THE TECHNIQUES OF CINEMA FOR HEAD-MOUNTED DISPLAYS

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Abstract

A recent convergence of technologies has made it possible for companies like OculusVR to bring virtual reality (VR) into the mainstream with relatively affordable head-mounted displays (HMD). Filmmakers are appropriating this new technology as a tool of cinema, which positions the screen mere centimeters in front of the viewer's eyes, filling their entire field of view (FOV) allowing them to feel present in another reality. This compression of the cinematic apparatus poses several creative and theoretical challenges, which have been the basis of my work. As a filmmaker grounded by a practice in traditional cinema, my research has centered around the creation of my own HMD film. *Crawl Space* is explicitly about my memories of childhood. The film also investigates the ramifications of mapping an established cinematic vocabulary onto HMD cinema, which fundamentally complicates the meanings that are signified by traditional formal techniques.

Acknowledgements

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Introduction

Even though *Crawl Space* hinges on non-traditional film technologies, I have always considered myself a traditional filmmaker. My methodological approach is informed and grounded by my fascination with film history and film technologies. The aesthetic of *Crawl Space* is inspired by several traditional filmmakers who have a strong authorial vision. For example, Stanley Kubrick's obsessive, graphic symmetry and wide-angle cinematography in The Shining (1980) establishes space as a domineering force; something I aimed to emulate with *Crawl Space* (see figures 1 and 2). I also borrowed techniques from Werner Herzog: In *Encounters in the End of the World* (2008), he uses an evocative combination of image and sound to create a sense of the sublime for his audience. Additionally, I have also chosen to imitate the way Michael Snow and Chris Marker relentlessly distort time in their films. Their approach to temporality in their work figuratively dismantles it before the eyes of the viewer, allowing them to glimpse the underlying apparatus and gain awareness of the film's construction.

Figure 1: Graphic symmetry in Stanley Kubrick's "The Shining (1980)"

Figure 2: Graphic symmetry and forward momentum in Stanley Kubrick's "The Shining" (1980)

Figure 3: The relentless depiction of time in Michael Snow's "Wavelength" (1967)

Crawl Space is first and foremost a film about memory and space and I chose to work with HMD technology because of its ability to communicate these ideas in an affective and interesting way. However, I hope that upon reflection, the viewer would understand my use of HMD technology as a means to an end, rather than the film's defining novelty. In other words, I did not want to make a film that felt like a technology demonstration. To that end, it is worth noting that *Crawl Space* was originally written as a traditional, two-dimensional short film, years before my first HMD experience. After having a demonstration of the Oculus Rift developer

headset in 2012, I knew without question that *Crawl Space* would be best told via this new medium. HMD technology displays three-dimensional (3D) images on a display that is worn directly in front of the viewer's eyes. These headsets present virtual space in a way that requires less (or perhaps what we might think of as a more intuitive) interpretation than does traditional cinematography. HMDs allow for space to appear genuine and tangible, which I believed would further the film's affect. Additionally, HMD technology tracks and digitizes the position and direction of the viewer's head, allowing them to look around, which is vital to feeling a sense of presence in a virtual world. Morton Heilig, inventor of the short lived *Sensorama*[1] makes an excellent distinction between this kind of presence, and the traditional cinema spectacle: "When you watch TV or a movie in a theatre, you are sitting in one reality, and at the same time you are looking at another reality through an imaginary transparent wall. However, when you enlarge the window enough, you get a visceral sense of personal involvement. You feel the experience; you don't just see it" (Rheingold, 1991, p. 55). Following my Oculus Rift demonstration, I was excited by the fact that my memory of virtual space was completely different from my memory of space constructed by traditional cinema. I felt as though I had gained an experiential memory of a *place*, rather than the memory of an image. Further, the Oculus Rift hardware evoked a sense of nostalgia with me; the rudimentary graphics, and clunky plastic headset reminded me of time spent playing console video games with my brother. For all of these reasons (embodied experience, visceral memory, nostalgia for a childhood lost), I was convinced that *Crawl Space* would be best told as cinema for HMD.

I acknowledge that my definition of *Crawl Space* as "cinema" and "film" may be met with some controversy. However, I justify this by citing the philosophy of expanded cinema

[1] A short-lived, binocular film projection invention of the 1960s which aimed immerse the viewer by stimulating several senses at once.

scholar Gene Youngblood, who believes that cinema as a practice is more broad and nebulous than many believe it to be. Youngblood argues that, like music, there are many instruments of which one can practice cinema. I believe that the HMD can be used as one such instrument; it is essentially no different than a camera, projector, or high definition display. To that end, I have chosen to frame *Crawl Space* within the context of the history of cinema to cement the argument that HMD video is simply a new iteration of immersive cinema and should be considered as such.

Crawl Space is a loosely autobiographical homage to, and eulogy of, my brother and I's childhood relationship. In many ways, my completion of this film has been the completion of a personal narrative arc; my figurative attempt at finally reaching the back of my childhood crawl space many years later. Ironically, at times, several seemingly insurmountable technical hurdles made me feel like a child crawling through an endless tunnel. These obstacles were working with a finicky homemade 3D 360° camera (which films in all directions) and mastering a new and puzzling equirectagular video workflow (which squeezes the entire 360° recording into a rectangular frame during post production). There were (and are) philosophical and phenomenological predicaments, too. For example, traditional cinema relies on the apparatus formed by the distance between a screen and an immobile viewer, whereas HMD cinema compresses the apparatus to a point where the viewer feels mobilized by a moving camera. How can I, as a traditional filmmaker contend with these disruptions of meaning caused by the collapse of the apparatus?

Brief Historical Overview

HMD cinema has its roots in architecture, music, stereography, and computerized virtual reality. Since this history is so broad, I have chosen to contain the following overview to several works and technological milestones that have overt connections to my MFA work.

Spaces of Illusion: Virtual Reality in Architecture

The modern definition of virtual reality implies "computerized worlds" but, the notion of virtual reality is actually far older than computers. In the context of art history, "virtual reality" can be used to describe any reality based on illusion. Author and multimedia artist Randall Packer writes that the earliest examples of virtual reality are perhaps the ancient subterranean paintings found in the Dordogne region of France (See figure 4) (Packer, 2005).

Figure 4: Cave Paintings of Lascaux

While these cave drawings do imply a virtual reality by using pictorial cues such as relative scale, contrast and perspective, more relevant to my work with *Crawl Space* and HMD cinema is a 50 BC Roman villa wall painting depicting a garden. The *Villa of Livia* (see figure 5) is remarkable in the way that the walls were painted to create a realistic panoramic environment

which surrounds the viewer from floor to ceiling. This serene garden scene was most likely intended as an escapist illusion of a space which exceeds the confines of the building. The *Villa of Livia* is relevant to HMD cinema because it is the earliest clear example of a virtual reality made to establish a sense of presence for the viewer; they momentarily feel as though they exist in another reality. The detailed, lush garden radiates outward from the viewer in every direction forming a juxtaposition to the walls encasing him or her. Atmospheric haze, perspective, relative brightness and relative scale (the stock-in-trade of traditional cinematography) all imply realistic spatial depth radiating outwards from the center of the chamber. These attributes establish that *Villa of Livia* is clearly an early attempt at creating a sense of presence via virtual reality.

Figure 5: One painted wall from The Villa of Livia.

Interestingly, the artist who painted the *Villa of Livia* also rendered a small fence that lines the base of the walls. This fence is a clever mediator between the viewer, the *real* floor they are standing on, and the surrounding virtual garden. This minimizes the viewer's awareness of the apparatus formed between themselves and the artwork by justifying the *real* floor and

incorporating it into the virtual reality depicted. This physically connects the viewer with the virtual space and dissolves the apparatus between themselves and the work.

Importantly, architecture may also create a sense of presence and immersion for viewers in more abstract ways. Randall Packer explains the immersive qualities of the Gothic Cathedral in Chartres:

> *With its magnificent rose windows and stained glass, resonant chambers, vaulted ceilings, and sacred labyrinth, the sanctuary transposed the virtues of the church by transporting the individual through the experience of immersion* (Packer, 2005, p. 1).

Further, Packer points out that this space of devotion immerses the viewer in an "architectural canvas for the depiction of scriptures" and that "the interior of the space, the great height of the cathedral evokes the ascent to heaven" (Packer, 2005, p. 1). Packer's assertions signal that virtual reality is not necessarily dependent on the realistic, outward, physical illusion of reality, but can also be a phenomenological experience triggered by an artful combination of elements. I equate this experience with a memory experience, or a daydream, which may allow a viewer to psychologically enter the essence of a space without the need for a realistic simulation to evoke it. This notion has played a pivotal role in my work with *Crawl Space,* where I aim to evoke a memory of space within a viewer using elements from the film's cinematography and mis-en-scene.

Virtual Reality in Theatre

In the mid 1800's German composer Richard Wagner expressed a desire to create an immersive experience for the viewer using techniques that "transplant [the viewer] upon the stage, by means of all his visual and aural faculties" (Packer, 2005, p. 2). Wagner aimed to immerse his audience by using several techniques that are now convention. For example, hiding

musicians in an orchestral pit, reintroducing classical amphitheater style seating and dimming the house lights, are all ways of further immersing audiences in the work by minimizing their awareness of the apparatus which separates them from the work. These techniques are commonplace today in traditional cinema and theatre, and I made conscious efforts to implement them in the exhibition of *Crawl Space*.

"—Scopes and "—Tropes"

The stereoscope was invented by Charles Wheatstone in 1838. It was an apparatus that used stereo optics to allow for the viewing of 3D images, referred to as stereographs, which consisted of a separate image for each eye. After 1850, stereographs were sold commercially, largely consisting of images of exotic places — an early form of commercial virtual tourism. Stereoscopes and stereograms are relevant to my work because these inventions are the precursor of 3D HMD technology. Also relevant to my work with *Crawl Space* are the phenakistascope and the zoetrope, which are early examples of technology that rely on the persistence of vision[2], enabling the viewer to see looping animations by creating a shutter effect. Additionally, with *Crawl Space,* I aimed to emulate the whimsy and inventiveness that I associate with these early devices.

Figure 6: Praxiniscope, l867 (Belisle, 2013)

[2] A quality of vision in which an image persists momentarily after it has passed, which makes film possible.

Immersive Cinema

All cinema is inherently immersive. Even though traditional cinema is contained within a visible frame that separates the viewer from the filmic world, from the start, filmmakers have used their technique to push their work towards the immersive throughout history. Fundamentally, the techniques of cinematography have evolved to emulate real 3D depth out of a 2D plane. This furthers cinema's immersive quality by allowing the viewer to feel as though they are looking *into* space, rather than at a flat image. Depth of field, variable focal length, contrast, and camera movement are all formal qualities that are manipulated by filmmakers to imply depth of space in cinema. Space is also constructed through editing as the viewer makes spatial and temporal connections between shots, forming an awareness of place that is not afforded by an image alone. Audio also plays a crucial role in pushing cinema towards the immersive. Similar to the floor of *The Villa Livia,* audio physically connects the viewer-occupied space with the virtual reality on-screen, which deepens the illusion of presence and immersion. Additionally, artful combinations of image and sound can also evoke a phenomenological experience of immersion similar to what is achieved by the Gothic Cathedral in Chartres.

Aspect Ratios and the "Fin Du Montage".

Film formats and aspect ratios have been in flux since the invention of cinema and, surprisingly, are rarely acknowledged as a crucial determinant in the way the viewer perceives space (Cardwell, 2015). Films made before the 1930's were primarily filmed in the nearly-square academy ratio (1.37:1) which, for example, only allows a viewer to see a limited amount of peripheral information in a close-up shot. After the Great Depression, perhaps fueled by an audience who desires to "live large" following years of privation, wider, horizontal screen

formats became the more popular choice among cinematographers. This new format offered certain aesthetic advantages: widescreen formats lessen the need for multiple shots and varying focal lengths to establish a scene (Cossar, 2009). In a widescreen close-up shot, the viewer can now see additional information on the sides of the frame which may replace the need for adding an establishing shot. Cossar furthers this argument by citing film theorist André Bazin on the artistic possibilities of widescreen cinema:

> *André Bazin prophesied that the "fin du montage" in widescreen films would create a new kind of cinematic experience—one where the filmmakers did not guide the spectator's gaze, but rather viewers were liberated and free to roam about the wide visual field (Cossar, 2009, p. 10).*

Here, Bazin is asserting that widescreen cinema would reduce the filmmaker's need for editing and camera movement; instead, the viewer would gain authorial control (at least to some extent) by directing their gaze anywhere within the widened frame at will. HMD cinema, which allows for the viewer to look around a 360° image that envelops him of her, obviously adopts Bazin's principal of an active viewer-directed experience.

"This is Cinerama!"

Cinerama (See figure 7 was Hollywood's most aggressive widescreen format, having a brief lifespan beginning in 1952. Cinerama was an ultra-wide cinema projection format that was marketed with claims that it puts the viewer "inside the picture" (Cooper, von Fritsch, Schoedsack, & Todd, 1952). Cinerama was recorded using three cameras that when synched together would capture a large panorama. Each filmstrip was then projected side-by-side on a large horizontal screen that curved around the audience.

Cinerama inventor Fred Waller outlines several components which construct the "realism of the process":

> *Our modern researchers in physiological optics and psychology have generally agreed that our interpretation of the image our retina receives, which is sight, depends on our experience. Through this experience we have developed a number of clues, our judgment of which gives us the ability to place ourselves in space, to judge the distance to objects in our surroundings, to know how fast we are moving and how other objects are moving in relation to us. All of this is our reality. (Waller, 1993, p. 296)*

Waller also describes several cinematographic techniques which he believed help constitute immersion in Cinerama, such as: atmosphere or color perspective, known size of objects, overlapping objects, relative brightness, movement parallax, and movement perspective (Waller, 1993). Despite its epic ambitions, Cinerama was ultimately doomed because of poor technical execution and the lack of compelling content which consisted primarily of gimmicky "virtual tourism" films.

Figure 7: A still from the trailer of "This is Cinerama! (1952)"

Anaglyph 3D Cinema

In an attempt to compete with the increasing popularity of television, studios and theatres in the 1940s began formulating marketable experiences, such as 3D cinema, to entice audiences back to theatres. Borrowing from the earlier techniques of stereography, 3D anaglyph films

require two separate cameras that record an image for each eye. These images are then married in the laboratory, leaving a red image and a cyan image that are superimposed on top of each other. The viewer then must sport red / cyan tinted glasses in order to filter the images to each corresponding eye, creating a 3D effect. Anaglyph films did not achieve mainstream success because feature length films that adopted this method were prone to misalignment during processing which caused visual fatigue (Lobban, 2015).

Since 2008, 3D films have achieved some success in the box office. More comfortable polarized glasses, along with digital projection technology with its higher frame rates and perfect image alignment allows for much more tolerable experiences.

Immersion in Contemporary American Narrative Cinema

Camera motivation, so crucial to HMD, has precedents in Hollywood, albeit, few and far between. One such example is Robert Montgomery's *Lady in the Lake* (1947). This feature length, classical detective noir aims to place the audience inside the point-of-view of the protagonist by aligning the viewer with the camera's lens. Montgomery, who also stars in the film, positions and moves the camera to mimic the optical point-of-view (POV) of the film's central character. The actors in the film perform by directing their dialogue and eye-lines directly at this POV in a way that embodies, engages, and aligns the viewer with the subjective motivations of the central character.

Figure 8: Optical POV in Robert Montgomery's Lady in the Lake (1947)

The film was largely regarded by critics as a failed experiment because the gimmick quickly wore thin (Eberwien, 1980).

Film theorist Christian Metz articulates one such criticism:

> *"What happens ordinarily in films, and is sometimes called 'identification,' is in reality a temporary association, an act of projection whereby the spectator momentarily mentally accompanies the character (on condition that he is at other moment seen from outside). Thus in his desire to achieve total identification [Montgomery] in fact inhibited that partial association which other films enjoy." (Eberwien, 1980, p. 197)*

According to Metz, the film was not successful because Montgomery failed to establish the central character as one we can empathize with[3]. The viewer is essentially "inside" the central character as he delivers his own dialogue and moves through the narrative. Montgomery immediately places his audience inside the central character without allowing them to understand

[3] Metz's language here also presupposes a male viewer, which also excludes the female from embodying the film's male central character. Additionally, the character's overt sexism serves to further alienate the viewer.

and empathize with him from the outside first. It is difficult to empathize with a character when the viewer is a slave to his desires and (in this case) questionable morals.

Further, the reduced size of camera technology has continued to push the optical first-person POV aesthetic in contemporary narrative cinema. Smaller handheld cameras are largely responsible for the embodied spectatorship created by *The Blair Witch Project* (1999), for example. Directors Daniel Myrick and Eduardo Sanchez put the camera in the hands of the characters, who are seemingly responsible for the film's cinematography. There are two important ways in which the film uses cinematography to embody the spectator: 1) The overly shaky, handheld quality of the camera movement made audiences feel nauseous, driving an awareness of their own bodies (Powell, 2002) and 2) the actors, at times, directly address the camera with their gaze and eye-lines. As film scholar Trevor Elkington writes:

> *In a film like The Blair Witch Project, space is constructed following a model in which the spectator is placed spatially within the film, and not outside of it as is the case with more traditional cinematography. In Blair Witch, the events occur around the body as the central means of perception, occurring in deep, full space, and not simply in front of the camera along a 180°-degree access (Elkington, 2001, p. 108).*

Elkington continues to describe the immersive effect achieved by the filmmakers who place the camera at eye level; putting the viewer at the "zero-point of spatiality" by breaking down "traditional relations between audience and image that posit the audience as here and the film as always over there, by forcing us to occupy a perspective within the film." (Elkington, 2001, p. 112) This trend can be seen continued in horror and sci-fi films of the 1980s, 90s and into the twenty-first century, such as *Terminator* (1984) and *The Matrix* (1999).

Expanded Cinema

The most overt historical attempts at achieving presence through cinema are works of expanded cinema. A.L. Rees, in his book *Expanded Cinema* (2011), offers his definition of this elusive category:

> '*Expanded Cinema' is an elastic name for many sorts of film and projection events. It is notoriously difficult to pin down or define. At full stretch, it embraces the most contradictory dimensions of film and video art from the vividly spectacular to the starkly materialist*. (Rees, 2011, p. 12)

"This 'expanded' cinema is the "explosion of the frame outward towards immersive, interactive and interconnected forms of culture"(Marchessault & Lord, 2007, p. 8). Exemplary of this "explosion" is Stan VanDerBeek's *Movie-Drome* (1963) that asks the viewer to lay on the floor and look upward at a domed screen that fills his or her FOV. Projected across this screen are still and moving images that form a structure that the audience can then decode (or *edit*) themselves. Harkening back to Bazin's "Fin Du Montage", *Movie-Drome's* associative nature gave an extreme sense of editorial agency to the viewer not afforded by mainstream cinema.

Figure 9: Stan VanDerBeek's Movie-Drome (1963)Stan VanDerBeek's Movie-Drome (1963)

Computerized Virtual Reality

Alongside traditional and expanded cinema of the 60's, Morton Heilig patented the concept for the earliest HMD, which he called the "Telesphere Mask." Although Heilig's HMD lacked the head-tracking technology crucial to present-day devices, it was none-the-less ground breaking. Envisioned as a visor worn over the eyes, the Telesphere Mask would display video images (VRS: Virtual Reality Society, n.d.). It wasn't until eight years later that the first "true" HMD was unveiled by Ivan Sutherland, a computer graphics specialist from the University of Utah, (Packer, 2005). Sutherland's device used two mini CRT displays, optics, and silvered mirrors which enabled low-resolution 3D graphics to be superimposed on the physical environment. Fundamental to the design was that the HMD could track the motion of the user's head, enabling a corresponding shift in the virtual perspective which furthers the illusion of genuine depth[4]. Sutherland's invention of head-tracked displays was pivotal in enabling future developments in virtual reality by scientists and artists.

Later, in the 1980s, artist and NASA researcher Scott Fischer managed the team behind the creation of the Virtual Interactive Environment Workstation (VIEW) system, with the goal of bringing virtual worlds "even closer to our sensory mechanisms" (Packer, 2005). VIEW integrated an HMD with a sensing glove, voice recognition, and immersive 3D audio, which digitally panned sounds as the user moved his or her head.

Despite advances made by Heilig, Sutherland, and Fischer, the history of VR is marked by the commercial and technical failure of several projects like Nintendo's Virtual Boy(1995)[5]

[4] According to Sutherland, "Although stereo presentation is important to the three-dimensional illusion, it is less important than the change that takes place in the image when the observer moves his head (Sutherland, 1968)".
[5] A consumer gaming device that presented video games stereoscopically through goggles that were suspended on a tripod.

and Sensorama[6] (1960). These commercial flops were most-likely due to the fact that the cumbersome and awkward hardware made for physically uncomfortable 3D experiences. These failed projects also lacked head tracking, which is essential in creating a comfortable, immersive VR experience as it lessens the disconnect between what the eyes see and the body feels.

In 2008, at just fifteen years old, gaming enthusiast Lucky Palmer was already cobbling together his own VR headset using low-cost parts. Palmer's homemade headset was made possible, in part by rapidly advancing mobile phone technology which reduced the cost of small, high-resolution displays and motion tracking hardware (Kumparak, 2014). The attainability of these components, coupled with advancements in gaming graphics, allowed for an affordable, high fidelity VR experience that had the potential to reach mainstream. Palmer founded OculusVR and launched a wildly successful Kickstarter campaign which validated his idea that VR was ready for mass adoption. After releasing several developer headsets and being acquired by Facebook, Oculus launched its first consumer headset in 2016 — the Oculus Rift.

Alongside Oculus' success, Google (perhaps somewhat jocularly) launched Cardboard; a "popup" VR viewer intended as a low-cost accessory for Android phones which utilized already present high-resolution displays as well as a gyroscope for motion tracking. Google Cardboard is open-source, and thusly has also been a success in driving early VR adoption rates with DIY enthusiasts.

[6] An experimental stereoscope invention that aimed to immerse the viewer by stimulating multiple senses, including smell.

HMD Cinema

The emergence of 360° video was the catalyst and driver behind my choosing to create *Crawl Space* as a work of cinema for HMD. While much VR work, mostly games, is interactive, 360° video, in contrast, with its fixed-length content is not controllable by the viewer. To help further this distinction one considers consumers of VR video game content "users" or "players", whereas consumers of 360° video are considered "viewers". Ironically, at these early days of consumer VR, 360° video often looks more life-like than video game content because it is usually recorded, or pre-rendered which requires less computational power, looking more life-like. 360° video is created by recording an equirectangular image, which captures everything around the camera into one flat, horizontal frame (see figure 10). Presently, 360° video can be recorded in both 2D and 3D using different arrangements of cameras. 3D 360° video is captured using an array of cameras that are arranged in stereo pairs; a 360° image is recorded for each eye separately. Conversely, 2D 360° has no perceivable stereo depth. Although 2D 360° video is easier to produce (and thus more popular), *Crawl Space was* recorded using a 3D 360° camera as the stereo image this camera array produces makes the space appear more tangible, allowing the viewer to feel present and gain a sensory experiential knowledge.

Not surprisingly, the bulk of 360° video content today is virtual tourism, much like the days of *Cinerama* and the early stereoscope. However, there are some noteworthy examples of 360° video that are breaking this convention. For example, Félix and Paul Studios in Montreal are producing immersive, 3D 360° video documentaries, music videos, and narrative content. Similarly, Sachka Unseld of Oculus Story Studio is pushing the boundaries of 3D 360° animation with his short narrative works, such as *Lost* (2015) and *Henry* (2016).

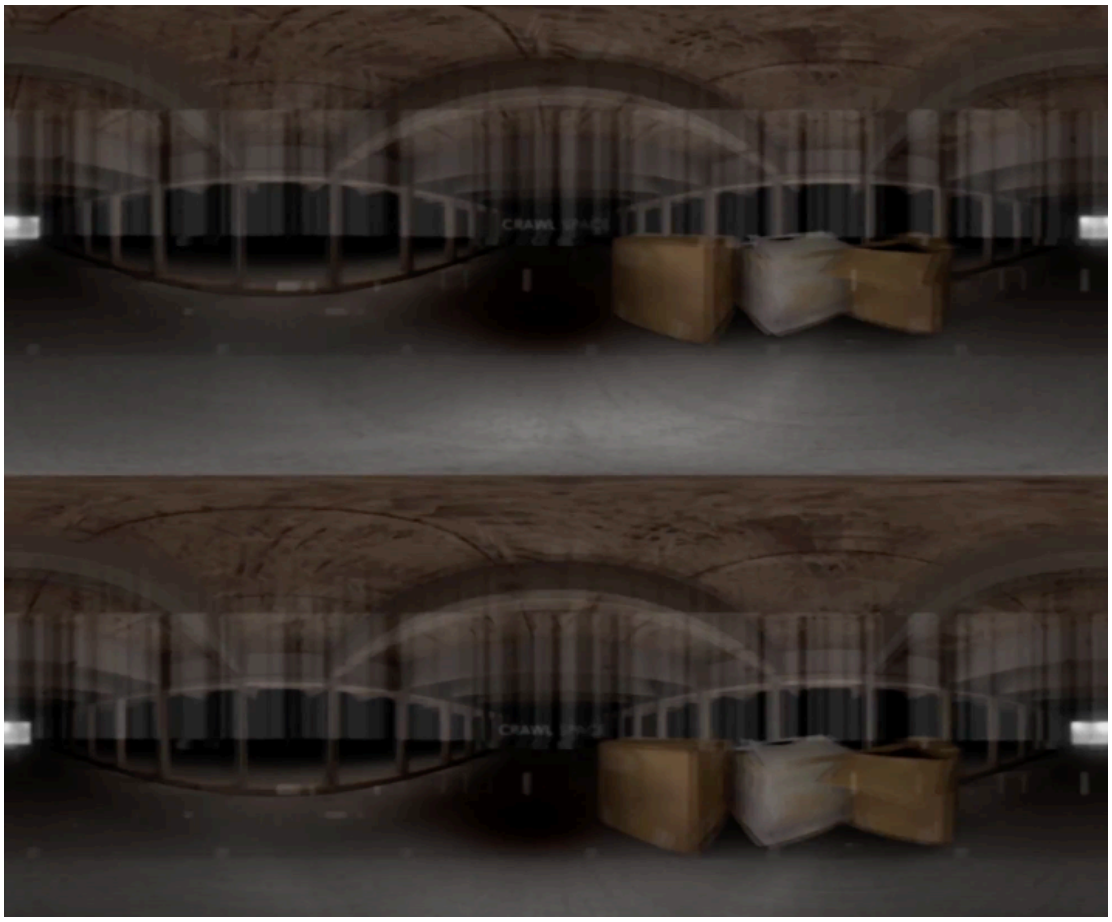

Figure 10: A frame from Crawl Space, which uses an over-under, equirectangular projection

The Aesthetics of Memory

Every frame of cinema represents a memory of a moment that passes the instant it is exposed. Walter Benjamin describes an image's temporality as a the "grave of our memory" (Lindroos, 1998, p. 214). As tombstone, each film frame is a marker of what is no longer. Scholar Kia Lindroos offers another interpretation, suggesting that a photograph actually signifies the *birth* of the perspective of the image maker and that cinematic memory is formed through the art of experience. Through experiencing the film, the viewer's own memory augments the memory of the filmmaker. Film theorist Gilles Deleuze would agree, describing this notion as the "the crystal-image": the moment that an image fuses the pastness of the recorded event with the presentness of its viewing. Film memory is therefore *multidirectional*; recorded images inspire the viewer's memory which effects the film's meaning and impression. In this "shared cultural memory" the viewer brings sometimes unconscious and almost forgotten images of that past into present consciousness (McNeill, 2010, p. 26).

Post-modernism has challenged the notion that film can be a representation of truth, record, and objectivity. No film can be an empirical representation of truth; the mere act of selection injects an image with the filmmaker's predilections and aversions which, themselves, are influenced by their memories. New Wave filmmakers like Agnès Varda, Chris Marker, and Jean-Luc Godard have all explored memory explicitly in this way. Exemplary of memory as technique is Agnès Varda's documentary *Les Glaneurs et la Glaneuse (2000) (The Gleaners and I)*. *Gleaners* is an intimate self-portrait of an aging filmmaker dealing explicitly with themes of memory, curation, and subjectivity. Varda diaries poverty, thrift, and scavenging across French history and culture while also making the connection between gleaning and her own methodology as a filmmaker. Varda's film uses memory as its guiding aesthetic by making

heavy use of montage complemented by narration using her own voice. The way Varda uses montage is indicative of the way we recall memory, selectively fusing together moments of the past, and making subjective, associative connections. She uses framing and composition to draw similarity to famous artworks that depict the act of gleaning creating an echo chamber that comments on, and advances art history and situates *Gleaners* within the larger cultural memory of art history and French culture (see figure 11).

Varda also makes the viewer blatantly aware that she is behind the camera in order to highlight her own subjectivity and its impression on the work. For example, she films her own hand snatching images (see figure 12). In the most powerful moment of the film, Varda mournfully remembers her life while filming the wrinkles in her hand with her MiniDV camera (see figure 13). In this scene, Varda speaks solemnly, "It is always a portrait"— a filmmaker's gaze looks out unto the world while simultaneously looking back at ones' self.

Figure 11: Varda referencing herself in the context of art history in "Les Glaneurs et la Glaneuse" (2000).

Figure 12: Varda's hand selectively "gleaning" images for history "Les Glaneurs et la Glaneuse" (2000).

Figure 13: Varda filming the wrinkles on her hand in "Les Glaneurs et la Glaneuse" (2000).

Varda's choice of medium further contributes to her work's aesthetic of memory. Her use of a handheld MiniDV camera, elevates the personal nature of the work. Video tape's lower resolution and limited dynamic range are associated with home videos which are often candid and highly personal recordings of memories. Her choice to use video lends the work a sense of honest reflection, in contrast to mainstream film, which is usually rehearsed and embellished.

Further, this medium evokes nostalgia in me as it enabled me as a filmmaker in my childhood, reminding me of the no-budget productions my brother and I constructed in our basement.

Memory as aesthetic is common in other works of French art cinema, too. For example, Marker's *Le Jetée* (1962) and Godard's *Histoire du Cinéma* (1989) both make use of montage, which due to its discontinuous, selective nature, can be considered comparable to the mnemic phenomena of remembering. *La Jetée*, a science fiction featurette set in a post-apocalyptic future, thematically explores memory and how it marks our identities. *La Jetée* is composed entirely of still photos and as each image vanishes, Benjamin's "graveyard of memory" becomes apparent, illuminating the bleak theme of the work. Marker's repeated use of crossfades in editing lend his film a fleeting quality, as though the protagonist is recalling a faded memory. This intagible quality is one I looked emulate with *Crawl Space* by using filtered effects which blur the image.

The aesthetics of memory are used in Hollywood, too. Christopher Nolan's *Memento* (2000), Charlie Kaufman's *Synecdoche, New York* (2008) and Michel Gondry's *Eternal Sunshine of the Spotless Mind* (2004) are examples of films that use memory a as mode of address. Most noteworthy because of its similarities to *Crawl Space* is *Eternal Sunshine of the Spotless mind* which tells the story of Joel, a man who hires a service to erase his ex-girlfriend Clemintine from his memory. In this film, Gondry uses a crafty combination of practical, staged analogue effects, and cinematography to present the mnemic phenomena of memory a visual way. For example, a high-contrast spot light vignettes Joel's presence in traumatic memories. This "tunnel-vision" compartmentalizes each memory as just one part of an expansive mindscape. Gondry uses this technique throughout the film as a method of framing and organizing Joel's memories. With *Crawl Space,* I chose to emulate this stark spotlight as a method of framing my memory as a small slice, or vignette of a much larger mental landscape.

Professor Russell Kilbourn suggests that Gondry also uses books and other prosthetic memory in the mise-en-scene as a metaphor for memory in *Eternal Sunshine*. He writes that the Barnes and Noel bookstore where Clemintine works is a "postmodern Library of Babel" and that the bookcase is a metaphor for memory that is traceable to first century Roman culture because of its lexical and structural resemblance (Kilbourn, 2010, p. 129). Similar to Gondry, I have chosen to represent my memory fragments as VHS tapes that are scattered across the floor in *Crawl Space*. These unlabeled tapes contribute to McNeil's shared cultural memory by allowing the viewer to project their own memories onto them. Since VHS tapes are largely obsolete today, they also help in establishing a pastness to the narrative.

In addition to the mise-en-scen, the musical score of *Eternal Sunshine* aids in constructing an aesthetic of memory. Jon Brion's melancholic, ambient score is manipulated to sound more analogue. The subtle, warbled, scratchy artifacts are typical of what one may hear on a low-fi cassette tape, not a high-fidelity Hollywood production. These analogue artifacts add warm sense of nostalgia to an otherwise sorrowful score. This is another technique of which the audio of *Crawl Space* emulates (see page 34 for fuller discussed of this technique).

Crawl Space acts as the catalyst between the narrator's memory, the memories of the viewer, and the cultural memory of cinema's aesthetic legacy; something Isabell McNeill calls a "shared cultural memory" (McNeill, 2010, p. 19). When developing *Crawl Space*, I borrowed from other filmmakers who have employed an aesthetic of memory. My use of retro video artifacts mimics the cinematography and editing of Varda and Gondry which I associate with a sense of nostalgia and mourning. I also believe that the degraded nature of analogue media is a testament to time's degradation of memory. And, like *Eternal Sunshine*, *Crawl Space* is lit in a way that it vignettes the viewer's field of vision, mimicking Gondry's aesthetic approach to

illustrate the compartmental mind. *Crawl Space* also makes reference to the larger cultural memory of cinema by borrowing several common compositional tropes of science fiction films. For example, the central framing and repeating vectors, parallel the psychedelic warp scene at the conclusion of Kubrick's *2001: A Space Odyssey* (1967). Whether or not a direct connection to *2001* is made by the viewer, this sequence might be familiar due to its rehearsal in pop culture, having been referenced in in movies and television like *Willy Wonka & the Chocolate Factory* (1971) and The *Simpsons* in 1992, thereby activating a cultural memory within the viewer. References such as this, help create a shared memory zone where memories of the filmmaker, the viewer, and a larger cultural memory collide.

The Body in Cinema Space

The apparatus of traditional cinema requires a physical separation between the representation and the viewer; film is meant to be "superficially" perceived from a distance (Elkington, 2001). However, by decreasing the viewer's awareness of the apparatus and their body's role in it, cinema can be made to feel less superficial and more and more immersive. For example, dim lighting, soft seats, and tiered cinema seating all work to reduce viewer distractions from their *real* surroundings, which increases their chances of being captivated by the film. However, even at its most immersive, traditional cinema is unable to envelop a viewer to the degree that HMD cinema is capable of. This powerful sense of presence does come with potential ergonomic and artistic trade-offs, though. For example, when the camera moves in HMD cinema the immobile viewer *sees* as though they are moving too; this phenomenological unfastening between his or her vision and their *real* movement can elicit motion sickness if done improperly. This bodily awareness will be destructive if this disconnect is not intended by the filmmaker. For example, I was determined to make *Crawl Space* an elegiac experience for the viewer, and therefore, was careful to plan the film around a linear, forward camera movement that was unlikely to induce nausea, which would have disrupted these aims.

Related to this experience of awareness of one's body in HMD cinema is the notion of the "uncanny valley", pioneered in the 1960s by robotics engineer Masahiro Mori, which identifies a model for explaining and predicting a viewer's emotional connection with a humanoid robot. Mori demonstrated that a viewer would be more emotionally connected to a robot as its human likeness increased — until a certain point. Mori noticed that a near, but imperfect degree of human-likeliness would push the viewer to emotionally withdrawal; the ontological slippage proves too disturbing for us to engage with.

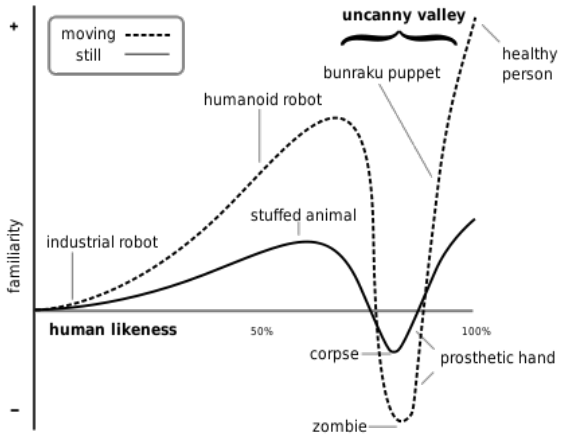

Figure 14: The Uncanny Valley.

The uncanny valley can be applied to virtual reality and HMD cinema too. However, instead of it referring to the degree of emotional connection between a viewer and a character, it refers to a high, but imperfect degree of likeness to *human perception*. The uncanny valley of VR disrupts and highlights the deficiencies of VR hardware, thus creating "destructive coenesthese"[7] which forms a viewer awareness of body that detracts from the artistic intent of the piece. An extreme, hypothetical example of deconstructive coenesthese would be of an HMD film told from the first-person perspective of a character that blinked for the viewer. Although blinking is a normal, lifelike attribute of vision, this would no doubt be distracting and cause destructive bodily awareness. Or, imagine a sequence from HMD cinema where you, the viewer, are soaring high above the Grand Canyon. This sequence could be destroyed by a viewer's fear of heights (as they virtually "dangle" hundreds of feet in the air), even though the filmmaker had intended this to be a majestic moment (as it surely would be in traditional cinema). Conversely, a horror film for HMD may benefit from drawing the viewer's attention to their own body as this focused

[7] Coenesthese is a term pioneered by theorist Jonathan Crary, which describes the phenomena of bodily awareness (Crary, 1990)

awareness intensifies fear. Coenesthese is a powerful new technique of storytelling for filmmaking for HMD, enabling way of entangling the body previously unavailable.

With *Crawl Space*, I aimed to avoid destructive coenesthese by creating a level of separation between the diegesis and the viewer by adopting the aesthetics of memory. Framing the film through the "lens" of memory helps to narratively justify the film's fantastical logic. To achieve this, I intentionally degraded the image using digital filter effects like grain and gaussian blur. The application of these filters led to an important discovery: image filters in HMD cinema tend to signify meaning about the viewer's narrative psychological state, rather than the diegetic world. To elaborate: in traditional cinema, filters are used primarily for compositional, aesthetic purposes; to convey meaning about the story. For example, a soft focus filter (which reduces contrast, and blurs the image) layers an ethereal quality to the world depicted. However, filters used in HMD cinema are applied *to the viewer* and tend to convey a narrative psychological state. For example, when the same soft focus filter is applied to HMD cinema, it may communicate that that the viewer has embodied a character whom is in a foggy state of delirium. Thankfully, the use of grain and gaussian blur in *Crawl Space* worked; the film unfolds as if it is the faded, distant memory of the character that the viewer embodies.

As mentioned, the meaning conveyed by camera movement is also fundamentally transformed in HMD cinema. In traditional cinema, movement of the camera is motivated by the filmmaker to add direction and momentum to the story. The traditional apparatus requires distance between the film and the viewer; the viewer *witnesses* movement superficially through cinema's window. However, in HMD cinema, the screen is placed directly in front of the viewer's eyes, making him or her feel as though it is their body moving due to the lack of grounding peripheral vision. Because of this phenomenon, camera movement in HMD cinema

must seem to the viewer to be motivated by the intent of the character that they embody, otherwise destructive coenesthese becomes likely; a viewer must *want* to move *before* the camera moves for them. This is an incredible challenge for filmmakers to address, thusly camera movement is presently rare in HMD cinema. With *Crawl Space* I tackled this challenge by staging the viewer on an imaginary space ship, conjured by the two brothers. This technique justifies the movement of the camera by establishing in the diegesis that the viewer's movements are controlled by a force outside of their will.

***Crawl Space*: Sequence Analysis**

Crawl Space was presented as an installation at the James Foster Penny Building from May 26 — 29, 2016 . Upon arrival viewers were greeted by an attendant who doubled as a concierge and usher. This person was staged at a podium underneath a light box which displayed the name of film "*Crawl Space*". My aim here was to establish a resemblance to the movie-going experience where the audience arrives and congregates under a marquee, a public gathering space, while waiting for the film to begin.

HMD cinema is a single-viewer-at-a-time experience. And while *Crawl Space* takes advantage of the intimate viewing experience afforded by this technology, these same conditions created some pragmatic concerns. In an ideal (higher-budget) scenario, the film would have been staged in multiple rooms simultaneously to allow more viewers to see the film in an evening while still preserving the solitary, isolated viewer experience. Therefore, with limited screening time, a sign-up sheet seemed like my most logical method of avoiding disorganized chaos which could have potentially have resulted in viewers grumbling as they entered the screening space.

In the gathering space outside the screening room was an array of monitors which displayed time-lapse videos of the various stages of the production of *Crawl Space*. It was important to include this behind-the-scenes information as it provided an additional context: exposing, in part, the autobiographical nature of *Crawl Space*. The screens helped to establish this by displaying me, the filmmaker, laboring over the production, explicitly connecting myself to the work. Through conversations with attendees, I learned that these supplementary videos did

communicate the personal nature of the work by demonstrating the physical construction process[8].

Figure 14: Playing in the Crawl Space with the Kinect Sensor

Once it was their turn, the viewer was ushered inside the screening room and given a verbal introduction to the HMD, intended to make the experience less intimidating to viewers new to virtual reality. The space was dimly lit by two flashlights. One flashlight was placed horizontally on the floor so that the light it casts rakes across a dozen-or-so the cardboard headsets that are strewn about the room. These "non-precious" headsets were an essential component of the installation, serving several purposes. On a purely aesthetic level, these headsets brought balance to a room that would have otherwise been weighted too heavily towards the center. Further, these headsets, scattered around the space also evoked a whimsical, child-like nostalgia, as if they were toys abandoned by children.

[8] It is also worth mentioning that part of the construction process was also performative. I reconstructed a place from my childhood that I could physically enter and play in again. This performance aspect was purely for me, by me, with no witnesses.

A second flashlight was suspended from the ceiling, illuminating the principal HMD in a small pool of light (in a Gondry-esque fashion). The flashlights themselves were not important per se, rather, it was the quality of light they emitted, along with the childhood associations of play and exploration which led to their incorporation. I also acknowledge that flashlights can be associated with horror and sci-fi genres, which I believe worked to establish an initial eeriness that works in tandem with the narrative. Additionally, the second flashlight serves a practical purpose by emitting a fairly focused beam of light which illuminated the headset while avoiding light spilling onto the nearby computer, drawing unwanted attention to its presence in the room.

The computer that powers the HMD was custom built with the *Crawl Space* installation in mind. In an ideal situation, the computer wouldn't be visible, however the technical restrictions of the HMD setup required that one be present[9]. Since a computer's presence was mandatory, it was important to me that its housing was as neutral as possible, without any flashing lights or molded features that I associate with the gamer aesthetic which, works against the film aesthetic that is foundational to my practice. I ultimately chose a matte black, quiet, minimalist case that (in a lovely coincidence) reminded me of the monolith from Kubrick's *2001: A Space Odyssey*. The computer's placement within the space was dictated by several factors. It made the most acoustic sense to have the user experience the film as close the center of the room is possible. This is also (inconveniently) where the room's primary power receptacles are located, therefore it made the most logical sense to minimize long, unsightly cables by placing the hardware as close to these outlets as possible, with the viewer being situated off-center, facing away from the entrance of the room.

[9] The Oculus DK 2 requires and its motion tracker require a connection to a computer via HDMI and USB. Hiding the computer in the rafters of the room would have required the cables be extended impractically. Additionally, it was important that the computer be easily assessable during the exhibition in case of technical malfunction.

Watching the film, the viewer sits on the floor, literally placing him or her on a child's level. Seating the viewer on the floor also incorporates the physical, tactile space into their experience. The tangibility of the floor allows for constructive coenesthese, as the constant connection to the cool, hard concrete highlights and celebrates the artifice of the experience. The floor also acts as a transition, or mediator between the physical space and the virtual one, similarly to the small fence that borders the room in *the Villa of Livia*.

Once the viewer dons the HMD, he or she sees "The film will begin shortly" floating as text in front of them. This introduction functions primarily on a practical level as it sets the viewer's expectations in terms of image quality, and also demonstrates to the viewer that the headset is working and aligned properly. My use of the word "film" here is also important. I believe that the use of this word establishes the viewer's expectations in regards to the interactivity of the piece. By stating clearly that this is a "film" the viewers are explicitly told to expect something outside of the typical gaming applications associated with the headset. This phrasing also highlights one of the principal aims of the piece: to utilize a new technology while maintaining continuity with an established practice.

The synthetic chime that sounds at the introduction was also born out of practicality. It was necessary to have some initial audio marker to cue to the usher outside of the room that the audio was working properly. This chime also notifies the viewer that the film is beginning and, in a way, separates the film from the introductory text as it fades away. Before the viewer sees an image, they hear the sounds of a VHS player starting up. The warbled audio and visual VHS artifacts (that I associate with memory) shroud the viewer as the image gradually fades up from darkness. As the image becomes clearer, the crawl space is gradually revealed, and the ambient

sounds of the diegesis flood the space. The combination of these techniques framed the film as a memory, both prosthetically and phenomenologically.

The waltz-like music featured during the first half of the film is a piece titled *Ballerina Music Box* written and performed by The Passenger (Jesse Creed) in 2011. This music was well-suited to *Crawl Space*, evoking images of a child's music box as the camera begins moving into the darkness ahead. The child-like innocence of the music, coupled with the eerie visuals work to establish an elegiac atmosphere. Additionally, the song itself has been treated by the artist with post-production audio filters which artificially degrade the quality of the audio. This treatment also injects the piece with a sense of memory, and loss which serves the aims of the film.

As the camera begins to move forward, the children's voices receive a digital filter that makes them sound like Apollo mission radio chatter. This furthers the sense of play by demonstrating the children's grandiose imaginings of space exploration, but also deepening a sense of memory since Apollo audio recordings now only exist as scratchy sounding archival records.

As mentioned previously, the linear forward momentum of the camera is perhaps one of the most important aspects of the piece. This relentless march is indicative of the passage of time but it also highlights the impact that the children's perspectives have on the space by stretching it endlessly. I also aimed for this forward movement to implicitly reference similar movements from science fiction films that marked my experience at this time[10]. I also believe that moving the camera in this way is perhaps the best means of preserving the agency the filmmaker in HMD cinema; guiding the viewer with camera *placement* instead of traditional framing.

[10] For example, Tie fighters chasing the Millennium Falcon though the tunnels of the death star in *Star Wars* (1977) and the psychedelic star gate sequence from *2001: A Space Odyssey* (1968)

The crawl space set was designed to work in tandem with this forward camera movement. The physically constructed struts and beams were repeated digitally in post-production. These repetitions were also intended to allude to the appearance of celluloid as it moves through the gate of the projector. As the viewer is jettisoned forward through the space, they momentarily *become* the projector. The light that emanates (seemingly) from within the viewer casts shadows of children playing on the illumined side walls. This is intended to symbolize self-reflection and memory, as the shadows seem to be cast from within the storyteller.

The objects that are scattered on the floor throughout the film also signal the film's autobiographical ambitions. Cardboard boxes, VHS tapes, and a television were (due to technical requirements) modelled using 3D compositing software to closely resemble objects that resided in the real crawl space of my childhood. Even though the viewer may not have personal connections with these specific items, their presence may trigger some personal associations; for example, unmarked VHS tapes are the most prevalent objects. By leaving the majority of these tapes are unlabeled, not tying them to specific films[11]. I hoped that these anonymous tapes would evoke in the viewer personal memories of home movies, creative projects or favourite films which would have further established a shared memory zone.

The moon landing sequence is also of deep personal importance to me. Here, the moon implicitly represents a childhood idea of adulthood; a place at the end of a long journey that beckons to be explored. However, the moon is ultimately an explicit metaphor for the back wall of the crawl space; a place I have never been. It's eerie, cratered surface, to this day, remains mostly untouched. This connection is made more explicit, in part, by the placement of the

[11] With a few exceptions. i.e.) one tape is labelled as *2001: A Space Odyssey* (1967)

camera once it reaches the surface. Here, I chose to orient the camera perpendicular to the surface, so that the viewer feels as though they are face-to-face with a wall, tying outer and inner space together.

Creative Missteps

Crawl Space is marked by many creative decisions which I regret. However, the most noteworthy of these choices surround the sound design of the film. Audio is crucial to cinema, offering the viewer practical information, guiding comprehension, and spurring emotional affect. Regrettably, my overwhelming concern with the visual language of HMD cinema resulted in my neglect of the film's audio at crucial moments of the narrative.

The early moments of the film are marked by one such regrettable decision: during post-production, I elevated the volume of the crawl space's ambience to help narratively establish the space. Regrettably, this ambience is clear and undistorted by post-production filters which would have helped further frame the film as memory. Following the logic of memory, the film's audio should have gradually gotten clearer as the story is *remembered*, rather than starting clear and gradually getting murkier as it did.

Key to the narrative of *Crawl Space* are the children's voices which were recorded and digitally panned so that each comes from its own speaker in the screening room. This spatialization of their voices establishes the children's positions in virtual space, making it easier for the viewer to distinguish between the two brothers. I have regrets that this spatialization was not embellished further by properly mixing these separate channels so that they sound akin to what a viewer might expect from a proper binaural sound design, which aims to emulate the attributes of human hearing. A binaural sound design[12] emulates the subtle reverberations that are heard by the ear opposite to the sound's source. These reverberations more-clearly establish for the viewer the site of a sound's genesis, and better allow him or her to follow sound's movement.

[12] To fully utilize binaural audio, the installation would have had to been modified so the viewer was wearing headphones instead of listening to the sound through speakers in the screening room.

This movement of audio in virtual space was intended to play a crucial role at the conclusion of the film. It was originally planned that once the viewer was facing the surface of the moon, their attention would be directed behind them by an audio cue of distant children playing. If the viewer should follow this cue by directing their gaze, they would see the earth slowly transform into the entrance of the crawl space far behind. If this were successful, many viewers would have been led to the realization that the film's journey was also metaphor for youth transitioning into adulthood. For me, this realization evokes a feeling of mourning; childhood is in the past and can only be revisited through memory. This moment in the film is lost due to overlooking the importance of audio in guiding the viewer's experience.

Conclusions

In 1970, theorist Gene Youngblood declared "Expanded cinema isn't a movie at all: like life it's a process of becoming, man's[13] ongoing historical drive to manifest his consciousness outside of his mind, in front of his eyes." (Youngblood, 1970, p. 41) The history of cinema and its apparent trends towards the immersive demonstrate that Youngblood's assertions bare some truth. Today, new HMD technology has further collapsed the traditional cinema apparatus, allowing filmmakers to manifest a convincing sense of presence for a viewer by placing the screen directly in front of his or her eyes.

As a filmmaker fascinated by film history and cinema technology, the prospect of inventing new formal techniques for HMD cinema excited me. To that end, I began work on my own HMD film which utilizes the traditional aesthetics of memory to tell a personal story about a sacred space from my childhood. While making this film, my methodology was shaped by my urge to preserve, and port traditional cinema to HMD, while still embracing the technologies unique qualities.

Through the process of making *Crawl Space*, I learned that many of the traditional formal techniques of cinema signify new meaning when translated to HMD. For example, camera movement in HMD cinema now mobilizes a traditionally immobile viewer, fundamentally transforming its meaning. And, post-production filters signify the psychological state of a viewer-embodied character. Further, my work has revealed what I believe is a new filmmaking techniques that are unique to HMD cinema, which I call "constructive" and "destructive

[13] I make the assumption that here, in 1970, Youngblood uses the words "man" and "his" to refer to "humanity's" historical drive. It is evident that that this historical urge to manifest one's consciousness is expressed by both male and female filmmakers.

coenesthese", whereby the filmmaker can explicitly manipulate a viewer's awareness of his or her body in the act of perception.

Looking forward, I see an HMD filmmaking shifting and adapting as the technology evolves. The future of 3D light field photography (which adds depth information to images) and headset eye tracking will soon expand the toolkit of HMD filmmakers. Future iterations of HMD content and hardware will surely impress and inspire new artists.

Looking back, I am proud of *Crawl Space*. I believe that I was able to create an affective, elegiac experience for the viewer, transcending that of a simple technology demonstration. One also hopes that the chosen title for this paper: *The Formal Techniques of Cinema for Head-Mounted Displays* does not imply that this is "*the"* definitive guide for future HMD filmmakers. This language and its grammar is still being written and it is the responsibility of future filmmakers to further define HMD filmmaking and its place within cinema's aesthetic legacy.

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