The Ashes and the Portal

An immersive stereoscopic experience on Cyclorama

Xindi Liu

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial

fulfillment of the requirements for the degree of

Master of in Fine Arts

In

Creative Technologies

Thomas J Tucker, Chair

Rachel L. Weaver

Robert Dunay

Zachary Duer

May 13, 2019

Blacksburg, Virginia

Keywords: Stereoscopic, Computer generated imagery, Cyclorama, Malawi, Library

The Ashes and the Portal

An immersive stereoscopic experience on Cyclorama

Xindi Liu

(ABSTRACT)

The Ashes and The Portal is an immersive stereoscopic animated short capturing the burned library after a fire disaster at Mzuzu University, Malawi, Africa, and it also illustrates the new design of the library from Virginia Tech architecture students. This animated short recreates the burned library and presents the new library design with photo-real image sequences which can immersively bring the audiences onto the site. the Ashes & the Portal utilizes the Cyclorama system, which is a 32 feet diameter and 16 feet tall cylindrical screen with four projectors that can display visual content. The surrounding panels with rendered footage could provide an immersive experience within this semi-public space. This project is a collaboration project between the School of Visual Arts and the School of Architecture + Design, also with technical support from the Institute for Creativity, Arts, and Technology. This project explores the potential use of the Cyclorama system as a platform for CG works, especially for stereoscopic animation.

The Ashes and the Portal

An immersive stereoscopic experience on Cyclorama

Xindi Liu

(GENERAL AUDIENCE ABSTRACT)

The Ashes and The Portal is a computer generated animation tells a story about burned library at Mzuzu University, Malawi, Africa and a new library design from Virginia Tech architecture students. Audience is required to wear a pair of 3D goggles to view the animation inside a giant curved screen which is surrounding the viewer. The photo-real footage of burned library and new library design can visually bring audiences onto the site and provide an immersive experience. This project is a collaboration project between the School of Visual Arts and the School of Architecture + Design, also with technical support from the Institute for Creativity, Arts, and Technology. This is an educational project that explores the potential use of the Cyclorama system as a platform for computer generated media works, especially for stereoscopic animation.

Acknowledgements

I would like to first thank Thomas Tucker who not only supported the development of my thesis, but also throughout my entirety of educational career from undergraduate to graduate program. I have learned so much from the researches and projects I have worked with you, your expertise, patience, kindness and your advice for future career development have guided me a lot. I would also like to thank Robert Dunay who provided the opportunity of a collaborative project with School of Architecture + Design, thank Rachel Weaver and Zachary Duer for their inspiring guidance and supports. The same sentiments also extend to many of my friends and colleagues who emotionally and technically supported me during my study here at Virginia Tech. I also want to thank the Institute for Creativity, Arts, and Technology and School of Visual Arts for the use of their facilities. Last but not least, I do like to express the deepest gratitude to my patients, thank you for supporting my studying abroad, understanding my choices and thoughtful encouragements.

Contents

List of Figures

Chapter 1

Introduction

It all began with rendering. The rendering I am talking about is digital rendering in computer generated imagery field. Rendering is not a movement of clicking the “render” button, it is a process of finding the right content and right destination. The process and progress of rendering represents my study experience in Creative Technologies at Virginia Tech.

the Ashes and the Portal is an immersive stereoscopic animated short capturing the burned library after a fire disaster at Mzuzu University, Malawi, Africa, and it also illustrates the new design of the library from Virginia Tech architecture students. This animated short recreates the burned library and presents the new library design with photo-real image sequences which can immersively bring the audiences onto the site. Three years of research and development are covered in this document as a record of the trajectory and process of making of **the Ashes and the Portal**.

Chapter 2

My Trajectory

Different artists have unlike art styles and outcomes because they all have their own divergent trajectories and experiences. As a digital artist, I consider the research experience as a very important aspect which will have significant influence on my future works. During my time at Virginia Tech, I have contributed my expertise in many collaborative projects with creative teams from different fields. I also benefited a lot from the challenges and obstacles while I working with other talented people. Here, I have selected some of the research projects which have influenced my thesis research work.

Figure 1.
Virginia Tech research timeline made by Xindi Liu

Blacksburg 16 Squares

I got the opportunity to join the team of Blacksburg 16 Squares, which is a 3D visualization research project on the history of architecture within the four block by four block grid area in the town of Blacksburg, Virginia. I was responsible for 3D modeling and texturing for three churches and one Farmer's market. While I was collecting photo references and modeling with Maya, a popular 3D computer graphics

application that I primarily work with, I found that I really appreciated the beauty of architecture and the beauty of passage of time. The beauty of architecture can be revealed from many aspects like form, line, shape, color or other properties of art. The more time I spent modeling the churches the more I understood the structure and the material. Even though the final version of the project was presenting with 3D printing with no texture but projection mapping, I did take this opportunity to practice my modeling and texturing techniques, and also as a study on architectural properties of art.

Figure 2.
3D prints churches modeled by Xindi Liu (photo taken by Xindi Liu)

Space Echoes

The Space Echoes project in October, 2016 was the first project I worked on with Thomas Tucker, Chair of Creative Technologies BFA and MFA in the School of Visual Arts at Virginia Tech. The Space Echoes project was an immersive stereoscopic animation piece that took place in ICAT Cube. [1] The Cube is a giant adaptable space which serves multiple platforms of creative practice by faculty, students, artists and researchers from different backgrounds. The visual components of the animations were projected onto a Cyclorama screen that is a 16 feet tall by 32

feet wide cylindrical screen. The Cyclorama system was first installed in the Cube in August, 2016 and I was lucky to become the first person who studied and worked on stereoscopic rendering specific for Cyclorama. The unique multimedia experience inside Cyclorama creates so many opportunities in presenting immersive visual and sound works. This experience gave me a potential option for my thesis project.

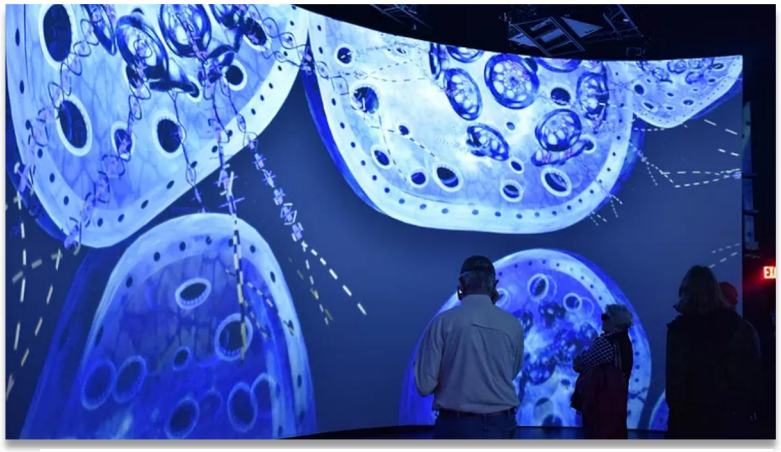

Figure 3.
Photo of Space Echoes showcase (photo taken by Lei Zhang)

Vauquois WWI Cave VR

The Vauquois World War I project is an educational Virtual Reality experience that allows the player to walk through the underground tunnel of Vauquois, an underground battlefield in France. This immersive experience requires historical information, interaction and believable visuals. This is an collaborative project made by a trans-disciplinary team. During the meetings we had together, the education team shared a lot useful information to our 3D team. In order to create a better immersive experience for the player, I modeled around eight props based on collected references and made them game ready objects. Because the game engine requires a clean and light scene for higher frame rate while playing, our 3D team needed to keep the game object into a lower poly-count mesh, but we also needed to work on generating the

detailed texture maps to fake the bumps, roughness, and reflection visual effects. Props play a significant role in a scene, not only in the actual film industry but also in the CG film industry. Through the use of props in a scene, the CG artists can illustrate environmental details and evoke emotional response from the player. In other words, the larger environment is created by smaller props.

While working on Vauquois World War I, I was able to collaborate with a creative team from different departments. The project has won several awards and the paper about this project was presented and published in 2018 IEEE VR Conference in Reutlingen, Germany through the great effort of my colleague Run Yu. [2]

Figure 4.
Game ready 3D assets and photo references made by Xindi Liu

Eco-Park Learning Center Visualization

Eco-Park Learning Center Visualization is a project I worked on with Professor Robert Dunay from the School of Architecture + Design and Center for Design Research at Virginia Tech. The four minute fly-through animation reveals the space, structure and function of the designs for the upcoming Eco-Park Learning Center at Prince William County. The project was handed to us with 2D floor plan and raw model from Rhino, which is a 3D software that architecture teams usually use. With the help of Professor Dane Webster and my colleague Lucas Freeman, we

finished the massive cleaning up job, texturing, modeling the floor and terrain, and I also did a night render for the Eco-Park. With my passion for architecture visualization, this was actually the first time I had worked on a real project besides my personal practice. This project became my thesis turning point not only because I met one of my committee members, Robert Dunay, through my work on Eco-Park, but also because it is a visualization work I made for a real architecture project. Rendering architecture is always interesting because it is not only finished by clicking the "render" button, but accomplished by deep research and complex setup that may repeat over time. I have gained a lot of experience working with architecture teams and dealing with their exports and visuals. They also shared a lot of their perceptions on visualizing the beauty of architecture, which provided more options for my thesis work.

Figure 5.
Night render of Eco-park learning center made by Xindi Liu

ACCelerate Projection Mapping

This is a large scale outdoor projection mapping project presented for ACCelerate Creativity and Innovation Festival in Washington, D.C. in 2017. The visuals was projected onto the entrance wall of the Smithsonian National Museum of

American History. While I was working on lighting, rendering and camera rigging, I found that the main challenge for me was figuring out the correct camera perspective setting for the giant entrance surface. In order to let the audiences believe visual effects projected onto the wall, I needed to create a virtual camera in 3D software placed at the audiences' eye level to capture the 3D animations. The relationship between virtual camera and abstract visuals has to be paralleled with the relationship between audience and entrance wall so that the projected visual can match the audiences' visual perspective. As long as there is a projector in use within a visual project, artists need to consider the relationship between projected surface and audience view. Usually in our daily life, we use projectors to directly project visual content onto the surface in front of us. But in some particular situations, especially in a large scale projection mapping piece, there is a perspective distortion because of the placement of the projector. Within this collaborative project, I gained not only the lighting and rendering experiences but also the understanding of real world and 3D virtual world, which actually helped me in the recent future.

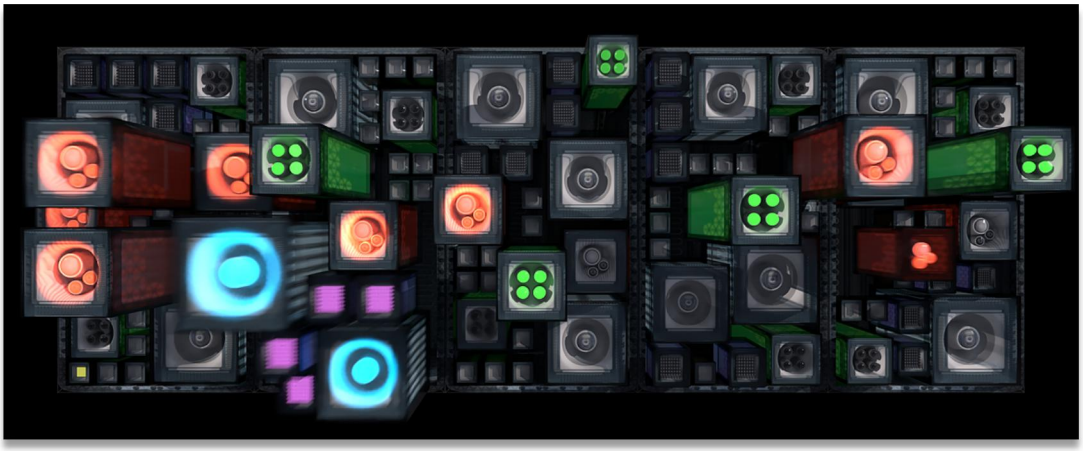

Figure 6.
Single frame render for ACCelerate Projection Mapping made by Xindi Liu

Watershed

I went to the 29th New Orleans Film Festival in October 2018 with a great team working on another interactive projection mapping piece, Watershed. This was a collaborative project that provided three-dimensional, fractured visual of rural Appalachian South. We designed the forms inside 3D software Autodesk Maya and then cut out the wooden piece with computer numerical control machine. I also helped with making animations and building the structures. It is always important to think about the space when doing an interactive projection mapping art work. Can the viewer walk in between the projector and visuals? Can the viewer see the visual content from a different angle or perspective? Our team also set up the VR experience under the Cinema Reset section at the New Orleans Film Festival, so we had the opportunity to experience some of the great VR short films in this section. I was lucky to talk to one of the VR filmmakers, Felicia Lowe, and another documentary filmmaker, Hao Zhang. It was a great experience for me to talk with filmmakers and visual artists outside my familiar community, and listening to their different voices really helped me go further in my own research. But I also noticed that the VR film experience is a very private one, and so I began to wonder about the set up of letting audiences sit in a public space to see private VR films. This made me to think more about the relationship between content and space.

Figure 7.
VR experience section and Watershed at far back (photo taken by Xindi Liu)

Throughout this journey, I was learning to work with a trans-disciplinary team on collaborative projects, which opened my mind and brought me away from my little workstation to an art world with more diversity. The different research experiences also allowed me to practise my technical skills and build a better understanding on presenting works with projection mapping.

Chapter 3

Making Choices

3.1 An architecture visualization project of new library design for Mzuzu University

Architecture visualization

I had been thinking about architecture visualization for a long time. My passion for architecture visualization began with the 3D church I modeled for the Blacksburg 16 Squares Project. My job was to recreate an existing church in virtual 3D world for future use. I carried my camera and took hundreds of photos of the church as reference for me to 3D model in Maya. But at this point, I was not only considering the photos as references for modeling, but also as resources for architecture study. I started to think about light and shadow as parts of architecture, and I wanted to let more people feel the material without touching it but only seeing it. Therefore, I started to play with my camera to capture the image of the architecture and work on my laptop to recreate the beauty of light and shadow.

The term architecture visualization is mostly used for today's architecture firms to provide vivid computer generated imagery, which is similar to when people talk about architecture rendering. However, rendering is not something new and uniquely related to the computer, even in today's rapidly developing CG industries. "A render is any depiction or interpretation that evokes something already existing or yet to exist," says German architect and digital designer, Fabio Schillaci, in his book *Construction and Design Manual, Architectural Renderings.* [3] We are not supposed to separate the digital form from the traditional hand drawing, and they are actually at

the same line of evolution. As a CG generalist who works on digital visualization and simulation, I noticed that architects spend ninety percent of their time working on theory study, sketch drawing and 2D planing. And this is great for them to come up with a functional new design, but they spend too little time on visualizing their great designs. From my perspective, I want to spend more time on visualizing the architecture. By capturing the changes of light and shadow, the beauty of architecture will be revealed by the passage of time.

Alex Roman, a Spanish photographer and CG artist, proved my idea by his art piece *The Third and the Seventh,* which is a 12-min pure computer generated animation short. [4] As a photographer, Alex Roman always captured the world through his lens and this helped him understand the setup of the camera inside a 3D software in the virtual world. The photographic aesthetic perception makes the short stand out from the usual architectural visualization work. In the film, the beauty of architecture is revealed by the movement of camera transmitting space and time with emotional displacement. Alex Roman also published a book, *From Bits To The Lens,* based on the production of the short film. The book contains a well crafted and documented process behind the screen, explaining the philosophical theory and the technique behind the architecture visualization. I was able to visit the library of Savannah of Art and Design to have a look at the book because there are only two physical copies in America accessible to the public. While I was holding the book and going through the photo-real rendered images and his personal perceptions, I felt like I was having a quiet, calm and deep conversation with Alex Roman. He told me that a structure and its main pattern sometimes keep repeating, but viewers always feel different because new elements keep adding visually, metaphorically and through passage of time.[5]

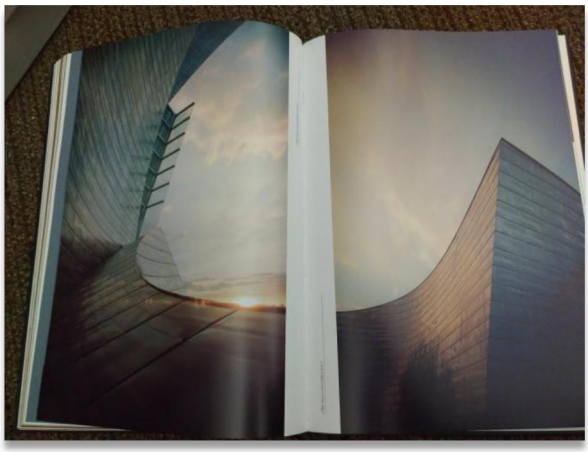

Figure 8.
Alex Roman's book From Bits to the Lens (photo taken by Xindi Liu)

Junichiro Tanizaki also influenced me a lot with his book, *In Praise of Shadows.* [6] The book introduces traditional Japanese aesthetic and compares that to Western perfection of light and clarity. Tanizaki also deeply talked about the reflection and shadow for different layered materials. This influenced me a lot regarding how I shade and texture a material now as a CG artist. The beauty of architecture is not revealed by showing the spotless and unblemished material; the traces of time become part of the architecture itself. Showing the imperfection of materials with the passage of time can emotionally tell a story behind static structures.

Mzuzu University

In the early morning of December 18, 2015, the Mzuzu University library in Malawi was completely destroyed by a fire accident. A total number of 53,000 books, 68 desktops computers, 403 reading chairs, 62 reading tables, 111 shelves, three heavy duty photocopiers, eight printers and some Malawian artifacts and manuscripts were destroyed.[7] The total value of the items damaged was more than 7 million dollars. For many years, the Mzuzu University library served as an educational center for the community to study, read and use computers. The information technology

department and network servers were also housed inside the library. All of these valuable resources for the region were destroyed by the fire. Malawi is one of the least developed and most impoverished countries on earth, with a per capita GNI (dollar value of a country's final income in a year, divided by its population) of just US$320 in 2016, which is one of the lowest in the world. The loss of the Mzuzu University library was devastating for the people in the region and the community.[8]

Ralph Hall is the associate processor at the School of Public and International Affairs at Virginia Tech. He was forwarded an email after the fire accident in March 2016 from Hayden Boyd, the President of the Malawi Education and Children's Welfare Foundation. The email stated the donation process that Mzuzu University wanted groups in the U.S. to follow. Approximately 8000 textbooks were being shipped to Mzuzu University temporary library with the help of Virginia Tech and Mzuzu University community members.[9] Also, the School of Architecture + Design at Virginia Tech was working on a new library design as a replacement for the burned library. Robert Dunay was one of the faculty members leading a student team working on the new library project. Because I had research experience with Robert Dunay on an architecture visualization project, I could easily reach out to him and get updates about the Mzuzu library project. I showed my interest in the project and potential visual presentation contribution to the project. Robert showed a lot of photos of the burned library to me and added me into the team drive for the project, which had a lot of useful resources about the fire and Mzuzu University. The architecture team took a trip to Mzuzu University in September 2017 and they shared a lot of photo references about the site and the burned library. After seeing the library's comparison photos of before and after of fire disaster, I was shocked and heartbroken. At this point, I did not want to be a bystander to what was happening; I wanted to contribute my

expertise to the team; I wanted to document and visualize the story with my artistic touch; I wanted to present my visualization to the Virginia Tech team, to the delegation team from Mzuzu University and to all of the community numbers who devoted their efforts to the recovery program for Mzuzu University.

Figure 9.
Mzuzu University library fire (Source from Dr. Mavuto Tembo)

3.2 A narrative with camera capturing passage of time

Does architecture tell a story? Yes, architecture can tell a story through passage of time. Buildings meet human needs by enclosing human habitation and providing functional uses.[10] Different kinds of buildings hold unique characters inherited by architects from various backgrounds. People feel different in a library compared to a hospital not only because they have different structures but also because the passage of time has influenced the building subtly. The smell of books and disinfectants can lead to different emotions, and the decay of a shelf in a library and a hospital appears differently. Architects spend a great deal of time designing buildings with concerns of function and form, so the first story before everything is giving birth to a new architecture design. But the beauty of architecture is not only

revealed by the perfect polished model, it also revealed by its interaction with passage of time.

The camera is my guiding thread through architecture spaces. It can capture not only the beauty of static structures but also the emotion at that particular moment. Emotion is subtly hidden blending within time, light, shadow, color, texture, and composition. Time contributes so much to architecture, however viewers can only capture the passage of time through other elements like light, shadow, material or color. On the other hand, the passage of time can be revealed by portraying nature side by side with architecture, such that architecture breathes when time passes, light changes or wind flows. Architecture is never alone; there is light passing through structures, shadows spinning in between columns, nature touching on the edge of material and saturation switching between dawn and dusk. As a CG artist, I use camera to tell story by incorporating light and motion. The change of light can tell the passage of time; the change of camera motion can tell different emotions in different scenes. By setting up different camera angles and focal lengths, I can illustrate different compositions with different emotions.

There are two main chapters in the visualization: one is the Ashes which represents the burned library, and the other is the Portal which represents the new library design. These two chapters hold different emotions that required me to make decisions on how to reveal them. In the Ashes section, I wanted to express the emotion of sorrow and distress from the loss of the library in the fire disaster. I chose to go back to the burned library virtually with a camera slowly panning through the ruins. The library went through many years and eventually suffered through the fire disaster. Time and fate had damaged the building so much that viewers couldn't enjoy the peace and quiet in the library. Light casts shadow through tilted burned shelves,

burn marks left on the surviving concrete walls, ashes float in the air. The camera moves slowly, the saturation gets dull, the texture of materials has decayed and bears burn marks. There is only a piece of grass standing in between ruins, representing hope. On the other hand, the Portal section introduces the birth of the new library design. The emotion in this section becomes encouraging and delightful with the reveal of the new library design. There is more energy in this section so that I made some choices on the setups of camera and color palette. The camera in this section flies faster, the color of light becomes warmer and brighter, more reflection becomes visible, and there are new textures for the new library. However, even though the library is brand new, I decided not to make the texture spotless and unblemished. In its first day, the building already starts showing traces of time, which I consider the beauty of passage of time. I believe that a new architecture is excited to embrace the world of nature and ready to interact with humans. When I talked to one of my architecture colleague, he always mentioned how he wants the design to meet human needs and how humans interact within the beautiful form. A piece of architecture is not built to stand perfectly forever; it is built to interact with humans for as long as possible. The passage of time tells a story of a piece of architecture from its first day and shares the beauty of architecture with light and shadow. And my goal as an CG artist is to re-create the environment and tell a story using my expertise on camera rigging, texturing, shading, lighting and rendering.

3.3 A visualization short projected on Cyclorama in the Cube

What is Cyclorama and why did I spend so much time studying the Cyclorama system? Cyclorama is a unique massive cylindrical projection screen for

immersive experience in the Cube located within the Moss Art Center on the Virginia Tech campus.[11] The Cube is a highly adaptable space ready for immersive experience, intimate performance, visual installation or other experimental investigations. The Cyclorama screen is one of the setups in the Cube which is built for immersive visual presentation. Two curved screens stand on ground dividing the space into a cylindrical inner space and outside space. Each screen is curved around 170 degrees so that there are two gaps in between the two screens for the audience to pass through. This setup makes the Cyclorama a semi-public space. Compared to the private VR film experience, the Cyclorama in the Cube provides an immersive environment for audiences to enjoy the work in this space, and also to keep awareness of the surroundings and to have conversations with other people. Audiences only need to pick up a pair of 3D goggles at the entrance and then walk straight into the Cyclorama space to enjoy the piece. The straightforward process can create a better environment for audiences to enjoy the visual content and hold some conversations.

Figure 10.
Cyclorama at Virginia Tech (source from https://www.elumenati.com/projects/virginia-tech-cyclorama/)

Jason Roberts is the designer and developer for an award wining puzzle video game. He gave a talk at the 2018 Game Developers Conference in San Francisco about the process of developing the game *Gorogoa.* During the talk, he shared his

understanding about “frame”, which I found insightful. He said that forgetting the frame can lead to immersion.[12] The screen on TV or mobile phone can help users to focus on the content inside a frame, which is convenient and space saving. However, the user cannot get a fully immersive experience in front of a small frame. When the frame becomes big enough compared to human size, people will start to lose awareness of the borderline, and the screen becomes “frameless”. Audiences will have a more immersive experience after stepping into the Cyclorama space; this is why I am choosing to project the work on Cyclorama rather than using a standard TV screen.

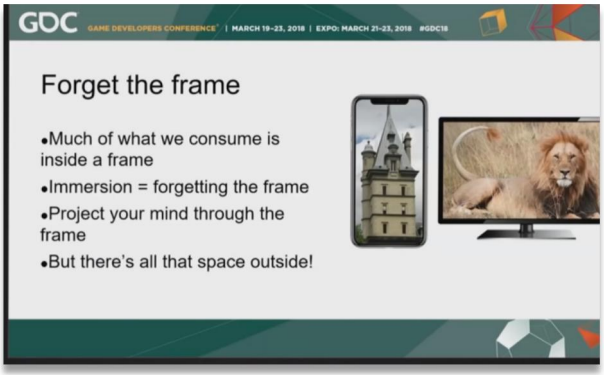

Figure 11.
Screenshot of video recording from Jason Roberts’ talk at 2018 GDC (https://www.youtube.com/watch?v=rZrGoUhcSNo)

3.4 An animated short rendered with stereoscopic effect

We human beings live in a world that is not static. Human eyes are built to capture moving objects and they will feel more immersive when they see visual movement rather than static renders. And thanks to great advance in CG algorithms in recent years, the render setting of motion blur can help make the virtual visual experience almost identical to reality. There are two options for me to bring the

visuals onto Cyclorama panels: one is using pre-rendered image sequences encoded into a video format, and the other is using game engines like Unity or Unreal to spout out real time rendering footage onto Cyclorama panels. Based on the test and study I did, it is really hard to export out the real time stereoscopic data especially with a high resolution. At this point, using the pre-rendered footage is a safer solution; with the help of render farm I could save a lot of time. Render farm is a computer cluster built to render a large number of computer-generated imagery. Render jobs take a great amount of time. For an one minute animation, render engine needs to render out 30 frames one by one if the render setting is 30 frame per second. The render time of one frame depends on the complexity of the visual content; the more complex the scene is the more render time it will take. As earlier stated, the big screen in front of viewers can make viewers feel frameless, which can create an immersive experience. Stereoscopic footage can bring the experience into a more immersive level by creating the illusion of depth with a binocular image. The first physical set of stereoscopic film system in Russia was developed by Semen Ivanov using 35mm film frames next to each other.[13] The setup of stereoscopic camera pair in the 3D virtual world is similar with the setup in the real world. Different systems have different settings to handle stereoscopic images; usually, artists can render out left and right eye image separately and then align them together with left at top and right at bottom.

Figure 12.
Example layout for stereoscopic rendered footage made by Xindi Liu

Chapter 4

Progress and Process

4.1 Building the visual content

The goal of the visualization is to document the birth of the new design replacing the burned library at Mzuzu University, and provide an immersive visual experience for the people in the community. After the research study of the shared photo resource from the architecture team who took a field trip to Malawi, I understood more about the story behind the project. I divided the visual content into two main chapters: one is the Ashes which represents the burned library, and the other is the Portal which represents the new library design. After sketching some storyboards, I settled down the detailed setup from title sequence, burned library section, transition section and new library section. I found out that using a linear perspective is a great way to create an illusion of depth with a stereogram. With the choice of using a linear perspective, visual content in depth can provide an immersive illustration to audiences. In order to virtually bring audiences to the site, I needed to setup a camera that represents human perspective in virtual 3D software. I modeled and textured the burned library from scratch based on the reference photos. The raw model of the new library was provided by my colleague, James Wood, from the School of Architecture + Design.

Figure 13.
Front desk section of burned library at Mzuzu University (photo taken by Amanda Milella)

Figure 14.
Perspective example of *Hall with colonnades on two floors* by Hans Vredeman de Vries

Figure 15.
Example of sketches for story boarding by Xindi Liu

Figure 16.
Example of perspective view, rendered image from burned library section made by Xindi Liu

Figure 17.
Example of perspective view, rendered image from auditorium section made by Xindi Liu

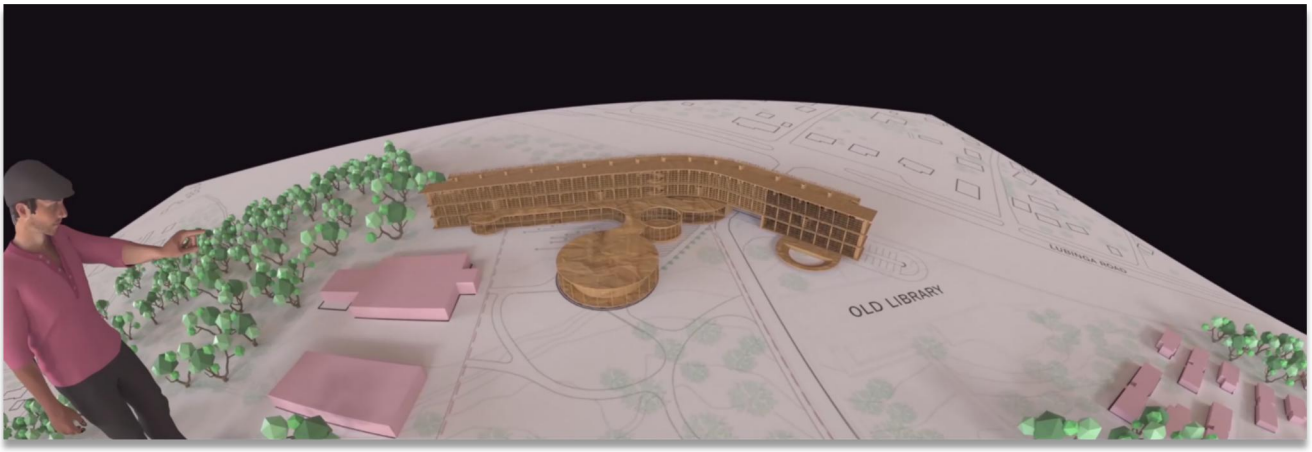

Figure 18.
Example of showing site plan, rendered image from plan section made by Xindi Liu

4.2 Figuring out the technical challenges

The challenge here was to figure out the stereoscopic camera setting specific for Cyclorama resolution. First, I needed to make sure that I was rendering out with the right resolution. With the curved screen, the ratio of one screen is three by one, which means I can render at 3000*1000 pixels or 6000*2000 pixels for a higher resolution. Second, I needed to make sure the visual content would have no distortion after exporting and importing. I was using a checker image I generated to identify focus area and edge area. Third, I needed to setup a stereo camera set in 3D software which represents human eyes. Finally, I needed to understand the attributes under the camera setting and understand the relationship between the virtual world and the real world. The stereo camera has three parts, left camera represents left eye, right camera represents right eye, and the center camera is the average view we can use as a preview camera. In order to capture a panorama shot matching with the physical Cyclorama panel, I needed to create a virtual spherical camera projection with horizontal and vertical sweep. For instance, a 180 degree horizontal sweep means the camera rotates horizontally from left to right. There would have been no problem if I was using a normal single lens camera to have a 360 degree horizontal sweep; in this case, I could get a full 360 degree image. However, there is a tricky trap for stereoscopic camera users; the axis for sweeping is based on the camera itself not the camera group, which means a 360 degree horizontal sweep will turn the left camera to right camera and the right camera to left camera. Thus, in order to capture a full 360 degree stereo image, I needed to setup two stereoscopic camera groups facing the opposite direction with 180 degree horizontal sweep. The last challenge was to understand two terms: **interaxial distance** and **zero parallax**. Interaxial distance indicates virtual distance between left stereo camera to right stereo camera. Zero

parallax indicates distance from stereo camera to focus location which has no “pop up” or “fade away” effect. Interaxial distance in the real world represents distance between two eyes; zero parallax in the real world represents distance between human eyes and projection screen. The goal here is re-creating a virtual scene that indicates the real world situation, including the relationship between objects to camera. With the main technical problem figured out, the other small challenges were easy to overcome.

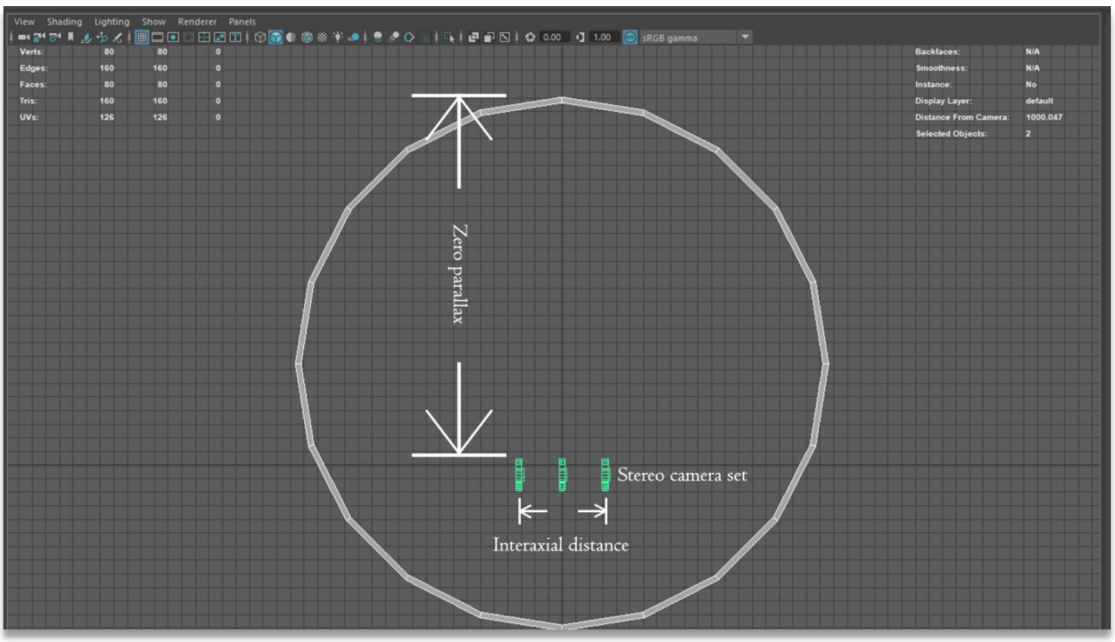

Figure 19.
Graph explaining Zero parallax and Interaxial distance made by XIndi Liu

Chapter 5
Reflection and hypothetical futures

5.1 Experimental visual presentation

The whole project concluded as a visual stereoscopic presentation projected on specific Cyclorama panels, which provided a new way of presenting visual works especially for immersive experience. During my thesis research, I went through many possible topics and different ways to present works. Finally, I decided on a stereoscopic architecture visualization short projected on Cyclorama screen in a semi-public space. I hope that my thesis project will be a foundation for any bigger project on finding a better way to present immersive visual works.

5.2 Possible future development

Within the time I spent on this thesis, I figured out that there is no perfect project, and there are always some parts you can explore further. For my thesis, the real time game engine might be the future answer for a quick and better result for providing immersive visuals; or if I had found this project earlier I may have had the chance to travel to Malawi, so I could have an “immersive” resource collection. Cyclorama is a very unique system for researchers to study on potential creative use. Even though it will be difficult for me to present my work again without Cyclorama system, I did provide my perception between virtual world and real world, and I tested out the potential use of Cyclorama for presenting immersive visual content which could be used in other similar situations.

5.3 Bigger community

I would like to share the Virginia Tech motto *Ut Prosim* at this point: That I may serve, in the spirit of community, diversity, and excellence. As an international student from China, I enjoyed the collaborative experiences with trans-disciplinary teams within the past several years. There are so many talented people with different areas of expertise in the community, and we had sent out our creative projects within the US and internationally, to a bigger community. I witnessed the interaction of different ideas, and collaboration is actually happening.

References

1. The Cube | Institute for Creativity, Arts, and Technology | Virginia Tech – Institute for Creativity, Arts, and Technology. (n.d.). Retrieved January 25, 2019, from https://icat.vt.edu/the-cube/
2. Yu, R. (2018). Experiencing an Invisible World War I Battlefield Through Narrative-Driven Redirected Walking in Virtual Reality. ISBN 978-1-5386-3365-6. Retrieved September 13, 2018, from https://ieeexplore.ieee.org/document/8448288/metrics#metrics.
3. Schillaci, F. (2009). Construction and Design Manual, Architectural Renderings. Page One Publishing Pte. ISBN 978-981-245-910-7
4. Roman, A. 2009, Nov 24. The Third & The Seventh [video file]. Retrieved from https://vimeo.com/7809605
5. Roman, A. (2013). From bits to the lens. ISBN-10: 8461652401
6. Tanizaki, J. (1977). In Praise of Shadows. Retrieved from http://wwwedu.artcenter.edu/mertzel/spatial_scenography_1/Class Files/resources/In Praise of%2
7. Chawinga, W. (2018). An Assessment of Mzuzu University Library after a Fire Disaster. Retrieved from https://www.researchgate.net/publication/331178866_An_assessment_of_mzuzu_university_library_after_a_fire_disaster.
8. International Monetary Fund (2017). Malawi : Economic Development Document. country report no. 17/184. Retrieved from https://www.imf.org/en/Publications/CR/Issues/2017/07/05/Malawi-Economic-Development-Document-45037.
9. Hall, R. (2018). Ready for the Mzuni Delegation. Retrieved from https://ralphphall.com/2018/02/10/mzuni-delegation/.
10. Stokstad, M., & Cothren, M. W. (2018). Art history Fourteenth to Seventeenth Century Art. Upper Saddle River: Pearson.
11. Cyclorama at Virginia Tech. The Elumenati, LLC. (2016). Retrieved from https://www.elumenati.com/projects/virginia-tech-cyclorama/.
12. [GDC]. 2018, Apr 30. Gorogoa: The Design of a Cosmic Acrostic [Video file]. Retrieved from https://www.youtube.com/watch?v=rZrGoUhcSNo

13. MAYOROV, N. (2012). A first in cinema... stereoscopic films in Russia and the Soviet Union. doi:io.i386/srsc.6.2.2i7_i