What Makes a “Model” Model?:
A Comparison of Historic Building Models using Photogrammetry and Lidar Scans

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Introduction to Environmental Remote Sensing

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Introduction

Museums and historical sites have been attempting to reach wider and wider audiences as the digital world has continued to expand. With the desire to engage audiences while preserving history and culture, many museums, archives, and historical sites have turned to digitization of their collections. Every year newer and more robust technologies become accessible and make it possible to digitally preserve objects, even buildings (Andaru et al., 2019) or sites (e.g., Notre Dame was scanned in the mid-2010s). These technologies allow for more audience participation with the ability to create your own virtual museum or collection using digitized collections (Caspani et al., 2017) or take tours of 3D models of historic sites. Capturing photographs have been made easier with our ever-improving smartphones and, for those hard-to-reach areas, the availability of drones that can fly around a specific building. Using photogrammetry methods and calculations, it is possible to create 3D models that can engage audiences who otherwise may not be able to visit. Photogrammetry can collect physical and environmental information through measuring and interpreting photographic images and deciphering spectral information. In this project, I used photogrammetry to interpret and recreate a 3D model from photographs of the Herbert Hoover birthplace cottage in West Branch, IA.

Other studies and projects have used lidar data to add more details and, perhaps, more accuracy to these models. Lidar scanners use a laser pulse to measure the distance between the scanner and the object or area of interest then can bring these data points together to create the scene. Of course, it’s important to note that lasers can only capture a scene it can see, so if there is something in the way of the scanner and the object in question you may miss some data points. Therefore, you want to use multiple scans from different angle to be able to collect the most accurate data.

In this project, I wanted to see if there was a difference in accuracy and appearance between three models: one using just photogrammetry, one using just Lidar scans, and the final one combining the two methods. I hypothesized that there may not be a notable change in appearance between the three, but that there would be increased accuracy using the lidar scans and that would make the third model using both sets of data an ideal fit. Meaning that the third model would look the nicest and would be the most accurate or to scale.

Data

There were approximately 171 photos taken around the Herbert Hoover birthplace cottage in West Branch, IA for the photogrammetry portion of this project. It is best to take photos on an overcast day to minimize the affect of the shadows in the pictures. I had tried to take photos on three occasions, with the third time creating the best results. When taking photos of a 3D object, you also want to try to capture as many angles as possible. This meant that I inched around the cottage several times and, in an attempt to get photos from higher angles, utilized an old selfie stick. I went out on December 11, 2020, before there was snow on the ground.

The lidar scans were taken on August 6, 2016 by the University of Iowa, this means that we have data from two different times of the year, but this only influenced the two shrubs in the front of the cottage. These scans had been registered and cleaned before this project, meaning the scans taken at different points around the cottage were aligned creating a 3D point cloud in the shape of the building. There were eight scans in total around the building.

I. Photographs of the Herbert Hoover Birthplace Cottage
    a. Taken on December 11, 2020 around 1:00 pm – it was a rainy, overcast day
    b. Taken on a Samsung Galaxy 10
II. Cleaned and registered Lidar scans of the Herbert Hoover Birthplace Cottage
    a. Scanned by the University of Iowa, August 6, 2016

Methods

The goal of this project was to compare three mesh models using photogrammetry and lidar scans to see which ones were more accurate and more visually appealing. The University of Iowa uses Leica Cyclone for working with Lidar data, so I started there with point clouds. Ultimately, I wanted to work with all my data in the same program and Cyclone doesn't do photogrammetry, so this led me to RealityCapture. It's a free program that mostly focuses on photogrammetry, but allows you to interact with Lidar scans as well. I wanted everything to go through the same program for consistency and as an experiment to see if we could easily take scan data from Cyclone to RealityCapture.

For the photogrammetry portion, I was easily able to upload the photos I took around the object, align the photos, and calculate a mesh or model to which I then added texture. I was given two options for coloring the model – colorize or texturize. The main difference between the two methods is the amount of detail. Colorizing uses the RBG values from each polygon point to add color to the model while texture does the same but will add more depth and realism. The first two times I went out to take photos of the object I was too excited and had not formed enough of a plan. Once I tried out the program more, I realized that the initial data would not suffice. That's when I found an explanation and the examples in Figure 1. After creating the model, I saved the aligned photos as a RealityCapture component, which will be used again for the scans and photo model.

The difficult part was to export the data from Cyclone to RealityCapture. Most Lidar data comes in binary file formats, like LAS or LAZ, but RealityCapture works with PTX (a text file) or E57 (a hybrid of binary and text), which meant that I had to figure out how to export the data from Cyclone in a way that would work with another program. I ended up using the Cyclone modelviewer to save each scan separately in an E57 file format. Then I was able to bring those files over to RealityCapture and align the point clouds before calculating the model. There was still some cleanup that was necessary. After cleaning up and filling the holes, I saved the project and went on to bring in the photogrammetry-aligned pictures from the last model.

At this point, I was able to combine the two techniques into one model, which basically allowed the accuracy of the Lidar scans to enhance the visuals from the photographs. Since both data sets were aligned before being combined, there was a little tweaking that needed to be done to line everything up. It’s possible to place control points on the photos and the point clouds where points should line up. The program is relatively accurate to begin with, but I wanted to make sure, so I placed a few control points around the base of the foundation and roof.

With all our models in hand, I had hoped to use two methods for evaluation, however, with all the difficulties I was having with creating the models, I ran out of time to utilize either of them. The more quantitative method would be to use the measuring tools built into the program to measure points on the object. In addition, I would utilize a more qualitative evaluation by creating a survey to send to employees at the Herbert Hoover Presidential Museum and Library, the Herbert Hoover National Historic Site, and other museum peers to get feedback on the models.

Results

As we can see in the appendix and the three attached videos, the two models that utilize photogrammetry appear to be more accurate and complete (Figures 2 and 5, Attached 1 and 4), while our model created using just the Lidar scans seems to be missing parts of the structure, such as walls and the front door (Figure 4 and Attached 2 and 3). When we compare Figure 4 and Attached 2 and 3 to Figure 3, we can clearly see that point data did exist and that it was somehow in the conversion process. There were countless attempts to convert data from one program to the other and many of these models lost significant amount of information, leaving me with outcomes that sometimes didn’t even resemble the original building.

Discussion

While working through this project, I ran into several roadblocks, especially when working with the Lidar scans. If I had more time, I would have really liked to get a better model from the scans, however, it was incredibly difficult to find any tutorials or threads on the support pages for RealityCapture that fully explained workarounds with Lidar data. At this point, it seems that RealityCapture is still in the earlier stages of integrating Lidar data and it may be that they need to improve some algorithms or produce more tutorials. It could also have been user error. I would be the first to admit that I was teaching myself a lot about some of these processes and may have missed small, but key, steps.

One thing that I think may have been causing issues is how the camera may have been registered between the two programs. RealityCapture has the ability to show where each of the cameras were located around the object so that, when looking at the photogrammetry model, over 100 little cameras appear to be hovering around the model. But when looking at the scans projection, there would be only one. I was not able to figure out a way to get all eight scanner locations to show up in the model viewer, which tells me that there may have been an over-simplification of the data between exporting from Cyclone and importing into RealityCapture that may have combined all the cameras into one. This would make it difficult for the program to get a good 3D model. RealityCapture has a workflow or table of contents feature that shows all the data and components used in a project, and I noticed that it would allow me to display different parts of the Lidar scans. It made me wonder if it also may not have been a camera issue, but that I was somehow supposed to combine the different scan components – I could not figure out if that was the issue either.

If I were to continue working on this project, I think that I would like to see how RealityCapture compares to another 3D program like Unity 3D, and look into programs used to distribute the finished product, such as Mapbox, both of which were used by Andaru et al., 2019. I would also like to figure out how to fix the camera angle issues in the Lidar data. There are several ways to make the models and 3D tour available for audiences online and that would be another step that I would like to add to this project that I did not have time to investigate.

All in all, this study did not prove my hypothesis wrong or right since I was not able to complete the full scope of the proposed project. Ideally, I would have been able to conduct both quantitative and qualitative forms of evaluation, however, I simply ran out of time. If I had more time to evaluate the models that were produced, I would have been able to properly apply units to the models allowing me to measure for accuracy and I would have been able to send a survey out to people. Because I kept struggling with the exporting and importing of data, I did not have the time to evaluate.

In the long run, we want to reach a point where we can accurately record these historical objects and sites for education and research possibilities, but also in case something disastrous happens to the original.

Appendix

There are three videos of the models as well that will be turned in along with this paper. They will be referenced as Attachment 1, 2, 3, and 4.

Attached 1 – " 01hoover_house_photogrammetry" – a video of a 360˚ circle around the photogrammetry model.

Attached 2 – "02just_lidar01" - a video of a 360˚ circle around the lidar scan model before coloring or texturing.

Attached 3 – "03just_lidar02" - a video of a 360˚ circle around the lidar scan model after applying texture.

Attached 4 – "04hoover-house-photogrammetry-lidar" - a video of a 360˚ circle around the photogrammetry + lidar scans model.

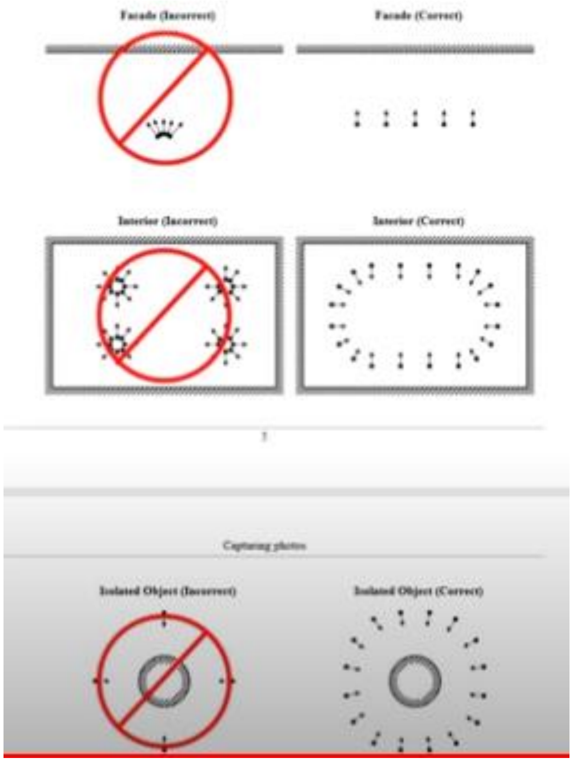

Figure 1 - diagrams for ideal photographing techniques for creating models of objects.

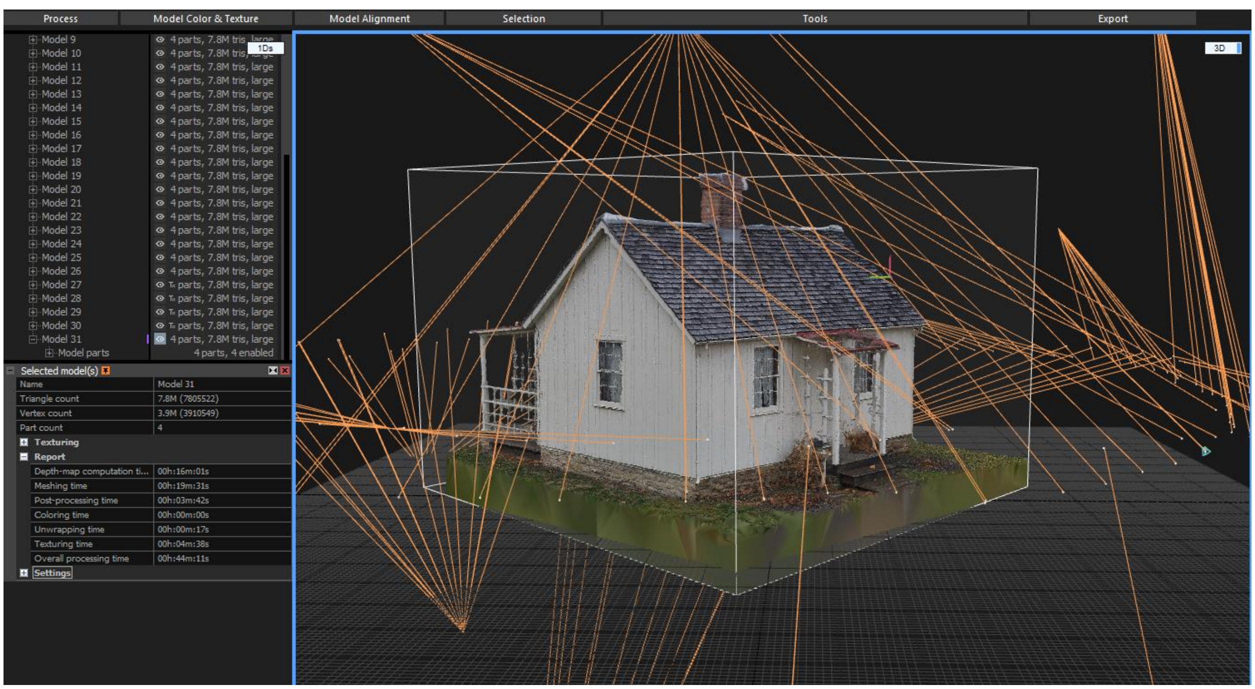

Figure 2 - textured model using photogrammetry

Figure 3 - point cloud from Lidar scans in Leica Cyclone

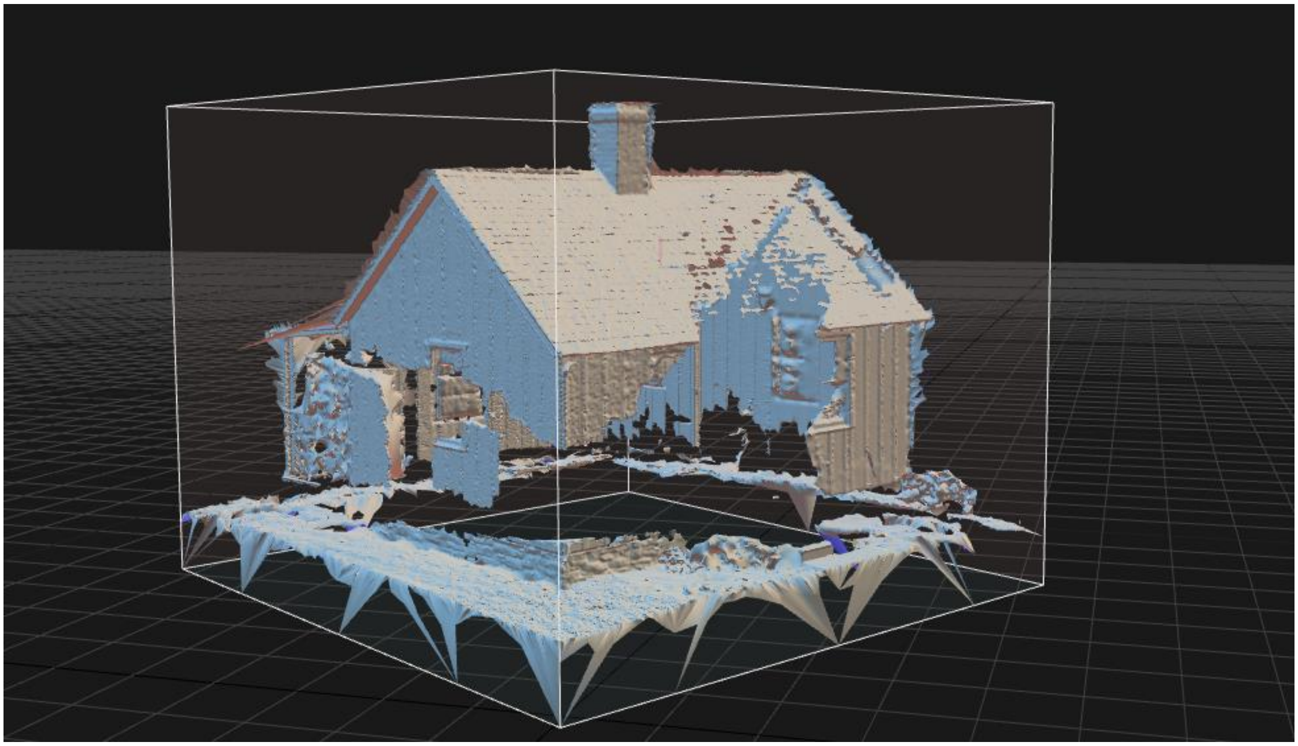

Figure 4 - Model created from point clouds imported from Cyclone into RealityCapture

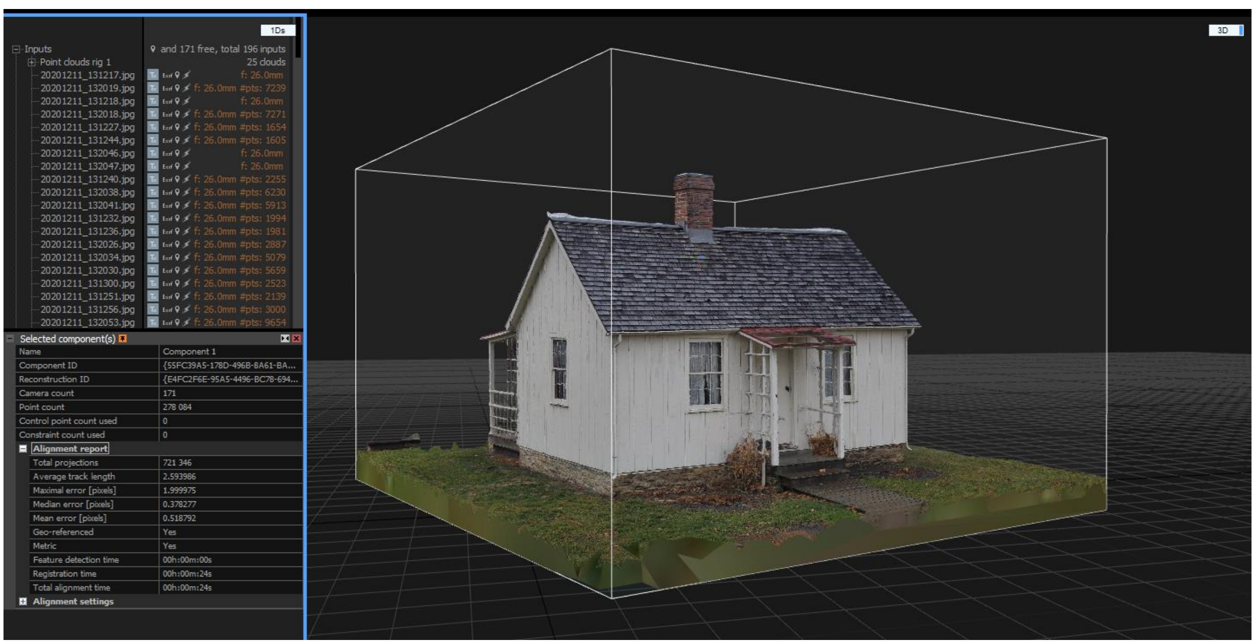

Figure 5 - textured model using photogrammetry and lidar scans

Bibliography

R. Andaru, B. K. Cahyono, G. Riyadi, Istarno, Djurdjani, G. R. Ramadhan, & S. Tuntas. (2019). THE COMBINATION OF TERRESTRIAL LIDAR AND UAV PHOTOGRAMMETRY FOR INTERACTIVE ARCHITECTURAL HERITAGE VISUALIZATION USING UNITY 3D GAME ENGINE. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W17, 39–44. https://doi.org/10.5194/isprs-archives-XLII-2-W17-39-2019

S. Caspani, R. Brumana, D. Oreni, & M. Previtali. (2017). VIRTUAL MUSEUMS AS DIGITAL STORYTELLERS FOR DISSEMINATION OF BUILT ENVIRONMENT: POSSIBLE NARRATIVES AND OUTLOOKS FOR APPEALING AND RICH ENCOUNTERS WITH THE PAST. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences., XLII-2-W5, 113–119. https://doi.org/10.5194/isprs-archives-XLII-2-W5-113-2017

Website links:

https://info.vercator.com/blog/reality-capture-101-point-clouds-photogrammetry-and-lidar

RealityCapture YouTube with tutorials: RealityCapture Videos