A 3D Model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge in Salem, Oregon

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Summary of Scope

Our project designs a 3D Model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge (otherwise known as the "Taco Bridge") located in Salem Oregon. Our mission was to fly the drone at Riverfront Park on Tuesday, February 27th to capture images to create a photogrammetric 3D model of the bridge.

During this project, we had a few obstacles that we needed to be aware of and address. Initially, the flight location was in close proximity to the Salem Municipal Airport. This means that we needed to apply for FAA permission to fly and had a height limit of 50ft. Another obstacle was the shape of the bridge. The bridge was difficult to create a pre-programmed flight plan for because of its oval shape and specific camera angle needs. To compensate for this, we flew the drone manually. Additionally, weather was also an obstacle. The weather was not ideal as it was overcast, windy, and had oncoming rain. Another obstacle was interference from pedestrians and cyclists. As our research area is a public area, we needed to remain respectful of pedestrians and cyclists using the bridge during the flight. With regards to data processing, we also had to attempt to keep as many moving objects out of our pictures as possible to preserve the quality of our 3D model. We also considered that the water reflectance underneath the bridge, the small wires on the bridge, and the bridge's white color blending with the overcast sky could present a problem when processing the data. All of these factors could make it difficult for the software to recognize the shape of the bridge to create a 3D model.

Despite these threats, our research was successful. We found that creating a photogrammetric model by drone is an effective method for creating a 3D model of the bridge. We also found that this method was successful in measuring the length, height, and width of the bridge.

Project Area

The project area for our research is located in downtown Salem, Oregon at Riverfront Park. The Peter Courtney Minto Island Bicycle and Pedestrian Bridge crosses over Pringle Creek as it flows into the Willamette River. The "Taco Bridge" connects downtown Salem to Minto-Brown Island via pedestrian and cyclist walkways. The connection between the two landmasses can be best seen in Figure 1 below, which includes a map zoomed into the location of the bridge. To see the location of the bridge in reference to downtown Salem, see Figure 2.

Figure 1: Zoomed in map of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge that crosses over Pringle Creek. This bridge connects Minto-Brown Island to Riverfront Park in Salem, Oregon.

Figure 2: Zoomed out map of downtown Salem, Oregon and the Willamette River with reference to the bridge location. The Peter Courtney Minto Island Bicycle and Pedestrian Bridge can be found in the bottom left corner of the image.

Research Questions

Our research project encompassed both a methodological inquiry and a practical question regarding the Taco Bridge. Our methodological question was, "Can we develop an accurate 3D model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge utilizing drone photogrammetry data?". The practical question of our research project included, "What are the dimensions (length, height, and width) of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge?". These questions will provide our research team with experience in creating a 3D model and information about the dimensions of the bridge.

Methods

Our methods of this project began with deciding on a landmark to make a 3D model of, creating a flight plan for the project area, conducting the drone flight to capture photos of our object, and then processing the captured photographs to test if we could create a successful photogrammetric model of the chosen figure. The project area that we chose was the Peter Courtney Minto Island Bicycle and Pedestrian Bridge (or the "Taco Bridge") located in Salem Oregon. Our research team chose this project area because the bridge presented an exciting challenge and was close in proximity to Willamette University. In previous classes, the Taco Bridge had been attempted to be drone captured before, but none of those missions were very successful. Our team wanted a challenge that would give us an interesting learning experience that would give us plenty of experience with planning a drone project mission and using the provided software to create a photogrammetric 3D model.

In the mission planning process, we discovered that it would be extremely difficult to preprogram a flight that would successfully capture the images needed to create a 3D model.

Instead of a pre-programmed flight plan, our mission must be flown manually. This was decided due to a multitude of obstacles that we knew we would encounter in our project. Firstly, the Taco Bridge was near the Salem Municipal Airport, which meant that we needed to apply for FAA permission to fly and had a height limit of 50ft from ground level. We knew that the bridge was tall and would likely come close to this height limit. Therefore, we would need to assess the height of the bridge and our flight limit during the flight and potentially change the angles of our pictures to compensate for this limitation. Another obstacle was the shape of the bridge. The bridge was difficult to create a pre-programmed flight plan for because the software app (Pix4D Capture Pro) we needed to use to create a flight plan would not allow for us to rotate the shape of the flight plan to capture the entire bridge. We also knew that the weather could be a significant obstacle. Flying manually would make it easier for us to manage the drone flight if weather interference became a problem. Another obstacle would be pedestrians and cyclist interference. The Taco Bridge is a public area, which means that our research team must remain respectful to pedestrians and cyclists using the bridge while we were conducting our flight. When being mindful of the data processing step while we planned our mission, we realized we would need to try to keep as many moving objects out of our pictures as possible to preserve the quality of our 3D model. If we flew our mission manually, we would be able to easily pause and adjust camera angles to avoid interference with pedestrians and cyclists. Because our research team decided to fly our mission manually, the picture overlap was not pre-programmed and instead done by manual estimation.

The drone and camera that we used to capture photographs of the bridge was a DJI Mavic 3. Our flight mission took approximately 45 minutes in total. Our research team flew the drone on both sides of the bridge multiple times and over the top of the bridge. As predicted, the weather was an obstacle. On the flight mission day, the weather was overcast, windy, and had oncoming rain. However, the conditions were stable enough and the mission was successful regardless. We were able to obtain 360 pictures by drone flight to capture all different angles to be used to create a successful 3D model. Each angle captured automatically included 3 different photographs with different lighting. All of these photographs were used to create our final 3D model.

After downloading the photos from a drive to the harddrive of our computer, we processed them through the software program Pix4D. The photos were uploaded to a Pix4D project and the output settings were set to a 3D-PDF file and a Google Maps Tile kml file. "1. Initial Processing", "2. Point Cloud and Mesh", and "3. DSM, Orthomosiac and Index" processes were ran as our first processing round, which took approximately three hours to complete. After this step, we selected "Triangle Mesh" and went through the ray cloud and assigned points that cluttered the 3D model of the bridge to "Dissabled". This would remove the points from our model so that it was less cluttered, but not delete them.

After this, we reran "2. Point Cloud and Mesh" and "3. DSM, Orthomosiac and Index" processing steps to update our outputs without the cluttered points in the ray cloud. This second processing round took approximately two hours to complete. After this round, we then re-editied the ray cloud by setting points to "Dissabled" to remove the clutter. See Figure 3 for pictures of the model during our processing within Pix4D. After this final step, the model was able to be rendered successfull.

After the successful completion of the 3D model, we then used the Polyline tool to measure the height, length, and width of the model. These measurements were recorded and saved for analysis of our research project.

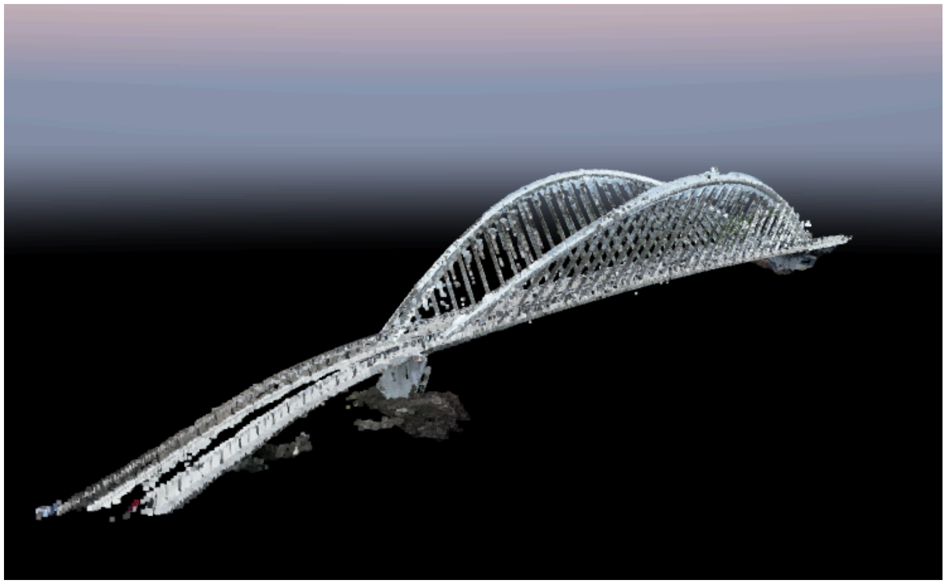

Figure 3: Screenshot of the our 3D model as it is shown in Pix4D after cluttered ray cloud points were removed. This image was taken after the first processing round and before the second processing round. The image shows that the 3D model of the bridge is complete and without gaps.

Results

The results to 3D model were rendered successfully. Out of 338 of the images that Pix4D used, 158 of them were calibrated and 177 were disabled. All 338 of the images were geolocated. There was a median of 407774 keypoints per imag and a 0.016% relative difference between initial and optimized internal camera parameters. No 3D ground control points (GCPs) were used.

The outputs of the project are a 3D-PDF file and a Google Maps Tile kml file. Figure 4 shows the 3D-PDF file and Figure 5 shows the Google Maps Tile kml file. The measured height within Pix4D of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge was 30 meters. The width was measured to be 20 meters and the length was measured to be 101 meters.

Figure 4: The 3D-PDF output file from the Pix4D 3D model creation. This is an overhead view of the 3D model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge. This PDF shows the bridge over the water and the beginning of the walkway on both sides of the bridge.

Figure 5: The Google Maps Tiles kml file output from the Pix4D 3D model creation. This image shows how the created kml file of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge is seen when opened in Google Maps.

Analysis

Despite the many threats to our data, we were surprised to find that the 3D model came out extremely successful. Our 3D model of the Taco Bridge was complete from all different angles and views. There were no gaps in the physical appearance of the 3D Taco Bridge model and various rotations and angles can be seen well and with detail.

This was a surprising result to our research team. Going into this project, our team was execlting a multitude of challenges with the data processing quality. We expected to have a very difficult time in creating a model of the bridge because the bridge is over water. Water is often difficult to work with since the reflectance of the water can cause complications with the 3D model creation. It can be difficult for the software to differentiate between pixels when shooting something reflective. However, our model was successful regardless of this obstacle. It can be inferred that the software had an easier time than expected differentiating between the bridge and the water beneath it. A little difficulty in the output of our model can be seen in the kml file in Figure 5 as the water looks very strange underneath the bridge. Our research team also expected to have a lot of difficulty with Pix4D being able to recognize the small white wires on the bridge, and the white bridge body itself, as it blends in with the overcast sky behind it. Shockingly, the model did extremely well and picked up the wires and created a complete image of the bridge. The pedestrian interference that we did have also turned out to not be a problem. There were no “ghost-like” people that showed up in our product as we expected. Pix4D did an excellent job of sorting out the people from the images to create the final 3D model.

In analyzing these results, our research question of “Can we develop an accurate 3D model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge utilizing drone photogrammetry data?” can be answered as successful. The 3D model output that was created was a shockingly accurate representation of the Taco Bridge. The dimensions of the bridge were also measured to acceptable accuracy of a height of 30 meters, width of 20 meters, and length of 101 meters. These results match up with the expected dimensions of the bridge. This project gave our research team the experience we needed with creating a photogrammetric model and drone survey flight planning. It also successfully informed us of the dimensions of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge.

Conclusion

Utilizing drone photogrammetry data, we embarked on a journey to model the Peter Courtney Minto Island Bicycle and Pedestrian Bridge. The methodological question guiding our exploration was whether we could construct a successful model through this approach. This question was answered as successful. To answer the practical question of this research project, the bridge's dimensions were found to be a height of 30 meters, a width of 20 meters, and a length of 101 meters. Through meticulous analysis of the gathered data, we achieved a comprehensive model that accurately represents the bridge in its entirety. Thus, our findings not only demonstrate the feasibility of creating a successful model using drone photogrammetry but also provide precise answers to the practical inquiries regarding the bridge's dimensions.

This study's implications extend beyond mere technical achievement, resonating deeply within the realms of urban planning and infrastructure assessment. By showcasing the effectiveness of Unmanned Aerial Systems (UAS) in constructing detailed models of vital infrastructure like the Peter Courtney Minto Island Bicycle and Pedestrian Bridge, our research project reinforces the transformative potential of drone technology in urban development. Such data-rich models not only aid in precise urban planning, but they also facilitate informed decision-making regarding infrastructure maintenance and expansion. Additionally, the successful application of drone photogrammetry in this study opens avenues for further exploration in infrastructure assessment, potentially revolutionizing how we approach and manage critical urban assets.

Reflecting on our project, it's evident that despite encountering numerous challenges—including adverse weather conditions, intricate details like small wires on the bridge, and logistical hurdles like navigating pedestrian traffic—the success of our 3D model of the Peter Courtney Minto Island Bicycle and Pedestrian Bridge surpassed our expectations. Despite these obstacles, the model's accuracy and detail were commendable. However, in hindsight, there are areas where improvements could have been made. Enhancing the data collection process to mitigate issues like water reflectance and optimizing flight paths to minimize interference from pedestrians could have further refined the model's quality. Additionally, exploring advanced image processing techniques or utilizing more sophisticated drone technologies might have addressed some of the challenges encountered. Overall, while our project achieved remarkable success, there remain opportunities for refinement and enhancement in future endeavors.