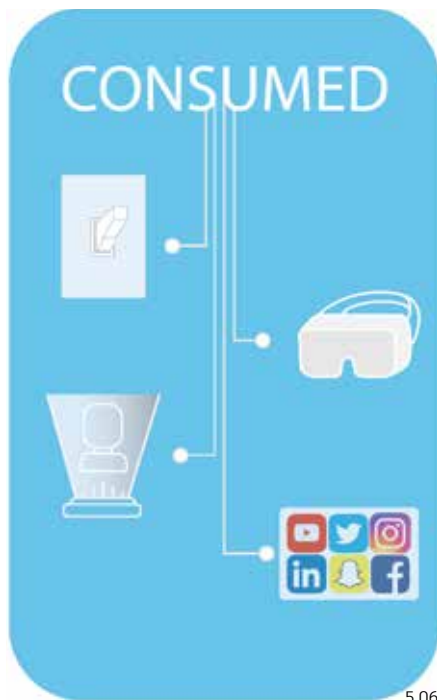
5.05

the building or any systems that have failed and communicate that through AR. It could show, through Augmented Reality, electrical and plumbing systems hidden behind walls to assist with onsite understanding or repair of the space. Though in many of these cases some may assume that this turns every interaction with the building into an AR installation. While this may be possible it should be far from the truth.

Though Augmented Reality has the potential to enhance experience and productivity within these

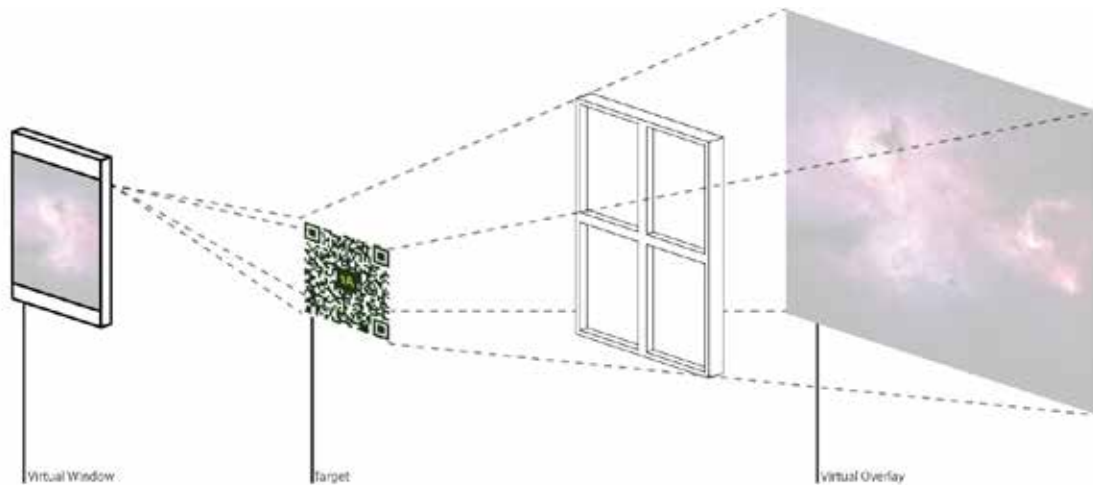
spaces it should not consume our reality. This idea of being consumed by technology means that every/most aspect of real-world interaction is substituted by a technological interaction. This means that while Augmented Reality can help in almost all fields of architecture, construction, and productivity within a space it should not be the only source of that interaction. The number one way of treating this is via a simple on/off switch. This would allow for users to opt-in or opt-out of any type of AR installation within their workflow or experience in

the space. The second of these is that AR installations should not mimic things that we can create. This would make it so that all persons know what is real and what is a virtual installation. Those interacting with these elements should never have to second guess if something is physical or virtual. The third of these is that human interaction should not become a virtualized event. While in the modern-day, virtualization of work and school has become a normal occurrence this should not become a precedent for further involvement in the virtual world. This would create a sort of **social media society** in which all human interaction is similar to that of virtualized social media.



5.06

# EXPLORATION

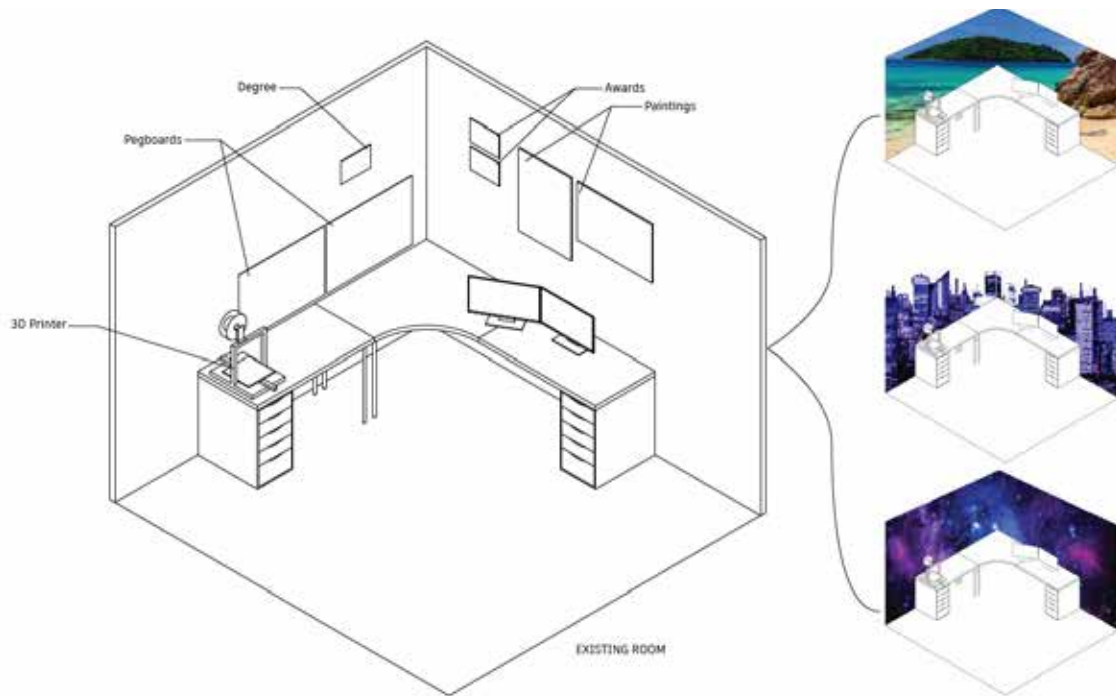


5.07

One stigma of AR technology to understand before discussing specific ways of Augmented Reality implementation in space is that while the current norm for AR is through a sort of Scan and view type of interaction, this is not the only way to experience AR. Augmented Reality is a projection of a Virtual Object into our existing space. Though projection can happen through many different mediums, this can be done through things such as AR Glasses and Holograms. These technologies allow for a more seamless interaction that seems much more personal than a

simple Scan and view interaction through smartphones.

With that, people can begin to see the possibilities of this technology and imagine possible interactions. One way is to create illusions that would transport boring views into exotic landscapes. This could be done by creating fake windows that look into new spaces such as urban or rural landscapes or view out into space to fully transport a space into a separate dimension. This could be taken a step further by removing walls with AR to create illusions of being in those spaces.



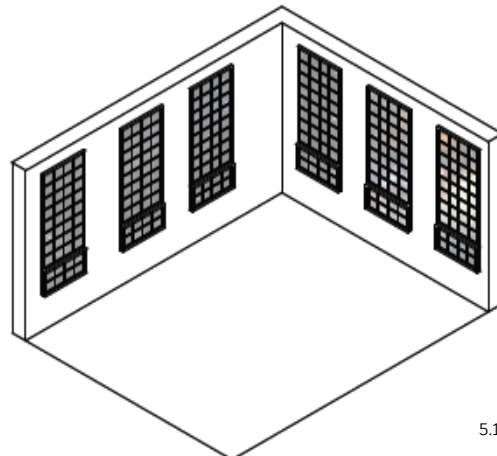
5.08

This idea creates a scenario where the user could be consumed by this technology. Thus this type of interaction should only be done if the user chooses to do so and only be shown to and by the user.



5.09

Designers could also incorporate virtualized facades. This is not as a replacement for physical facades but as an enhancement. Similar technology can be seen currently with projection installations along building facades that add animations, color, and life to a building's facade.



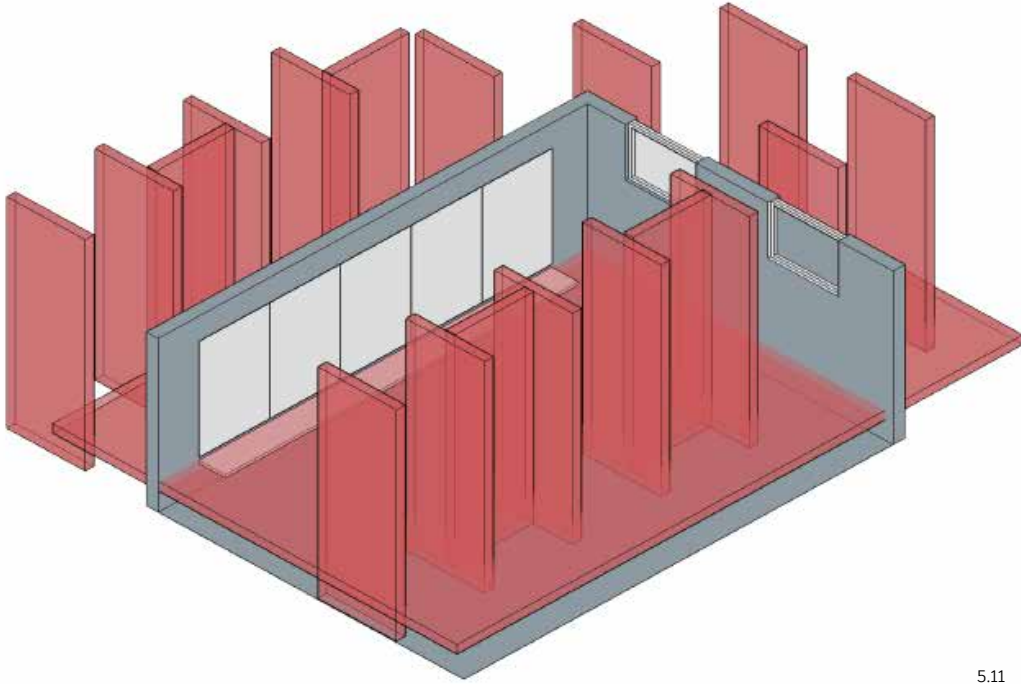
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## EXPLORATION

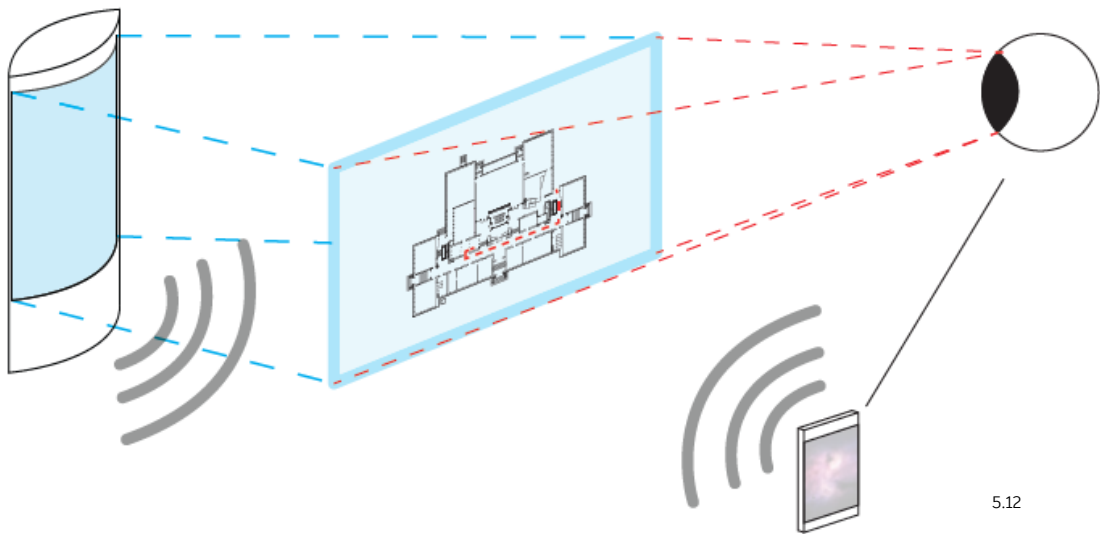
As discussed earlier, kiosks are a good way to start with Augmented Reality design. These systems are often used to display any important information for the building's users to read though can often become bundled up with too much information that many of the users do not need. This thesis' proposition with these is to not change any of the information that is displayed on these systems but to use Augmented Reality to show a personalized virtual representation that would remove any unnecessary information that does not pertain to the user and show a custom feed of anything relative to their visit. This could be very useful for things such as wayfinding and queue lines within supermarkets and malls.

The final example this thesis will discuss is the idea of using AR in a similar way to extending Virtual Reality into our space. Virtual Reality at its core is a visual illusion that expands space to trick the user into believing that they are in a new environment. AR could use this type of technology to intersect planes of the physical and virtual world to create a room that seems much larger than they truly are. This could also help with

viewing unfinished projects to see what rooms and corridors would look like when finished.



5.11



5.12



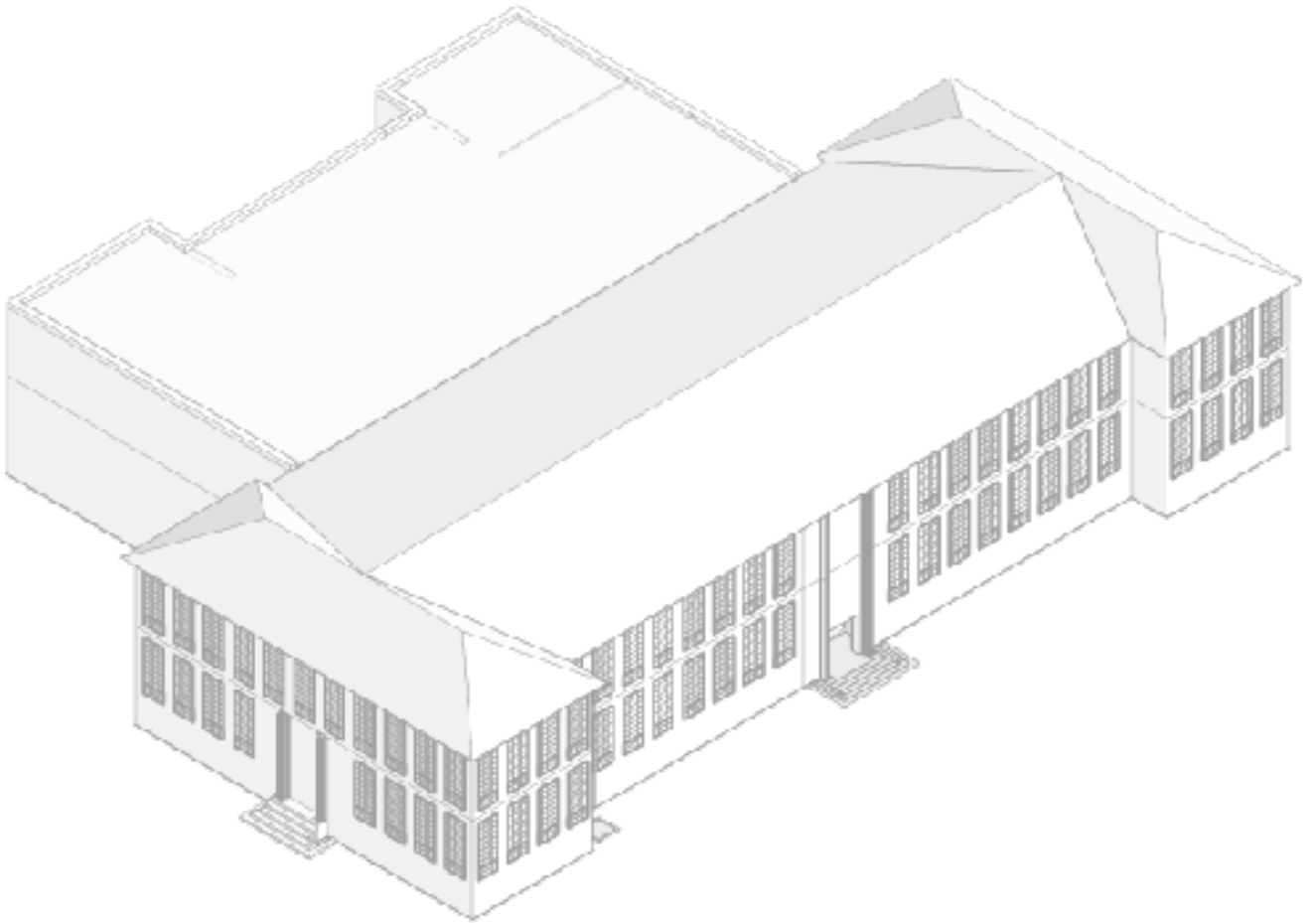


# DESIGN GUIDELINES

## PURPOSE

Design Guidelines are important for users' safety and understanding of design decisions. As architects, we follow building codes, which are mostly designed with the user in mind. These rules and codes are meant to create more fluid and connected spaces that many of us are used to as well as create proper amenities for the public to use within these public environments. This is why commercial structures require much more skill to create than residential. A single person living in a home has a better understanding of that space and has the ability to change the space as he/she chooses though a person in a commercial space does not have that luxury. Design is held to a standard to keep aspects such as ADA clearances, plumbing installations, HVAC installations, and other systems within a certain design light. Architects and engineers are expected to design these systems in their projects with the same care as materiality and space organization. Similarly, creating design guidelines for Cybrids is a way of holding architects and designers accountable for their design decisions. These Design Guidelines are not laws or rules nor are they on track to become this;

though these design guidelines are meant to be a collective standard on how the early Cybrid designer should act and the ideas they should keep in mind when creating these installations. Increasing the amount of technology within a given space can always introduce errors, if not handled right and as such the early AR and cybrid installations should be used as experimentation and tests to set precedence for the future of this building material.



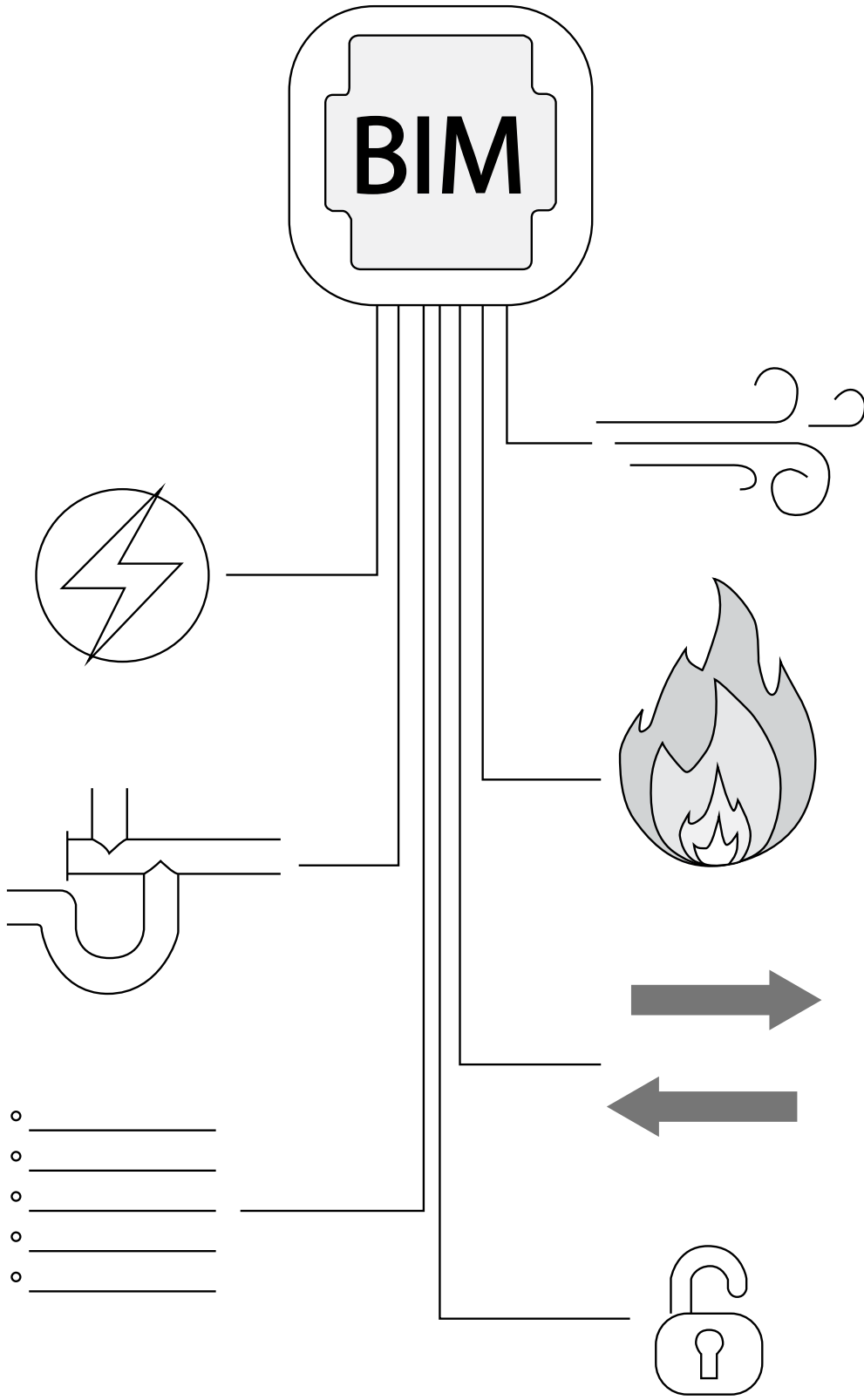
# DESIGN GUIDELINE A

## **Cybrids to be designed within the BIM Model and become part of the Design process**

The BIM Model as discussed earlier is the central piece of the modern design process. It is a combination of all aspects of project construction and features. In the design process, all design decisions are first incorporated into this 3-dimensional virtual model and tested either visually, mathematically, or through the use of simulation software. These models are/should be created to be 1:1 scale replicas of the future project and thus should incorporate all static and dynamic variables in the use of the building.

Augmented reality is a fully virtual experience that has been translated into our reality. Along with this, architecture is designed through the use of virtualization. We create in the virtual world, test, revise, then create. The introduction of the Cybrid only comes into play when we create the physical spaces and environments in which these entities will live. In this sense, there is a newly added layer of the design process which is the integration. The integration phase is the time in which the virtual design and

the physical design become a fluid hybrid. As this is not a reality there is no way to explain specifics on how this happens; though, understand that the Cybrid only exists in the physical environment. it cannot exist within a fully virtual or fully physical space. These environments where the Cybrid is introduced must be designed as a midway point between the physical and virtual worlds.



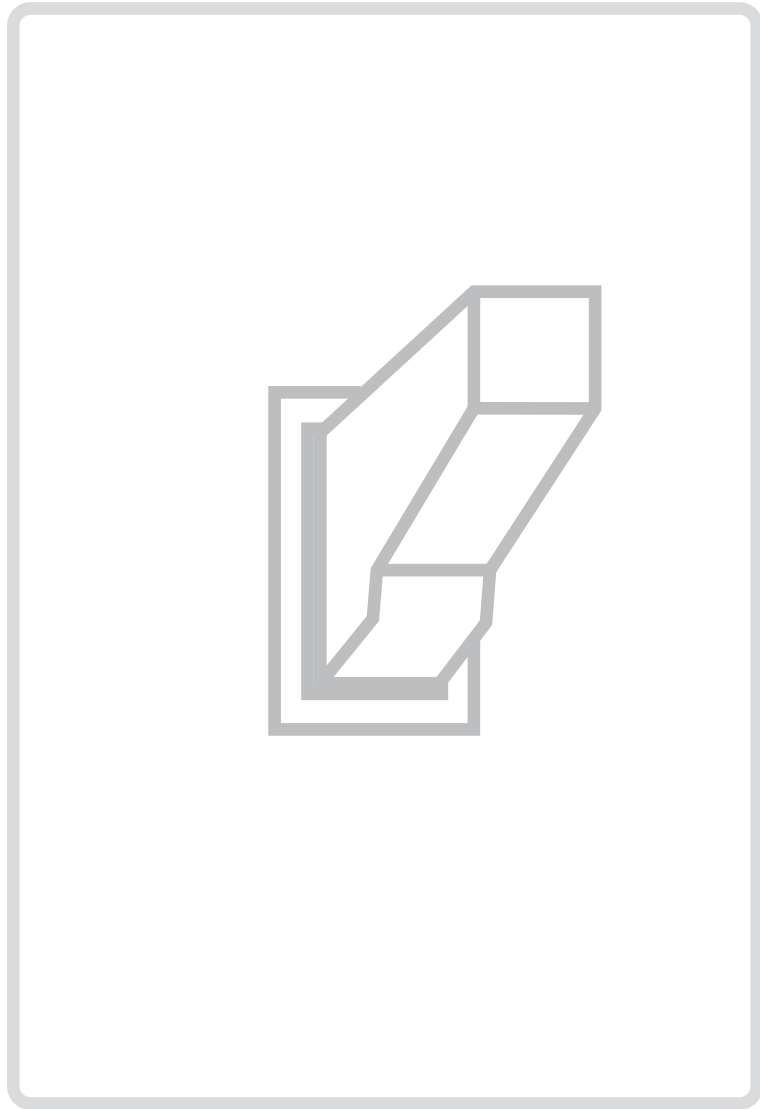
## DESIGN GUIDELINE B

### **BIM Models to become Centralized Intelligence of Buildings**

The BIM Model contains all necessary information for the construction and assembly of the overall design and internal systems of a building. These models in a sensitive area are overtaken by the physical over time and are of no more use to us other than future reference or modifications. This creates a hidden opportunity in which the BIM can be used to control many of these systems. Currently, due to the Michigan and International Building code, many aspects such as Lighting, plumbing, heating, and cooling need to have some sort of active sensor for controlling the efficiency of these systems. This is to create built environments that do not waste resources on spaces that are not being used. These existing triggers and systems are generally on a per install basis and do not communicate. The issue presented is that each room becomes its separated block to which many of the systems are tied.

Creating a centralized control system for the building through the use of the BIM Model allows for these structures to better

communicate with all interior systems. This would include Fire suppression, HVAC, Heating, Electrical, and Lighting. Plumbing, Security, and information display. To further this integration, structures could communicate with us by adjusting these controls to better suit our preferences or communicate issues with the systems to better help with maintenance.





## DESIGN GUIDELINE C

### **Systems should be deployed with a level of comfort considered**

The purpose of this guideline is 2 fold. Firstly, Technology can be used as a destructive entity if used incorrectly. This brings a question of if this type of design is made to **Consume** us or envelop us within a space. This type of environment would become toxic in nature and cause many people to feel that private space could become a myth. Secondly, Architects should design these, spaces to work with and without technology. Architecture has always been about creating inviting and beautiful spaces that serve a specific purpose while not overstepping the ethical values that make our work shine.

These systems should be integrated with changeability over time so that they can evolve with the structure over time. Many of the current dynamic systems that are integrated within the structure are stuck in place and costly/difficult to move through Augmented reality installations have the ability to be easily changed based on changes within a space or changes in the area of deployment entirely.

These systems should also be integrated with some sort of 'on/off' feature so that they can be easily turned off. This can be similar to light switches in which all Augmented reality variables could be hidden from view by either a single person or a whole audience. The controllability and ease of access to these controls are one of the most important aspects of deployment. It allows for user-based control rather than community-based. It would allow for interactions with Cybrids to be scalable similar to dimming a light.



## DESIGN GUIDELINE D

### **Obvious Distinction between Physical and Virtual**

Cybrids should be different from than materials or sculptures that we can create. This is based on the idea of **Consumed** in which the user cannot tell what aspects of the real world exist physically and what aspects of the real world are virtual projections. Similarly, **Virtual Facades** could begin to take shape in which existing materials are replaced by superimposed Virtual versions. This undermines the idea that Augmented Reality ad Cybrids should not replace the existing but enhance it. When designing Virtual Facades the Designer should first look in-depth at the Physical representation. The physical Representation of the Facade should be the primary focus of design while the virtual elements that can be added should only be used to emphasize the physical materials. These can use Characteristics such as indirect lines between Masonry, texture, or woodgrain and create animations of layer shifts on top of these existing displays of Design. users of our design should have the right to understand what exists and what does not. That is the principle of Consumed. All users should have

access to good design and not only those who choose to partake in virtual installations within our design.



## DESIGN GUIDELINE E

### **Virtual Entities should be Physically interactive.**

As discussed as part of the “Perform Unconscious” Study, Augmented reality can become a truly interactive environment. creating these installations allows architects to study the effects that the technology has on space and the users of a space. Transformation of space becomes easy with simple projection and a small amount of set design can create an immersive environment. it is important to remember that most interaction that happens out in public can be considered a form of Performance. Many individuals will not show their true selves in public or unknown scenarios thus it is the architect’s job to indirectly show the user that they can and should interact with these installations.

With this prior knowledge, Augmented Reality installations and Cybrid entities are in themselves interactable pieces of architecture. Though many people will openly interact with these if they do not believe that it is allowable. it is the architect’s job to make sure that the user is well aware of the functionality and intractability of a specific hybrid.

Imagine Normal screens and touch screens. How does a user know which is usable and which is visual? Through this users can begin to help shape the technology and feel much more comfortable with this technology.









# GLOSSARY

## **Augmented Reality (AR)-**

Is interactive technology that modifies physical surroundings with superimposed virtual elements

## **Building Material -**

Is generally understood to be the components that make up the construction of a building

## **Consumed -**

By technology means that every/most aspect of Real world interaction are substituted by a technological interaction

## **Cybrids -**

Are objects that bridge this gap between the Direct entitled and Mediated Entities

## **Direct Entities -**

Are objects of which we can physically touch and manipulate

## **Experimental World -**

Is the virtual canvas of which anything is possible

## **Mediated Entities-**

Are objects that are representations of direct entities

## **Location Based Augmented Reality -**

Is an AR strategy in which virtual objects are imprinted onto an existing space or object in the physical world

## **Parasite -**

Is an organism that lives on or in a host organism and gets its food from or at the expense of its host

## **Video Feedback -**

Is a technique of positioning a camera toward a screen displaying the live video recording from the camera. In a sense the Camera is recording itself similar to sharing a shared screen on a desktop



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