Re-Creating the Nunalleq Cultural Center for use in Virtual Reality

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Abstract

Seeing how virtual and augmented reality devices are becoming more commonplace in everyday households, it is hard to not notice the value virtual reality headsets have. During my week long stay in Quinhagak Alaska I became acquainted with the Nunalleq Cultural Center (see figure 1-2[1]); a rather intimate two room building lined with beautiful wood paneling built to house and work on the artifacts gathered from the nearby archeological sites. Because of the museum's location not many people have heard of it nor can they visit. Due to this archeological site being one of the largest in North America I thought this site would be the perfect subject to recreate for exploration and interaction through a virtual reality headset.

Background Information

The idea of a digital museum is not new to Quinhagak Alaska, my research advisor Dr. Sean Gleason along with Dr. Alice Watterson who I worked with during my visit to Quinhagak have been working on a digital museum [2] which allows people to learn about the archeological site and the artifacts within the collection. Dr. Watterson has been scanning the artifacts over the past couple of years for use in this digital museum. This of course helped guide me to the idea of recreating the museum for Virtual Reality. I came up with the idea of recreating the museum in Quinhagak Alaska for use in virtual reality while on site. While I was there I knew that I would at least be creating the collections room to use as a proof of concept. Since I was in Quinhagak Alaska for only a week I was limited in the data and reference that I could gather, meaning this summer was crucial to develop a working proof of concept of the Virtual Reality Museum. I also needed to develop workflows that would make doing a project like this easier and more accurate. I immediately sat down and came up with a quick plan for what I would need to make this possible; what I settled on doing was grabbing a photogrammetry[3] scan of the collections room which I would use as reference for physically modeling the room to an exact 1-1 scale. The photogrammetry scan of the collections room ended up being 589 images in total and was done through Polycam[4]. This is not a large data set in terms of photogrammetry, Polycam can take up to 2000 image datasets but the quality of the photo scan I got was high enough quality for me to work with(see figure 3[5].) With this photoscan of the collections room I was then able to get the measurements of every object, the scan along with the image dataset also allows me to see all of the objects material qualities so I can replicate them as accurately as possible

Re-Creating the Landscape in Alaska

Before I began physically modeling the museum I started the summer by working on a project involving Digital Elevation Mapping (DEM) data to create an accurate landscape map of the surrounding area to Quinhagak Alaska. For this small project I used publicly available USGS IFSAR[6] DEM data. This data which came in the form of a GEOTIFF image was then brought into Blender[7] through the BlendGIS addon. What this does is take the depth of each pixel of the image, attributing it a "point" or vertex within the digital 3D space. Then those vertices within 3D space are connected like a game of connect the dots and the space between the connections are filled in to

1 See figures 1-2 for reference of the Nunalleq Cultural Center.

2 The digital museum that Dr. Gleason, Alice Watterson and many other archeologists along with members from the tribe who have worked on and contributed to can be found at (https://www.nunalleq.org).

3 A photogrammetry scan utilizes a large set of 2D images to create a 3D model by determining the depth and scale of an object by determining the change in perspective of an object between one image and the next by utilizing around a 75% pixel overlap between the images.

4 Polycam is a free and subscription based photogrammetry application made to work with mobile devices, allowing people to create photo captures virtually anywhere.

5 See figure 3 for a photo of the collections room photogrammetry scan.

6 The USGS (United States Geographical Survey) IFSAR (Interferometric Synthetic Aperture Radar) project was done to map the entirety of the state of Alaska. 7 Blender is a free to use 3D modeling and animation application.

create a mesh. After doing this to 23 of the IFSAR[7] GEOTIFF images I had an accurate 3 dimensional map of a 52 mile area surrounding Quinhagak Alaska(see figure 4[8]).

The initial goal for this map was to use it to help teach survival techniques during the winter time. I was working on the map to implement into this project to allow people to plan where they are going to travel and have different survival scenarios come up that they can work through to learn how to deal with. This project really resulted in me looking at animation in a different way, I was forced to look at it from a game developer point of view, something I hadn't really done before.

We wanted the map to be during the Winter time for a few reasons, one of the main reasons was the quality of the map. While the map was accurate, because of the recording method many of the points were jagged when in reality they would be smooth. So to achieve a more realistic map I ended up smoothing the map in Blender over the course of multiple days. During this part of the project I was also working to optimize the map to make it runnable through a web application, making it usable to a larger number of people in Alaska where consistent internet to be able to download a large app is not guaranteed. During the optimization process of the map I was able to bring the size from 13 gigabytes down to 1.2 megabytes, resulting in a massive improvement in performance.

After working on the map and adding in a snow texture to the ground along with a few buildings in the location of the largest nearby city which was Bethel Alaska. After doing this I began to realize that game development was not something that I was good at or had much passion for. My roots are in 3D modeling and animation and not game development which is a completely different world production wise. But what the map project did for me was teach me some very important fundamentals in applications such as Unreal Engine[9] and Blender which I hadn't had much experience with before this summer. These applications are also necessary for the development of virtual reality applications and experiences which is integral to the VR museum project I conceptualized while in Quinhagak. So with the map project becoming a lost cause I decided to move onto the VR museum which is what a majority of my time this summer was spent working on.

Breaking Ground on the Virtual Museum

For the Virtual Reality Museum project I started out by researching other virtual reality museum projects that have already been done before. The most common example of these virtual museums are the collections of museums and sites that are in the google arts and culture collection. These virtual museums are different from what I was envisioning for my project. The museums within the google arts and culture collection are panoramic images meaning your view of the museum is comprised of 2 dimensional images, greatly restricting the ability of the user to explore and interact with the content. After doing a bit more research I was able to find another example of a virtual reality museum in China which sought to recreate an actual museum space for exploration through a VR headset [10]. The Smithsonian has also re-created certain spaces with art and media from their collection for view inside of a VR headset[11]. The experience created by the Smithsonian is accurate and very well done, but it limits you to only the East wing, leaving something to be desired from the player. Although this was much closer to what I wanted to do with the Cultural Center in Alaska. One of the great points made in the article that resonated with me was that it is the duty of the creator to depict space in as accurate a way as possible. This made me focus on small details such as the screws mounting a handle to a dresser, or in which order the masks are in their display case.

One thing I noticed during my literature review was that there are not many Virtual Reality museums out on the market yet. There are a few such as the one in China which I mentioned before as well as one which is focused around an archeological site in Peru

7 (Interferometric Synthetic Aperture Radar) essentially (I think) uses radar pulses to gather digital elevation data by interpreting the energy shifts caused from the radar pulses which are then colorized to represent the changes in elevation.

8 See figure 4 for a photo of the DEM map that I was able to generate from the IFSAR along with a comparison photo from google maps.

9 Unreal Engine is a free to use 3D rendering and game engine. I used Unreal Engine to add in the Virtual Reality capabilities.

10 "VR and Cultural Heritage Recreation — AMT Lab @ CMU." n.d. Accessed July 28, 2024. https://amt-lab.org/blog/2021/10/vr-and-cultural-heritage-recreation.

11 "Beyond the Walls: Experience the Smithsonian American Art Museum in Virtual Reality | Smithsonian American Art Museum." n.d. Accessed August 26, 2024. https://americanart.si.edu/beyond-the-walls.

(CARALPERU[12]). Another Singaporean based company called hiverlab is working to digitize and make available heritage sites across Singapore[14]. Taking this into account I really wanted to explore what could be possible with recreating a museum for use in Virtual Reality headsets while also beginning to develop a solid workflow for future projects in this area by creating a polished proof of concept with the Cultural Center in Quinhagak.

Making my Best Case

When starting on recreating the collections room of the museum in Alaska I began by blocking in the walls and floors. I did this part of the collections room in Adobe Substance Stager using measurements from the photogrammetry scan I took while onsite. This part of the collections room was easy since the walls and floors are comprised of cubes and planes, cubes for the walls and a plane for the floor. After the walls and floor were created I began to start recreating the cases and shelving units. The cases were all custom built to house the mass collections of artifacts so making sure to accurately depict the wooden cases was very important to me.

There were two different types of wooden cases of the same size that I had to create. The first case had 8 drawers occupying it while the other type of wooden case had 5 drawers. The handles for the drawers go the entire length of the drawer and taper off at the ends slightly, each dresser also had 4 legs which I made sure to include. After the base meshes for the wood dressers were created to scale I had to make it look like actual wood since the actual dressers don't come to exact corners and the wood elements themselves naturally have slight deformities. So to do this I smoothed the corners and randomized and smoothed certain vertices within the meshes to create the impression of cutting and carving of the wood. I then made sure to add in the nails along the handles of the dresser that I was able to see in my reference data.

After creating the meshes for the wooden dressers I started on the metal dresser which is supported by a low 6 legged wooden table. The metal dresser had 5 drawers, each with 2 handles and 1 nameplate. Creating the metal dresser was easy enough since the metal dresser has sharper edges. The wooden table supporting the metal dresser had 6 legs each one made up of two pieces of wood screwed together. After getting all of the measurements from the Polycam photogrammetry model I manually constructed the wooden pieces, making sure to follow my workflows from the wooden dressers for making the meshes appear more lifelike. When constructing the wooden table I even made sure to include all of the screws that were visible to the players, each leg had 6 screws in 2 columns of 3 while the corners of the tabletop had 4 screws in a square configuration(see figure 6[13]). That concluded the work I had to do for the mesh of the metal dresser, there was only one of these dressers in the museum so there was no need for any other variations of it(see figure 5[14]).

After completing the metal dresser I moved onto the metal shelving units which there were two of within the collections room. These shelving units are common metal shelves, I attempted to replicate them as closely as possible, but details such as the amount of metal cylinders in rows and columns making up each shelf were impossible to acquire while off the site, these details also weren't recorded well through the photogrammetry model due to the fact that metal objects do not record well through photogrammetry due to their reflectivity. So in an effort to portray the metal shelf as accurately as possible I created my model of it to the same scale with the same amount of shelves, albeit the shelves themselves in their composition are not accurate. There was also one other key detail to the metal shelves that I had to be conscious of, this detail was the fact that all four of the support poles of the shelving unit had many little notches which were used to adjust the height of the shelves. For this I used a metal shutter material[17] on the poles. Because the metal shutter material is essentially an image of a metal shutter which is in essence is just multiple metal rows which when manipulated to be as close to each other as possible give the impression of a metal pole with many small notches, which in reality are just the gaps between many metal shutters. The two metal shelves were the exact same so the one that I modeled was then duplicated to double as the second shelf as well.

After the metal shelves were completed I began working on one of the star attractions of the

12 "CARALPERU" is an application that can be downloaded and explored through the Meta Quest store.

14 "Hiverlab: Creating a Virtual Heritage of the World's Most Historic Sites." n.d. Accessed August 26, 2024. https://www.cnbc.com/2016/12/07/hiverlab-creating-a-virtual-heritage-of-the-worlds-most-historic-sites.html.

13 See figure 6 for a reference of the screw models added into the metal dresser table.

14 See figure 5 for reference of the 5 different cases and shelves that I modeled for the project.

17 A material in 3D modeling is how a mesh gains visual attributes ranging from a solid color to complex details such as woodgrain and even depth. The materials I used were licensed from Adobe Substance Assets.

collections room which was the glass display case that houses the larger more intact artifacts of higher importance such as ceremonial masks and objects such as bowls. This object was a bit more complex than the other ones. What separated this object from the others is that it is a thick base made up of multiple parts including metal corners, a wood center and a rubber lining along the bottom leading upward to a glass and metal display portion that juts out forward. The upper display portion of the case was composed of 12 metal pieces and 5 metal panes, with two platforms, one of which was suspended halfway up the case. After I created the mesh for the case and the base of it I imported scans of the masks which were housed within it on the suspended shelf. Because the masks were laser scanned onsite by Alice Watterson they were their exact sizes and had very high quality meshes. So I imported the masks into Substance Stager and arranged them in the proper order within the glass display case.

After the glass display case was completed that was the end of modeling all of the furniture on the floor of the collections room. I then took all of the models that I outlined above and arranged them along the floor plane making sure to keep them in the same place as they are in reality. After I arranged the shelves and cabinetry, I began to make the shelves that line the walls of the collections room[15](see figure 7). There are seven shelves around the collections room, these shelves are there to support a variety of boxes, most of which are plastic, that contain thousands of different artifacts ranging from fragments of wood to more complete objects such as arrow points, although most of the more intact artifacts will be found in the more easily accessible cabinets. There are four distinct types of boxes that line the shelves of the collections room, one of them is a normal looking smaller rectangular clear plastic storage container, while the other is a larger more cube shaped clear plastic container, the third type of box was a smaller white paper box, similar to one used to store baseball cards, the last type of box that I had to model was a longer yet short square shaped box which was yellow in color. After I modeled all of the boxes I began to arrange them in the proper order, but due to the massive amount of plastic boxes along the wall shelves I had to cut back on the plastic containers for now, although future versions will include every storage container in the proper order.

Making the real in Unreal

At this point I had all of the meshes in place in Substance Stager so I began to apply the proper materials to everything. Because I was not onsite while working this I was not able to rip materials from the actual museum to use on the meshes I created. So instead of creating the materials from real world data from the museum I had to license the materials from Adobe Substance Assets. So to make this work I had to spend a long time matching up the propper types of wood and metals to accurately portray the models as realistically as possible. I began to apply the materials to all of the models which didn't take too long. It was at this point that I began to export everything from Adobe Substance Stager to Unreal Engine; what this entailed was exporting the Substance Stager models to .OBJ then importing them into Unreal Engine. What I immediately noticed was that any materials that weren't applied via the UV mode which bases the materials location and properties off of the UV maps of the meshes. Once I made sure that every material was now set to UV projection mode I re-exported and imported the models and materials into Unreal Engine which worked for the most part(see figure 8[16]).

The new problem that arose from this was that the plastic materials were glitching out creating visual artifacts which would appear anytime the user would move their head while in VR mode. In order to fix this I had to do a lot of manipulation of the plastic materials. Once I changed the color and opacity of the plastic materials as well as raising the roughness of the materials and lowering the metallicness of it in Unreal Engine. After I adjusted the plastic material parameters I was able to get the materials working in VR mode, albeit the material does not 1 for 1 accurately depict the plastic containers in Quinhagak. One other difference that for now is computationally challenging is the objects within the plastic containers; in reality you can see through the containers and see some of the objects within them, but because the amount of computational power needed to render that many objects with Ray Tracing in VR smoothly would just be unachievable. So for now the plastic containers are empty, although I am toying with the idea of creating a material that would look like objects behind plastic to apply to the boxes to give the illusion of objects within the box.

After I imported and tweaked all of the objects I had created for the collections room I was left with one more key feature, the ceiling. What was unique about the ceiling of the museum was the tread which ran along aloof the sides and corners of the museum along with a wood pillar that split the ceiling down the middle, this wood beam also had wooden decor lining it, so replicating it was very important to me. The

15 See figure 7 for a reference of this step of the procedure.

16 See figure 8 for a shot of how the Virtual Museum looked in Unreal Engine at this stage.

ceiling of the museum also had 4 lights with power cords which lead into the other room. I measured the ceiling and all of its components and began to re-create it.

The hardest part of the ceiling was the wood beam which split the ceiling down the middle. This beam has eight rectangular spaces which are separated by a decoration consisting of three pieces of wood one wider flush against the beam with another thinner but deeper piece of the same wood protruding from the thicker piece finally ending with a thinner darker piece of wood. After I finished sculpting the ceiling beam and the ceiling tread I added in the light fixtures. The light fixtures are your standard fluorescent ceiling lights which are contained within a metal casing with a textured plastic light cover, something you can expect to find in many schools and offices. I got the fluorescent light tubes and the plastic light cover down from a premade asset [17] but I have not made the metal casing for it yet although that won't be too difficult.

After I completed the ceiling and applied all of the proper materials to the meshes I exported it from Substance Stager and imported it into Unreal Engine. Once the ceiling was brought into Unreal Engine I began to create the lighting within the scene. While the correct way of doing this would be to use a light meter to take detailed recording of the actual light within the room to then bring into Unreal Engine to produce accurate lighting. But since I was not on site I had to improvise the lighting within the scene. I decided to add a point light for each of the 4 light fixtures within the room. I edited the color and power of the lights to most accurately reflect the lighting I saw within the images of the collections room that I took. The lighting I would say is close enough to what it is in reality, but this also served as a good lesson which will improve my workflows in the future (see figure 9[18]).

Final Touches

Once I created the lighting for the collections room I began to stress test it in Unreal Engine making adjustments to my render setting to lighten the load on unnecessary rendering. Changing the lights from movable to stationary as well as boosting the antialiasing provided some of the most stability and optimization improvements than anything else I tried. After I made all of the changes I thought were necessary I was able to have a very smooth experience through the VR headset. I then moved into the main portion of the user experience, which was having the ability to interact with the artifacts by being able to pick them up freely. Luckily Dr. Watterson who has been working on scanning the artifacts within the collection for use within the Digital Museum, sent me the artifacts she had already scanned so that I may use them within the Virtual Museum [19].

Once I began to import the .GLTF[20] artifact models into Unreal Engine I began to choose which artifacts I wanted to showcase in the demo during my presentation as well as the demo video I was planning on filming. I chose a variety of artifacts that I thought were cool and unique to showcase the learning potential of the virtual reality experience. After I imported the models into Unreal Engine I had to import a grabbable cube as well as change the mesh of the grabbable cube to that of the desired artifact. After I did that I was able to pick up the 3D artifact models within the VR Headset (see figure 10[21]). While I was filming the demo video I dropped one of the mask models on the floor, while this was a mistake it proved to give me valuable feedback. When I sent the video over to Dr. Watterson; she replied that I may want to create a system that would prevent artifacts from falling to the floor as some of the artifacts in the collection such as the ceremonial masks hold great importance and even though the artifacts are digital they should still be treated with the utmost respect. Since I had only been focused on creating the Virtual Museum it was great to get some feedback that made me look at the project differently which will change the final version greatly improving it.

Closing Thoughts

With the feedback I was able to gather from the demo video that I made I decided to sit back down and begin planning a more final version of this Virtual Museum which would include more refined interactions, as well as the other room of the Museum which is used as a lab to work on the artifacts during the field season. Since the second room of the Museum which I hadn't created yet had windows in it. This creates a different kind of problem that I had luckily been working on at the start of the summer

17 Premade assets are assets that other people make that you can license and use. I licensed the assets I used for this project from Adobe Substance Assets. Using premade assets for everyday items helps to save time.

18 See figure 9 for a picture of the museum with the added ceiling and lighting.

19 For simplicity and accuracy I am referring to the museum project that Dr. Gleason and Dr. Watterson have been working on as the Digital Museum and the virtual reality project that I have been working on as the Virtual Museum.

20 .GLTF is a 3D model file type.

21 See figure 10 for a shot of me interacting with an artifact through the VR headset.

with the IFSAR DEM files which I was able to use to make an accurate map of the surrounding area to Quinhagak. So what I will do to not only preserve accuracy but also provide a more aesthetic experience is to actually recreate the landscape that the Museum sits on and import it into Unreal Engine so that whenever a player looks outside of the window the view they are seeing is the exact same view someone onsite would also be seeing.

While there are some Virtual Museums out there, many of them decided to create a new space for the digitized works, rather than actually recreating the space that the pieces are housed within, something that I would argue is integral to the full understanding of something. While I do not think seeing something in its original context causes a massive level of difference in understanding of the object, I can understand how wishing to see an entire collection as a museum or organization wishes it to be can be very helpful and very entertaining. This is why I think cultural and heritage sites are the prime example for this kind of technology. When compared to an art gallery it is hard to see the massive advantages of being able to hold a painting rather than just being able to zoom in on a high fidelity photo of it. Whereas with cultural heritage sites you could imagine an emphasis being placed on the location and surrounding features. Items such as artifacts are also perfect for this kind of technology. Since we want to preserve artifacts as long as possible, being able to pick them up and study them without any real consequence to the artifact is an invaluable experience.

What I want out of this project that I am working on is to have a working proof of concept. A project that shows what can be accomplished in terms of re-creating a site for exploration and education. I am hoping that this project will give me direction for future projects in this area. I know this project has already helped me flush out workflows which I will continue to experiment with this upcoming semester through an independent study course I will be taking. In this course I will be attempting to recreate one of the buildings on my college campus. What I will be implementing with this project that is different from the Nunalleq Center is that I will hopefully be able to record most of the objects and features of the building using photogrammetry with minimal editing to get it working for Virtual Reality in Unreal Engine. This will hopefully not only improve the overall quality of future Virtual Reality re-creations but also provide an extra layer of precision.

I will be continuing my work on the Nunalleq Cultural Center Virtual Museum through this semester till I have a fully polished version of it. This will include the second room, the landscape, and an entirely custom user interface which will allow for people to choose whether or not they wish to watch a video of a Village Elder talking about and explaining what the artifact is. I am also hoping to make this Virtual Museum experience available to the public through the Meta Quest store and Steam, although that will be the last step.

Figure 1: The collections room in Quinhagak Alaska

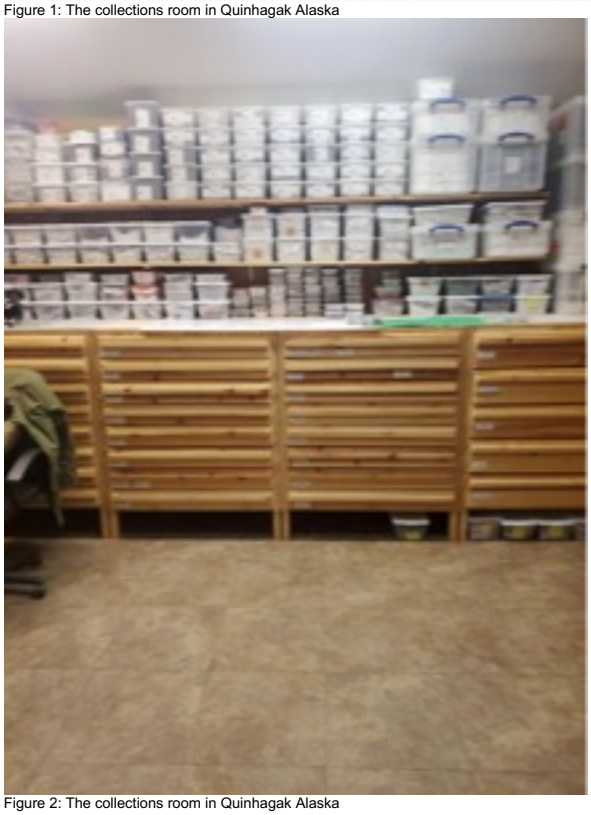

Figure 2: The collections room in Quinhagak Alaska

Figure 3: Screenshot of the Polycam photogrammetry model that I generated of the collections room.

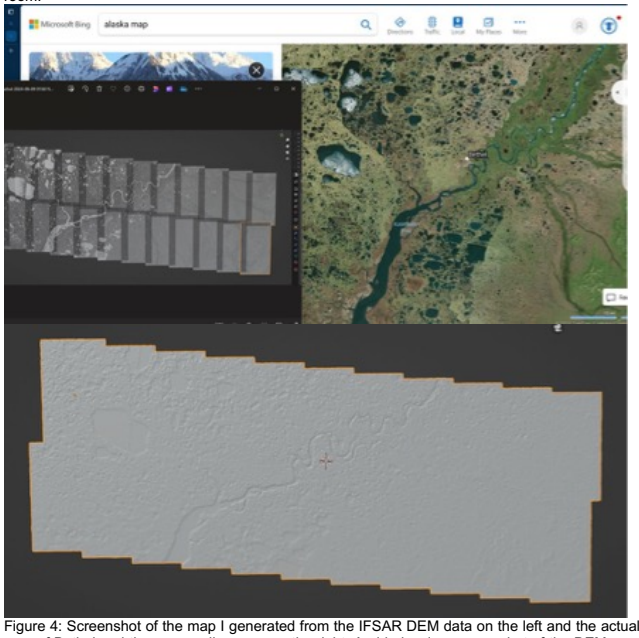

Figure 4: Screenshot of the map I generated from the IFSAR DEM data on the left and the actual map of Bethel and the surrounding area on the right. And below is a screenshot of the DEM map after I smoothed and optimized it.

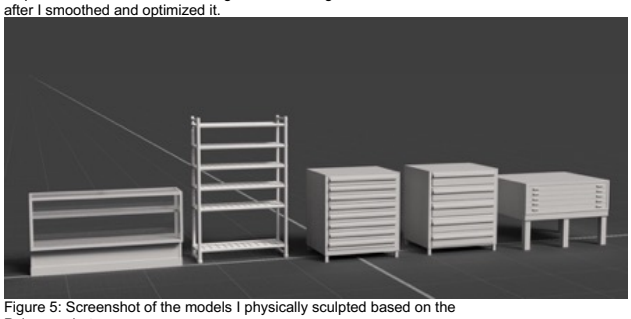

Figure 5: Screenshot of the models I physically sculpted based on the Polycam photoscan.

Figure 6: Screenshot of the models I physically sculpted based on the Polycam photoscan.

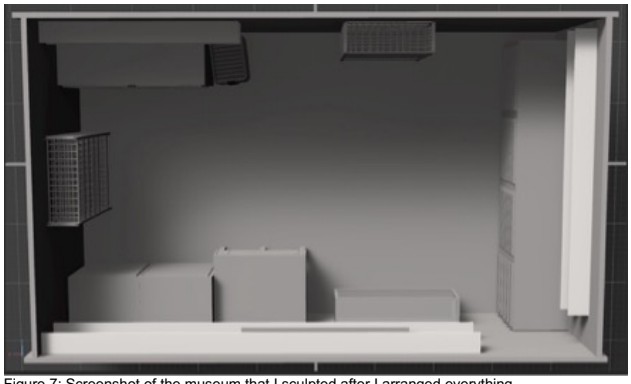

Figure 7: Screenshot of the museum that I sculpted after I arranged everything.

Figure 8: Screenshot of the museum model after I brought them into Unreal Engine.

Figure 9: Screenshot of the museum model after I brought them into Unreal Engine.

Figure 10: Screenshot from the demo video I took of the museum inside of the Virtual Reality headset.