The Making of the Mesoamerican Museum

With the erosion of time, wars, and neglect much of our cultural heritage has been lost. This is evident, as an example, with the recent wars in the Middle East where many cultural artifacts, monuments, and architecture has been destroyed. The destruction of cultural heritage is not only an obliteration of materials but is also an annihilation of our history. It is hard to know where we are historically without the knowledge of where we were in the past. For that reason, I decided to leverage my skills in look development, the application of photorealism textures and materials, and animation, to pursue an MSIS Degree in Digital Cultural Preservation. My capstone project was to create an exhibition of Mesoamerican cultural and historical artifacts in virtual space in a manner that they could be observed and studied worldwide.

For this project I determined the following parameters were crucial:

- Access and availability of Mesoamerican historical cultural artifacts.
- Economy and cost had to be within my budget.
- Portability of Equipment for transportation and ease of set-up and takedown.

Access to artifacts was solved as I was fortunate to be invited to an exhibition showing in Antigua, Guatemala which displayed and curated over 200 artifacts from the Maya and Aztec cultures. I was given full access to study and scan these artifacts so that they could be accurately reproduced and displayed in 3D space. During the last two weeks of February 2020, I traveled to Antigua, Guatemala to scan the artifacts that were on display at this museum exhibit co-sponsored with the Ministry of Culture of Spain, the Ruta Maya Foundation, and Missouri State University. This exhibit, "Images of the Maya Gods in the 16th Century: The Encounter of Two Worlds was on display from July 16, 2019 to March 1, 2020 and featured over 200 Mesoamerican Artifacts.

Figure 1 – Wall poster in Antigua

Figure 2 – Example of Display

While at the showing in Antigua, I took many photographs of the facilities as well as the artifacts on display. I also took care to measure each artifact and recorded each one in an Excel spreadsheet to record their numerical object identification tags, brief descriptions, heights and widths, and photographic image numbers. I also took photos of the displays and how they were arranged so that when creating the digital museum, I could replicate both the facilities, displays, and artifacts as accurately as possible.

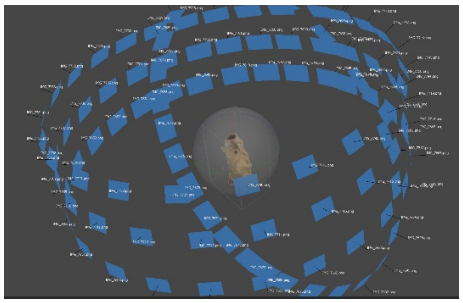
For the sake of economy, it was decided to use the process of photogrammetry to scan the artifacts rather than laser technology for a couple of reasons. The equipment needed for photogrammetry is economical and far more portable. Since this project was on a tight budget this proved to be the best option. Also, I leveraged open-source software whenever possible.

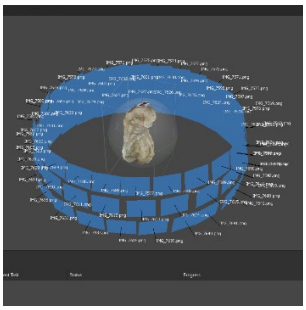
When I needed to use proprietary software, I was able to leverage educational licenses which greatly reduced costs.

In preparation I borrowed several artifacts from a local private collection to determine best practices and software to be used. After several failed attempts, I had success in coming up with the following workflow and needed equipment. Figure 1 is one of my first successful attempts to reproduce an artifact in 3D space using Meshroom software for photogrammetry, Blender for 3D modeling and rendering, and Substance Painter for texturing the 3D Model. Eventually I substituted the use of Agisoft Metashape in lieu of Meshroom. Although it is a proprietary software, Agisoft offered educational licenses which proved to be economical.

Figure 3 – Male Nazcan Artifact
Courtesy of Dr. Chuchiak
Missouri State University

Photogrammetry is the process of taking a series of photographs around an object in a 360-degree pattern at various levels and distance. The bottom of the object can generally be captured by turning the object on its side. Figures 2 and 3 are representations of actual camera locations that were used on two artifacts. As shown, it is best to take over 100 photos that lap over each other by 25 to 30 percent. Shadows should be kept at a minimum.





Figures 4 and 5 – Examples of Camera Positions for Photogrammetry

During my practice sessions, I determined the equipment needed for the photogrammetry of these artifacts included the following:

- A camera that will take high resolution photos in raw format. For my purposes I used a Cannon Rebel EOS T3.
- A stable tripod. The tripod should be of professional grade to reduce shaking and for stability.
- A platform, preferably white, to display the artifact while photographing. For my purposes I used the ComXim Professional 360 Degree photography Turntable. This turntable has an 88-pound capacity and is 12.6 inches in diameter with remote control for speed and direction.

Figure 6 - Turntable

- Camera shutter remote control. This is optional but helps to reduce camera shaking caused by touching the camera while shooting.
- Suitable lights that will emit diffuse lighting to illuminate the object and reduce shadows and backdrops. White backdrops are best to reduce extraneous objects in the photographs and for light reflection and shadow reduction.

Figure 5
Lights and Backdrops

For the most part I took an average of 125 to 150 photos of each artifact in as many positions as possible. If the artifact had an interior surface I attempted to illuminate and photograph the interior as well.

The Processing of Photographs for Photogrammetry

Once the photos were collected, I found it advisable to mask out any extraneous environment revealing only the artifact over a transparent background. Doing this helped to reduce artifacts produced in the next stage of processing the photos. I used the automatic IA function in Photoshop to achieve this effect and ran all the photographs as a batch function. This was not foolproof, but Photoshop produced clear masked out photos over 95 percent of the time. See Figures 6 and 7 for a before and after captures by processing the background from the photographs.

Figure 6 – Raw Image

Figure 7 – Masked Image

Masked photos can then be processed through software designed specifically for converting photographs to a 3D mesh and producing a diffuse color map. The first software that I used was Meshroom, which worked satisfactory most of the time. The advantage of Meshroom is that it is a free software. However, for professional results I decided to use Agisoft Meteshape. This software is harder to use but produced seamless results. It was cost effective since I was able to purchase 2 educational standard licenses for under 150 dollars each. Two licenses were advisable since I could install one on my laptop which I took to Guatemala and one

additional license on my main PC in my office. Once the photographs were processed, I was able to export the 3D mesh as an OBJ file and the diffuse color map as a TIF file.

Processing the Resulting 3D Object

The processed mesh (3D Object) is generally produced as a high-resolution mesh of generally 80,000 to 180,000 faces per artifact. For the purposes of using this mesh in a game engine for Virtual Reality or First-person shooter, those face counts were much too high. It was necessary to reduce the face count but preserve the detail as much as possible. This was achieved through a 3D software application. For my purposes I resorted to using Blender, which produces professional results and is Open Source and therefore comes with no cost. Once the OBJ file for the mesh and the diffuse color map is imported into Blender it was necessary to resize the mesh to the correct dimensions of the physical artifact and to duplicate the mesh. The first copy was labeled by its artifact control number and with a subscript of either being high or low resolution. The mesh labeled "artifact_low" was then decimated to reduce the face count to around 9,000 faces. It was necessary at that point to produce a new UV map and material for that mesh and to bake a new diffuse color map from the high-resolution mesh to the low-resolution mesh. The new color map was then saved and both the high and low resolution meshes were then exported out as FBX files for the next process.

Figure 8 – Raw Mesh before Texturing

Texturing the Objects

Substance Painter was then employed to complete the texture maps to produce a final high-quality mesh in 3D. The low-resolution mesh and the diffuse color map were imported into Substance Painter and additional texture maps were then baked out against the high resolution FBX file. The final texture map to be produced was the roughness map which was produced by using a sand filter since most of the artifacts were clay ceramic based. These texture maps were then exported out for use again in Blender and Unreal Engine. The texture maps were applied to the low-resolution mesh in Blender and the virtual camera was set up for high quality renders of each artifact for both stills and a short rotating animation of each artifact.

Figure 9 – Mesh after Texturing

Creation of the Digital Space

Once all the artifacts had been captured and as much detail concerning the facility where they were displayed was recorded, the process of putting it all into digital space was started. For this process I leveraged Blender and Unreal Engine from Epic Games. I was given the architectural plans of the facilities which with onsite measurements from which I was able to construct the main plaza and rooms where the event was held again using photographic references as a guide for materials and textures.

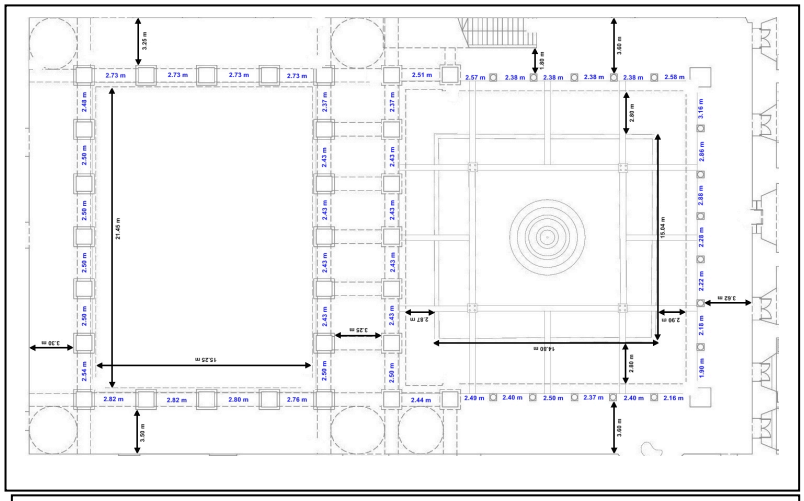


Figure 10 – Main Plaza Plans La Cooperaciton de Espana

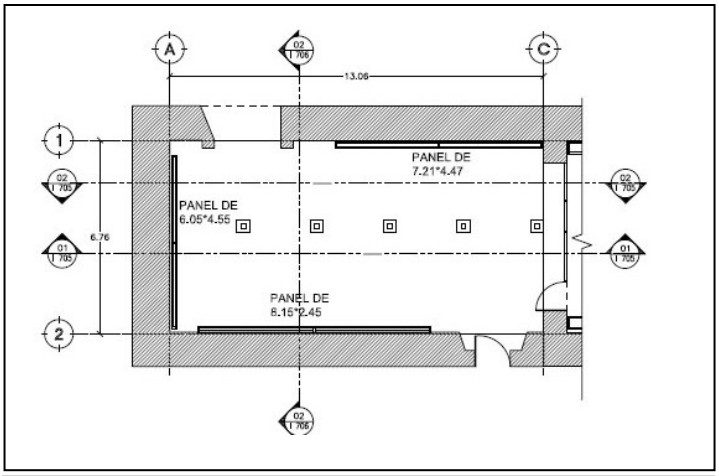


Figure 11 – Plan of Display Room 1

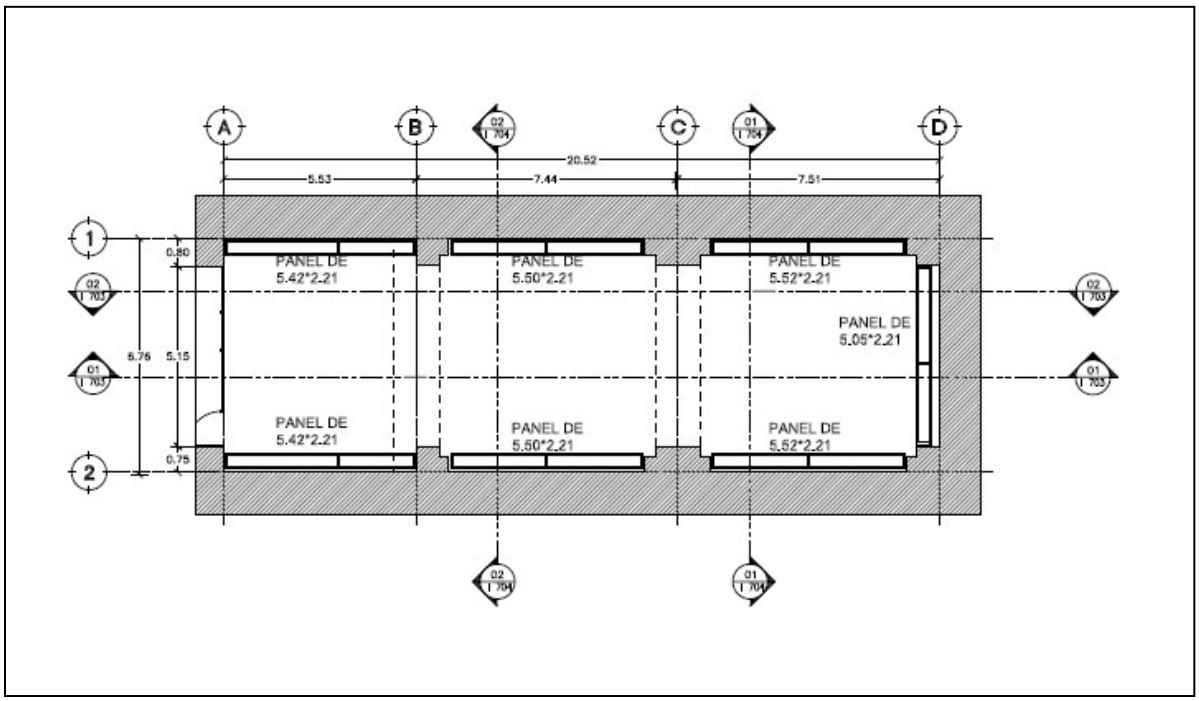


Figure 12 – Plan of Display Room 2

The reproduction of these facilities in 3D software, complete with materials and textures, were then exported from Blender as an FBX file and then imported into Unreal Engine as Virtual Reality. Display cases were then modeled as well as all the artifacts that were scanned. Everything was then exported out as an FBX file and imported into Unreal Engine.

Final Virtual Museum Design

The design of the experience was determined to be less like a game but rather what it would be like to visit a museum. The displays were arranged much like they were as the showcase in Antigua. The visitor in Virtual Reality can teleport to every display, pick up, and examine every artifact. Menus were provided at each display with a likeness of the artifact. When these menu squares are selected the viewer will then be teleported to a wall sized monitor where they can view a video of the artifact complete with a voice over description of the item and subtitles for the hearing impaired. The entire experience can be completed in a standing or seated position.

Figure 12 – Display Case #8 in Virtual Reality

Figure 13 – Tutorial Monitor in Virtual Reality

Figure 14 – Overview of Displays

Figure 15 – Overview of Both Halls

Ongoing Plans

The eventual goal of this project is to make it as accessible to the public as possible. Although Virtual Reality is becoming increasingly popular and affordable it is not accessible everywhere. In the future this experience will be ported over to a first-person shooter format which can then be experienced on a PC, Tablet, and even on a Raspberry PI. This format, although not as immersive, would make it available to third world areas where internet and technology are not abundant. Also, the language used is entirely English which defeats the purpose of wide-spread use. Voice-overs and subtitles will be made to include Spanish as well as English so that this experience could then be disseminated to towns and villages in Latin America where access to historical culture is compromised. There remains physical detail that is missing from the recreation of the facilities that hosted the show and it is my hopes that additional work will attend to that.

The concept of preserving our historical culture in digital form is in no way the best solution. However, the ravages of time will eventually erode the physical forms we now possess. Additionally, the ability for students and the general-public to study these cultural items are not always possible. Even in the native countries were these cultural items originated, much of the native population has not had access to them. It is the fervent wish that projects like this will make the availability and access to heritage that would otherwise be lost.