**NVIDIA Omniverse**

NVIDIA Omniverse is an extremely versatile all-in-one tool to help with building a Digital Twin. However, its hardware requirements are extreme. We decided to not use Omniverse since only one of our computers would be capable of running it (Spec Requirements Listed Below). However, if the hardware requirements were not an issue, we would have researched more about Omniverse and possibly used it for this project.

| Element | Minimum Spec | Good | Ideal |
|---|---|---|---|
| OS | › Ubuntu 18.04/20.04<br>› Windows 10/11 | › Ubuntu 18.04/20.04<br>› Windows 10/11 | › Ubuntu 18.04/20.04<br>› Windows 10/11 |
| CPU | › Intel Core i7 (7th Generation)<br>› AMD Ryzen 5 | › Intel Core i7 (9th Generation)<br>› AMD Ryzen 7 | › Intel Core i9, X-series or higher<br>› AMD Ryzen 9, Threadripper or higher |
| Cores | 4 | 8 | 16 |
| RAM | 32GB* | 64GB* | 64GB* |
| Storage | 50GB SSD | 500GB SSD | 1TB NVMe SSD |
| GPU | GeForce RTX 2070 | GeForce RTX 3080 | RTX A6000 |
| VRAM | 8GB* | 10GB* | 48GB* |

**MATTERPORT**

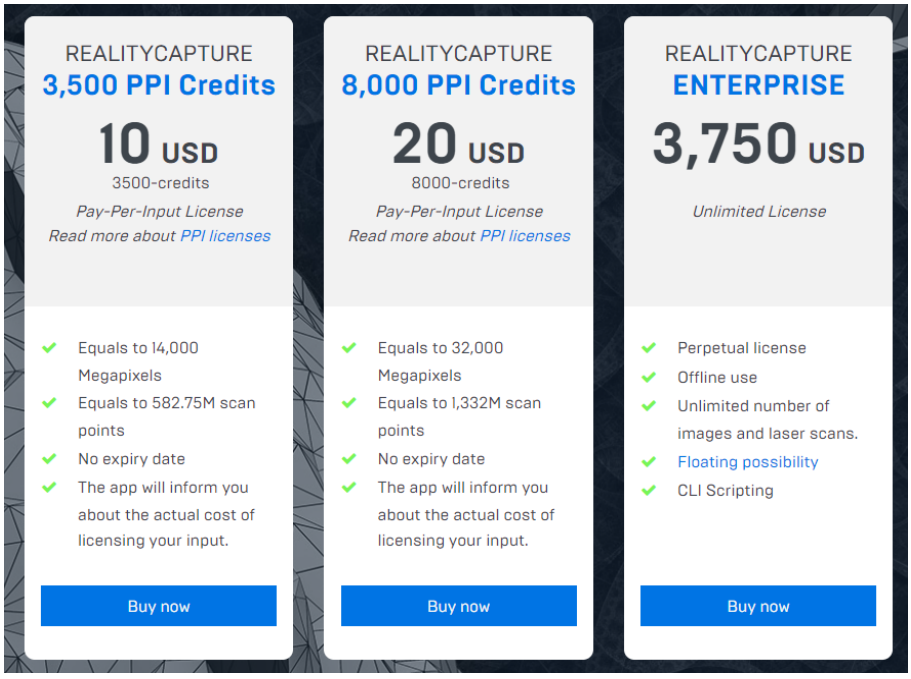
Matterport would have been useful software to create the 3D Model from camera footage. However, it requires a 360-degree camera which we did not have access to. Also, since there were going to be moving parts within the room, those parts would have to be completely removed from the room before we started to create the model. Unfortunately, we were unable to create the 3D model from the security camera footage. So, we manually placed the objects within Unreal Engine and can update the objects' positions while the detection script is running.

**PHOTOGRAMMETRY SOFTWARE**

Photogrammetry is the science of making measurements from photographs. It takes in multiple photographs and displays a map, drawing, or 3d model of a real world object or scene. Conversely, aerial photogrammetry extends its scope to encompass vast landscapes and terrains, utilizing aerial imagery to craft comprehensive three-dimensional models.

There are plenty of photogrammetry software out there, however the majority on desktop are not free. PhotoModeler, Recap Pro, PhotoScan (Agisoft Metashape), Itwin Capture, and Pix4dMapper are all some options we explored but they are all a bit expensive. Some do offer a free demo to upload images but you cannot export the object until a payment is made. We did try a software called Meshroom by alicevision since it was free.This application failed from the start because it did not accept HEIC files which is what IPhones automatically have their image files as. We had to use a free image converter (heictojpg.com/#google_vignette) to change the file format of lots of photos to JPEG files. After uploading the photos, constructing the object was also not ideal. It took too much time to construct the object and the application kept crashing. The robot model was never finished so this option was discarded.

After this we attempted to use Reality Capture since it was the cheapest desktop application. It built a 3D model by taking in several images around the object. Reality Capture can also take drone images and laser scans. As for pricing in reality capture services, it typically depends on several factors, including the complexity and size of the project. Reality Capture does a pay-per-input (PPI credits) license on images which basically allows the user to use that image in the future for unlimited amounts of time. The processing of more images and megapixels will result in more PPI credits being used. Their website offers a calculator to make an estimate of how much it would cost to license some images. For example, 5 images of 12 megapixels each is estimated to be 15 PPI credits. They do offer pricing packages which are displayed below.



This way you can make a one time payment and use up your credits over time. The bright side is you can upload your images and construct your object before paying, this way you can see if you are happy with your results before investing. For this project the $10 package was bought to create the robot but plenty of credits were left. The following links give a tutorial on how to use.

- https://www.youtube.com/watch?v=tw6wNNEbH_M
- https://www.youtube.com/watch?v=sVWYLJxMPq0&t=428s

The downside to using Reality Capture and why we switched to LumaAI is that even though it is cheap it's still not free. It also takes a lot of images and patience to create the model. The individual taking images will need to get all angles of the object slowly for the images because the images should only have a small angle change in between them. The object was also not as great as LumaAI results.

LumaAI is a free IOS application that will generate a 3D model minutes after scanning around the object. It is a quicker process compared to Reality Capture and can do the object reconstruction on an iPhone. The downside is that they do not have an Android application. The app is user friendly and displays an imaginary line around the object. The user will have to scan around the object keeping the camera on the line to scan it correctly and it will only accept the scan if you followed the line correctly. It takes a bottom, middle, and top view of the object to reconstruct a 3D model. The results were satisfactory with only needing small touch ups.

Blender is a free and open-source 3D computer graphics software tool used for animation, 3D modeling, video editing, and creating digital art. We used Blender mainly for touching up the 3D models created already. Some of the background and floor was removed and some gaps were filled. We did use Blender to create the shelf objects since the shelfs were too big to take images or scan for the photogrammetry apps. Blender is a difficult app to work with if you are unfamiliar with it. We did have to watch plenty of YouTube videos and read many articles to become familiar and learn how to use the app.